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RAZORBILLS (*ALCA TORDA*) FOLLOW SUBARCTIC PREY INTO THE CANADIAN ARCTIC: COLONIZATION RESULTS FROM CLIMATE CHANGE?

ANTHONY J. GASTON[1] AND KERRY WOO

Environment Canada, National Wildlife Research Centre, Carleton University, Ottawa K1A 0H3, Ontario, Canada

ABSTRACT.—We describe the occurrence and behavior of Razorbills (*Alca torda*) visiting Coats Island, Northern Hudson Bay, an area where sea-ice cover in summer has been much reduced since the mid-1990s. Coats Island is 300 km from the previous most-westerly breeding site for the species and nearly 2,000 km from the nearest large colony, in Newfoundland and Labrador. Razorbills appeared at Coats Island coincidentally with an increase in the delivery of Capelin (*Mallotus villosus*) and sand lance (*Ammodytes* spp.) to Thick-billed Murre (*Uria lomvia*) nestlings at the same site and disappeared when sand lance also disappeared. Razorbill populations are expanding in eastern North America, and this expansion may partly account for their dispersal. The ability of Razorbills to track changes in a preferred prey item well outside the boundary of their normal range suggests that this species is capable of adapting rapidly to climate change. *Received 29 November 2007, accepted 27 May 2008.*

Key words: *Alca torda*, *Ammodytes*, climate change, Hudson Bay, range extension, Razorbill.

Alca torda suit ses proies subarctiques dans l'Arctique canadien: une colonisation qui résulte des changements climatiques?

RÉSUMÉ.—Nous décrivons la présence et le comportement d'*Alca torda* fréquentant l'île Coats, dans le nord de la baie d'Hudson, une zone où la couverture estivale de glace en mer a été fortement réduite depuis le milieu des années 1990. L'île Coats se trouve à 300 km du site de reproduction de l'espèce le plus à l'ouest et près de 2000 km de la plus proche grosse colonie, à Terre-Neuve-et-Labrador. L'apparition d'*A. Torda* à l'île Coats a coïncidé avec l'augmentation de la distribution de *Mallotus villosus* et d'*Ammodytes* spp. aux oisillons de *Uria lomvia* au même site. *A. torda* a disparu du site en même temps qu'*Ammodytes* spp. Les populations d'*A. torda* sont en expansion dans l'est de l'Amérique du Nord et cette expansion peut en partie expliquer leur dispersion. La capacité d'*A. torda* à suivre les changements d'une proie préférentielle en dehors des limites de sa épartition normale suggère que cette espèce est capable de s'adapter rapidement aux changements climatiques.

OVER THE PAST two decades, reductions in spring and summer sea-ice cover have occurred in Hudson Strait and northern Hudson Bay (Gagnon and Gough 2005, Stirling and Parkinson 2006). Reductions in the extent of summer sea-ice have been most marked since 1995 and have been associated with changes in the diet of nestling Thick-billed Murres (*Uria lomvia*) at colonies in northern Hudson Bay (Gaston et al. 2003). The most striking aspect of this change has been replacement of the ice-associated Arctic Cod (*Boreogadus saida*; Mehlum and Gabrielson 1993), characteristic of High Arctic waters, by the Low Arctic Capelin (*Mallotus villosus*), which is most abundant in waters with little or no summer sea-ice cover (Carscadden et al. 2001).

Until the mid-1990s, Arctic Cod was the most common prey item in the diet of nestling Thick-billed Murres throughout the Canadian Arctic (Gaston and Jones 1998), whereas Capelin is an important diet item for Low Arctic alcids in Canada, especially Atlantic Puffin (*Fratercula arctica*) and Common Murre (*U. aalge*; Birkhead and Nettleship 1983, Gaston and Jones 1998, Baillie and Jones 2003). The Razorbill (*Alca torda*), by contrast, feeds especially on sand lance (*Ammodytes* spp.), as well as on Capelin, in Low Arctic and boreal waters off Atlantic Canada (Birkhead and Nettleship 1983, Chapdelaine and Brousseau 1996).

