REPORT

Mary River Project

2022 Marine Mammal Aerial Survey Program

Submitted to:

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Distribution List

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Executive Summary

In July and August 2022, WSP Canada Inc. (WSP), on behalf of Baffinland Iron Mines Corporation (Baffinland), completed a Marine Mammal Aerial Survey Program (MMASP) designed to assess narwhal distribution and abundance in the Regional Study Area (RSA) and Admiralty Inlet. The 2022 MMASP was staged in two separate legs. Leg 1 (19 July to 2 August) targeted a 15-day window at the end of July and early August to collect data on the presence/absence and distribution of marine mammals in the RSA relative to ice conditions at that time of year and prior to the start of shipping operations. Shipping operations began on the evening on 30 July 2022. Leg 2 (9 to 23 August) targeted a 15-day window in August to obtain an annual abundance estimate for the Eclipse Sound and Admiralty Inlet narwhal summer stocks during the open-water season. Survey design and data collection methodology previously developed by Fisheries and Oceans Canada (DFO) (Matthews et al. 2017; Marcoux et al. 2016; Doniol-Valcroze et al. 2015a; Asselin and Richard 2011) and implemented by Golder Associates Ltd. (amalgamated under WSP Canada Inc. in January 2023) in 2019 (Golder 2020a), 2020 (Golder 2021a), and 2021 (Golder 2022c) was adopted to allow for comparable abundance estimates.

Two types of aerial surveys were flown: a visual-based survey in which marine mammal sightings were collected along established line transects using a double-platform approach with Marine Mammal Observers (MMOs) stationed at independent observation platforms at the front and rear of the aircraft, and a photographic-based survey in which digital single-lens reflex (DSLR) cameras were installed on the aircraft to collect high definition photographic images of the survey area directly below the aircraft. Photographic surveys were flown in areas of high narwhal concentrations where accurate counts would be difficult to obtain using visual means. Marine mammal sightings, environmental conditions and survey data were entered into a database (Mysticetus©).

During the visual-based surveys, a total of 3,359 sightings (i.e., group of individuals within one to two body lengths of each other) of 7,621 individual marine mammals were recorded by the observers during July and August 2022 (including Legs 1 and 2 surveys in Eclipse Sound and Admiralty Inlet). A total of eight different marine mammals species were observed during the surveys: narwhal (*Monodon monoceros*; 2,397 sightings totalling 4,863 individuals), ringed seal (*Pusa hispida*; 477 sightings totalling 541 individuals), harp seal (*Pagophilus groenlandicus*; 243 sightings totalling 1,753 individuals), beluga whale (*Delphinapterus leucas*; 28 sightings totalling 208 individuals), bowhead whale (*Balaena mysticetus*; 19 sightings totalling 27 individuals), polar bear (*Ursus maritimus*; 16 sightings totalling 18 individuals), bearded seal (*Erignathus barbatus*; nine sightings totalling nine individuals), and walrus (*Odobenus rosmarus*; one sighting of an individual walrus). Unidentified seal (167 sightings totalling 196 individuals) and unidentified whale (five sightings of individuals) were also recorded during the surveys.

During the photographic surveys, a total of 9,740 sightings of 15,966 individual marine mammals were recorded by the 2022 MMASP photo analysis combined across all surveys. Photographic surveys were conducted in high density areas of Milne Inlet, Tremblay Sound and Admiralty Inlet. Three different species of marine mammals were recorded for the photographic surveys: narwhal (9,730 sightings totalling 15,936 individuals), beluga whale (five sightings totalling 25 individuals), and bowhead whale (five sightings of individual bowhead whales).

At the beginning of the Leg 1 survey program, open water was present in the central portion of Navy Board Inlet, south Milne Inlet (Assomption Harbour and Koluktoo Bay), Tremblay Sound and in eastern Eclipse Sound (i.e., Pond Inlet strata). By the end of the Leg 1 survey program, open water was present throughout the RSA.

Results from the 2022 Leg 1 survey indicated high narwhal numbers at the start of the program (21–24 July) with narwhal numbers dropping during the second half of the program (27 July–1 August). Prior to the first ore carrier transit on 30 July 2022, large numbers of narwhal had already migrated through the RSA and were primarily concentrated in south Milne Inlet and Tremblay Sound.

For the Leg 2 surveys, narwhal summer stock abundance was calculated for the Eclipse Sound stock, the Admiralty Inlet stock, and the combined Eclipse Sound and Admiralty Inlet stocks. The 2022 narwhal abundance estimate for the combined Eclipse Sound and Admiralty Inlet stocks was 46,408 narwhal (CV = 0.13, 95% CI of 36,129–59,611) based on aerial surveys conducted on 17–18 August 2022. This estimate was not statistically different than the combined stock abundance calculated during the previous DFO survey conducted in August 2013 (45,532 narwhal, CV = 0.33, 95% CI of 22,440–92,384; Doniol-Valcroze et al. 2015a), the 2019 Baffinland estimate of 38,677 (CV = 0.11, 95% CI of 31,155–48,015), and the 2020 Baffinland estimate of 36,044 (CV = 0.12, 95% CI of 28,267–45,961). The 2022 combined estimate was statistically lower than the 2021 Baffinland estimate of 75,177 (CV = 0.08, 95% CI of 63,795–88,590).

For Eclipse Sound stock alone, the narwhal abundance estimate was 4,592 narwhal (CV = 0.10, 95% CI of 3,754–5,617) based on an average of Baffinland's aerial surveys conducted on 17 and 21 August 2022. The 2022 estimate was statistically higher than the 2021 estimate of 2,595 (CV = 0.33, 95% CI of 1,369–4,919; Golder 2022c), indicating that narwhal numbers appear to be increasing from the numbers observed in 2021. The 2022 estimate remains statistically lower than the 2016 estimate of 12,039 (CV = 0.23, 95% CI of 7,768–18,660; Marcoux et al. 2019) and the 2019 abundance estimate of 9,931 (CV = 0.05, 95% CI of 9,009–10,946; Golder 2020a), indicating that narwhal numbers remain lower than 2016 and 2019 levels. The 2022 estimate was not statistically different than the 2013 abundance estimate of 10,489 (CV = 0.24, 95% CI of 6,342–17,347; Doniol-Valcroze et al. 2015a) or the 2020 abundance estimate of 5,018 (CV = 0.03, 95% CI of 4,736–5,317; Golder 2021a).

For Admiralty Inlet stock alone, the narwhal abundance estimate was 43,042 narwhal (CV = 0.15, 95% CI of 32,218–57,502) based on an average of Baffinland's aerial surveys conducted on 14 and 18 August 2022. This estimate was not statistically different than the abundance calculated during the previous DFO survey conducted in August 2013 (35,043 narwhal, CV = 0.42, 95% CI of 14,188–86,553; Doniol-Valcroze et al. 2015a) and the 2020 Baffinland estimate of 31,026 (CV = 0.14, 95% CI of 23,406–41,126). The 2022 estimate was statistically higher than the 2019 Baffinland estimate of 28,746 (CV = 0.15, 95% CI of 21,545–38,354). The 2022 estimate was statistically lower than the 2021 Baffinland estimate of 72,582 (CV = 0.09, 95% CI of 61,333–85,895).

Findings from the aerial surveys are consistent with results obtained via the Bruce Head Shore-Based Monitoring Program conducted in 2022 (WSP 2023), suggesting that narwhal numbers in the RSA appear to be increasing from the numbers observed in 2021. Given that the combined stock estimate for Admiralty Inlet and Eclipse Sound indicated that the regional narwhal population remained stable relative to pre-shipping conditions, and in consideration of the available IQ regarding the degree of exchange between narwhal groups on their summering grounds, the observed changes in narwhal abundance in Eclipse Sound in recent years likely reflects a natural exchange between the two putative stock areas that began prior to Baffinland shipping operations, with animals shifting between Eclipse Sound and Admiralty Inlet based on where habitat conditions may be more favorable that season (e.g., ice coverage, prey availability, predation pressure). With the recent influence of rapidly warming ocean temperatures and longer open-water seasons due to climate change, more pronounced changes in habitat conditions are to be expected throughout the Arctic along with commensurate changes in animal distributions and migratory movements. For example, it is well documented that sea ice in the Arctic is presently undergoing rapid reduction due to climate warming (Stroeve et al. 2012; IPCC 2013; Overland and Wang 2013) and this has been directly associated with notable shifts in species distributions for both Arctic marine mammals (Laidre et al. 2008, 2015; Frederiksen and Haug 2015; Nøttestad et al. 2015; Víkingsson et al. 2015; Albouy et al. 2020; Chambault et al. 2022;) and their prey (Frainer et al. 2017; Steiner et al. 2019, 2021; Møller and Nielsen 2020). How this might be manifesting on a micro-geographic scale in the North Baffin region is presently unclear, although some insight is offered when considering changes reported in other Arctic environments in close proximity to Eclipse Sound.

Two major oceanographic changes have recently been observed in coastal areas of Southeast Greenland; a lack of pack ice in summer and increasing ocean temperatures (NAAMCO 2021). This has had cascading effects on the marine ecosystem, as observed through shifts in fish species assemblages in the region (i.e., change in fish community structure) and previously undocumented occurrences of temperate water cetaceans in Southeast Greenland in high abundances (e.g., humpback whales, fin whales, killer whales, pilot whales and white beaked dolphins) (NAAMCO 2021). Traditional narwhal habitat in this area has become restricted by the warming oceans and the ability of narwhal to adapt to warming water temperatures is constrained due to their general physiology. Shifts in narwhal distribution in Greenland have also been documented in recent years, with multiple sightings of narwhal in areas well north of their traditional range (e.g., Dove Bay, Greenland Sea, Northeast water and Petermann glacier front) (NAAMCO 2021). Current evidence suggests that a combination of hunting and climate change is negatively impacting the long-term viability of narwhal stocks in Southeast Greenland (NAAMCO 2021).

A recent study by Chambault et al. (2022) predicted the future distribution of Eastern Baffin Bay narwhal under two different climate change scenarios using narwhal satellite tracking data collected over two decades. The long-term predictive models suggested that the current distribution of Baffin Bay narwhal during summer will undergo a northward shift of more than 200 km by the end of the century to cope with climate change, and that summer narwhal habitats in this region were predicted to decline from 31 to 66% over this period, depending on the climate model. These changes may already be underway in the Eastern Canadian Arctic and may affect Eclipse Sound and Admiralty Inlet differently.

For the above reasons, the potential for climate-driven shifts in species distributions cannot be ignored as a potential driver of the recently observed changes in summer narwhal distribution in Eclipse Sound. To better understand what is occurring, additional engagement and monitoring with Inuit stakeholders and regulatory agencies are needed, inclusive of collaborative regional-scale monitoring to better understand how climate change is impacting the Baffin Bay narwhal population as a whole.

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ᔪᓚᐃ ᐊᒻᒪᓗ ᐋᒡᒌᓯ 2022-ᒥ, WSP ᑲᓇᑕ ᑎᒥᖁᑖ, ᑭᒡᒐᖅᑐᕐᓂᕐᔪ ᐹᕝᕚᓛᓐ ᓴᕝᕝᓴᓂ ᐅᔭᕐᓂᐊᖅᐲᑦ ᑯᐊᐳᓈᓴᙱᓂᒃ (ᐹᕝᕚᓛᓐ), ᐱᔭᓈᖅᓯᓚᐅᖅᑐᑦ ᑕᓇᐅᒥ ᐳᐃᔨᓂᒃ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᕐᓂᒃ (MMASP) ᐋᖅᑭᒃᓯᒪᔪᑦ ᖃᐅᔨᓴᕐᓂᐊᕐᓗᑎᒃ ᑑᒑᓕᑦ ᓇᓅᓐᓂᖕᖏᓐᓂᒃ ᐊᒻᒪᓗ ᐱᑕᖃᕐᓂᖏᓐᓄᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᒥ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᒃ ᐃᒪᖓᓂ. 2022 ᑕᓇᐅᒥ ᐳᐃᔨᓂᒃ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᖅ ᐋᖅᑭᒃᑕᐅᓯᒪᓚᐅᖅᑐᑦ ᒪᕐᕉᒃ ᐃᓚᒃᑯᑦ ᖃᖓᑕᓂᐅᓗᑎᒃ. ᖃᖓᑕᓂᖅ 1 (19 ᔪᓚᐃᒥ 2 ᐋᒡᒌᓯᒧᑦ) ᑐᖅᖀᖓᔪᑦ 15-ᓄᑦ ᐅᓪᓗᓄᑦ ᐱᓕᕆᐊᖑᓇᔭᖅᖢᑎᒃ ᓄᙳᐊᓂ ᔪᓚᐃ ᐊᒻᒪᓗ ᐋᒡᒌᓯ ᐱᒋᐊᓕᓵᖅᑎᓪᓗᒍ ᑲᑎᖅᓱᐃᓇᓱᐊᖅᖢᑎᒃ ᖃᐅᔨᓴᕈᑎᕕᓂᕐᓂᒃ ᐱᑕᖃᕐᓂᖏᓐᓄᑦ/ᐱᑕᖃᙱᓐᓂᖏᓐᓄᑦ ᐊᒻᒪᓗ ᓇᓅᓐᓂᖏᓐᓄᑦ ᑕᓇᐅᒥ ᐳᐃᔫᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᓂ ᐊᒃᑐᐊᔪᑦ ᓯᑯᐃᑦ ᖃᓄᐃᓕᖓᓂᖓᓄᑦ ᐊᕐᕌᒍᖓᓂ ᐱᒋᐊᖅᑳᖅᑎᓐᓇᒋᑦ ᐅᒥᐊᕐᔪᐊᖅᑲᕐᓇᒥ. ᐅᒥᐊᕐᔪᐊᖅᑲᖅᑲᑦᑕᕐᓇᖅ ᐱᒋᐊᓚᐅᖅᑐᑦ ᐅᓐᓄᖓ 30 ᔪᓚᐃ 2022. ᖃᖓᑕᓂᖅ 2 (ᐋᒡᒌᓯ 9-ᒥᑦ 23-ᒧᑦ) ᑐᖅᖀᖅᑲᓚᐅᖅᑐᑦ 15-ᓂᒃ ᐅᓪᓗᓂᒃ ᐋᒡᒌᓯᒥ ᐱᔪᒪᓪᓗᑎᒃ ᐊᕐᖁᒍᑕᓖᑦ ᐱᑕᖃᕐᓂᖏᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᖁᑦᑐᑦ ᑕᓯᐅᔭᒥ ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᒃ ᐃᒪᖓᓂ ᑑᒑᓕᑦ ᐊᐅᔭᒃᑯᑦ ᐱᑕᖃᕐᕕᒋᕙᒃᑕᖏᓐᓂᒃ ᓯᑯᖃᙱᑎᑦᑎᓪᓗᒍ. ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᐋᖅᑭᒃᑕᐅᓯᒪᔪᑦ ᐊᒻᒪᓗ ᖃᐅᔨᓴᕈᑎᓂᒃ ᑲᑎᖅᓱᐃᓂᕐᒧᑦ ᐱᓕᕆᔾᔪᔾᔫᑦ ᑭᖑᓂᖕᒑᑦᑎᓐᓂ ᐋᖅᑭᒃᑕᐅᓚᐅᖅᓯᒪᔪᑦ ᐃᒪᕐᒥᐅᑕᓕᕆᓃᒃᑯᓐᓂ (ᒫᑎᐅ ᐊᑕᖏᖅᖢᑎᒃ 2017; ᒪᐅᓲ ᐊᑕᖏᖅᖢᑎᒃ 2016; ᑑᓂᐅᑦ-ᕙᐅᑦᑯᕕᔅ ᐊᑕᖏᖅᖢᑎᒃ 2015a ᐊᓯᓕᓐ ᐊᒻᒪᓗ ᓇᑦᓯᑦ 2011) ᐊᑐᓕᖅᑎᑕᐅᓪᓗᑎᒃ ᒎᑐᒃᑯᓐᓂ ᐱᓕᕆᖃᑎᐆᑦ ᓕᒥᑎᑦ (ᑲᑎᖓᑎᒃ ᐊᑐᖅᑕᐅᓪᓗᓂ WSP ᑲᓇᑕ ᑎᒥᖁᑖᒃᑯᑦ ᔫᓄᐊᓇ 2023-ᒥ) 2019-ᒥ (ᒎᑐ 2020a), 2020 (ᒎᑐ 2021a), ᐊᒻᒪᓗ 2021 (ᒎᑐ 2022a), ᐊᑐᓕᖅᑕᐅᓪᓗᑎᒃ ᐱᔪᓐᓇᕈᒪᓪᓗᑎᒃ ᖃᓄᐃᓐᓂᖅᓴᐅᖕᒪᙵᑕ ᐱᑕᖃᕐᕕᐅᔪᓂ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ.

