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SHORT NOTE

Has early ice clearance increased predation on breeding birds by polar bears?

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Abstract Past studies suggest that polar bears (*Ursus maritimus*) consume terrestrial food only opportunistically and derive little nutritional benefit from it. Here, we present observations of at least 6 bears consuming large numbers of snow goose (*Chen caerulescens*) eggs at two locations in the eastern low Arctic in 2004 and 2006. We also report two records of a polar bear eating the eggs and chicks of cliff-nesting thick-billed murres (*Uria lomvia*) in 2000 and 2003. Climatic warming has resulted in progressively earlier ice break-up in Hudson Bay, forcing bears ashore much earlier than historical records indicate. Advancement in the nesting dates of birds has been more modest, and this mismatch in timing could lead to an increasing overlap between the nesting period of birds and the period during which bears are on land. At these sites in these years, bears were on land prior to the hatch of nests, and the predation that ensued was catastrophic for the birds at a local scale. Although anecdotal, our observations highlight the complexity of trophic interactions that may occur in a changing Arctic.

Keywords Polar bear · *Ursus maritimus* · Snow goose · *Chen caerulescens* · Climatic change · Thick-billed murre · *Uria lomvia* · Predation

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Introduction

The Arctic climate is changing at an unprecedented rate, and evidence of effects on wildlife is growing (Post et al. 2009). Many of the emerging examples are intuitive and direct. Advancing schedules of ice break-up in western Hudson Bay force polar bears (*Ursus maritimus*) ashore earlier, leaving bears in poorer condition when sea-ice returns in fall (Stirling et al. 1999; Obbard et al. 2006; Stirling and Parkinson 2006). For arctic breeding birds such as the lesser snow goose (*Chen caerulescens caerulescens*), changing climatic conditions on the breeding grounds can affect timing of breeding, clutch size and egg size (Skinner et al. 1998).

In addition to these direct effects of climate change on wildlife, complex interactions between trophic levels are predicted to occur (Gauthier et al. 2004; Berteaux et al. 2004). However, the complexity of the interactions makes precise predictions difficult. Mismatches in the timing of phenological events are considered a key mechanism through which a changing climate might adversely affect arctic wildlife (Gaston et al. 2009; Post et al. 2009). Here, we document an advance in the timing of appearance of polar bears on shore at one site and describe several recent instances of extensive predation of snow goose and thick-billed murre (*Uria lomvia*) eggs by polar bears in years when the bears came ashore early. Although anecdotal, our observations suggest an indirect link between marine ice conditions and the reproductive success of birds, highlighting the complexity of interactions that may occur in a changing Arctic.

Study species

Polar bears are highly adapted to life on the frozen ocean and depend on ice for long-range movements, finding mates and accessing prey (Stirling and Derocher 1993). The most carnivorous of the Ursids, polar bears favour ringed seals (*Phoca hispida*) but also prey upon a variety of other marine mammals (e.g. Stirling and McEwan 1975; Smith 1980; Lowry et al. 1987). They have difficulty capturing prey in open water, and come ashore during ice-free periods in regions with seasonal sea ice. They rely primarily on stored fat throughout the ice-free period but have been observed to feed opportunistically on terrestrial foods including grasses (e.g. *Elymus arenarius*), marine algae (e.g. *Laminaria* spp., *Fucus* spp.), berries (*Vaccinium uliginosum, Empetrum nigrum*), carrion including conspecifics and remains left from human hunting, and occasionally caribou, fish, rodents and birds (Russell 1975; Donaldson et al. 1995; Stempniewicz 2006; Schliebe et al. 2008; Rockwell and Gormezano 2009). Despite these numerous accounts of bears taking terrestrial foods, these behaviours have traditionally been considered opportunistic, and the food considered to be of limited energetic importance (e.g. Ramsay and Hobson 1991; Hobson et al. 2009; but see Derocher et al. 1993).

The lesser snow goose is widespread and abundant in the eastern Arctic, and nests colonially in coastal tundra (Mowbray et al. 2000). Laying dates are highly synchronised and are strongly associated with local weather and snow conditions (Skinner et al. 1998). Hatching dates vary geographically and seasonally but typically occur between mid-June and early July in Hudson Bay and the Foxe Basin (e.g. Skinner et al. 1998; this study).

