Marine mammal biodiversity and rare narwhal (Monodon monoceros) observations near northern Ellesmere Island, Canada

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Abstract. A climate-driven decline of sea ice has increased international interest in understanding the ecology of seldom studied high-Arctic regions projected to retain the last remnants of summer sea ice. Arctic marine mammals are vulnerable to future environmental change due to their high dependence on sea ice. We completed aerial surveys in August 2019 to document the occurrence and location of marine mammals within the recently designated Tuvaijuittuq Marine Protected Area which acts as a last refuge for ice-associated species. We present photographic evidence of narwhals (Monodon monoceros), Atlantic walruses (Odobenus rosmarus), bearded seals (Erignathus barbatus), and ringed seals (Pusa hispida) in Archer Fjord, northern Ellesmere Island, Nunavut, Canada (81°14′–81°49′ N). We discuss these observations in the context of historical records and more recent opportunistic sightings from the region to support the hypothesis of an expansion north of the currently accepted range of narwhal. The diversity and number of observations of marine mammals in Archer Fjord is a striking contrast to the relative scarcity of the rest of the surveyed region, with very few observations of ringed seals throughout the more northerly study area. Our observations highlight opportunities to further explore high-latitude areas that may host unique marine mammal biodiversity in the region, including narwhal.

Key words: aerial survey; Arctic; Atlantic walrus; bearded seal; climate change; high latitude; range; ringed seal; sea ice.

The low accessibility and high costs of field research in the high-Arctic have resulted in few observations and limited knowledge of animal biodiversity and distribution in these remote areas (Mallory et al. 2018). A rapid climate-driven recession of sea ice has generated international interest in understanding how these high-latitude systems will respond to further change. For example, a multinational agreement was reached in 2018 that banned commercial fishing in the Central Arctic Ocean until there is sufficient ecological knowledge of the region. Arctic marine mammals are especially vulnerable to future environmental changes due to their dependence on sea-ice habitat for activities such as hunting, breeding, and molting (Laidre et al. 2008). In response to increased interest to protect high-latitude sea-ice habitat that serves as the last
place of refuge for pagophilic (ice-associated) marine mammal species, such as narwhal (*Monodon monoceros*), Atlantic walruses (*Odobenus rosmarus rosmarus*), ringed seals (*Pusa hispida*), and polar bears (*Ursus maritimus*), the Canadian government designated the Tuvajjittuq Marine Protected Area by Ministerial Order in August 2019. Concurrently, large-scale multi-year research projects such as the Multidisciplinary Arctic Program (MAP)-Last Ice led by Fisheries and Oceans Canada (DFO) have been conducting research into this little-studied area (Florko et al., in press). Results are anticipated to fill gaps in knowledge on high-Arctic ecosystem structure and function and inform decision makers on the effectiveness and enhancement of conservation initiatives such as Tuvajjittuq (Lange et al. 2019).