ᒪᕐᕉᒃ ᖃᓄᐃᑦᑑᓂᖏᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓃᑦ ᖃᖓᑕᔭᐅᓚᐅᖅᑐᑦ; ᑕᑯᓐᓇᖅᑕᑎᒍᑦ ᖃᐅᔨᓴᕐᓃᑦ ᑕᓇᐅᒥ ᐳᐃᔨᓂᒃ ᑕᑯᔭᐅᔪᑦ ᑲᑎᑕᐅᓪᓗᑎᒃ ᐋᖅᑭᒃᑕᐅᓯᒪᔪᒃᑯᑦ ᑐᑭᓕᓈᑦ ᖃᖓᑕᕝᕕᐅᔪᒃᑯᑦ ᐊᑐᖅᖢᑎᒃ ᒪᕿᐃᓕᖅᑲᖓᔪᓂᒃ-ᐋᖅᑭᒃᓯᒪᓂᐅᔪᓂᒃ ᐊᑐᕋᓯᐊᖅᖢᑎᒃ ᑕᓇᐅᒥ ᐳᐃᔨᓂᒃ ᓇᐅᑦᑎᖅᓱᖅᐲᑦ ᐃᓂᖃᖅᖢᑎᒃ ᐃᓛᒃᑯᑦ ᓇᐅᑦᑎᖅᓱᕝᕕᖕᒥ ᓯᕗᓂᐊᓂ ᐊᒻᒪᓗ ᐃᖅᑯᐊᓂ ᖃᖓᑕᓲ, ᐊᒻᒪᓗ ᐊᔾᔨᖑᐊᓂᒃ–ᐊᑐᖅᖢᑎᒃ ᖃᐅᔨᓴᕐᓃᑦ ᖃᓇᓴᐅᔭᒃᑰᖅᑐᓂᒃ ᐊᑕᐅᓯᕐᒥᒃ-ᐃᓚᓚᐅᔭᓛᑦ ᐊᔾᔨᓕᐅᕈᐃᑦ ᐋᖅᑭᒃᑕᐅᓪᓗᑎᒃ ᖃᖓᑕᓲᕐᒧᑦ ᑲᑎᖅᓱᐃᕐᑯᓪᓗᑎᒃ ᐊᔾᔨᙳᐊᑦᑎᐊᕙᑦᓚᓇᖕᓂᒃ ᖃᐅᔨᓴᒃᕕᐅᔪᒥ ᐊᑦᑎᖓᒍ ᖃᖓᑕᓲᒃ. ᐊᔾᔨᙳᐊᑎᒍᑦ ᖃᐅᔨᓴᕐᓃᑦ ᖃᖓᑕᓂᐅᓚᐅᖅᑐᑦ ᓄᓇᓂ ᐅᓄᖅᑑᑎᓪᓗᒋᑦ ᑑᒑᓕᑦ ᑕᒪᖅᓯᒪᙱᖢᑎᒃ ᓈᓴᖅᑕᐅᓇᓱᒃᑎᓪᓗᒋᑦ ᐊᔪᕐᓇᕿᔭᓚᐅᖅᑎᓪᓗᒍ ᑕᑯᓂᑐᐃᓐᓇᒃᑯᑦ. ᑕᓇᐅᒥ ᐳᐃᔨᓂᒃ ᑕᑯᓂᖅ, ᐊᕙᑎᒥ ᖃᓄᐃᓕᖓᓂᖏᑦ ᐊᒻᒪᓗ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᑎᑎᖅᑲᕐᑯᐄᑦ ᐃᓕᔭᐅᓚᐅᖅᑐᑦ ᖃᓇᓴᐅᔭᒧᑦ ᑐᖅᑯᐃᕝᕙᓄᑦ (Mysticetus©).

ᑕᑯᓐᓇᖅᑕᑎᒍᑦ ᖃᐅᔨᓴᕐᓃᑦ, ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 3,359 ᑕᑯᔭᐅᔪᑦ (ᓲᕐᓗ ᑲᑎᙵᔪᑦ ᐊᑐᓂ ᐊᑕᐅᓯᕐᒥ ᒪᕿᕐᓂᓘᓐᓃᑦ ᖃᓂᒌᒃᑕᖅᑐᑦ) 7,621 ᐃᓛᒃᑰᖅᑐᑦ ᑕᓇᐅᒥ ᐳᐃᔫᑦ ᑎᑎᕋᖅᑕᐅᓚᐅᖅᑐᑦ ᑕᑯᔭᐅᓯᒪᓪᓗᑎᒃ ᐱᓕᕆᑎᓪᓗᒋᑦ ᔪᓚᐃ ᐊᒻᒪᓗ ᐋᒡᒌᓯ 2022-ᒥ (ᐱᖃᓯᐅᑎᓪᓗᒋᑦ ᖃᖓᑕᓂᖅ 1 ᐊᒻᒪᓗ 2 ᖃᐅᔨᓴᕐᓃᑦ ᑕᓯᐅᔭᒥ ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᒃ ᐃᒪᖓᓂ). ᑲᑎᓗᒃᑖᖅᖢᒋᑦ ᐱᖓᓱᓂᒃ ᐊᕐᕕᓂᓖᑦ ᐊᔾᔨᒌᙱᑦᑐᑦ ᑕᓇᐅᒥ ᐳᐃᔫᑦ ᐅᒪᔪᑦ ᐊᔾᔨᒌᙱᑦᑐᐊᓘᔪᑦ ᐅᔾᔨᖅᓱᔭᐅᓚᐅᖅᑐᑦ ᐱᓕᕆᑎᓪᓗᒋᑦ ᑖᒃᑯᓂᖓ ᖃᐅᔨᓴᕐᓂᕐᓂᒃ: ᑑᒑᓕᒃ (*Monodon monoceros*; 2,397 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 4,863 ᐃᓛᒃᑰᖅᑐᑦ), ᓇᑦᑏᑦ (*Pusa hispida*; 477 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 541 ᐃᓛᒃᑰᖅᑐᑦ), ᑲᐃᕈᓕᒃ (*Pagophilus groenlandicus*; 243 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 1,753 ᐃᓛᒃᑰᖅᑐᑦ), ᖃᑯᖅᑕᑦ ᕿᓚᓗᒐᑦ (*Delphinapterus leucas*; 28 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 208 ᐃᓛᒃᑰᖅᑐᑦ), ᐊᕐᕕᑦ (*Balaena mysticetus*; 19 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 27 ᐃᓛᒃᑰᖅᑐᑦ), ᓇᓄᐃᑦ (*Ursus maritimus*; 16 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 18 ᐃᓛᒃᑰᖅᑐᑦ), ᐅᒡᔪᐃᑦ (*Erignathus barbatus*; 9 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 9 ᑕᑯᔭᐅᔪᑦ), ᐊᒻᒪᓗ ᐊᐃᕖᑦ (*Odobenus rosmarus*; ᐊᑕᐅᓯᕐᒥᒃ ᑕᑯᔭᐅᔪᖅᑲᖅᑐᓂ ᐃᓄᑐᐊᖅ ᐊᐃᕕᖅ). ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᖅ ᓇᑦᑎᖅ (167 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 196 ᐃᓛᒃᑰᖅᑐᑦ) ᐊᒻᒪᓗ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᕿᓚᓗᒐᑦ (ᑕᓪᓕᒪᓂᒃ ᑕᑯᔭᐅᔪᖅᑲᖅᑐᓂ ᐃᓛᒃᑰᖅᑐᓂᒃ) ᑎᑎᕋᖅᑕᐅᓚᐅᖅᑐᑦ ᑖᒃᑯᓇᓂ ᖃᐅᔨᓴᕐᓂᖅᑲᖅᑎᓪᓗᒋᑦ.

ᐊᔾᔨᙳᐊᑎᒍᑦ ᖃᐅᔨᓴᕐᓂᕐᓂ, ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 9,740 ᑕᑯᔭᐅᒧᑦ ᑖᒃᑯᓇᓂ 15,966 ᐃᓛᒃᑰᖅᑐᓂ ᑕᓇᐅᒥ ᐳᐃᔨᓂᒃ ᑎᑎᕋᖅᑕᐅᓚᐅᖅᑐᑦ ᑕᓇᐅᒥ ᐳᐃᔨᓂᒃ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᕐᓂᒃ (MMASP) ᐊᔾᔨᙳᐊᓂ ᕿᒥᕐᕈᓂᕐᓂᒃ ᑲᑎᑕᐅᓪᓗᑎᒃ

ᖃᐅᔨᓴᕐᓂᓗᒃᑖᓂ. ᐊᔾᔨᙳᐊᑎᒍᑦ ᖃᐅᔨᓴᕐᓃᑦ ᐱᓕᕆᐊᕐᒍᓚᐅᖅᑐᑦ ᐱᑕᖃᕐᕕᐅᓪᓚᕆᒃᑐᓂ ᕿᙳᐊᓂ, ᑲᖏᖅᓱᕈᓗᒃ ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ. ᐱᖓᓱᑦ ᐊᔾᔩᙲᑦᑐᑦ ᐆᒪᔪᐃᑦ ᐊᔾᔩᙲᐊᕐᔪᒃᑐᑦ ᑕᕆᐅᒥ ᐳᐃᔩᑦ ᑎᑎᕋᖅᑕᐅᓚᐅᖅᑐᑦ ᐊᔾᔨᙳᐊᑎᒍᑦ ᖃᐅᔨᓴᕐᓂᕐ: ᑑᒑᓖᑦ (9,730 ᑕᑯᔭᐅᓪᓗᑎᒃ ᑲᑎᓗᒃᑖᖅᓱᕆᑦ 15,936 ᐃᓵᒃᑰᖅᑐᑦ), ᖃᑯᖅᑕᑦ ᕿᓚᓗᒐᑦ (ᑖᓪᓕᒪᑦ ᑕᑯᔭᐅᓪᓗᑎᒃ ᑲᑎᓗᒃᑖᖅᓱᕆᑦ 25 ᐃᓵᒃᑰᖅᑐᑦ), ᐊᒻᒪᓗ ᐊᕐᕚᑦ (ᑖᓪᓕᒪᑦ ᑕᑯᔭᐅᓪᓗᑎᒃ ᐃᓵᒃᑯᖅᑕᖅᑐᑦ ᐊᕐᕚᑦ).

ᐱᒋᐊᕐᓂᖓᓂ ᖃᖓᑕᓂᖅ 1-ᒥ ᖃᐅᔨᓴᕐᓂᕐᒥ ᐱᓕᕆᐊᒥ, ᓯᑯᖃᓚᐅᙱᑦᑐᖅ ᕿᑎᐊᓂ ᐃᓪᓗᐊᑕ ᓱᓪᓗᐊᓂ, ᓂᒋᖅᐸᓯᐊᓂ ᕿᙳᐊᓂ (ᐊᓴᒡᓴᓐ ᑲᖏᖅᓱᐊᓂ ᐊᒻᒪᓗ ᖁᕐᓗᖅᑑ ᑲᖏᖅᓱᐊᓂ) ᑲᖏᖅᓱᕈᓗᖕᒥ ᐊᒻᒪᓗ ᑲᓇᖕᓇᖅᐸᓯᐊᓂ ᑕᓯᐅᔭᖅ (ᓲᕐᓗ ᒥᑦᑎᒪᑕᓕᒥᕈᔪᒃ). ᐃᓱᖅᐸᓯᐊᓂ ᖃᖓᑕᓂᖅ 1 ᖃᐅᔨᓴᕐᓂᕐᒥ ᐱᓕᕆᐊᒥ, ᓯᑯᖃᙱᑦᑐᐃᓐᓇᐅᓚᐅᖅᑐᖅ ᓄᓇᐃᑦ ᐊᕙᒃᑐᖅᓯᒪᔪᑦ ᖃᐅᔨᓴᕐᕕᖓᓂ. ᖃᐅᔨᔭᐅᔪᑦ 2022 ᖃᖓᑕᓂᖅ 1 ᖃᐅᔨᓴᕐᓂᖅ ᓇᓗᓇᐃᖅᓯᓚᐅᖅᑐᖅ ᐅᓄᖅᑑᓂᖅᑭᓐᓂᒃ ᑑᒑᓖᑦ ᓈᓴᐅᑎᖅᑭᑦ ᐱᒋᐊᕐᓂᖓᓂ ᐱᓕᕆᐊᑉ (21-24 ᔪᓚᐃ) ᑑᒑᓖᑦ ᓈᓴᐅᑎᖅᑭᖅ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᐊᓪᓗᑎᒃ ᑭᖑᓪᓕᕐᒥ ᓇᑉᐸᖓᓂ ᐱᓕᕆᐊᑉ (27 ᔪᓚᐃ - 1 ᐋᒡᒋᓯ). ᐱᒋᐊᖅᑕᐅᖅᑳᖅᑎᓐᓇᒋᑦ ᓯᕗᓪᓕᖅᐹᑦ ᓴᕕᒃᓴᓂᒃ ᐅᓯᔪᑦ ᐅᒥᐊᕐᔪᐊᑦ ᐅᑎᖅᑕᕐᓂᖅᑭᑦ 30 ᔪᓚᐃ 2022, ᐊᒥᓱᑦ ᑑᒑᓖᑦ ᐊᐅᓪᓛᓂᒃᓯᒪᓕᓚᐅᖅᑐᑦ ᓄᓇᓂ ᐊᕙᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ ᐊᒻᒪᓗ ᐱᑕᖃᓪᓗᐊᑕᖅᓱᓂ ᓂᒋᐊᓂ ᕿᙳᐊᓂ ᐊᒻᒪᓗ ᑲᖏᖅᓱᒍᓗᖕᒥᓗ.

