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RESEARCH NOTE

Polar bear predation on barrier island bird colonies in Arctic Alaska increases with sea-ice decline

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Abstract

Anthropogenic carbon emissions are warming the Arctic, disrupting ecosystems, and changing the behaviour and interactions of their component species. As summer sea ice diminishes, polar bears (*Ursus maritimus*) are losing access to traditional seal prey and are increasingly forced onto land, where bears can consume eggs, nestlings and sometimes adults of coastal-nesting marine birds. This behaviour has been poorly documented in northern Alaska. We present observations of polar bears in the Alaskan Beaufort Sea preying on Mandt's black guillemot (*Cepphus grylle mandtii*) and Pacific common eider (*Somateria mollissima v-nigrum*). At Cooper Island, predation on guillemots was episodic (27% of years) and negligible from 1975 to 2007, but increased during 2008–2010, when bears caused 43% nestling mortality. Bear-resistant nest cases deployed in 2011 initially reduced losses until 2024 and 2025, when bear predation led to complete reproductive failure. In 2024, at a common eider colony on Spy Island, a single polar bear destroyed 89% of nests in less than a day. Despite extensive surveys of common eider colonies between the 1970s and early 2000s, reports of polar bear predation at these colonies were isolated and rare. These observations reveal a rapid shift in predation pressure, adding to existing climate-related impacts on these birds, including less prey and flooded or eroded nesting habitat. Our observations demonstrate how sea-ice loss is transforming Arctic ecosystems, creating unsustainable pressures on vulnerable bird populations and underscoring the urgency for solutions that will need to address the root causes of climate warming.

To access the supplementary material, please visit the article landing page

Keywords

Somateria mollissima; *Cepphus grylle*; Arctic climate change; predator–prey interactions; nest boxes; predation intervention

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Introduction

Global carbon emissions are continuing to rise (Dhakal et al. 2022; Energy Institute 2024), with the resulting increase in atmospheric temperatures causing climate change worldwide and an accelerated warming trend in the Arctic (Meredith et al. 2019; Overland et al. 2019). In the Beaufort Sea, this trend is amplified by short-lived climate forcers like black carbon and aerosols from oil and gas activities (Ødemark et al. 2012; Gunsch et al. 2017), loss of reflective sea ice and snow allowing the ocean and land to absorb more heat, and increased cloud cover and moisture trapping heat near the surface, along with shifts in poleward heat transport (Previdi et al. 2021; Ballinger & Overland 2022; Polyakov et al. 2024). As a region dominated by snow and ice that responds rapidly to rising temperatures, the Arctic is experiencing widespread ecological impacts, including regime shifts in physical habitats (Post et al. 2009; Sumata et al. 2023) and changes in interactions among the species that live there (Rosenzweig et al. 2008; Gilg et al. 2012; Post et al. 2013). One of the most visible manifestations of these changes is sea-ice loss, with the decrease in annual extent directly proportional to cumulative anthropogenic fossil fuel emissions (Stroeve & Notz 2018). Simultaneously, thick multi-year ice has been replaced by thinner first-year ice (Maslanik et al. 2007; Maslanik et al. 2011; Babb et al. 2023), disrupting the cryopelagic (sympagic) ecosystem, as under-ice biota are most abundant and diverse beneath older, thicker ice (David et al. 2016; Ehrlich et al. 2020; Hop et al. 2021).

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One clear example of how climate-driven modifications to sea ice have affected ice-dependent species is a reduction of the extent of polar bear (*Ursus maritimus*) habitat and access to their traditional seal prey (Derocher et al. 2004; Regehr et al. 2007; Lunn et al. 2016). Forced to land by sea-ice reductions, some polar bears are increasingly dependent on alternative terrestrial foods for their nutritional needs (Fischbach et al. 2007; Durner et al. 2009). Over recent decades, marine bird colonies in the Canadian Arctic, Greenland and Svalbard have been increasingly predated by foraging polar bears (Smith et al. 2010; Prop et al. 2013; Iverson et al. 2014; Barnas et al. 2022). Hundreds of eggs can be consumed in a short period, significantly reducing reproductive output, and sometimes causing localized population declines (Drent & Prop 2008; Gormezano et al. 2017). Ours are the first reports of large-scale polar bear predation of birds and their eggs in Alaska.