Before 2018, information on marine mammals in Tuvajjittuq has been primarily based on opportunistic sightings from explorer records (Greely 1886, Peary 1910), which often lack key biological contexts such as abundance, sex, age classes, and behavior. In August 2015 in Petermann Fjord, Greenland, an area adjacent to the southeastern portions of Tuvajjittuq, an ice breaker-based survey observed ringed seals, bearded seals (*Erignathus barbatus*), harp seals (*Pagophilus groenlandicus*), and polar bears (*Lomac-McNair et al. 2018, Lomac McNair et al. 2019). In August 2018, MAP-Last Ice completed the first summer aerial surveys to document marine mammal occurrence within Tuvajjittuq and observed Atlantic walruses in Archer Fjord—an area much farther north than their previously recorded range (Yurkowski et al. 2019). To build on these findings, we conducted aerial surveys in August 2019 where we observed a broader diversity of marine mammal species than in August 2018, and most notably, narwhal farther north than their currently recognized range in Canada (Lowry et al. 2017, Hobbs et al. 2019). A DeHavilland Twin Otter flying at a target speed and altitude of 110 knots and 305 m was equipped with a Nikon D810 digital single-lens reflex (DSLR) camera and a 35-mm lens mounted in a port in the belly of the aircraft. Images were captured directly below the aircraft, covering a 312 m wide strip with ~40% overlap between successive images. In total, 57 survey transects were flown covering 1054 km² (Appendix S1: Fig. S1; see Yurkowski et al. 2019 for more details). We photographed 29 individual narwhals (seven adult males, seven adult females, one yearling, and 14 unknowns due to submergence on 14 August 2019), three Atlantic walrus (18 August 2019), 30 ringed seals (14 and 18 August 2019), and four bearded seals (14 August 2019) along 2 transects covering 84.12 km² in Archer Fjord and Lady Franklin Bay (Figs. 1, 2; Appendix S1: Table S1, Fig. S1). There was also a visual observer recording wildlife sightings and environmental observations. The visual observer spotted 25 narwhals (14 August 2019; some of which were likely outside of the view of the camera), 36 Atlantic walrus (21 individuals on 14 August 2019, 15 individuals on 18 August 2019) that dove into the water before the plane passed over them and were also outside of the view of the camera, and 18 seals (11 individuals on 14 August 2019, seven individuals on 18 August 2019) along the same 2 transects in Archer Fjord and Lady Franklin Bay (Fig. 2). The data were insufficient to estimate density for narwhals, Atlantic walrus, and bearded seals. In addition to marine mammals, gulls (family Laridae) were also observed in Archer Fjord. Environmental conditions during our time in Archer Fjord on 14 August were open water to light drift ice cover (0–10%), calm sea state (0–1 Beaufort Sea Scale), and no cloud cover (0%), fog, or precipitation. On 18 August, conditions shifted to more drift or light pack sea ice cover (10–40%), calm or light breeze sea state (0–2 Beaufort Sea Scale), heavy cloud cover (100%), light fog, and light precipitation.

The currently accepted northern extent of narwhal range in Canada is to approximately 80°30’ N in the Nares Strait (Lowry et al. 2017, Hobbs et al. 2019), but systematic surveys have not observed narwhals north of ~79°30’ N in Kane Basin (Doniol-Valcroze et al. 2015). However, historical records report a number of narwhals (at least five but total number of individuals not reported) as far north as Hall Basin (~81°30’ N) and a tusk recovered as far as Floeberg Beach (~82°27’ N) in 1881 (Greely 1886). A narwhal hunted at Cape Union (~82°15’ N) in 1909 (Peary 1910) also suggests common occurrence in Hall Basin and potential to reach the Lincoln Sea. Additionally, an ice breaker expedition not equipped to survey for marine mammals, opportunistically observed a group of up to 30
narwhals from a helicopter in the southeastern region of the Petermann Fjord adjacent to the Petermann Glacier front, Greenland in August 2012 (K. Lomac-McNair, personal communication, July 2020). Our novel observations at 81°18’N indicate summer habitat use of Archer Fjord by an aggregation of narwhals with a yearling approximately 175 km north of the previously surveyed range of narwhals in Canada (Doniol-Valcroze et al. 2015). Together with historical records, our observations of this narwhal aggregation that included a yearling, support the northern extent of the narwhal’s range in Canada to include Archer Fjord, Lady Franklin Bay, and Hall Basin (COSEWIC 2004; Fig. 2).