Thick-billed murres nest in dense colonies, typically numbering in the tens to hundreds of thousands of individuals, on sea-cliffs throughout much of the circumpolar Arctic. In the eastern Canadian Arctic, they lay their single egg in late June or early July and incubate for approximately 33 days (Gaston and Hipfner 2000).

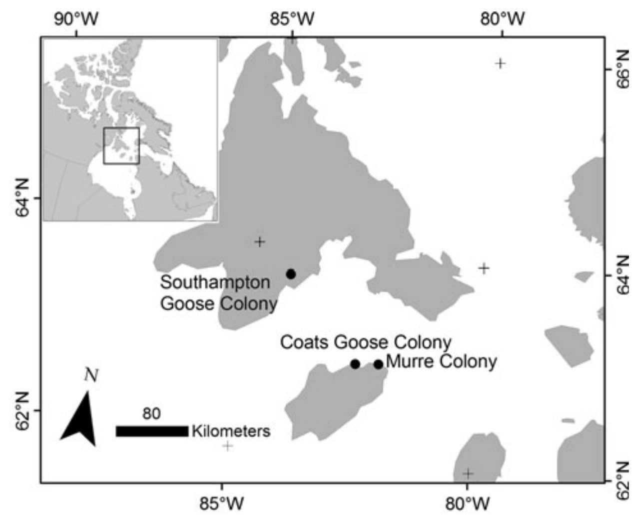

Fig. 1 The locations of our observations of bears consuming the eggs of snow geese and the eggs and chicks of thick-billed murres

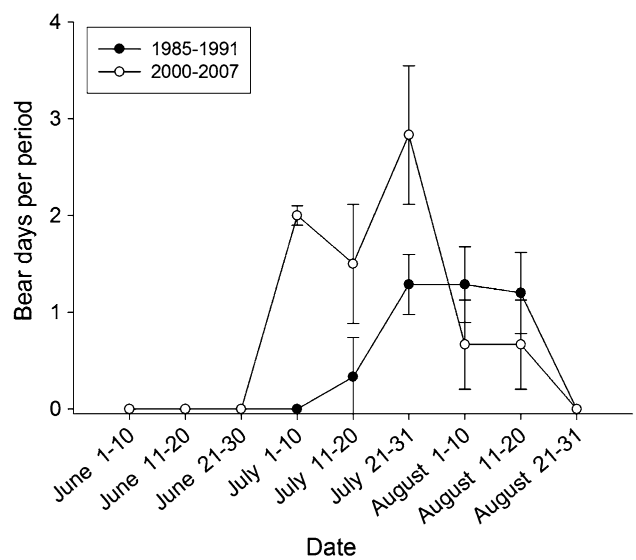

Fig. 2 The number of days upon which polar bears were seen (mean among years ± SE) from a research camp at a colony of thick-billed murres on Coats Island, Nunavut

Observations

Arrival of polar bears on shore

Thick-billed murre population studies have been conducted at a research camp on northern Coats Island annually since 1985 (N62° 57′ W82° 00′, Fig. 1). Researchers recorded days upon which bears were sighted, and observations were binned into 10- or 11-day periods. Observations were made incidentally to our other work, and the period during which camp was occupied varied among years. We considered only years in which camp was occupied early enough in the season to capture first sightings of polar bears. We divided the data into three periods, representing a period of relatively late ice break-up (1985–1991), a period of rapid advancement in ice break-up (1992–1999) and a period of relatively stable but early ice break-up (2000–2007) as observed at our study site (Gaston et al. 2005). The earliest sighting of a polar bear during 1985–1991 was 11–20 July, while during 2000–2007, the earliest sightings were during 1–10 July. Acknowledging the limitations of the data, our observations suggest that bears were on land in the vicinity of the murre colony earlier in the season in 2000–2007 vs. 1985–1991 (Fig. 2).