Predation of marine birds by polar bears in Arctic Alaska has been sparsely documented (e.g. Johnson & Noel 2005; Bourque et al. 2020; Rode et al. 2021). However, evaluating the magnitude and prevalence of such impacts is critical for conservation planning (Dey et al. 2018) and the food security of local Iñupiaq communities that rely on several colonially nesting waterbird species (Braund 2010; Naves et al. 2021). The southern Beaufort Sea polar bear population, occupying Alaska and western Canada, has experienced significant declines in summer sea-ice habitat (Stern & Laidre 2016; Stroeve & Notz 2018). Consequently, the number of bears forced to nearshore barrier islands and the mainland coast in summer and fall has increased sixfold in the last two decades (Atwood et al. 2016; Wilson et al. 2017). Part of a 1600 km stretch from Cape Lisburne (Alaska) to Cape Parry (Canada), the Alaskan Beaufort Sea coast lacks rocky headlands and consists of eroding tundra bluffs fronted by barrier islands. The barrier islands provide critical nesting habitat for marine birds on account of their relative isolation in summer from terrestrial predators, such as Arctic fox (*Vulpes lagopus*), that are often unable to swim to them (Quinlan & Lehnhausen 1982; Reed et al. 2007) and their proximity to productive nearshore and lagoon feeding grounds (Divoky et al. 2015). Historically, polar bear occurrence on these islands during summer has been rare, resulting in little documented impact on bird colonies (Noel et al. 2005). In this report, we summarize the first observations of polar bears foraging on barrier island marine bird colonies in Arctic Alaska, including a half-century record of polar bear foraging trends in a declining Mandt's black guillemot (*Cepphus grylle mandtii*; hereafter "guillemot") colony on Cooper Island (Divoky et al. 2024), and a recent predation event at a Pacific common eider (*Somateria mollissima v-nigrum*; hereafter "common eider") colony on Spy Island (Fig. 1). Although

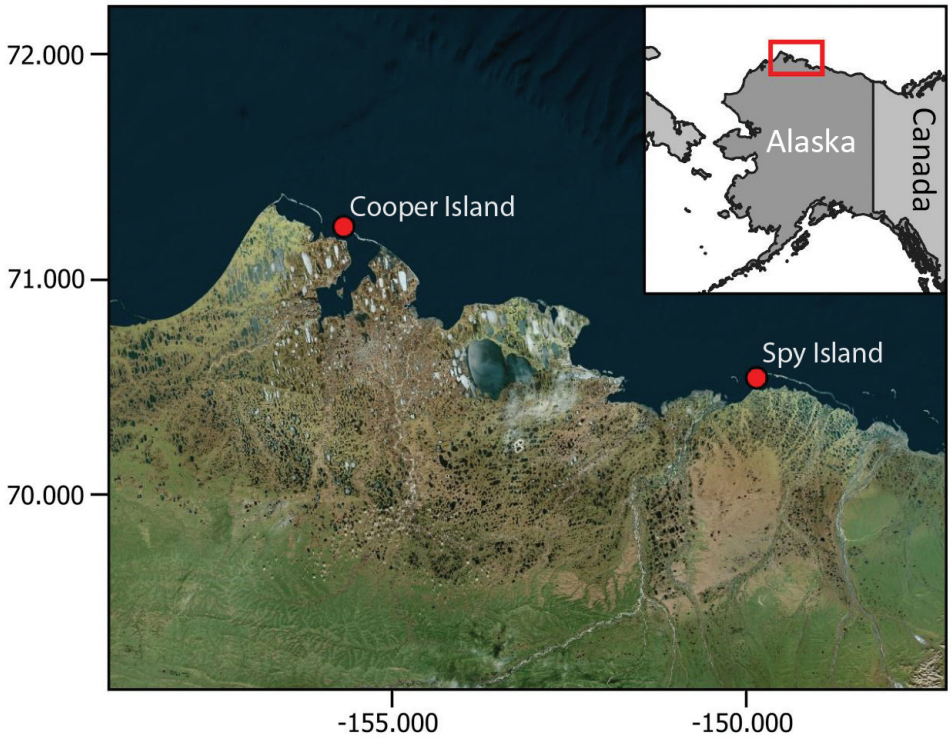

Fig. 1 Locations of Cooper Island and Spy Island in the Beaufort Sea, northern Alaska. Inset shows study area in relation to the state of Alaska.

such events currently affect a small fraction of the regional metapopulations of these birds, they demonstrate a rapid ecological shift driven by loss of Arctic sea ice.