The speed at which species may be capable of responding to the biotic changes brought about by climate change is a matter of concern in planning for a warmer planet (Brown 1991, Boyd and Madsen 1997). Given the changes taking place in ice cover in Hudson Strait and Hudson Bay and the fact that diets of nestling Thick-billed Murres in the region are now dominated by a fish more characteristic of the diets of Low Arctic and boreal auks, we might expect the gradual colonization of the Hudson Strait region

[1]E-mail: tony.gaston@ec.gc.ca

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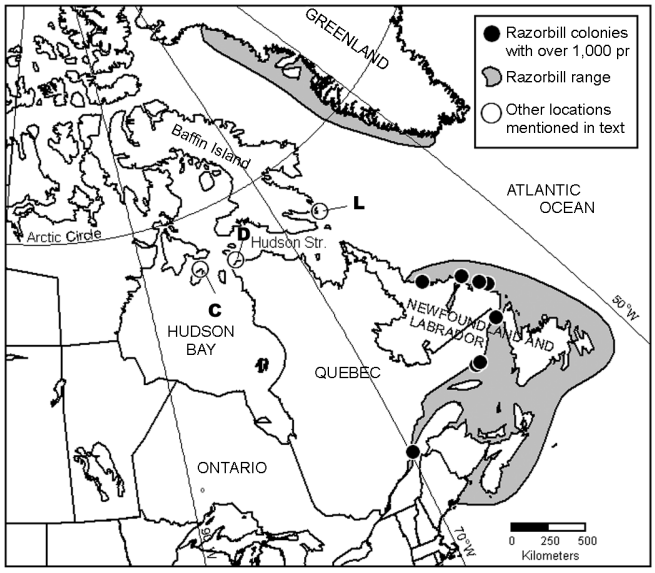

Fig. 1. Map of Eastern Canada showing the principal range of the Razorbill in North America and Greenland and the location of places mentioned in the text: C = Coats Island, D = Digges Sound, and L = Lok's Land.

by species such as Common Murre, Atlantic Puffin, and Razorbill. However, the region is very remote from areas currently supporting large populations of those species (Fig. 1). Gannet Islands, Labrador, currently the nearest colony supporting >1,000 of each of these species, is ~1,000 km from the mouth of Hudson Strait. How and when these species might colonize the habitat that global warming is apparently preparing for them is an important question in understanding the consequences of climate change.

Here, we describe observations of a potential colonization attempt by Razorbills at Coats Island, 300 km west of the previous westernmost known breeding site of the species and 2,000 km by water from the nearest large breeding aggregation. We relate the arrival and dynamics of the colonization attempt to changes in diet exhibited by the locally breeding Thick-billed Murres and speculate about what the appearance and disappearance of Razorbills at this site may indicate about the potential colonizing ability of the species.

The distribution of the Razorbill in North America extends from the Gulf of Maine (Matinicus Rock, 43°47′N) and the estuary and Gulf of St. Lawrence to the coast of Labrador, where the northernmost known colony is situated at 56°26′N (Chapdelaine et al. 2001). A population of several thousand pairs also occurs along the west coast of Greenland to 74°N (Boertmann et al. 1996). In addition, two small breeding populations are known in Nunavut: one in Loks Land, off southeastern Baffin Island (62°21′N) and one at Digges Sound off the northeastern tip of the Ungava Peninsula (62°33′N; Brown et al. 1975, Gaston and Malone 1980; Fig. 1). There have been additional summer sightings at two other localities in Hudson Strait (F. G. Cooch pers. comm., A. J. Gaston unpubl. data; Fig. 1).

In addition to the small Arctic populations of Razorbills referred to above, a small colony of ≤30 pairs of Atlantic Puffins breeds on Dome Island, near Digges Island, not far from the westernmost outpost of Razorbills (Gaston and Malone 1980). The Black Guillemot (*Cepphus grylle*) is the only other auk found in the region and breeds throughout Atlantic Canada and the eastern Arctic. The nearest substantial colonies of Atlantic Puffin and Common Murre occur in Central Labrador, north to ~56°N (Brown et al. 1975).

Methods

Observers studying the breeding biology of Thick-billed Murres have been present at Coats Island in summer annually since 1984. In addition to the observations of Thick-billed Murres, a check-list of birds recorded in the vicinity of the colony has been kept daily throughout the period when the camp was occupied. In addition to observations at the Thick-billed Murre colony, frequent observations were made ≤3 km in either direction along the coast, an area that includes many apparently suitable Razorbill nest sites.