ᖃᖓᑕᓂᖅ 2 ᖃᐅᔨᓴᕐᓂᕐᒧᑦ, ᑐᒑᓖᑦ ᐊᐅᔭᒃᑯᑦ ᐱᑕᖃᕐᓂᖅᑭᑦ ᓈᓴᐅᓯᖅᑐᖅᑕᐅᓚᐅᖅᑐᑦ ᑕᓯᐅᔭᕐᒥ ᐱᑕᖃᕐᕕᐅᔪᒧᑦ, ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᐱᑕᖃᕐᕕᐅᔪᒧᑦ, ᐊᒻᒪᓗ ᑲᑎᕆᓯᑦ ᑕᓯᐅᔭᒥ ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᐱᑕᖃᕐᔪᐅᔪᓄᑦ. ᑑᒑᓖᑦ ᐱᑕᖃᕐᓂᖅᑭᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᒧᑦ ᑲᑎᕆᓯᑦ ᑕᓯᐅᔭᒧᑦ ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓄᑦ ᐃᑕᖃᕐᕕᐅᔪᑦ ᐃᒪᓐᓇᐅᓚᐅᖅᑐᑦ 46,408 ᑑᒑᓖᑦ (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.13, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 36,129-59,611) ᑐᙳᕙᖃᖅᓱᑎᒃ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓃᐅᔪᓂᒃ ᐅᑯᐊ ᐅᓪᓗᖅᑭᓐᓂ 17–18 ᐋᒡᒋᓯ 2022. ᑖᓐᓇ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᖅ ᓈᓴᐅᑎᑎᒍᑦ ᐊᔾᔨᙱᖅᑭᑕᖓ ᑖᒃᑯᓇᙵᑦ ᑲᑎᕆᓯᑦ ᐱᑕᖃᕐᕕᐅᔪᑦ ᓈᓴᐅᑎᖅᓱᖅᑕᐅᓚᐅᖅᓯᒪᔪᑦ ᐃᒪᕐᒥᐅᑕᓕᕆᔩᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᖅᑲᖅᑎᓪᓗᑎᑦ ᐋᒡᒋᓯ 2013-ᒥ (45,532 ᑑᒑᓖᑦ, ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.33, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 22,440–92,384; ᑑᓂᐅᓪ-ᕕᐅᓪᑯᕈᔅ ᐊᑕᖅᑭᖅᓱᑎᒃ. 2015a), ᑖᒃᑯᐊ 2019 ᐹᕙᓈᓐᑯᑦ ᒥᒃᓴᐅᓴᒃᑕᖅᑭᑦ ᐃᒪᓐᓇᑎᒋᐅᔪᑦ 38,677 (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.11, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 31,155–48,015), ᐊᒻᒪᓗ ᑖᒃᑯᐊ 2020 ᐹᕙᓈᓐᑯᑦ ᒥᒃᓴᐅᓴᒃᑕᖅᑭᑦ ᐃᒪᓐᓇᑎᒋᐅᔪᑦ 36,044 (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.12, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 28,267–45,961). 2022-ᒥ ᑲᑎᕆᓯᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᔪᑦ ᓈᓴᐅᑎᑎᒍᑦ ᐅᓄᙱᓐᓂᖅᓴᐅᓚᐅᖅᑐᑦ ᑖᒃᑯᓇᙵᑦ 2021 ᐹᕙᓈᓐᑯᑦ ᒥᒃᓴᐅᓴᒃᑕᖅᑭᑦ ᐃᒪᓐᓇᑎᒋᐅᔪᑦ 75,177 (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.08, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 63,795–88,590).

ᑕᓯᐅᔭᕐᒥ ᐱᑕᖃᕐᕕᐅᔪᑐᐊᒧᑦ, ᑑᒑᓖᑦ ᐅᓄᕐᓂᖅᑭᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 4,592 ᑑᒑᓖᑦ (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.10, 95% ᑕᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 3,754–5,617) ᑐᙳᕙᕆᓪᓗᑎᑦ ᓈᓴᐅᑕᐅᒐᔾᔪᒃᑐᑦ ᐹᕙᓈᓐᑯᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᖅᑭᓐᓄᑦ ᐱᓕᕆᐊᕐᒍᓚᐅᖅᑐᑦ ᐅᓪᓗᖅᑭᓐᓂ 17 ᐊᒻᒪᓗ 21 ᐋᒡᒋᓯ 2022. 2022-ᒥ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᓈᓴᐅᑎᑎᒍᑦ ᐅᓄᕐᓂᖅᓴᐅᓚᐅᖅᑐᑦ 2021 ᒥᒃᓴᐅᓴᒃᑕᐅᔪᓂ ᐃᒪᓐᓇᑎᑏᖅᑐᓂ 2,595 (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.33, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 1,369–4,919; ᒎᑐ 2022c), ᓇᓗᓇᐃᖅᓯᓪᓗᓂ ᑖᒃᑯᐊ ᑑᒑᓖᑦ ᓈᓴᐅᑎᖅᑭᑦ ᐅᓄᖅᓯᕙᓪᓕᐊᖅᑰᔨᓂᖅᑭᓐᓂᒃ ᑕᑯᔭᐅᓯᒪᔪᓂ 2021-ᒥ. 2022-ᒥ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᓱᓕ ᓈᓴᐅᑎᑎᒍᑦ ᐅᓄᙱᓐᓂᖅᓴᐅᓪᓗᑎᒃ ᑖᒃᑯᓇᙵᑦ 2016-ᒥ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᓂ ᐃᒪᓐᓇᑎᑏᖅᑐᓂ 12,039 (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ= 0.23, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 7,768–18,660; ᒪᐅᑑ ᐊᑕᖅᑭᖅᓱᑎᒃ. 2019) ᐊᒻᒪᓗ ᑖᒃᑯᐊ 2019-ᒥ ᐅᓄᕐᓂᖅᑭᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᔪᑦ 9,931 (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.05, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 9,009–10,946; ᒎᑐ 2020a), ᓇᓗᓇᐃᖅᓯᔪᑦ ᑖᒃᑯᐊ ᑑᒑᓖᑦ ᓈᓴᐅᑎᖅᑭᑦ ᓱᓕ ᐅᓄᙱᓐᓂᖅᓴᐅᓂᖅᑭᓐᓂᒃ 2016-ᒥ ᐊᒻᒪᓗ 2019-ᒥ ᓈᓴᐅᑎᐅᓚᐅᑐᓂ. 2022-ᒥ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᓈᓴᐅᑎᑎᒍᑦ ᐊᔾᔨᙱᓐᓂᖅᓴᐅᔭᖅᑭᑦ ᑖᒃᑯᓇᙵᑦ 2013-ᒥ ᐅᓄᕐᓂᖅᑭᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᓂ ᐃᒪᓐᓇᑎᒋᐅᓪᓗᑎᒃ 10,489 (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ= 0.24, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 6,342–17,347; ᑖᓂᐅᓪ-ᕕᐅᓪᑯᕈᔅ ᐊᑕᖅᑭᖅᓱᑎᒃ. 2015a) ᐅᖕᕙᓘᓐᓃᑦ 2020 ᐅᓄᕐᓂᖅᑭᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᐃᒪᓐᓇᑎᒋᐅᔪᑦ 5,018 (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.03, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑭᑦ ᐃᒪᓐᓇᑎᒋ 4,736–5,317; ᒎᑐ 2021a).

ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᐱᑕᖃᕐᕕᐅᔪᒥᑐᐊᖅ, ᑑᒑᓖᑦ ᐅᓄᕐᓂᖅᑭᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᐃᒪᓐᓇᑎᑏᓚᐅᖅᑐᑦ 43,042 ᑑᒑᓖᑦ (ᓈᓴᐅᓯᖅᓯᔾᔪᓰᑦ = 0.15, 95% CI of 32,218–57,502) ᑐᙳᕙᕆᓪᓗᑎᑦ ᓈᓴᐅᑎᐅᒐᔾᔪᒃᑐᑦ ᐹᕙᓈᓐᑯᑦ ᖃᖓᑕᓲᒃᑯᑦ

ᖃᐅᔨᓴᕐᓂᖅᑭᓂᖓᑦ ᐱᓕᕆᐊᖑᓪᓚᐅᖅᑐᑦ ᐅᑦᑐᖅᑭᓂ 14 ᐊᒻᒪᓗ 18 ᐋᒡᒌᓯ 2022. ᑖᓐᓇ ᒥᒃᓵᔅᓴᒃᑕᐅᓯᒪᔪᑦ ᓈᓴᐅᑎᑎᒍᑦ ᐊᔾᔨᒌᙱᑐᐊᓚᐅᙱᑦᑕᖓ ᐅᓄᕐᓂᖅᑭᓐᓄᑦ ᓈᓴᐅᓯᖕᑕᐅᑎᓪᓗᒋᑦ ᑭᖑᓂᖓᓪᑎᓐᓂ ᐃᒪᕐᒥᐅᑕᓕᕆᔾᔾᑯᑦ ᖃᐅᔨᓴᕐᓂᖅᑭᓂ ᐋᒡᒌᓯ (35,043 ᑑᑦᑎᑦ, ᓈᓴᐅᓯᖕᓯᔾᔪᔫᑦ = 0.42, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑎᑦ ᐃᒪᓐᓇᑎᒋ 14,188–86,553; ᑖᓂᐅᑉ-ᕕᐅᑉᑯᕗᔾ ᐊᑕᖅᑎᖅᑲᑎᒃ. 2015a) ᐊᒻᒪᓗ 2020 ᐹᕙᓐᓛᓐᑯᑦ ᒥᒃᓴᐅᓴᒃᓯᒪᔭᖅᑎᑦ ᐃᒪᓐᓇᑎᒌᖅᑐᑦ 31,026 (ᓈᓴᐅᓯᖕᓯᔾᔪᔫᑦ = 0.14, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑎᑦ ᐃᒪᓐᓇᑎᒋ 23,406–41,126). 2022-ᒥ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᓈᓴᐅᑎᑎᒍᑦ ᐅᓄᕐᓂᖅᓴᐅᓚᐅᖅᑐᑦ ᑖᒃᑯᓇᙵᑦ 2019-ᒥ ᐹᕙᓐᓛᓐᑯᑦ ᒥᒃᓴᐅᓴᒃᑕᖅᑎᑦ ᐃᒪᓐᓇᑎᒋᐅᔪᑦ 28,746 (ᓈᓴᐅᓯᖕᓯᔾᔪᔫᑦ = 0.15, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑎᑦ ᐃᒪᓐᓇᑎᒋ 21,545–38,354). 2022-ᒥ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᓈᓴᐅᑎᑎᒍᑦ ᐅᓄᖅᑭᓐᓂᖅᓴᐅᓚᐅᖅᑐᑦ ᑖᒃᑯᓇᙵᑦ 2021 ᐹᕙᓐᓛᓐᑯᑦ ᒥᒃᓴᐅᓴᒃᓯᒪᔭᖅᑎᑦ ᐃᒪᓐᓇᑎᒌᖅᑐᑦ 72,582 (ᓈᓴᐅᓯᖕᓯᔾᔪᔫᑦ = 0.09, 95% ᓇᓗᓇᕈᓐᓃᖅᑎᓯᒪᔪᑦ ᐊᑯᓚᐃᓐᓂᖅᑎᑦ ᐃᒪᓐᓇᑎᒋ 61,333–85,895).

ᖃᐅᔨᔭᐅᔪᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᕐᒥ ᒪᓕᒃᑐᑦ ᖃᐅᔨᔭᐅᔪᓂᒃ ᐱᔭᐅᓯᒪᔪᓂᒃ ᐃᓗᕕᓕᖅᒥ ᓯᒡᔭᒦᕗᑎᒃ ᖃᐅᔨᓴᖅᐸᑦᓕᐊᖅᑭᓐᓇᕈᑎᒧᑦ ᐱᓕᕆᐊᒧᑦ ᐱᓕᕆᐊᖑᓪᓚᐅᖅᑐᑦ 2022-ᒥ, ᐃᒪᓐᓈᖅᑑᑎᖃᖅᑰᔾᔪᑦᓗᓂ ᑖᒃᑯᐊ ᑑᑦᑎᑦ ᓈᓴᐅᑎᖅᑎᑦ ᑕᐅᕙᓂ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕝᕕᐅᔪᒥ ᐅᓄᖅᓯᕙᑦᑎᐊᖅᑰᔾᔪᑦ ᓈᓴᐅᑎᖅᑎᑦ ᑕᑯᔭᐅᓯᒪᔪᑦ 2021-ᒥ. ᑕᐃᒪᐃᒻᒪᑦ, ᑕᒪᒃᑯᐊ ᖃᐅᔨᔭᐅᔪᑦ ᐃᑲᔪᖅᑐᐃᔪᑦ ᐊᒃᑐᐃᓂᕐᒧᑦ ᓇᓚᐅᖅᑖᖅᑕᐅᓯᒪᔪᓂᒃ ᐋᖅᑭᒃᓯᖅᑕᐅᓯᒪᔪᑦ ᑕᐃᑲᓂ ᑭᖑᓪᓕᖅᐹᒥ ᐊᕙᑎᓕᕆᓂᕐᒧᑦ ᐊᒃᑐᐃᓂᕐᓄᑦ ᐅᓂᒃᑳᓂ ᑖᔅᓯᒧᖓ ᑮᓇᐅᔭᒃᓵᓕᓂᕐᒧᑦ ᐱᓕᕆᐊᒧᑦ, ᑕᐃᑲᓂ ᐅᒥᐊᖅᔪᐊᑦ ᓂᐱᖅᑭᓂᑦ ᐊᒃᑐᐃᓐᑦ ᑑᑦᑎᖕᓄᑦ ᓂᕆᐅᒋᔭᐅᓯᒪᔪᑦ ᑭᓪᓕᖃᓂᐊᕋᓯᒋᔭᐅᑉᓗᑎᒃ ᒫᓐᓇᓚᐅᖃᖕᒧᑦ ᐊᒻᒪᓗ ᓇᔪᖅᑕᖓᓄᐊᖅᑕᐃᓕᒪᓕᕐᓗᑎᒃ ᐃᓕᖅᑯᓯᕆᓗᓂᔾᔪᒃ.