Methods and results

Mandt's black guillemot predation

The breeding biology and demography of a Mandt's black guillemot colony have been studied on Cooper Island (71°20′N, 155°41′W), 35 km east of Utqiaġvik, Alaska, since 1975 (Divoky et al. 1974; Divoky et al. 2015; Divoky et al. 2024) through annual nest surveys that record breeding pair numbers, egg and chick fate, and adult survival and attendance through the breeding season. This research has included the annual monitoring of eggs, chicks and adults to allow assessment of environmental and demographic factors affecting colony growth and breeding productivity. The species typically breeds in cavities associated with rocky shorelines, which are not present in most of Arctic Alaska. On Cooper Island, guillemots nest in abandoned debris or cases provided by investigators (Fig. 2; Divoky et al. 1974).

The colony experienced an initial period of growth, from 19 pairs in 1975 to 217 pairs in 1990, due to high breeding productivity and immigration rates. It has since declined to 21 pairs in 2025, as less late summer sea ice and a warmer sea surface reduced the availability of Arctic cod (*Boreogadus saida*), the preferred prey, at the study colony and the source colonies that were providing immigrants (Divoky et al. 2024).

From 1975 to 2001, the impact of polar bear predation on eggs and nestlings on Cooper Island was sporadic and of small magnitude, occurring in only nine of the 33 years (27%) and disturbing <3% of the nests. In only one year (1990) did predation cause major (>50%) nesting mortality. From 2001 through 2007, polar bear occurrence remained low and sporadic. A marked increase in polar bear predation was observed from 2008 to 2010, during which polar bears disturbed 38% of nests. While loss of eggs remained relatively low (<5%), 43% of the 423 nestlings hatched in these years were consumed by polar bears (Fig. 3).

In response to that predation, in 2011, researchers replaced wooden nest sites with modified plastic carrying cases (sold by Nanuk, Montreal). These were initially effective, as bears would typically examine the sites briefly without disturbing them much. However, after 2020, bears increased their manipulation of plastic nest boxes until eggs, chicks, or adults were ejected, even submerging them in water to flush attending adults (Fig. 4), culminating in complete reproductive failure in 2024 and 2025. Examples of polar bear predation behaviour and interactions with artificial nest structures on Cooper Island are provided in Supplementary Videos S1-S4. While in earlier years bears consumed only parts of carcasses, they now eat entire birds quickly, reflecting a shift towards more efficient and aggressive foraging.

The timing of polar bear arrivals on Cooper Island has also moved forward. Initially concentrated during the August chick-rearing period, bear activity now also occurs in June and July, when parent guillemots are incubating eggs. The seasonal advancement in predation and disturbance has resulted in more loss of eggs, through predation and breakage, and a greater probability of predation on adults incubating eggs or brooding young. The 2024