Visits during 1984–1987 lasted two to three weeks from about 1 August. Thereafter, observers were present from at least mid-July to mid-August in all years except 2000, when the field crew did not arrive until 28 July. While the camp was occupied, observers spent approximately 15–20 person-hours daily watching from the cliffs. Once the presence of Razorbills on the colony had been proven, observations were made of the display site once or twice daily (see below). Most observers over the years have been familiar with the identification of different auk species.

From 1988 onward, we recorded the food delivered to nestling Thick-billed Murres annually during three 24-h or 48-h watches spread through the nestling period. Because Thick-billed Murres deliver prey held in the bill, different species of fish can be readily identified as birds arrive to feed their nestlings. Details of these feeding watches were presented by Gaston et al. (2003). Maximum counts of Razorbills in each year were compared by least-squares regression with the proportion of Capelin and sand lance (arcsin transformed) in the nestling diet.

Results

Timing of Razorbill observations.—The first observation of a Razorbill at Coats Island was in 1998, when a single bird was sighted on 21 August on a Thick-billed Murre breeding ledge that was under observation daily throughout our project. No further sightings were recorded until 2001, when up to nine Razorbills were recorded daily from 7 to 14 August. In 2002, Razorbills were present daily from 4 to 14 August, with a peak of 12 on 13 August. In 2003, observations began on 26 June, the first Razorbill was seen on 17 July (9 present), and birds were seen until 13 August, but 9 was the highest count. Highest counts in 2004 and 2005 were 3, with sightings from 18 July to 10 August and 7 July to 3 August, respectively. No Razorbills were seen in 2006 or 2007. In 2001–2003, camp closed the day after the last Razorbill sighting, so their presence may have continued after our departure.

Behavior.—Most Razorbills were seen on top of, or adjacent to, a small stack ~4 m above the sea, situated at the northern end of the Thick-billed Murre colony. The stack provided no suitable nest sites for Razorbills, being subject to wave-wash during storms. Birds sitting on the stack displayed to and allopreened one another around the base of the bill. They periodically flew around

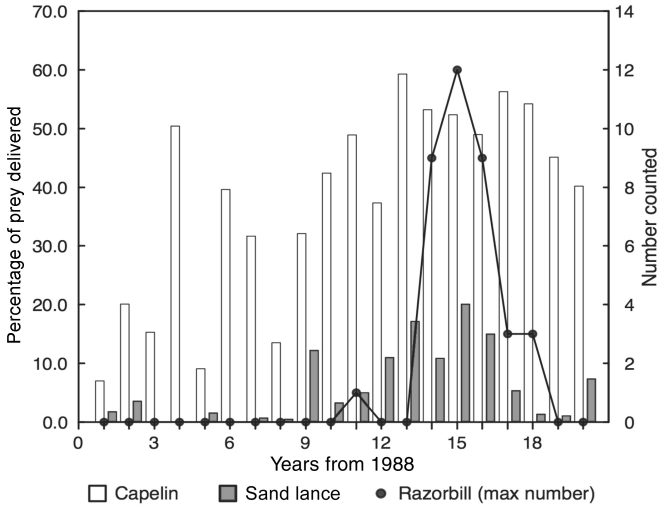

Fig. 2. Proportions of Capelin and sand lance in the diet of nestling Thick-billed Murres at Coats Island during 1988–2007 and maximum counts of Razorbills on the island in the same period.

over the sea and re-alighted. They were nervous of observers and frequently flew off if we approached within 40 m.

On two days in 2003, up to nine Razorbills were observed on the water below steep, rocky slopes ~300 m from the Thick-billed Murre colony. Individuals repeatedly flew up to an area of the cliffs ~10 m above the sea and looked into rock crevices, apparently prospecting for nest sites. Likewise, later that year, two Razorbills flew off from the lower part of the Thick-billed Murre colony, where they may have been prospecting for nest sites. Despite this evidence of prospecting, no birds were seen at the potential prospecting sites in 2004 or 2005.

Changes in Thick-billed Murre nestling diets.—Up to 1996, the most common fish delivered to nestling Thick-billed Murres at Coats Island was Arctic Cod (mean of 42% of deliveries). However, after 1996, Arctic Cod constituted a mean of only 14% of deliveries, the difference being made up by increased deliveries of Capelin and, to a lesser extent, sand lance (Fig. 2). Maximum numbers of Razorbills counted at the colony during 1988–2007 ($n = 20$) correlated with the proportions of both Capelin (adjusted $R^2 = 0.17$, $P = 0.04$) and sand lance (adjusted $R^2 = 0.37$, $P = 0.002$). In a backwards-stepwise multiple regression, only the proportion of sand lance was entered.