ᐱᔾᔪᑎᒋᑦᓗᒋᑦ ᑲᑎᔾᔪᒋᑦ ᐱᑕᖃᕐᕕᐅᓂ ᒥᒃᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᐊᒻᒪᓗ ᑕᓯᐅᔭᒥ ᓇᓗᓇᐃᖅᓯᖅᑰᔾᔪᑦ ᑖᒃᑯᐊ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᑑᑦᑎᑦ ᐅᓄᕐᓂᖅᑎᑦ ᓯᓚ ᓱᕋᙱᑦᑐᑦ ᐃᓯᒪᒋᑦᓗᒋᑦ ᐅᒥᐊᖅᔪᐊᖅᑲᖅᑕᖅᑳᖅᑎᓐᓇᒍ ᖃᓄᐃᓕᖓᓂᐅᓚᐅᖅᑐᓄᑦ, ᐊᒻᒪᓗ ᐃᓯᒪᒋᖅᑲᓯᐅᑎᑦᓗᒋᑦ ᐊᑐᐃᓐᓇᐅᔪᑦ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖅᑲᖅᑎᑦ ᐱᔾᔪᑎᒋᑦᓗᒋᑦ ᓄᒃᑕᖅᑕᖅᑐᓂᖅᑎᑦ ᑖᒃᑯᐊ ᑑᑦᑎᑦ ᑲᑎᙵᔪᑦ ᐊᐅᔭᒃᑯᑦ ᓇᔪᖓᖅᑭᓐᓂ, ᐅᔾᔨᕆᔭᐅᔪᑦ ᐊᔾᔨᐅᖅᑐᑦ ᑑᑦᑎᑦ ᐱᑦᑕᖅᑲᖅᑎᖅᑭᓐᓄᑦ ᑕᓯᐅᔭᒥ ᒫᓐᓇᕈᓗᒃ ᐊᕐᕋᒍᓂ ᓴᖅᑮᔭᖅᑎᑦᑎᐊᒃᓴᐅᔪᑦ ᐊᓯᔾᔨᖃᑦᑕᐃᓐᓇᖅᑐᓐᓂᖅᑭᓂᒃ ᑖᒃᑯᐊ ᒪᕐᕉᒃ ᐱᑦᑕᖅᑲᐅᔾᔫᒃ ᐱᑎᒋᔭᐅᓂᖅᓴᑦ ᐊᐅᓚᓂᖃᖅᑲᖅᑎᖅᑎᓇᕆᑦ, ᓂᔪᕐᑎᑦ ᓅᖃᑦᑕᕐᓂᖅᑭᓐᓄᑦ ᐊᑯᓐᓂᖓᓂ ᑕᓯᐅᔭᐸ ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᐱᔾᔪᑕᐅᑉᓗᑎᒃ ᐱᐅᒋᔭᐅᓂᖅᓴᑦ ᐃᒻᒪᑦ ᓇᔪᖓᖅᑎᑦ ᓯᓚᑎᖅᑭᓂ ᖃᓄᐃᓕᖓᓂᖓᓄᑦ ᐊᒃᑐᐊᔪᑦ ᑕᑎᐅᒥ ᓯᑯᑉ ᖃᓄᐃᓕᖓᓂᖓᓄᑦ, ᓂᕿᒃᑕᑦ ᐊᑐᐃᓐᓇᐅᓂᖅᑎᑦ ᐊᒻᒪᓗᐅ/ᐅᕝᕙᓘᓐᓂᑦ ᓂᕿᒃᓴᖅᓯᐊᓇᔭᐅᓯᒪᓂᖅ. ᑎᑎᕋᖅᑕᐅᓯᒪᑦᑎᐊᖅᑐᑦ ᑕᒪᓐᓇ ᑕᓇᐅᒥ ᓯᑯ ᐅᑭᐅᖅᑕᖅᑐᒥ ᒥᑦᑕᕙᑦᑕᓕᐊᕐᒪᑦ ᐱᔾᔪᑕᐅᑉᓗᑎᒃ ᓯᓚᐅᑉ ᐅᖅᑯᓯᕙᑦᑕᓕᐊᓂᖓ (ᓴᑐᕈᕕ ᐊᑕᖅᑎᖅᑲᑎᒃ 2012; IPCC 2012; ᐆᕝᕙᓛᓐ ᐊᒻᒪᓗ ᕗᐊᖕ 2013) ᑕᒪᓐᓇᓗ ᐊᒃᑐᐊᓂᖅᑲᓪᓚᑦᑖᖅᑐᑦ ᐅᔾᔨᕐᓇᖅᑐᓂᒃ ᐊᓯᔾᔨᖅᑐᓄᑦ ᐆᒪᔪᑦ ᐊᔾᔨᒌᙱᑐᐊᕐᔪᑦ ᓇᓃᖃᑦᑕᕐᓂᖅᑭᓂᒃ ᑕᒪᕐᒦᖕᓄᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᑕᓇᐅᒥ ᐳᐃᔾᔪᓄᑦ (ᓚᐃᑐᓇ ᐊᑕᖅᑎᖅᑲᑎᒃ 2008, 2015; ᕙᑐᓇᒃᓴᑦ ᐊᒻᒪᓗ HᐊᐅᒻᒪᓗH ᐊᑕᖅᑎᖅᑲᑎᒃ 2015; ᓘᑦᑖᑦ ᐊᑕᖅᑎᖅᑲᑎᒃ 2015; ᕘᐃᑭᖕᓴᓐ ᐊᑕᖅᑎᖅᑲᑎᒃ 2015; ᐃᐅᐳᐃ ᐊᑕᖅᑎᖅᑲᑎᒃ 2020; ᓵᓪᐹᑦ ᐊᑕᖅᑎᖅᑲᑎᒃ 2022) ᐊᖑᓇᓱᒃᐸᒃᑕᖅᑎᑦᓗ (ᕗᕌᓄ ᐊᑕᖅᑎᖅᑲᑎᒃ 2017; ᓴᑕᐃᓄ ᐊᑕᖅᑎᖅᑲᑎᒃ 2019, 2021 ᒧᓗ ᐊᒻᒪᓗ ᓂᐅᓴᓐ 2020). ᖃᓄᖅ ᑕᒪᓐᓇ ᐱᕙᓪᓕᐊᑐᐃᓐᓇᓇᐊᖃᕐᒪᖕᒋᖅ ᒥᑭᑐᒻᒪᓇᒃᑐᑦ-ᓄᓇᖓᑕ ᐊᖏᓂᖅᑎᑦ ᕿᑭᖅᑖᓘᑉ ᐅᐊᖕᓇᖓᑕ ᓄᓇᕐᑯᑎᖅᑭᓂ ᒫᓐᓇ ᓇᓗᓇᖅᑐᖅ. ᒫᓐᓇᓕᓴᑦ ᖃᐅᔨᓴᕈᑎᑦ ᑖᒃᑯᓇᙵᑦ ᓵᐸᑦ ᐊᑕᖅᑎᖅᑲᑎᒃ (2022) ᓇᓚᐅᖅᑖᖅᓯᒪᔪᑦ ᑕᒪᒃᑯᐊ ᓯᕗᓂᒃᓴᒥ ᓇᓃᓐᓂᖅᑎᑦ ᑲᓇᖕᓇᖓᓂ ᕿᑭᖅᑖᓘᑉ ᐃᑭᖓᓂ ᑑᑦᑎᑦ ᐊᑐᖅᑲᑎᑦ ᒪᕐᕉᒃ ᐊᔾᔨᒌᙱᑦᑐᑦ ᓯᓚᐅᑉ ᐊᔾᔨᖅᑲᐃᓕᐊᓂᖓᓄᑦ ᐋᖅᑭᙳᐊᖅᑕᐅᓯᒪᔫᒃ ᐊᑐᖅᑲᑎᑦ ᑑᑦᑎᑦ ᖃᖓᒃᑕᖅᑎᑕᐅᓯᒪᔫᒃᑯᑦ ᓂᕕᖓᑖᖅᑎᓐᓄᑦ ᑕᑯᔭᐅᔪᓐᓇᕈᑏᑦ ᑎᑎᖅᑲᕐᑯᑏᑦ ᑲᑎᑕᐅᓯᒪᔪᑦ ᐅᖓᑖᓂ ᒪᕐᕉᒃ ᕐᑯᑖᒃ ᐊᕐᕌᒎᒃ. ᐊᑯᓂᐅᔫᒃᑯᑦ ᓇᓚᐅᖅᑖᖅᑕᐅᓯᒪᔪᑦ ᐋᖅᑭᙳᐊᖅᑕᐅᓯᒪᔪᑦ ᐃᒪᐃᓐᓇᓯᒋᓐᓈᔪᑦ ᑕᒪᓐᓇ ᒫᓐᓇ ᓇᓃᓐᓂᖅᑎᑦ ᕿᑭᖅᑖᓘᑉ ᐃᑭᐊᓂ ᐊᐅᔭᒃᑯᑦ ᐊᑐᖅᑕᐅᓛᖅᑐᑦ >200 ᑭᓛᒥᑎᑦ ᐊᑐᖕᒋᕐᓗᒋᑦ ᕿᓄᐃᓵᕈᑎᖃᕆᐊᖅᑎᓪᓗᒋᑦ ᓯᓚᐅᑉ ᐊᔾᔨᖅᐸᓪᓕᐊᓂᖓᓂᒃ, ᑕᒪᓐᓇᓗ ᐊᐅᔭᒃᑯᑦ ᑑᑦᑎᑦ ᓇᔪᖓᖅᑎᑦ ᑕᐅᕙᓂ ᓇᓚᐅᖅᑖᖅᑕᐅᓯᒪᔪᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᐊᓂᐊᕋᓯᒋᔭᐅᑉᓗᑎᒃ ᐊᑯᓐᓂᖓᓂ 31 ᐊᒻᒪᓗ 66% (ᒪᓕᒃᑲᑎᑦ ᓯᓚᒧᑦ ᐋᖅᑭᙳᐊᖅᑕᐅᓯᒪᔪᑦ). ᑕᒪᒃᑯᐊ ᐊᓯᔾᔨᐅᑏᑦ ᐱᓕᕆᐊᖑᓯᒫᓂᑐᐃᓐᓇᕆᐊᓖᑦ ᑲᓇᖕᓇᖓᓂ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓᓄᑦ ᐊᒻᒪᓗ ᐊᒃᑐᐃᑐᐃᓐᓇᕆᐊᓖᑦ ᑕᓯᐅᔭᕐᒥ ᐃᒃᐱᐊᕐᔪᓗ ᐃᒪᖓᓂ ᐊᔾᔨᒌᙱᑦᑕᖓᒍᑦ.

ᒪᕐᕈᒃ ᐊᖏᔫᒃ ᑕᕆᐅᑉᓕᕆᓂᕐᒧᑦ ᐊᓯᔾᔨᖅᑑᑦ ᒫᓐᓇᕋᑖᖅ ᐅᔾᔨᕆᔭᐅᔫᒃ ᓯᔾᔭᖅᑭᓂ ᓂᒋᖅᐸᓯᐊᓂ ᑲᓇᖕᓇᖅᐸᓯᐊᓂ ᐊᑯᑭᑦᑐᓂ; ᐱᑕᖃᑦᑎᐊᖃᑦᑕᕈᓐᓃᕐᓂᖅᑭᓐᓄᑦ ᑐᑯᑦᑐᖃᑦ ᐊᐅᔭᒃᑯᑦ ᐊᒻᒪᓗ ᑕᓇᐅᖅ ᐃᒪᖓ ᐆᓇᖅᓯᕙᑦᑕᓕᐊᓂᖓᓄᑦ (ᐅᐊᖕᓇᖓᓂᑦ

ᐋᑦᑖᓐᑎᒃ ᑕᕆᐅᒥᑦ ᐳᐃᓈᑦ ᑲᒥᓴᙳᑦ 2021).ᑕᒪᓐᓇ ᐊᒃᑐᐃᒐᓚᒃᓯᒪᔪᖅ ᑕᕆᐅᒥ ᐆᒪᔪᑦ ᓇᔪᒐᖕᒋᓐᓂᒃ, ᐅᔾᔮᕆᔭᐅᓯᒪᓪᓗᓂᓗ ᐊᓯᔾᔨᖅᑐᑎᙵᑦ ᐃᖃᓗᐃᑦ ᐊᔾᔨᒌᙱᐊᕐᔪᒃᑐᑦ ᑲᑎᙳᖃᑦᑕᕐᓂᖏᑦ ᑕᐃᑯᓂ (ᓲᕐᓗ ᐊᓯᔾᔨᖅᑐᑦ ᐃᖃᓗᐃᑦ ᑲᑎᙳᙯᕖᑦᑯᒃᑕᖏᑕ ᐋᖅᑭᒃᓯᒪᓂᖏᑦ) ᐊᒻᒪᓗ ᑭᙶᓂᖕᒑᑦᑎᓐᓂ ᑎᑎᕋᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᖃᓄᐃᓐᓂᐅᔪᑦ ᐃᒪᐅᑉ ᓂᒡᓚᓱᖕᓂᖕᒐᓄᑦ ᕿᒥᕐᓗᖃᙱᑦᑐᑦ ᓂᕆᖅᐸᓯᐊᓂ ᑲᓇᖕᓈᔾᖕᒐᓂ ᐊᑯᑭᑦᑐᑦ ᐅᓄᖅᑑᔪᑦ (ᓲᕐᓗ ᕿᓚᓗᒐᐅᔾᔦ, ᕙᓐ ᕿᓚᓗᒐᐃᕐ, ᐋᕐᓗᐃᕐ, ᐊᖅᕚᑦ ᐊᒻᒪ ᖃᐅᓪᓗᖅᑐᓂᒃ ᓯᒡᔫᑦ ᕿᓚᓗᒐᐅᔾᔦ) (ᐅᐊᖕᓇᖕᒐᓂᑦ ᐋᑦᑖᓐᑎᒃ ᑕᕆᐅᒥᑦ ᐳᐃᓈᑦ ᑲᒥᓴᙳᑦ 2021). ᐃᓕᖅᑯᓯᕐᑯᖃᖕᒋᑦᑎᒍᑦ ᑑᒑᑦ ᓇᔪᒐᖕᒋᑦ ᑕᐅᑯᓂ ᑮᓪᓕᓕᖅᑕᐅᓯᒪᓕᖅᑐᑦ ᐆᓇᖅᓯᕗᓪᓕᐊᔪᒧᑦ ᑕᕆᐅᒧᑦ ᐊᒻᒪᓗ ᑑᒑᑦ ᓱᖕᒋᐅᑎᔪᓐᓇᕐᓂᖏᓐᓄᑦ ᐆᓇᖅᓯᕗᓪᓕᐊᔪᒧᑦ ᐃᒪᕐᒧᑦ ᑮᓪᓕᖅᑲᓪᓗᓂ ᐱᔾᔪᑕᐅᓪᓗᑎᒃ ᑎᒥᖕᒋᖅ ᖃᓄᐃᓕᖕᒐᓂᖏᑦ. ᐊᓯᔾᔨᖅᑐᑦ ᑑᒑᑦ ᓇᓃᖃᑦᑕᕐᓂᖏᑦ ᐊᑯᑭᑦᑐᓂ ᑎᑎᕋᖅᑕᐅᓯᒪᔪᑦ ᒫᓐᓇᓕᓴᓂ ᐊᕿᔫᔪᓂ, ᐊᒥᓱᑦ ᑕᑯᔭᐅᔪᑦ ᑑᒑᑦ ᐃᓂᓂ ᐅᐊᖕᓇᖕᒐᓂ ᓇᔪᒐᕆᒐᔪᒃᑕᖕᒋᓐᓂ (ᓲᕐᓗ ᑕᕝ ᑲᖕᒋᖅᕚᖕᒥ, ᐊᑯᑭᑦᑐᑦ ᑕᕆᐅᖕᒐᓂ, ᐅᐊᖕᓈᔾᖕᒐᓂ ᑲᓇᖕᓇᖅᐸᓯᖕᓂ ᐊᙳᓇᓱᒃᕙᐅᕙᒃᑐᑦ ᐊᒻᒪᓗ ᓯᓚᐅᑉ ᐊᓯᔾᔨᖅᐸᓪᓕᐊᓂᖕᒐ ᐊᒃᑐᐃᓂᕐᓗᒃᓯᓯᒪᓕᖅᑐᑦ ᐊᑯᓂᐅᔪᒃᑯᑦ ᐃᓄᐃᓐᓇᕈᓐᓇᕋᔭᕐᓂᖕᒋᓐᓄᑦ ᓂᕆᖅᐸᓯᐊᓂ ᑲᓇᖕᓇᖅᐸᓯᐊᓂ ᐊᑯᑭᑦᑐᑦ (ᐅᐊᖕᓇᖕᒐᓂᑦ ᐋᑦᑖᓐᑎᒃ ᑕᕆᐅᒥᑦ ᐳᐃᓈᑦ ᑲᒥᓴᙳᑦ 2021).