Snow goose nest predation

Our first observation of predation on snow goose nests was recorded in 2004 on southern Southampton Island,

Table 1 Summary of bear observations, ice conditions and hatch of snow goose nests at Southampton and Coats Islands, 2004 and 2006

Site	First bear sighted	Regional ice concentration	Local ice conditions	First gosling seen
Southampton island goose colony, 2004	23-Jun	63% on 25 Jun	1 km landfast, sparse pack beyond on 30-Jun	>30-Jun
Coats island goose colony, 2006	24-Jun	32% on 25 Jun	Ice-free by 28-Jun	27-Jun

Regional ice concentration data ("North Hudson Bay Narrows") retrieved from the Canadian Ice Service (www.ice-glaces.ec.gc.ca)

approximately 9 km from the coast at N63° 44′ W84° 01′ (Fig. 1). At 2330 h, 23 June, a lone bear was spotted eating snow goose eggs (Table 1). The bear was an adult female, visibly fat and moved slowly from nest to nest, consuming the entire contents of each nest. The bear remained in the area, within the goose colony, and was sighted regularly until 10 July, when the crew left the area. It was observed eating eggs directly on many occasions, and the effect of the predation on local nest success of snow geese was pronounced. Although we have no precise count of the number of nests consumed, approximately 400 nests were present in the regularly surveyed areas near camp. We observed 100% nest failure in these areas and attribute the vast majority of this failure to predation from this single bear. This bear was also regularly observed eating snow goose eggs in areas where we did not survey; so the total effect of this single bear on local reproductive success of geese was substantial.

At the time that the bear was first sighted, landfast ice was still present immediately south of the camp. On 30 June, we estimated that at least 1 km of landfast ice remained, with sparse, drifting pack beyond it. This was a particularly late year for snow goose breeding across much of the eastern Arctic, and all geese were still incubating (i.e., no nests had hatched) at this time.

The second observation comes from a research camp approximately 120 km to the southeast, on the northern coast of Coats Island (N62° 55′ W82° 26′), in 2006. A small colony of breeding snow geese is found near the coast, containing approximately 350 nests with a density of roughly 4 nests/ha.

Bears were first seen in the area of the snow goose colony on 24 June (Table 1). We saw three bears feeding within the colony and an additional two resting on blocks of ice at the shore. Bears were sighted in the colony daily until 2 July, but it was difficult to determine the total number of individuals consuming eggs. On 25 June, we counted at least five bears within the colony: a mother and cub, a large adult male and two smaller individuals. While feeding, bears consumed the entire contents of a nest and walked directly to the next; it was clear that bears recognised the scent or appearance of the nests and were searching for them.

Ice-out was early in 2006, and polar bears were first sighted on land when the ice had nearly left the area. On 13 June, we saw the first evidence of ice break-up several kilometres offshore, to the north of our study site. By 16 June, open water was visible across much of the horizon. From 20–26 June, the ice was completely broken and moving rapidly in and out with the changing winds and tides. By 28 June, the ice had completely cleared the area (Table 1).

Because ice-out was atypically early, bears had come ashore before snow goose nests had begun to hatch. The first snow goose gosling was seen on 27 June. By 2 July, the majority of the snow goose nests had been consumed, and the few nests remaining had hatched. Bears were sighted only irregularly after this date, primarily resting along the coast or travelling overland to or from the south coast of the island (a distance of 40 km).

Thick-billed murre predation

We observed a single polar bear entering the thick-billed murre colony at Coats Island, Nunavut, Canada during 20–25 July 2000 and 26–31 July 2003. The latter observation is presumed to be a different individual, because it was a young bear and likely too young to have been independent 3 years prior. In both years, the bear climbed onto cliff ledges and consumed all murre chicks and eggs that were available. The bears consumed more than 100 eggs and chicks in both years (Mallory et al. 2009). No predation by bears had been observed in 17 seasons of observations at the same site prior to 2000.

Discussion

At the southern edge of their range, in Hudson Bay, the retreat of sea ice forces bears ashore for periods exceeding 4 months (Stirling et al. 1977; Stirling and Derocher 1993). The timing of this retreat to land is influenced by the timing of ice break-up, and recent data suggest that in much of the eastern low Arctic, the break-up of sea ice is up to three weeks earlier than in the 1970s (Gough et al. 2004; Stirling et al. 2004; Stirling and Parkinson 2006). Polar bears are curious and opportunistic animals, and as the ice-free season increases in length and bears spend more time on land, it is not surprising that individuals would search for novel opportunities to supplement their diet.