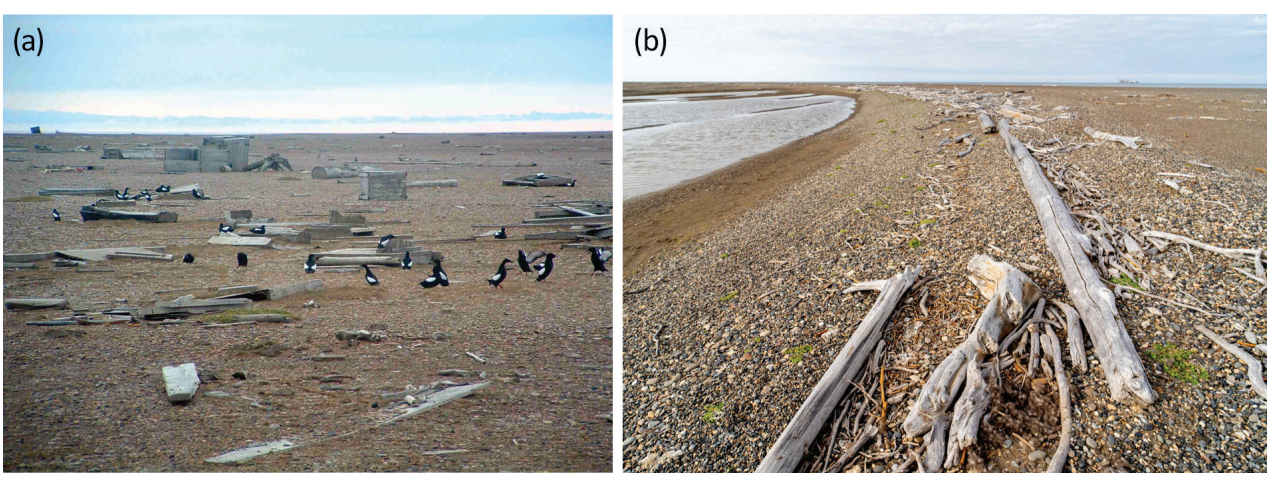

Fig. 2 Barrier island nesting habitat for marine birds along the Beaufort Sea coast of northern Alaska, shown at (a) Cooper Island and (b) Simpson Lagoon (Egg Island, representative of nearby Spy Island). These low-lying islands, composed primarily of sand and gravel, are scattered with driftwood and other debris that provide some cover for nesting birds.