ᖁᑖᓃᑦᑐᑦ ᐱᔾᔪᑏᑦ ᐱᔾᔪᑎᑦ, ᐱᑕᖃᑐᐃᓐᓇᓇᐊᖃᕐᓂᖕᒐᓄᑦ ᓯᓚᒧᑦ-ᐊᐅᓚᑕᐅᔪᑦ ᐊᓯᔾᔨᐅᑏᑦ ᐆᒪᔪᓂ ᐊᔾᔨᒌᙱᐊᕐᔪᒃᑐᑦ ᓇᓃᓐᓂᖕᒋᓐᓄᑦ ᓱᖁᑎᒋᔭᐅᙱᑦᑑᔪᓐᓇᐃᓕᔪᖅ ᐅᓂᒃᑳᖅᑕᐅᔪᓐᓇᑐᐃᓐᓇᓇᐊᖃᕐᓂᖕᒐᓄᑦ ᒫᓐᓇᕋᑖᖅ ᐅᔾᔮᕆᔭᐅᔪᑦ ᐊᓯᔾᔨᐅᑏᑦ ᐊᐅᔭᒃᑯᑦ ᑑᒑᑦ ᓇᓃᖃᑦᑕᕐᓂᖕᒋᓐᓄᑦ ᑕᓯᐅᔭᒥ. ᑐᑭᓯᑎᐊᒃᑲᓐᓂᖁᓪᓗᑕ ᖃᓄᐃᑐᓕᖕᒐᓕᑐᐃᓐᓇᓇᐊᖃᕐᓂᖕᒋᓐᓄᑦ, ᐃᓚᐅᑎᑦᑎᓂᒃᑲᓐᓃᑦ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᓂᒃᑲᓐᓃᓪᓗ ᐃᓄᖕᓂᒃ ᓇᖕᒥᓂᖃᖅᑎᐅᔪᓂᒃ ᐊᒻᒪᓗ ᒪᓕᒐᓕᕆᓂᕐᒧᑦ ᑎᒥᐅᔪᓂᒃ ᐱᑕᖃᕆᐊᖃᖅᑐᖅ, ᐱᖃᓯᐅᑎᓗᑎᑦ ᐱᓕᕆᖃᑎᒌᖕᓃᑦ ᓄᓇᓂ ᐊᕙᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔮᓴᖅᐸᓪᓕᐊᖕᒋᓐᓇᕐᓂᕐᓂᒃ ᖃᐅᔮᓴᖅᐸᒡᓗᑎᒃ ᐅᓄᕐᓂᖕᒋᓐᓂᖕᒋᓐᓄᑦ ᖃᓄᐃᓕᖕᒐᓂᐅᔪᑦ ᐊᑕᖕᒋᕐᓗᑎᑦ ᕿᑭᖅᑖᓘᑉ ᐃᑭᐊᓂ ᑑᒑᑦ ᐱᑕᖃᕐᕙᖕᒋᓐᓂ.

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Abbreviation and Acronym list

AIC	Akaike's Information Criterion
AIN	Admiralty Inlet North stratum
AIS	Admiralty Inlet South stratum
ASL	Above sea level
Baffinland	Baffinland Iron Mines Corporation
BF	Beaufort Sea State
BB	Baffin Bay stratum
C_a	Availability correction factor
CI	Confidence Interval
CV	Coefficient of Variation
DFO	Fisheries and Oceans Canada
DS	Distance Sampling
DSLR	Digital Single Lens Reflex
ERP	Early Revenue Phase
ESE	Eclipse Sound East stratum
ESW	Eclipse Sound West stratum
FEIS	Final Environmental Impact Statement
ft	Feet
Golder	Golder Associates Ltd.
GPS	Global Positioning System
IQ	Inuit Qaujimajatuqangit
km	Kilometres
km^2	Square kilometres
km/h	Kilometers per hour
kn	Knots
m	Metre
MEWG	Marine Environmental Working Group

MHTO	Mittimatalik Hunters and Trappers Organization
Milne Port	Port at Milne Inlet
MIN	Milne Inlet North stratum
MIS	Milne Inlet South stratum
MMASP	Marine Mammal Aerial Survey Program
MMP	Marine Monitoring Program
Mtpa	Million tonnes per annum
MMOs	Marine Mammal Observers
MR	Mark-recapture
MRDS	Mark-recapture distance sampling
MSV	Multipurpose support/supply vessel
NB	Navy Board Inlet stratum
NEBI	North and East Baffin Region
NIRB	Nunavut Impact Review Board
NWBM	Nunavut Wildlife Management Board
PAM	Passive Acoustic Monitoring
PI	Pond Inlet stratum
Project	Mary River Project
PC	Project Certificate No. 005
QA/QC	Quality Assurance/Quality Control
QIA	Qikiqtani Inuit Association
RSA	Regional Study Area
SBO	Ship-based Observer
Steenbsy Port	Port at Steensby Inlet
TS	Tremblay Sound stratum

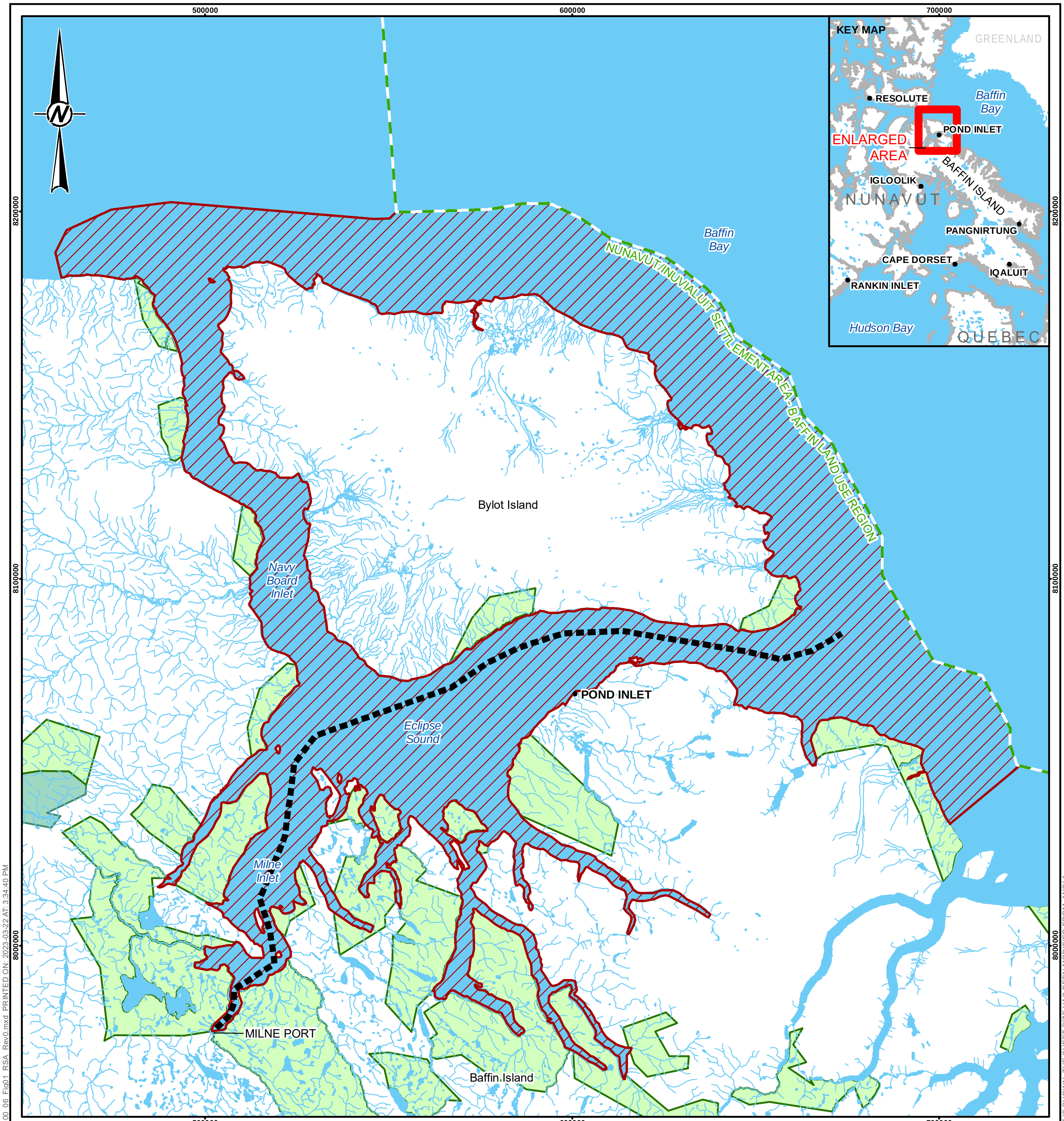
1.0 INTRODUCTION

This report presents the results of the 2022 Marine Mammal Aerial Survey Program (MMASP) conducted on North Baffin Island during July and August 2022. Marine mammal aerial surveys were conducted by WSP using distance-based line-transect sampling combined with high-resolution photography. The primary objectives of the surveys were to collect data on the presence/absence and distribution of marine mammals prior to and during initial shipping operations in the Regional Study Area (RSA), and to obtain an annual abundance estimate for the Eclipse Sound and Admiralty Inlet narwhal summer stocks during the open water season.

1.1 Project Background

The Mary River Project (hereafter, "the Project") is an operating open pit iron ore mine owned by Baffinland Iron Mines Corporation (Baffinland) and located in the Qikiqtani Region of North Baffin Island, Nunavut (Figure 1). The operating mine site is connected to Milne Port, located at the head of Milne Inlet, via the 100 km long Tote Road. An approved but yet-undeveloped component of the Project includes a South Railway connecting the Mine Site to an undeveloped port at Steensby Inlet (Steenbsy Port).

To date, Baffinland has been operating in the Early Revenue Phase (ERP) of the Project and is authorized to transport 4.2 Mtpa of ore by truck to Milne Port for shipping through the Northern Shipping Route using chartered ore carrier vessels. A production increase to ship 6.0 Mtpa from Milne Port was approved for 2018–2022 and shipping is expected to continue for the life of the Project (20+ years). During the first year of ERP operations in 2015, Baffinland shipped ~918,000 tonnes of iron ore from Milne Port involving 13 return ore carrier voyages. In 2016, the total volume of ore shipped out of Milne Port reached 2.6 million tonnes involving 37 return ore carrier voyages. In 2017, the total volume of ore shipped out of Milne Port reached 4.1 million tonnes involving 58 return ore carrier voyages. Following approval to increase production to 6.0 Mtpa, a total of 5.1 Mtpa of ore was shipped via 71 return voyages in 2018, 5.9 Mtpa of ore was shipped via 81 return voyages in 2019, 5.5 Mtpa was shipped via 72 return voyages in 2020, and 5.6 Mtpa via 73 return voyages in 2021. In 2022, a total of 4.7 Mtpa of iron ore was shipped via 62 return voyages with the first inbound transit into the Regional Study Area (RSA) from Baffin Bay of the season occurring on 30 July and the last outbound transit of the season occurring on 13 October 2022.



LEGEND

- COMMUNITY
- SHIPPING ROUTE (APPROXIMATE)
- WATERCOURSE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- MARINE MAMMAL REGIONAL STUDY AREA
- NUNAVUT LAND CLAIMS AGREEMENT – ARCTIC BAY INUIT OWNED LAND
- NUNAVUT LAND CLAIMS AGREEMENT – POND INLET INUIT OWNED LAND
- WATERBODY

0 25 50

1:1,500,000 KILOMETRES

REFERENCE(S)

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PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
MARINE MAMMAL REGIONAL STUDY AREA

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

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1.2 Regulatory Drivers and Community Engagement

In accordance with existing Terms and Conditions of Nunavut Impact Review Board (NIRB) Project Certificate (PC) No. 005, Baffinland is responsible for the establishment and implementation of the Marine Monitoring Plan (MMP) which comprises environmental effects monitoring studies that are conducted over a sufficient time to allow for the following objectives:

- To measure the relevant effects of the Project on the marine environment.
- To confirm that the Project is being carried out within the pre-determined terms and conditions relating to the protection of the marine environment.
- To assess the accuracy of the predictions contained in the Final Environmental Impact Statement (FEIS) for the Project.

The MMASP is one of several monitoring programs that collectively make up the MMP for marine mammals. The MMASP was designed to address PC conditions related to evaluating potential disturbance of marine mammals from shipping activities that may result in changes in animal distribution, abundance, and migratory movements in the study area. Specifically, this included the following Terms and Conditions:

- Term and Condition No. 101 - "The Proponent shall incorporate into the appropriate monitoring plans the following items:
  - b. Efforts to involve Inuit in monitoring studies at all levels.
  - c. Monitoring protocols that are responsive to Inuit concerns.
  - e. Schedule for periodic aerial surveys as recommended by the Marine Environment Working Group (MEWG)."
- Term and Condition No. 109 (for Milne Inlet specifically) - "The Proponent shall conduct a monitoring program to confirm the predictions in the FEIS with respect to disturbance effects from ships noise on the distribution and occurrence of marine mammals. The survey shall be designed to address effects during the shipping seasons, and include locations in Hudson Strait and Foxe Basin, Milne Inlet, Eclipse Sound and Pond Inlet. The survey shall continue over a sufficiently lengthy period to determine the extent to which habituation occurs for narwhal, beluga, bowhead and walrus".
- Term and Condition No. 110 - "The Proponent shall immediately develop a monitoring protocol that includes, but is not limited to, acoustical monitoring, to facilitate assessment of the potential short term, long term, and cumulative effects of vessel noise on marine mammals and marine mammal populations. The Proponent is expected to work with the Marine Environment Working Group to determine appropriate early warning indicator(s) that will ensure rapid identification of negative impacts along the southern and northern shipping routes."
- Term and Condition No. 111 - "The Proponent shall develop clear thresholds for determining if negative impacts as a result of vessel noise are occurring".
- Term and Condition No. 126 - "The Proponent shall design monitoring programs to ensure that local users of the marine area in communities along the shipping route have opportunity to be engaged throughout the life of the Project in assisting with monitoring and evaluating potential project-induced impacts and changes in marine mammal distributions".

Since 2013, regular community engagement meetings regarding the Project have been carried out in Arctic Bay, Clyde River, Sanirajak, Igloolik, and Pond Inlet. Primary concerns identified by the communities with respect to potential Project effects on marine mammals along the Northern Shipping Route include the following:

- Loss or alteration of narwhal and ringed seal habitat due to port construction and shipping.
- Injuries or mortality of marine mammals due to ship strikes.
- Acoustic disturbance effects on marine mammals from port construction and shipping that may lead to changes in animal distribution, abundance, migration patterns, and subsequent availability of these animals for harvesting.

1.3 Adaptive Management Protocol

Adaptive management is a planned and systematic process for continuously improving environmental management practices by learning about their outcomes (CEAA 2009). Adaptive management provides flexibility to identify and implement new mitigation measures or to modify existing ones during the life of a project. Adaptive strategies are implemented when unanticipated adverse effects are observed, or if effects exceed identified thresholds.

In support of Baffinland's Phase 2 Proposal for the Project, Baffinland developed a draft Adaptive Management Plan (AMP) which provides a framework for how adaptive management is incorporated into Project operations (Baffinland 2020). As part of this process, a Marine Mammal Trigger Action Response Plan (TARP) was developed for the Project which identifies a number of performance indicators, effect thresholds and pre-defined actions (i.e., responses) that are used to evaluate and respond to potential Project effects on narwhal and other marine mammal species in the Project area (Baffinland 2021b). The TARP shares the same objective as the EWI identified in Section 1.3, although uses a broader range of effect indicators that are measured against a series of tiered thresholds (i.e., low, moderate and high-risk thresholds) that are designed to guide short-term and long-term adaptive management strategies. The pre-defined actions identified in the TARP describe the responses that Baffinland would implement should the corresponding threshold levels be exceeded and assuming there is some degree of certainty that the measured change is Project-related. Three levels of action have been identified: low, moderate, and high. These responses range from increased monitoring and data analysis (e.g., trend analysis); identification of possible sources; to risk assessment and/or mitigation. On 22 March 2021, Baffinland released the most current version of the Marine Mammal TARP and Action Toolkits as part of its responses to Post-Hearing Questions related to Phase 2 (Baffinland 2021b).

1.3.1 Low Risk Threshold

As part of the tiered approach for adaptive management for the Project, the following criteria have been identified which represent 'Low Risk' thresholds for narwhal:

- Confirmed moderate severity behavioural responses (Severity Score 5 and 6) that do not persist for a prolonged period (i.e., for several hours) following the exposure event, as described in Section 3.0 of the 2022 Bruce Head report (WSP 2023).

For the threshold to be met, response in movement behaviour would need to be observed as a trend in the data across individuals. In the event that these threshold criteria are exceeded, a commensurate 'Low Risk' response would be triggered (Baffinland 2021a).