Although bears have been observed to eat eggs previously, accounts of this behaviour seem increasingly common. Stempniewicz (2006) and Drent and Prop (2008) reported that bears have become more numerous during the bird-breeding season in west Spitsbergen and have been observed consuming the eggs of barnacle geese (*Branta leucopsis*), thick-billed murres and little auks (*Alle alle*). Similarly, we recorded raids by bears on a breeding colony of thick-billed murres at Coats Island twice since 2000, although no bear had been seen consuming eggs or nestlings in 17 previous field seasons. Bears have entered a snow goose colony at Churchill, Manitoba, 6 times in the past 40 years, with 4 of these occasions occurring since 2000 (Rockwell and Gormezano 2009). We suggest that this apparent increase in the frequency of egg consumption among bears is a result of bears coming ashore earlier than they previously did, and prior to the peak hatch of nesting birds.

Information from radio-collared bears suggests that they remain on the ice hunting seals as long as possible and come ashore only when ice conditions are no longer suitable (Stirling and Derocher 1993; Stirling et al. 1999). Our first sightings of bears at Coats Island advanced by approximately 20 days between 1985 and 2007. Over this same period, a regression of ice conditions over year suggests an advancement of 19.7 days in the date of 50% ice coverage in Hudson Bay (see Gaston et al. 2009). Thus, the timing of arrival on land by polar bears appears to be tracking the rapidly advancing schedule of ice break-up. The timing of birds' breeding, in contrast, has advanced at a more modest rate.

For snow geese in the Hudson Bay region, nest initiation dates are correlated with spring temperatures and local snow cover (Cooke et al. 1995; Skinner et al. 1998). Although we have no information on advancement in goose nesting dates for the areas of our observations, geese at the Cape Churchill Peninsula in western Hudson Bay have advanced their dates of nesting by less than 2 days per decade since 1968 (Rockwell and Gormezano 2009), in contrast to the changes of a week or more per decade in the timing of ice clearance from Hudson Bay. Likewise, the timing of breeding of thick-billed murres at the Coats Island colony has advanced by only 5 days since 1988 (2.5 days per decade), during which time the date of 50% ice cover has advanced by 9 days per decade (Gaston et al. 2009).

Traditionally, bears in the Hudson Bay region came ashore in late July (e.g. 23 July in 1991; Stirling and Derocher 1993), once the eggs of most birds had hatched. The accounts above describe bears observed on land as early as 23 June (in 2004) and 24 June (in 2006) at Southampton Island and Coats Island. From 2000–2007 at a research camp at East Bay, Southampton Island (N63° 59′ W81° 40′), first sightings ranged from 25 June–5 July, with a mean of 29 June. The goose nests that we observed at Coats Island (100 km south of East Bay) began to hatch on 28 June 2005 and 27 June 2006 (for the small number that were not predated by bears and achieved hatch). Our observations therefore suggest that bears come ashore much earlier than they previously did and now overlap with the incubation period of both geese and thick-billed murres. Similarly, researchers on the Cape Churchill peninsula have noted that the earliest bears to arrive on land now overlap with nesting snow geese and consume some eggs (Rockwell and Gormezano 2009).

Our observations suggest that some polar bears are consuming substantial quantities of eggs with dramatic local impacts on the reproductive success of snow geese (e.g. apparently complete breeding failure in the vicinity of our camp on Southampton Island, and nearly complete failure near our Coats Island camp) and potential nutritional benefits to individual bears. We suggest that this is primarily a result of earlier ice clearance forcing bears ashore prior to snow goose hatch, but other factors might also increase the spatial and temporal overlap between bears and geese.

Expanding populations of snow geese mean that existing colonies are increasing in size, and new colonies are being formed. The first record of breeding by snow geese on Coats Island, for example, was in 2002 (AJG and P. Mineau, unpubl.), and surveys as recent as 1994 found no evidence of nesting geese (Gaston and Ouellet 1997). Thus, while mismatched phenology may have played a role in the overlap of bears and geese here, this colony was unavailable to bears previously.

Still, our observations demonstrate an earlier arrival of bears to land in this region, suggest an increase in their consumption of eggs and highlight the complexity of ecological interactions that may occur in a changing arctic environment. The recent intrusions of polar bears onto near-vertical cliffs to consume eggs and chicks of thick-billed murres, a potentially hazardous situation for bears, further demonstrate the lengths to which these opportunistic animals may go to supplement their diet during a longer ice-free season.

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