Discussion

Although we saw Razorbills at Coats Island annually for several years and although we observed apparent prospecting for breeding sites, we have no evidence that the species actually bred. After a peak of ≥12 birds in 2002, numbers declined and the species was not seen in 2006 and 2007. The correlation with numbers of sand lance, the species' preferred prey in Atlantic Canada, suggests that there may have been a connection between the arrival of Razorbills and the increase in availability of sand lance in local waters. It seems unlikely that temperature itself was involved, given that July temperatures recorded at Coats Island since 1988 have not increased (A. J. Gaston unpubl. data). The peak maximum and minimum temperatures during that period occurred in 1998 and 2000, respectively.

The timing of arrival of the Razorbills was later than that of breeding and nonbreeding Thick-billed Murres (Gaston 2002), which suggests that their arrival at Coats Island was not the result of traveling with a mass of migrating Thick-billed Murres. The latter pass through Hudson Strait in May–June, whereas our earliest Razorbill sighting was on 17 July. The lateness of the arrivals presumably would have precluded the possibility of breeding, even if the birds had been in condition to do so.

What is remarkable about our observations is the fact that Razorbills, of which no more than a handful were known to breed in the Eastern Canadian Arctic, seem to have tracked the appearance of their usual prey so quickly. Although their nearest breeding site is 300 km to the east, they appeared off Coats Island just two years after sand lance first appeared there in large numbers, in 1996, and peaked in the same year that sand lance peaked. They were not seen after 2004, a year when sand lance almost disappeared from the diet of nestling Thick-billed Murres. The other two common auks of Atlantic Canada, the Atlantic Puffin and Common Murre, have been sighted very infrequently at Coats Island, and never has more than one individual of those species been seen in a given year. This is despite the fact that Atlantic Puffins outnumber Razorbills at Digges Sound, their nearest breeding site (Gaston et al. 1985).

Hudson Strait is a vast area with innumerable rocky islands where small numbers of auks could nest. The possibility that Razorbills are more numerous there than has been reported cannot be discounted. However, it seems unlikely that such an unreported population would be large enough to supply at least 12 potential new recruits for Coats Island. Between Digges Sound, at the mouth of Hudson Strait, and Coats Island there is only Mansel Island, a flat expanse of sand and gravel ridges formed by raised beach deposits and unlikely to provide suitable nesting sites for Razorbills. Hence, the attempted colonization of Coats Island took place over a stretch of ≥300 km of water and at a distance of ~2,000 km over water from the nearest large population at Gannet Islands and smaller populations in central-western Greenland.

Dispersal is most likely to occur from populations that are expanding and, hence, creating a surplus of potential recruits (Paradis et al. 1998). Of the three Low Arctic auks, populations of Razorbills were expanding during the 1990s over most of their North American range (Chapdelaine et al. 2001, Robertson and Elliot 2002), whereas Atlantic Puffins were more or less stable, though increasing at their largest colonies off southeastern Newfoundland (Robertson et al. 2004), and Common Murres were decreasing in Labrador (Robertson and Elliot 2002), though increasing elsewhere in the northwest Atlantic (Chapdelaine 1999, Robertson et al. 2004). Set against this contrast, both Atlantic Puffin and Common Murre are more numerous, by an order of magnitude, than Razorbill in eastern North America (Gaston and Jones 1998). Taken together, the demographic data on the Low Arctic auks in Eastern Canada would not necessarily have led us to expect that Razorbills would be the most likely species to begin to colonize northern Hudson Bay.

Recent information from banding at several sites in eastern North America suggests that the Razorbill may be a rather

dispersive species. Of particular interest is a Razorbill banded as a nestling at Digges Island and recaptured as a breeder at the Gannet Islands, Labrador (Lavers et al. 2007), a postnatal dispersal of ~1,700 km. Our observations support the idea that Razorbills may readily disperse over long distances and lead us to conclude that, in the absence of data on dispersal ability and colonization propensity, it will be difficult for biologists to predict the range expansions that are likely to occur in the short term as a result of climate change.

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