1.3.2 Moderate Risk Threshold

As part of the tiered approach for adaptive management for the Project, the following criteria have been identified which represent ‘Moderate Risk’ thresholds for narwhal:

- Confirmed ‘moderate severity’ behavioural responses (Severity Score 5 and 6) that persist for a prolonged period (i.e., for several hours) following the exposure event, as described in Section 3.0 of the 2022 Bruce Head report (WSP 2023).

AND

- A statistically significant decrease in the proportion of immature narwhal relative to baseline conditions (2014/2015 values).

For the threshold to be met, behavioural responses would need to be observed as a trend in the data across individuals. In the event that these threshold criteria are exceeded, a commensurate ‘Moderate Risk’ response would be triggered (Baffinland 2021a).

1.3.3 High Risk Threshold

As part of the tiered approach for adaptive management for the Project, the following criteria have been identified which represent ‘High Risk’ thresholds for narwhal:

- Confirmed moderate severity behavioural responses (Severity Score 5 and 6) that persist for a prolonged period (i.e., for several hours) following the exposure event, as described in Section 3.0 of the 2022 Bruce Head report (WSP 2023).

AND/OR

- Confirmed high severity responses (Severity Score 7 to 10) as described in Section 3.0 of the 2022 Bruce Head report (WSP 2023).

AND

- A statistically significant decrease in the proportion of immature narwhal relative to baseline conditions (2014/2015 values).

AND/OR

- >25.0% decrease in the Eclipse Sound stock size (abundance) relative to the 2019 aerial survey abundance.

For the threshold to be met, behavioural responses would need to be observed as a trend in the data across individuals. In the event that these threshold criteria are exceeded, a pre-determined ‘High Risk’ response would be triggered, as defined in Baffinland (2021a).

1.4 Existing Environment

Narwhal

The most current abundance estimate for the Baffin Bay narwhal population, corrected for availability and observer bias, is 141,909 individuals (DFO 2015a; Doniol-Valcroze et al. 2020). In Canada, the Baffin Bay narwhal population is currently managed as four summering stocks, each represented by a different geographic aggregation (Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island; DFO 2015a). There are also large numbers of summering narwhal around Ellesmere Island that range over Jones Sound, Smith Sound, Norwegian Bay, and adjacent bays and fiords. Collectively, these narwhal are recognized by Fisheries and Oceans Canada (DFO) as the Jones Sound and Smith Sound stocks (DFO 2015a). The relationship of these stocks with the four recognized Baffin Bay stocks and the Inglefield Bredning stock in Greenland is unclear. The abundance estimate of the Eclipse Sound summering stock was estimated to be 20,225 individuals in 2004 (Richard et al. 2010), approximately 10,489 in 2013 (DFO 2015a), and 12,039 in 2016 (Marcoux et al. 2019). Lower numbers of narwhal observed in 2013 in the Eclipse Sound stock compared to 2004 was explained by possible mixing between the Eclipse Sound and Admiralty Inlet summering stocks given the relatively higher number of narwhal observed in Admiralty Inlet that same year (Doniol-Valcroze et al. 2015a). Documented movements of individual narwhal between Eclipse Sound and Admiralty Inlet also raised the possibility of some degree of exchange between the two summering areas during the period when aerial surveys are typically conducted (DFO 2020; Doniol-Valcroze et al. 2015a). The combined abundance estimate of the Eclipse Sound and Admiralty Inlet summering stock was estimated to be 45,532 in 2013 (Doniol-Valcroze et al. 2015a).

Inuit Qaujimajatuqangit (IQ) also suggests that Pond Inlet and Arctic Bay share the same stock of narwhal (Jason Prno Consulting Services Ltd. [JCPS]2017). For example, the following respondent described narwhal travelling by Pond Inlet on their way to Arctic Bay and states that the two areas share the same stock of narwhal:

> *“Narwhal go through Pond Inlet first before they get to Arctic Bay. Whales are like that too. They migrate. We may have more narwhals and whales in our waters. Pond Inlet hunters are concerned, because they travel, trying to reach the inlets. In the fall, they start heading back along the coast. It’s a cycle of migration. They are feeding. This area, Eclipse Sound, might have less whales and narwhals due to increased traffic going through. They may come more to the Arctic Bay area. We share the same stock of narwhals. We know from the past there are less narwhals there. We know there are already impacts, compared to the past. It’s mainly about Pond Inlet. We can’t really do anything here. For us, it’s more benefit. We’ll get more narwhals. But I’m sympathetic to Pond Inlet. It’s mixed emotions.”* - Jobie Attitaq, 20-22 November 2015, p. 221, JPCS (2017).

Interview data from the following respondent (QIA 2019) also suggest the same narwhal will utilise both Pond Inlet and Arctic Bay areas:

> *“This could be the route to go, with the narwhals and sent here. From this side, narwhals ... I think some narwhals coming to Arctic Bay, I think some goes through here and some going up to Milne Inlet. But, either way. I mean the narwhals coming from here, like when the ice breaks up like end of June or a week after first week of July when the ice breaks, narwhals usually go by Pond here, coming from the floe edge.* (P23, 28-Apr-19)” - Anonymous, 28 April 2019, p. 42, QIA 2019.

Available information on narwhal distribution (Richard et al. 1994; Heide-Jørgensen et al. 2002; COSEWIC 2004a; Laidre et al. 2004; Marcoux et al. 2009; Richard et al. 2010; Watt et al. 2012; DFO 2015a; Elliott et al. 2015; Thomas et al. 2015, 2016; Golder 2018a) indicated that the RSA is regularly used during summer and fall, although the distribution of narwhal varies throughout the season. In spring and early summer, narwhal migrate to their summering habitats. In the case of the Eclipse Sound stock, they concentrate mainly in Milne Inlet, Koluktoo Bay, and Tremblay Sound during the summer. IQ suggests narwhal are concentrated in Tremblay Sound, western Eclipse Sound, Milne Inlet, and Koluktoo Bay (JPCS 2017, QIA 2019).

> *"Our narwhal hunting is floe edge and then Milne Inlet and Tremblay, but we've also come in here, like, Mount Herodier area. We don't often go into Navy Board, but we have..."* - Anonymous, 27 April 2019, p.39, QIA 2019.
>
> *"Yeah, both Tremblay and Milne are, like, usually on a daily basis you'll see narwhal ... You can see anywhere from, like, a pod of fifty to, like, several, several, several pods, which are travelling together, like, I'd say hundreds at a time ... Like, there's been times when water is dead calm, like, mirror, and we see the first few narwhal and then before we know it, it's like, the waves have hit, because there's that many narwhal in the area."* - Anonymous, 27 April 2019, p.42, QIA 2019.
>
> *"I know this, the change of – narwhals. There's usually narwhals around here [mouth of Qinngua]. But since the Baffinland is carrying ships, most of the narwhals are now like away from the area they usually be. Yeah. Like lots of narwhal usually around here ... But one time, I think it was last year, people were noticing the difference too. They started seeing killer whales here instead of narwhals. Yeah. I think the shipping route is the effect of the animals."* – Anonymous, 8 February 2019, p. 48, QIA 2019.

Marine mammal aerial surveys conducted for the Project were first undertaken during the 2006–2008 open-water seasons. Subsequent aerial surveys were conducted in 2013 and 2014 to establish marine mammal distribution and density estimates along the Northern Shipping Route during the open-water season and prior to ERP operations. In 2015, aerial surveys were undertaken with a modified approach to attempt to examine potential effects of Project shipping on marine mammal distribution and density estimates during the first year of ERP operations. In 2016, photographic aerial marine mammal surveys were conducted by DFO along the Northern Shipping Route and adjacent inlet areas. Aerial photography from these surveys was analyzed by Golder Associates Ltd. (amalgamated under WSP Canada Inc. in January 2023) on behalf of Baffinland in 2016 to calculate narwhal abundance and density estimates for Milne Inlet, Eclipse Sound, Tremblay Sound and Pond Inlet, based on conventional distance sampling methods (Golder 2018b). The analysis was limited to two survey days (15 and 21 August 2016). DFO released the results of their analysis of the 2016 aerial surveys in June 2019 (Marcoux et al. 2019). From 2019 to 2022, aerial surveys were conducted using distance-based line-transect sampling combined with high-resolution photography to determine the relative abundance and distribution of marine mammals near the Pond Inlet floe edge prior to and during initial shipping and icebreaking operations, and to obtain abundance estimates of narwhal during the open-water season for the Eclipse Sound and Admiralty Inlet summer stock areas (Golder 2020a, 2021a, 2022c).

Bowhead whale

Bowhead whale aerial survey abundance estimates for the Eastern Canada-West Greenland (EC-WG) population in 2002–2004 and 2013 indicated population numbers in the thousands and increasing significantly since commercial whaling protection was provided in the early 20th century (COSEWIC 2009, DFO 2015b). This population of whales spends summers in Baffin Bay and adjoining waters of the Canadian High Arctic with the RSA included as part of their summer aggregation area (COSEWIC 2009).

Milne Inlet, Eclipse Sound and Pond Inlet are not thought to represent important summering areas for bowhead given the low number of bowhead sightings reported in these areas during the summer season. During eight years of shore-based monitoring conducted for Baffinland from 2013 to 2017 and 2019 to 2021, a total of 21 bowhead were recorded near Bruce Head (Thomas et al. 2014; Smith et al. 2015, 2016, 2017; Golder 2018c, 2020b, 2021b, 2022a). Similarly, a total of 14 bowhead were recorded along the Northern Shipping Route during three consecutive years of aerial surveys conducted between 2013 and 2015 during the open water period (Elliott et al. 2015; Thomas et al. 2015, 2016). Based on the most recent High Arctic Cetacean Survey completed by DFO in the Project area, the predicted number of bowhead in Eclipse Sound during 2013 was 32 (Doniol-Valcroze et al. 2015a). During Leg 1 of 2019, when bowhead were migrating through the RSA, the calculated abundance of bowhead in the RSA was 176 (15 July) and 1,291 whales (21–22 July) (Golder 2020a). Bowhead numbers during Leg 2 of 2019, 2020 and 2021 were too low to calculate an abundance with only four bowhead recorded in the RSA in 2019 (Golder 2020a), one bowhead recorded in 2020 (Golder 2021a), and two bowhead recorded in 2021 (Golder 2022c). During four years of the Ship-Based Observer (SBO) program conducted for Baffinland from 2013 to 2015 and in 2018, bowhead whale were not observed (SEM 2014, 2016; Golder 2019). In 2019, 23 sightings of 25 individual bowheads were recorded during the SBO program (Golder 2020c).

Observations of bowhead whale in the RSA were consistent with IQ, including observations of bowhead aggregating in the RSA in Aujaq (end of July to September; Hay et al. 2000, JPCS 2017). For example, bowhead were reported to enter the inlets late into July when the ice is breaking up and can occur in large numbers:

> *"Bowhead whales may be at the floe edge at this time. We don't try to catch them because we need permission. August 2010 was our last bowhead hunt. We see porpoises sometimes, but do not harvest them [Group Discussion]."* – Anonymous, 3-4 March 2015, p.158, JPCS 2017.

> *"…bowhead whales started to penetrate deeper into the inlets to start feeding..….late into July when the ice is breaking up. That was also the time that they would be feeding without fear of predators such as killer whales. [Kooneeloosie Nutarak, Sr., PI/ws] BB179"* – Kooneeloosie Nutarak, p.37, 17-18 March 1997, Hay et al. 2000.

According to Hay et al. (2000), "One informant from Pond Inlet reported an annual occurrence of bowheads at the floe edges off Pond Inlet, Navy Board Inlet, and Tallurutiit/Lancaster Sound. Others have reported that bowhead whales occur in large numbers in the Pond Inlet area during summer. One informant reported that his wife counted a minimum of 74 bowheads on migration in Navy Board Inlet during summer 1996" (p.67).

Bowhead whales were also described to migrate through the area with their calves at this time of year. According to the JPCS (2017) IQ report, "bowhead whales will also migrate through the area with their calves in Aujaq but are not actively harvested by Inuit due to strict quotas that are in place" (p.32).

> *"July is the month that we change from using a snowmobile on the ice to a boat on the water. Bowheads will migrate through with calves but we haven't seen them calve in this area. They go in family groups (the bowhead harvest site from 2010 was marked on the map). It took us 3 days to butcher the whale."* – Anonymous, 3-4 March 2015, p.159, JPCS 2017.

Killer whale

Killer whales frequent the high Arctic primarily during the open-water season (Higdon 2007) and have been recorded in the region as early as the mid-1800s (Reeves and Mitchell 1988). Earlier studies reported that this species was uncommon in northern Baffin Bay and Lancaster Sound between August and October (Koski and Davis 1979). By 2001, regular sightings of killer whales were reported in Cumberland Sound, Lancaster Sound, and Pond Inlet (Baird 2001). Regular occurrences of killer whale have been reported in Pond Inlet during spring, summer, and fall, with most of the reported sightings occurring during July–August (Higdon 2007). Killer whales have also been observed in and around Eclipse Sound and Tremblay Sound (Campbell et al. 1988; Marcoux et al. 2009) and in Milne Inlet and Koluktoo Bay on several occasions when they were observed hunting narwhal (Ferguson et al. 2012). During five consecutive years of shore-based monitoring conducted for Baffinland from 2013 to 2017, no killer whale were recorded (Thomas et al. 2014; Smith et al. 2015, 2016, 2017; Golder 2018c). Although, killer whales were observed in South Milne Inlet by Mr. Panipakoocho as he departed Bruce Head camp in 2015 (Smith et al. 2016). On 18 August 2019, observers stationed at Bruce Head observed one sighting of eight killer whales in south Milne Inlet (Golder 2020b). On 26 and 27 August 2020, 67 and 18 killer whales, respectively, were observed from Bruce Head (Golder 2021b). Killer whale were not observed in the RSA during three consecutive years of aerial surveys conducted between 2013 and 2015 during the open water period (Elliott et al. 2015; Thomas et al. 2015, 2016). Killer whales were observed during the 2019 MMASP on 21, 26, and 29 August (Golder 2020a). While it is unclear whether the same killer whales were observed repeatedly in 2019, and where they travelled between surveys, the observations demonstrate that killer whales were likely in the RSA from 17–30 August during Leg 2 of the 2019 MMASP. During the 2020 MMASP, three killer whale sightings were observed on 27 August and one sighting was observed on 29 August (Golder 2021a). It is likely the third sighting of killer whales on 27 August was a resighting of the first sighting. There were two sightings of killer whale in the RSA during Leg 1 of the 2021 MMASP, including one sighting of 11 killer whale near Pond Inlet on 27 July and another sighting of nine killer whale in Navy Board Inlet on 8 August. There were no sightings of killer whale during Leg 2 of the 2021 MMASP (Golder 2022c).

IQ indicates that it is not common for killer whales to be observed at floe edge or leads because their dorsal fins interfere with ice travel. According to IQ from QIA (2018), “beluga are subject to predation by killer whale and polar bear and can become entrapped in ice. When chased by killer whales, they move to shallower waters that cannot be navigated by killer whales. Despite the risk of entrapment, ice is used to avoid killer whales whose dorsal fins interfere with movement in icy waters” (p.45) and “killer whales are generally not noted at floe edge or leads. Their dorsal fins interfere with ice travel…” (p.56).

IQ respondents also reported that killer whales do not normally arrive until Aujaq, i.e., July to September (JPCS 2017, QIA 2018, 2019).

> *“The same harvesting activities as Upirngaaq occur, but in different areas. No polar bears are harvested and walrus would be very rare. We are starting to see porpoises. We have not harvested them. We see killer whales in Eclipse Sound at this time of year. They do not come until summer. Killer whales are “sea wolves”. We consider them our hunting partners, we don’t hunt them [Group Discussion].”* – Anonymous, 3-4 March 2015, p. 158, JPCS 2017.