Observations of numerous narwhals in Archer Fjord identifies knowledge gaps about their ecology and population status in the area. First, the presence of narwhal in Archer Fjord may be an annual summer occurrence, but lack of long-term monitoring in the area may have precluded discovery of this baseline information. Alternatively, these observations may represent an ecological range shift. However, the short timeframe of our survey precludes conclusions concerning narwhal habitat use and reliance on this area, our observations of 29 individuals and a yearling near the head of Archer Fjord, and the opportunistic observations of a large group well within Petermann Fjord in 2012 suggests important habitat use of the area throughout summer. The lack of information on the number of individuals observed and ecological context from explorer records makes it difficult to conclude whether these sightings represent ecologically important and recurrent use, or transient visits to the area. Second, genetic and movement ecology would determine where these high-Arctic aggregations fit into the management context of the eight currently defined summering stocks of the high-Arctic Baffin Bay population of narwhal (Hobbs...
et al. 2019). This aggregation may be a part of the northernmost stock (Smith Sound) which is vital information for responsible co-management with Inuit from Canada and Greenland that hunt narwhals for cultural and subsistence purposes.

The number of Atlantic walrus individuals observed in Archer Fjord in 2019 ($n = 21$ visual and three photographic) was higher than 2018 ($n = 7$ visual and 1 photographic; Yurkowski et al. 2019). The presence and observations of numerous Atlantic walruses in Archer Fjord for two consecutive years support the range extension of the current Atlantic walrus distribution proposed by Yurkowski et al. (2019). The number of seal observations in Archer Fjord was also greater in 2019 ($n = 34$ seals) compared with the 2018 surveys ($n = 3$). The difference in observations between the two years could have been due to the earlier 2018 surveys (one week).

Tuvaajuittuq is characterized by heavy year-round sea ice conditions and a very dynamic sea ice cover (Moore et al. 2019). Interannual differences in sea-ice conditions in Tuvaajuittuq and the connected Canadian high-Arctic region, (i.e., Kennedy Channel and Kane Basin) could have also influenced the difference in marine mammal biodiversity and number of observations between 2018 and 2019. Tuvaajuittuq and the connected Kennedy Channel and Kane Basin region experienced lighter sea-ice conditions in 2019 compared with 2018 (Appendix S1: Fig. S2). In particular, the sea-ice conditions from Smith Sound and Kane Basin in the south to Hall Basin and Nares Strait in the north likely acts as a choke point moderating the ability of marine mammals such as narwhal and Atlantic walrus to reach Archer Fjord (COSEWIC 2004, Higdon and Ferguson 2009, Yurkowski et al. 2019). An earlier sea-ice breakup in 2019 may have also
changed the timing and biomass of phytoplankton blooms and increased the summer availability of marine resources in the region (e.g., Arrigo and van Dijken 2015). This could support an increased abundance of marine mammals that require abundant food resources in the summer months to support their high annual metabolic and nutritional requirements.

During our two surveys in August 2018 (Yurkowski et al. 2019) and 2019 (this study), narwhals, Atlantic walruses, and bearded seals were only observed within the two transects covering Archer Fjord and Lady Franklin Bay (Appendix S1: Fig. S1). Although ringed seals were observed in some of the 55 transects outside Archer Fjord in 2019 (none in 2018) and considerably farther north (~82°50' N, 59°13' W), there were very few sightings in this large region compared to the 30 individuals observed within Archer Fjord. The numerous observations and aggregations of many marine mammal species in Archer Fjord suggest this area is a seasonal oasis of relatively higher productivity in the high-Arctic. Future work examining environmental properties such as bathymetry, temperature, and sea-ice dynamics, as well as the resulting biological productivity may help researchers understand how Archer Fjord and Lady Franklin Bay can support the habitat requirement of narwhals, Atlantic walruses, bearded seals, and ringed seals in the summer at the northern limits of their ranges. The findings of multi-year high-Arctic research programs (e.g., MAP-Last Ice) highlight the need for continued monitoring of marine mammals at the northern edge of their range to help understand the mechanisms of biodiversity, distribution shifts, and demographic changes in a rapidly changing Arctic.

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**Supporting Information**

Additional Supporting Information may be found online at: http://onlinelibrary.wiley.com/doi/10.1002/ecs2.3534/full