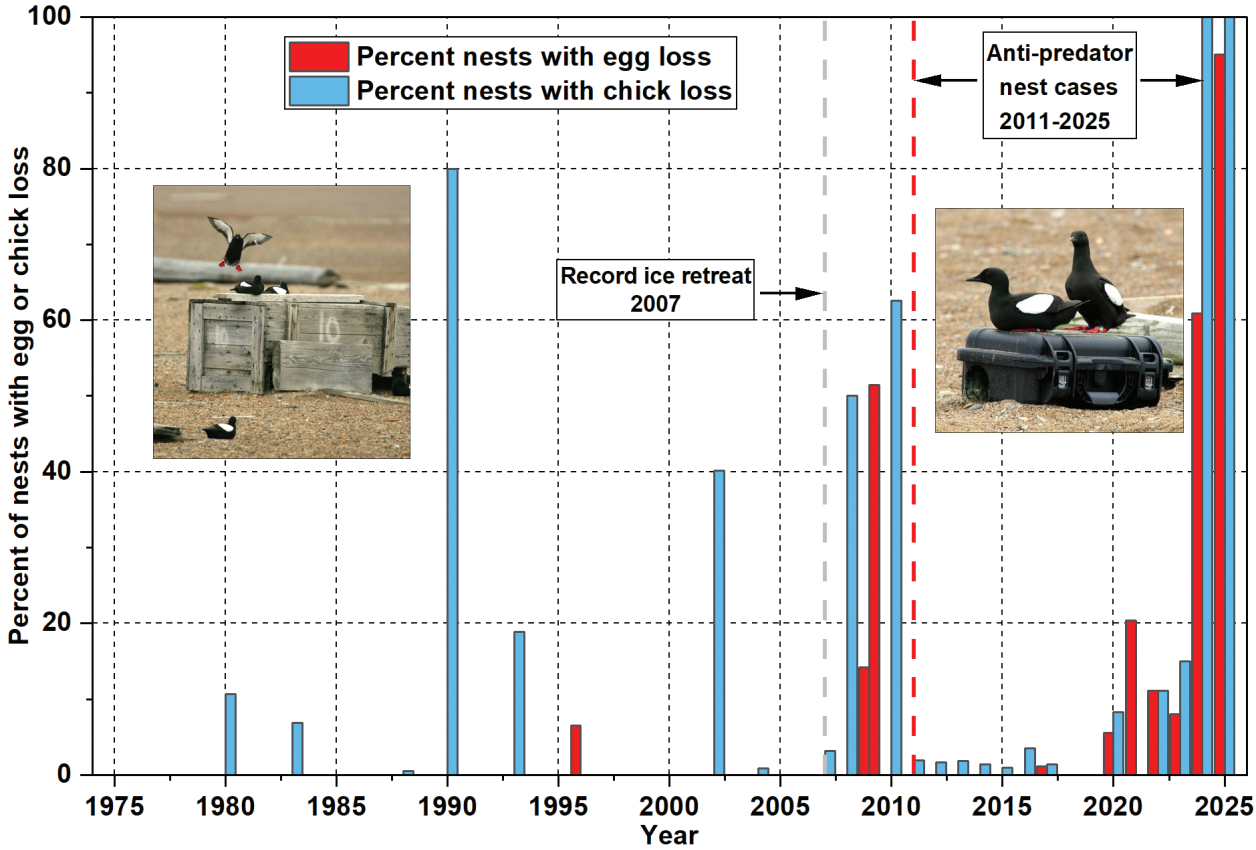

Fig. 3 Percent of nests of Mandt's black guillemot (*Cepphus grylle mandtii*) with eggs experiencing egg loss and nests with chicks experiencing chick loss due to predation, 1975–2025. Predation rates remained low until the mid-2000s, after which a record sea-ice retreat in 2007 resulted in decreased ice in subsequent years and a sharp increase in losses from polar bear predation. Anti-predator nest cases were deployed in 2011.

Fig. 4 Polar bear (*Ursus maritimus*) family group interacting with a Mandt's black guillemot (*Cepphus grylle mandtii*) nest case on Cooper Island, northern Alaska.

and 2025 breeding seasons each had three adults killed by bears. Only two adults had been killed by bears in the previous half-century.

Pacific common eider nest predation

On the barrier islands of the Beaufort Sea coastline, common eiders typically nest in colonies ranging from fewer than a dozen to over 200 nests. These colonies are often formed in driftwood piles, low dune ridges or sparse vegetation such as sandwort (*Honckenya peploides*), which provide minimal visual cover (Fig. 2).

Extensive field surveys of barrier island common eider colonies in the southern Beaufort Sea were conducted from the 1970s to the early 2000s (e.g. Schamel 1977; Johnson & Herter 1990; Noel et al. 2005). While these studies occasionally noted polar bear tracks or isolated cases of egg consumption, such events were considered rare and not emphasized as a source of nest loss compared to predation by Arctic foxes or glaucous gulls (Noel et al. 2005).

The first measurable polar bear predation event affecting common eider nests in Alaska occurred in 2017 within the Arctic National Wildlife Refuge during a monitoring programme evaluating nesting success and colony

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stability across the Beaufort Sea. From 2016 to 2017, camera monitoring of a subset of these colonies captured images of polar bears destroying 11% of the 214 nests that were being monitored (Wiese et al. 2017).

In July 2024, a more extensive polar bear nest predation event in Alaska was documented during a long-term study of bird nesting ecology in Simpson Lagoon. Spy Island (70°35'N, 149°50'W), a 58-ha barrier island about 6 km from the mainland coast and the Colville River delta, has been periodically monitored since 1983 (Johnson et al. 1987). On 7 July 2024, researchers inventoried all nesting attempts by common eiders, glaucous gulls (*Larus hyperboreus*), and other sea- and waterbirds. Within this colony, time-lapse cameras adjacent to three common eider nests monitored incubation behaviour by capturing images every five seconds.

Follow-up surveys on 17 July revealed extensive disturbance, including numerous nests with crushed, partially consumed eggs, large dig marks and fresh polar bear tracks and scat. Eggshell fragments bore the crushing patterns of polar bear chewing, distinct from the piercing typical of marine bird predators. Time-lapse cameras provided direct evidence of predation, capturing images of a polar bear consuming all eggs at monitored nests, with foraging bouts lasting less than two minutes per nest (Fig. 5). Physical evidence (tracks, scat, crushed eggshells) within 1 m of the nest bowl and/or photographic images implicated polar bears in 89% of nest failures (91 of 102 failed nests). In contrast, predation rates at central Beaufort colonies from 1998 to 2002 ranged from 32 to 95%, almost entirely attributed to glaucous gulls and Arctic foxes, although incidental flushing of incubating females by polar bears also indirectly led to nest predation (Noel et al. 2005). Based on camera timestamps, the polar bear likely depleted the colony in one day, spending a minimum of 21 hours on the island between 02:56 and 23:59 on 11 July 2024.

Fig. 5 Remote camera (Plotwatcher Pro) timelapse image documenting a polar bear (*Ursus maritimus*) consuming Pacific common eider (*Somateria mollissima v-nigrum*) eggs at a nesting colony on Spy Island, Alaska, 11 July 2024.