> *“And one of the other reasons that we see now is that there is a whole lot more killer whales coming to Pond Inlet area, like lots of them; and again, I was talking about earlier that there’s different factors involved in narwhals not migrating to Pond Inlet area as they used to, and I believe this is one of them as well. The killer whales two years ago stayed in Milne area all summer and kept the narwhals away from that area; and again, they’re killers, they’ll just kill. (P13, 06-Feb-19)”* – Anonymous, 6 February 2019, p. 141, QIA 2019.

IQ from QIA (2018) reported that, "… killer whales have been observed leaving before freeze up so that they will not be trapped in ice. As with other whales, harvesters have indicated that killer whales seem to avoid areas with too many boats and that they may be sensitive to noise" (p.56). Killer whales have not been observed during any of the five SBO programs between 2013 to 2019 (SEM 2014, 2016; Golder 2019, 2020c).

In 2009, Argos tracking tags were simultaneously deployed on killer whale and narwhal in Admiralty Inlet to understand how predation risk from killer whale affects narwhal behaviour (Breed et al. 2017). Results from the study showed that the presence of killer whale strongly altered the behaviour and distribution of narwhal. Killer whale presence also caused narwhal to move closer to shore. Dive behaviour was also affected, causing narwhal to perform deeper dives and shorten their dives. Behavioural changes in narwhal were reported to extend beyond active predation events, with altered behaviour and habitat use persisting steadily for the duration (10 days) that killer whales shared the habitat with narwhal.

Beluga whale

Beluga in the RSA are part of the Eastern High Arctic – Baffin Bay population; one of seven populations known to occur in Canadian waters at some point during the year (COSEWIC 2004b). It is assumed these beluga shift from their winter habitat in Baffin Bay and along Western Greenland to the ice-free or pack-ice in Baffin Bay. During the spring migration, beluga travel from Baffin Bay into areas along east and north Baffin Island as the landfast ice breaks up, occupying regions of Lancaster Sound, Barrow Strait, Peel Sound and Baffin Bay during the summer open-water season. The RSA lies within the full extent of beluga summer habitat though is not part of beluga core summer habitat and any beluga observed in the RSA are probably passing through on their way to their summer core habitat.

During five consecutive years of shore-based monitoring conducted for Baffinland from 2013 to 2017, no beluga were recorded (Thomas et al. 2014; Smith et al. 2015, 2016, 2017; Golder 2018c). In 2019, six beluga were recorded, and in 2020 and 2021, one beluga was recorded each year during the shore-based monitoring program (Golder 2020b, 2021b, 2022a). Beluga were not observed in previous Baffinland aerial surveys in the RSA from 2013 to 2015 (Elliott et al. 2015; Thomas et al. 2015, 2016). A total of four beluga were observed in the RSA during the 2019 MMASP (Golder 2020a). Three were sighted during the early shoulder season and one was sighted during the open water season. A total of five beluga were observed in the RSA during the 2020 MMASP (Golder 2021a) with four sighted during the early shoulder season and one during the open water season. During the 2021 MMASP, all seven beluga observed in the RSA were recorded during the early shoulder season (Golder 2022c). During three consecutive years of ship-based monitoring conducted for Baffinland from 2013 to 2015, beluga were not observed (SEM 2014, 2016). No belugas were observed during the 2018 SBO program (Golder 2019), but one beluga whale was recorded during the 2019 SBO program (Golder 2020c).

Observations of low numbers of beluga in the RSA are consistent with IQ which reports that, "beluga traditionally do not remain near Pond Inlet... Rather, they migrate through Eclipse Sound and Navy Board Inlet moving westward and northward." (p. 47, QIA 2018). Beluga and narwhal are also reported to travel in tandem and frequently inhabit that same area at similar times and hunting of both species takes place near the floe edge and during open water periods, e.g., May and September (QIA, 2018). However, beluga have also been reported to give birth in the area (QIA 2018) "…during Upirngasaaq, the whales gather at the floe edge waiting for the break-up of ice. Beluga have been known to birth in southern Navy Board Inlet, southern Milne Inlet, and Koluktoo Bay." (p. 47).

Polar bear

Polar bear are common in the RSA and throughout most of the Canadian Arctic archipelago. Individuals belonging to the Baffin Bay population occupy drifting pack ice and landfast ice between Baffin Island and west Greenland during winter but can be concentrated along the landfast ice edge in Lancaster Sound (Koski 1980; Ferguson et al. 2000; Ferguson et al. 2001). Polar bears were also concentrated along the landfast ice edge near Pond Inlet and Navy Board Inlet during spring. In August, polar bear are forced ashore by the absence of ice (Taylor and Lee 1995; SWG 2016) and spend this period on Bylot Island and Baffin Island (Lunn et al. 2002). Denning activity by pregnant females is concentrated along the North coast of Bylot Island and coastal areas of Baffin Island near Pond Inlet, Admiralty Inlet and Navy Board Inlet (Baffinland 2010). Generally only males and subadults are found in offshore pack-ice areas with only rare sightings of females with young observed in these areas (APP 1982). Polar bears also frequent fast-ice edges in this area (APP 1982). Polar bears from the Lancaster Sound subpopulation tend to occupy the central and eastern part of their range during winter but move westward during spring to summer on multi-year pack ice in eastern Viscount Melville Sound (Schweinsburg et al. 1982).

During eight years of shore-based monitoring conducted for Baffinland from 2013 to 2017 and 2019 to 2021, a total of 11 polar bears were recorded near Bruce Head (Thomas et al. 2014; Smith et al. 2015, 2016, 2017; Golder 2018c, 2020b, 2022a). A total of 14 polar bears were recorded in the RSA during three consecutive years of aerial surveys conducted between 2013 and 2015 (Elliott et al. 2015; Thomas et al. 2015, 2016). In 2019, six polar bears were recorded in the RSA during the shoulder season (July) and 14 polar bears were recorded during the open water season (Golder 2020a). During aerial surveys conducted in 2020, 24 polar bears were recorded in the RSA during the shoulder season and 25 polar bears were recorded over the open water season (Golder 2021a). A total of 38 polar bears were recorded in the RSA during the 2021 MMASP; 16 polar bears during the shoulder season and 22 polar bears during the open water season (Golder 2022c). Over three consecutive years of ship-based monitoring conducted for Baffinland from 2013 to 2015, polar bear were not observed (SEM 2014, 2016). Two polar bears were observed in each of the 2018 and 2019 SBO program (Golder 2019, 2020c).

IQ supports many of these findings (JPCS 2017, QIA 2019) reporting concentrations of polar bear along landfast ice in the area, including Pond Inlet and Navy Board Inlet during the spring.

> *"… pond Inlet floe edge activities continue in Upirngaksaaq, including the hunting of ringed and bearded seal, narwhal, polar bear, and walrus (although this species in not often hunted here)."* (p.26, JPCS 2017).
>
> *"March, April, May is when it is busier for polar bear hunting. [Elijah]"* – response regarding land use in Eclipse Sound and Navy Board Inlet areas, Elijah, 9-10 May 2016, p.228, JPCS 2017.
>
> *"I do a lot of seal hunting around that area [floe edge at Sannirut]. And when I go look for polar bear, that's where I usually go too, because there's always a fresh track. (P09, 05-Feb-19)"* – Anonymous, 5 February 2019, p.39, QIA 2019.

As well, IQ reports female denning activity in coastal areas of Baffin Island near Pond Inlet.

> *"More polar bear dens are found southeast of the floe edge. Young seals can't be found in those areas because the bears eat them [Group Discussion]."* – Anonymous, 3-4 March 2015, p.155, JPCS 2017.
>
> *"We used to use that for overnight site for hunting caribou. Just right beside that cabin, just only about 50 feet away from the cabin there [close to Sannirut] was a little land, a slope like this onto the shore in that area, there was a polar bear denning just about 50 feet away from a cabin here. (P11, 06-Feb-19)"* – Anonymous, 6 February 2019, p.107, QIA 2019.

Ringed seal

Population structures of ringed seal across the Canadian Arctic are poorly understood in general. The ringed seal population in Canada and adjacent waters (West Greenland, Alaska, and Russia) is estimated at 2.3 million seals, with low confidence (COSEWIC 2019). Finley et al. (1983) estimated the Baffin Bay region (Canada and Greenland) to have approximately 787,000 ringed seals. Kingsley (1998) estimated the size of the Baffin Bay ringed seal population using two methods, one based on polar bear energetic models, and another using published density data and estimates of ice areas. The polar bear model yielded a ringed seal population estimate of 1.2 million. The estimate based on sea ice type and availability and estimated ringed seal density was 697,200 hauled out seals, which would yield a similar population estimate as the polar bear predation model (1.2 million seals) (Kingsley 1998).

Aerial surveys of ringed seal in the RSA have been undertaken during the molting period (spring) when ringed seal are largely on the sea ice and easy to count (Yurkowski et al. 2018, Young et al. 2019). Yurkowski et al. (2018) noted several ringed seal hotspots throughout the RSA during the June spring molt, well ahead of the start of yearly shipping operations in July. Their results provided density estimates ranging from 0.57 to 0.79 seals/km^2 for Eclipse Sound, 0.93 to 1.27 seals/km^2 for Milne Inlet, and 0.27 to 0.77 seals/km^2 for Navy Board Inlet. Ringed seal surveys were also undertaken in June 2021 in the RSA. Results from the 2021 survey indicated that ringed seal densities are stable in Eclipse Sound and Navy Board Inlet strata and increased in Milne Inlet stratum compared to surveys flown in 2016 (Golder 2022b). Ringed seal hotspots were identified in similar geographic areas in 2021 as in 2016–2017, with hotspots in western Eclipse Sound, southern Milne Inlet and Tremblay Sound.

IQ from reported in JPCS (2017) indicated that the seal pupping season runs from February to March with seal pupping occurring throughout the RSA. Seal pups occur in the area as late as the middle of April.

> *"…seal hunting also continues in Ukiuq and seal pupping will last into March. Ringed seal pups are preferred by local Inuit and are harvested throughout Eclipse Sound."* (p.32, JPCS 2017).
>
> *"There are seal pups in the area until the middle of April."* – Elijah, 27-29 April 2015, p.165, JCPS 2017.
>
> *"There are no certain areas for seal pups; they are born everywhere. Even along the routes we travel. That is something that needs to be monitored."* - Paniloo, 27-29 April 2015, p. 171, JPCS 2017.

Harp seal

The Northwest Atlantic harp seal population was estimated at 6.8 (95% CI 5.8 – 8.0) million animals in 2017 and was projected to increase to 7.6 (95% CI 6.6 – 8.8) million animals in 2019 (Hammill et. al. 2021). Harp seal are seasonal visitors to the Arctic, arriving along the southwest coast of Greenland in late May and June (APP 1982) and then entering Lancaster Sound in July and August (Johnson et al. 1976; Greendale and Brousseau-Greendale 1976; APP 1982). Harp seal tend to enter Pond Inlet and Navy Board Inlet at the end of July (Miller 1955) with larger groups observed near the southern entrance of Navy Board Inlet and occasionally in Eclipse Sound throughout August and September (Miller 1955; Beckett et al. 2008). The number of adult harp seal entering Lancaster Sound and Eclipse Sound is variable (Tuck 1957; Greendale and Brousseau-Greendale 1976; Johnson et al. 1976; Riewe 1977, APP 1982).

IQ also notes that harp seal occur in the area, are harvested occasionally, and harp seal presence in the area has increased (JPCS 2017).

> *"The hunters and elders had some concerns during the past summer. We only saw harp seals in our area… [Jimmy]"* – Jimmy, 26–27 October, p. 177, JPCS 2017.
>
> *"... I would prefer more people hunt harp seals because we have too many. It's a change we've observed."* – Elijah, 26–27 October, p. 179, JPCS 2017.

Bearded seal

The distribution of bearded seal is largely determined by the presence of shallow water and distribution of ice (Burns 1981; Finley and Evans 1983; Kingsley 1986; Harwood et al. 2005; Kovacs et al. 2011). Bearded seal generally move into inlets and bays <200 m deep to feed during open-water periods and return to areas offshore of the floe edge in the fall once landfast ice has formed (Burns and Frost 1979). They are rarely found in fast-ice areas but are widely dispersed in open-water areas of pack ice where leads and cracks are frequent and where ice pans are sufficient for haul-out sites (McLaren and Davis 1982). No dedicated abundance survey has recently been completed for bearded seals in the Canadian Arctic.

IQ also reported that bearded seal were associated with the distribution of ice and harvested in the Pond Inlet area.

> *"Seal hunting along the ice cracks occurs in the winter (the perennial ice cracks were indicated on the corresponding map). We hunt mainly ringed seals and occasionally bearded seals along the cracks. Seal hunting at breathing holes occurs anywhere there is ice [Jimmy/Joshua/Elijah]."* – Jimmy/Joshua/Elijah, 3-4 March 2015, p.155, JPCS 2017.
>
> *"The busiest time of the year at the Pond Inlet floe edge is June; but it is used all the time when there is ice. It is always busy. It can be used up to July. May is also very busy. Walrus come through during this season, but not often. Bearded and ringed seals are here at the floe edge too."* – Anonymous, 3-4 March 2015, p.156, JPCS 2017.
>
> *"We go to the south coast of Bylot Island, west of Pond Inlet, to hunt seal. That's where it is busiest. We hunt ringed, bearded, and sometimes hooded seals. We don't hunt harp seals. Ringed seals are the most popular. Hooded seals are rare but we sometimes get them [Paniloo]."* – Paniloo, 3-4 March 2015, p. 154, JPCS 2017.
>
> *"People hunt whatever they can catch. In May, hooded and bearded seals sometimes come into the area. [Joanasie]"* – Joanasie, 9-10 May 2016, p. 228, JPCS 2017.

2.0 LEG 1: EARLY SHOULDER SEASON SURVEYS IN ECLIPSE SOUND

2.1 Introduction

2.1.1 Objectives

The 2022 MMASP was staged in two separate survey legs. Leg 1 targeted a 15-day window starting in mid-July, when narwhal undergo their spring migration through Eclipse Sound. The objective of the Leg 1 surveys was to collect data on the presence/absence and distribution of marine mammals prior to and during initial shipping operations in the RSA.

2.2 Survey Team and Training

Leg 1 of the 2022 aerial survey took place over a 15-day period (19 July to 2 August 2022) with an aircraft based out of the Mary River mine site. The survey team consisted of personnel that flew in the previous survey years (2019 and 2020), with one WSP biologist, two contracted marine biologists with previous marine mammal survey experience as Marine Mammal Observers (MMOs) on this program, two contracted Inuit observers with previous MMO experience, two pilots, and one mechanic (Figure 2).

Prior to mobilization, the survey team attended a Baffinland orientation that was held at Mary River on 20 July 2022. The orientation aimed to familiarize team members with Baffinland’s policies and procedures, including health and safety, while working at Mary River. Following the Baffinland orientation a training session was held with the survey team to go over the training manual and health and safety plan.