Discussion

The consumption of eggs and disruption of bird colonies by polar bears across the Arctic has become increasingly common, with numerous reports from Canada, Svalbard, and Greenland documenting the rise of this behaviour over the past several decades (Prop et al. 2015). Our observations from northern Alaska expand the geographic extent of these reports and demonstrate that this is a circumpolar occurrence.

This behavioural shift in polar bear habitat use is driven by the recent rapid loss of sea-ice habitat, reducing both the distribution and persistence of the bears' primary hunting platform and altering the structure of the cryopelagic ecosystem. While localized impacts from these reductions, such as reduced reproductive success in individual bird colonies, are readily measurable, our observations of novel foraging behaviours demonstrate broader cascading consequences of climate change in the Arctic. As sea-ice loss reduces the availability of preferred seal prey, polar bears are increasingly turning to alternative resources in terrestrial environments.

Recent declines in Arctic sea-ice extent and volume are likely driving this shift through both physical and biological pathways. The primary physical effect – loss of the stable sea-ice hunting platform – is well documented through satellite observations. Biological changes, however, are less monitored but may be equally important. As sea ice has become younger and thinner, the cryopelagic food web has shifted: Arctic cod and under-ice zooplankton, which are more abundant under older multi-year ice, have declined (Hop et al. 2021; Geoffroy et al. 2023). At Cooper Island, the sharp increase in nest predation and polar bear occurrence coincided with the 2007 western Arctic sea-ice regime shift (Livina & Lenton 2013; Moore et al. 2022), which was marked by record-low summer sea-ice extent and high volumes of unusually warm inflow through the Bering Strait (Woodgate et al. 2010) that shaped ice conditions in subsequent years. The widespread and abrupt loss of multi-year ice in 2007 is thought to have triggered ensuing trophic shifts in ringed (*Pusa hispida*) and bearded seals (*Erignathus barbatus*; Carroll et al. 2013), and declines in their abundance may, in turn, contribute to the increased movement of polar bears onto terrestrial landscapes.

The decline in sea ice is among the greatest climate-driven losses of habitat globally (Post et al. 2013; Macias-Fauria & Post 2018; Stroeve et al. 2025). It has had profound local impacts on species such as Mandt's black guillemot (Divoky et al. 2024). On Cooper Island, a warmer sea surface and the retreat of the summer ice pack have reduced the availability of Arctic cod, lowering the breeding productivity of the guillemots breeding there (Divoky et al. 2015). Immigration has been greatly curtailed, apparently because of decreased fledging success at source colonies in the Chukchi Sea (Divoky et al. 2024). Recent model predictions estimate that the Cooper Island guillemot colony will reach quasi-extinction by 2050 (Divoky et al. 2024); however, polar bear predation may advance this date.

Like guillemots, common eiders face compounded pressure from climate change, including nesting habitat loss from flooding events and shoreline erosion (Liebezeit et al. 2012), potential changes in the nearshore benthic ecosystem (Dunton et al. 2012), and increased predation on barrier islands. Nearshore islands have historically provided breeding birds some refuge from intense mammalian predation because Arctic foxes can often not swim to them (Barry 1968; Waltho & Coulson 2015). Fox predation has been episodic, often associated with periods when land-fast or drifting sea ice facilitated access. For example, Arctic foxes caused complete nesting failures of common eiders and glaucous gulls on Egg Island, in Simpson Lagoon, in 2002 and 2003 (Reed et al. 2007). Future predation pressure on barrier island bird colonies will likely vary among islands and depend on such factors as distance from the mainland, inter-island spacing and species-specific predator access mechanisms. Continued sea-ice loss and earlier break-up of land-fast ice may impede Arctic foxes from reaching islands during the nesting season, as observed in High-Arctic systems where island isolation earlier in the season has boosted bird colonization of newly fox-free islands (Dørum et al. 2025). In contrast, polar bears are capable of swimming long distances and may continue to access nearshore barrier islands under ice-free summer conditions. Thus, declining fox access may be offset by polar bear predation.

While colonial nesting mitigates predation risk (Sears 1979; Siegel-Causey & Kharitonov 1990), this strategy may lose effectiveness as predator regimes change (Öst et al. 2022). Simulation models have predicted that northern common eiders (*Somateria mollissima borealis*) in the eastern Canadian Arctic may respond to increasing polar bear predation by dispersing into smaller colonies (Dey et al. 2017). However, this prediction was developed in a region where polar bears and common eiders have been historically sympatric, whereas in the southern Beaufort Sea, such overlap has only recently developed with sea-ice loss. Furthermore, such strategies may become less possible for common eiders nesting on barrier islands where nesting habitat may be constricted to only those islands resistant to climate-driven flooding (Liebezeit et al. 2012).

The Beaufort Sea is predicted to be ice-free (sea-ice concentration <15%) in summer by the end of the century (Årthun et al. 2021). Accordingly, southern Beaufort Sea polar bears will experience continued shifts in foraging opportunities, increasingly relying on terrestrial food sources like bird colonies (Rogers et al. 2015; Fry et al. 2023). The apparent shift in polar bear foraging behaviour, coupled with its likelihood of recurrence, underscores the importance of long-term monitoring to track and understand the pace of ecological change in sensitive barrier island ecosystems.

In northern Alaska, where barrier islands line roughly half of the Arctic coastline, they represent the first landfall for polar bears abandoning the sea ice and likely experiencing nutritional stress from the loss of their sea-ice hunting platform. The relatively high nest densities, small land area, and limited cover of barrier islands (Noel et al. 2005) allow bears to forage slowly and efficiently, conserving energy while consuming eggs and nestlings (Gormezano et al. 2016; Jagielski et al. 2021).

Jagielski (2020) postulated that an adult polar bear needs to eat approximately 54 common eider eggs to meet its daily energy requirement of 54 000 kJ (Pagano et al. 2018). Based on the average hatch size of common eiders at other colonies in the central Beaufort Sea during 2024, we estimate that the polar bear on Spy Island consumed about 255 eggs, supplying it with the energy it needed for 4.7 days. This is roughly equivalent to the total gross energy content of a yearling ringed seal (Stirling & McEwan 1975). While common eider colonies represent a high caloric density resource, the observation of numerous diarrhoea piles on Spy Island and other islands where common eider egg foraging has occurred suggests digestive inefficiencies associated with large-scale egg consumption. Such bouts of diarrhoea are likely self-limiting as the gastrointestinal microbial community adjusts to an egg-heavy diet, but they nonetheless accelerate the passage of food through the gut and may reduce nutrient absorption. This implies that the gross energetic intake from eggs could overestimate the net nutritional benefit to polar bears, particularly when compared to their fat-rich ancestral prey. Additionally, the concentration of bird colonies poses risks beyond digestive upset, as eggs can serve as a vector for highly pathogenic avian influenza, which has been documented as fatal in at least one Alaskan polar bear (DEC 2025). Future microbiome or faecal pathogen sampling could clarify how diet shifts towards marine bird prey influence both the nutritional return and the health risks of this foraging strategy.

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Polar bears can adapt their foraging strategies based on experience, returning annually to profitable sites (Mauritzen et al. 2001; Lone et al. 2013; Prop et al. 2015). Thus, as long-lived individuals, polar bears can revisit the same marine bird colonies annually through many years, passing on this behaviour to their offspring (Lillie et al. 2018). Sustained predation pressure may lead to recruitment failures in marine bird colonies, as seen in other regions where polar bear predation has significantly impacted colony population trajectories (Smith et al. 2010; Rockwell et al. 2011; Gilchrist et al. 2025).

Conclusion

Our observations underscore the role of polar bears as a sentinel species and highly visible charismatic organism, signalling the rapid and profound transformations of the Arctic cryopelagic ecosystem. The increased presence of polar bears on barrier islands and their predation on marine bird colonies mark a visible, measurable consequence of sea-ice loss. The behaviour of these apex predators serves as a harbinger of broader ecological shifts with potentially far-reaching implications for nearshore environments (see Barnas et al. 2020; Barnas et al. 2024) throughout the Arctic. Understanding the changing dynamics between polar bears and marine bird colonies provides insights into how climate change reshapes predator–prey interactions and disrupts long-standing ecological patterns.

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Disclosure statement

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