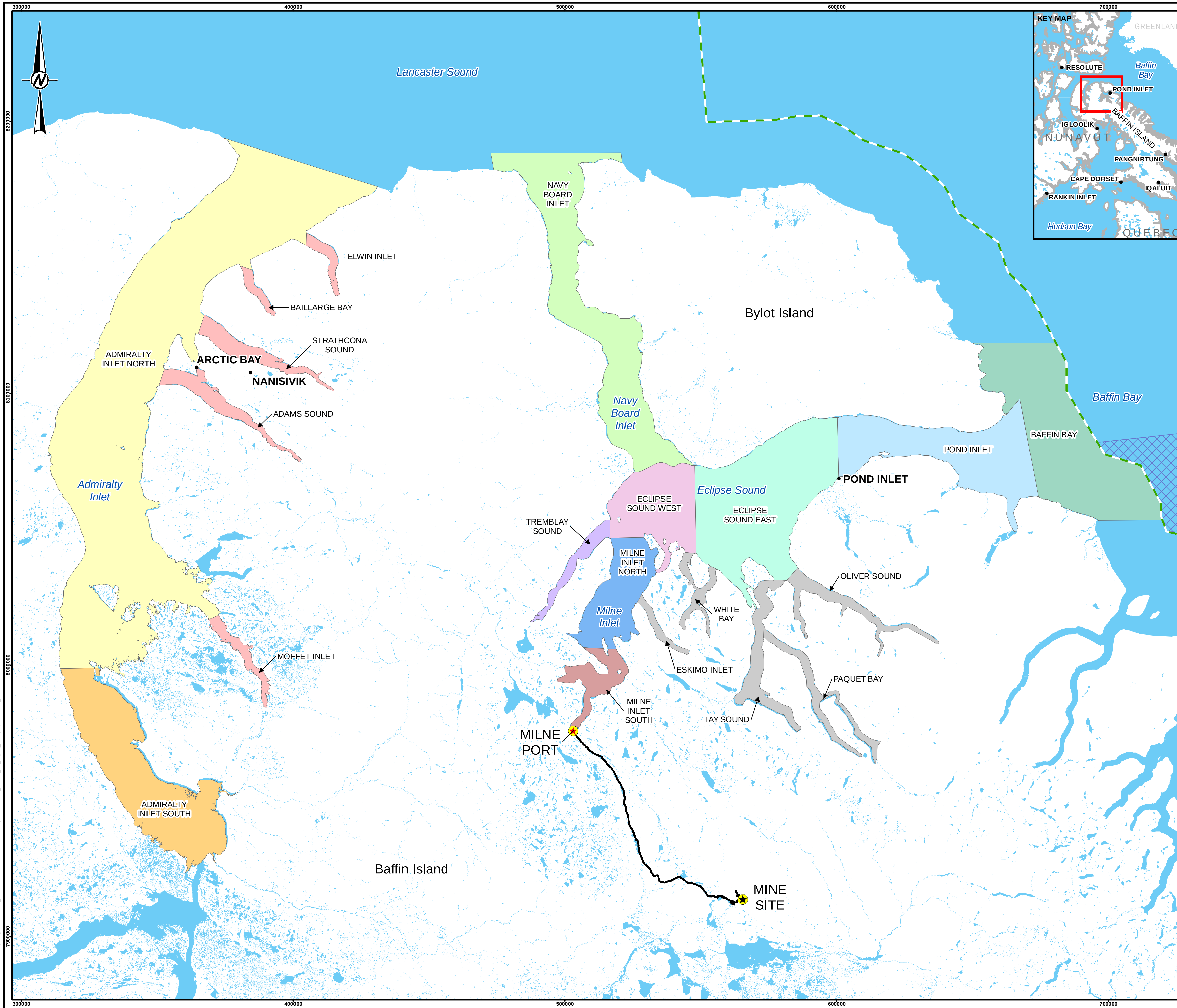
Figure 2: 2022 Marine Mammal Survey Team — Leg 1.

2.3 Study Area and Design

The study area for the Leg 1 surveys was based on the boundaries used in previous surveys from 2013 to 2016 (DFO 2017; Golder 2017), with an additional stratum in Baffin Bay added in 2019 and surveyed from 2019 to 2021 (Figure 3; Golder 2020a, 2021a, 2022c). Leg 1 was designed to collect data on the presence/absence and distribution of marine mammals prior to and during initial shipping operations in the RSA (Figure 4). One survey was flown in Admiralty Inlet on 26 July to verify narwhal presence/absence in this area.

Systematic random visual line-transect surveys were flown for all strata when conditions allowed with the location of the first line chosen at random. The blue transects had an east-west parallel line design, with a transect line spacing of approximately 5 km (see Figure 4). The red transects had a north-south parallel line design, with transect line spacings of approximately 8.6 km for the Eclipse Sound East and Pond Inlet strata, and approximately 4.3 km for the Eclipse Sound West stratum. East-west parallel line design, with a transect line spacing of approximately 10 km was used for Navy Board Inlet due to the low numbers of narwhal observed in previous survey years and northeast-southwest parallel line design, with an approximately 4 km transect line spacing, was used for Milne Inlet North transects (see Figure 4). A single transect was flown down the center of each of the fjords.

The survey design consisted of systematically placed and evenly distributed (when possible) line transects across the survey area (Figure 4). Transects were generally straight and uniformly spaced across large waterbodies but were occasional skewed to follow the shoreline contour. This was necessary in areas where the survey aircraft could not safely perform the turns necessary to cross waterbodies perpendicular to shorelines.



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE
- MILNE INLET TOTE ROAD
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

GEOGRAPHIC STRATA

ADMIRALTY INLET GRID

- ADMIRALTY INLET NORTH (AIN)
- ADMIRALTY INLET SOUTH (AIS)
- ADMIRALTY FJORDS

ECLIPSE SOUND GRID

- BAFFIN BAY (BB)
- ECLIPSE SOUND EAST (ESE)
- ECLIPSE SOUND WEST (ESW)
- MILNE INLET NORTH (MIN)
- MILNE INLET SOUTH (MIS)
- NAVY BOARD INLET (NBI)
- POND INLET (PI)
- TREMBLAY SOUND (TS)
- ECLIPSE FJORDS

0 25 50

1:1,400,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

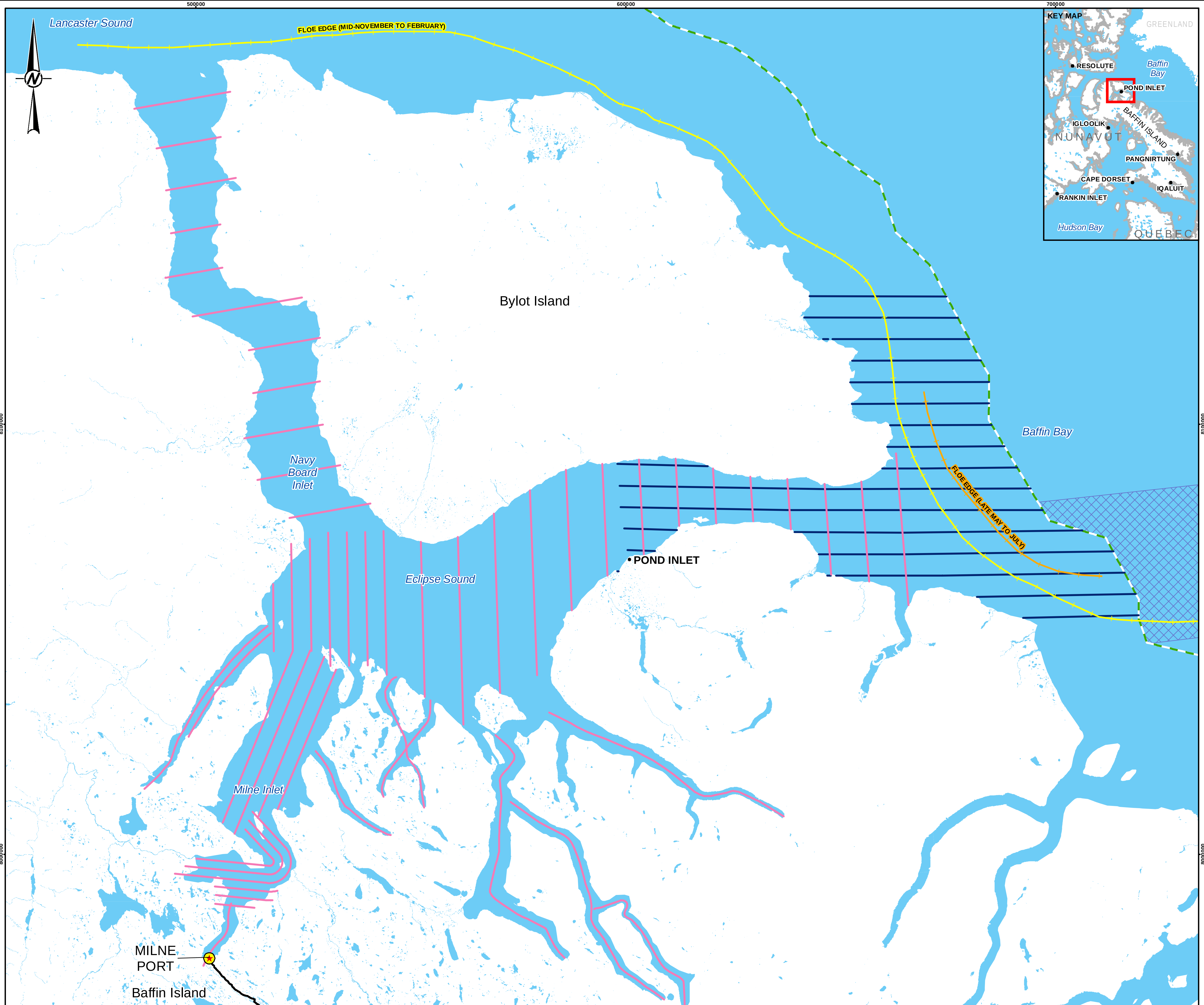
PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
GEOGRAPHIC STRATA FOR 2022 MARINE MAMMAL AERIAL SURVEYS

CONSULTANT

YYYY-MM-DD	2023-03-31
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	3



LEGEND

- COMMUNITY
- MILNE INLET TOTE ROAD
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

FLOE EDGE (APPROXIMATE)

- LATE MAY TO JULY
- MID-NOVEMBER TO FEBRUARY
- MILNE PORT

TRANSECT LINES

- FLOE EDGE ABSENT
- FLOE EDGE PRESENT

0 25 50

1:900,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE

TRANSECT LINES FOR ECLIPSE SOUND GRID DURING LEG 1

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

2.4 Material and Methods

2.4.1 Field Methodology

Surveys were flown in a de Havilland Twin Otter (DH-6) equipped with bubble windows and an optical glass covered camera hatch at the rear. Visual line transect surveys were conducted at an altitude of 305 m (1,000 ft) and a ground speed of 185 km/h (100 kn) with four experienced MMOs. MMOs were stationed at the front and rear bubble windows that provided a view of the track line directly below the aircraft. MMOs were instructed to focus their attention on the area closest to the track line and to use their peripheral vision for sightings farther afield. Observers counted all sightings of marine mammals by speaking into a handheld digital recorder. Sightings observed while transiting between transects or to the survey area were recorded as off-effort. Using a geometer (or clinometer), the perpendicular declination angle to the center of each sighting was measured once it was abeam of the observer. MMOs noted the species and number of animals in the sighting. A ‘sighting’ was defined as animals within one or a few body lengths of each other and oriented or moving in a similar direction. A sighting could also consist of one individual if no other animals are in close proximity. When time permitted, observers were instructed to give additional details on the sightings, such as the presence of calves, tusked narwhal, behaviour, and direction of travel. The two MMOs stationed on the same side of the aircraft were separated acoustically to achieve independence of their conditional detections. A fifth member of the survey team was responsible for monitoring the camera system and entering additional sighting data obtained from the primary observers into the database.

Two MMOs were designated as ‘Primary’ observers and two were designated as ‘Secondary’ observers. In addition to counting animals, all observers were responsible for dictating the following environmental conditions throughout the surveys into the recorders: ice concentrations (in tenths), sea state (Beaufort scale), fog (% of field of view and intensity) and glare (% of field of view and intensity). These environmental conditions were recorded at the start and end of each transect, at regular intervals (every 2 minutes) along the transect or sooner if changes were detected throughout the transect.

The area directly below the aircraft was photographed continuously throughout each visual survey using the camera system described in Section 3.4.1.2. Photographs taken during the visual surveys were used to supplement visual sightings for missed geometer angles and group sizes.

Sightings from observers were automatically entered into the Mysticetus program by the observers using geometers during the survey. Geometers were linked to the Mysticetus program, allowing observer data (i.e., date, time, location, and declination angles) to be enter electronically into the Mysticetus program in real time. Additional sighting data and environmental conditions recorded on audio recorders were transcribed into the Mysticetus program after the flight. Sightings were georeferenced and transect lengths were calculated in Mysticetus. Strata areas were determined in ArcGIS. Sightings where angles of declinations were not recorded were compared to the photographic records. The perpendicular distance was retrieved from the pixel position of the sighting on the photo if a visual sighting was identified without ambiguity on the corresponding photo. If the sighting was not made within the swath width of the picture, could not be found, or could not be identified from other sightings unambiguously, the sighting was coded as missing distance. Sightings where group size were not recorded, or were coded as ‘uncertain’, were compared to the photographic records, and group size was retrieved if a match could be made based on perpendicular distance. Otherwise, sightings with missing group size were given the average group size in that stratum (posterior to estimation of the expected group size so that it does not affect the estimation of its variance).

2.4.2 Data Analysis

Animal detection rates were calculated and expressed as number of sightings/km and number of animals/km (used as a proxy for relative abundance). Observational effort was calculated relative to survey distance in linear kilometres using trackline Global Positioning System (GPS) data extracting segments of effort using start and end times recorded during surveys while on transect. Sightings were therefore expressed relative to observational effort consistent with other similar studies and methods (Nichols et al. 2005). Relative narwhal abundance was calculated using the following two methods:

1) Systematic — A pre-established grid of systematic transect lines was surveyed in areas in the RSA with <9/10 ice concentrations. This included open-water areas and areas associated with low to moderate ice cover.

2) Dedicated — Transect lines were surveyed along open-water leads associated with consolidated sea ice (≥9/10 ice concentrations), along the floe edge, and along the ship route.

Animal sighting rates were calculated and expressed as number of sightings/km (no. of sightings relative to survey effort in km). Animal detection rates were calculated and expressed as number of animals/km (used as a proxy for relative abundance)[1].

2.5 Leg 1 Survey Results

Early season aerial surveys for narwhal were conducted in the North Baffin area during July and early August 2022. The objectives of the surveys were to collect data on the presence/absence and distribution of marine mammals prior to and during initial shipping operations in the RSA. Early shoulder season surveys (Leg 1) were flown in the Eclipse Sound grid from 21 July to 1 August. A total of five surveys on marine mammal presence/abundance were attempted in Leg 1.

2.5.1 Ice Cover

When surveys began on 21 July 2022, ice conditions consisted of areas of open water to up to 9-10/10 ice cover (i.e., 90-100% ice concentrations) along the shipping corridor (Figure 5). Open water areas were observed during surveys in south Milne Inlet (Assomption Harbour and Koluktoo Bay), Tremblay Sound, central Navy Board Inlet, and the eastern half of Eclipse Sound. Ice was present in various stages of melt in north Milne Inlet, western and central Eclipse Sound, and Navy Board Inlet (Figure 5). During surveys from 22 July to 30 July, ice conditions were variable, gradually breaking up until the first day of shipping on 30 July with the convoy entering the RSA in the evening.

By 30 July, aerial surveys noted that most of Eclipse Sound consisted of open water with some ice remaining in Milne Inlet South; however according to Canadian Ice Service (CIS) charts, there were scattered patches of ice concentrations ranging from <1-9/10 (Figure 6). During the first flight on 30 July, two ice belts were observed

---

[1] Observational effort was calculated relative to survey distance in linear kilometres using trackline GPS data and extracting segments of effort using start and end times recorded during surveys while on transect.

along the shipping route in Milne Inlet; one at Stephens Island and one at Bruce Head spanning from shore to shore (Figure 7). Fednav determined that the ice remaining along the shipping route was less than 3/10 concentrations based on satellite imagery and aerial photographs. During the second flight on 30 July, both ice belts had dispersed and were pushed up against shore, creating a path of open water along the entire Northern Shipping Route in the RSA for the start of the shipping season. On 1 August, when the last flight of Leg 1 was flown, the RSA was ice free (Figure 8).

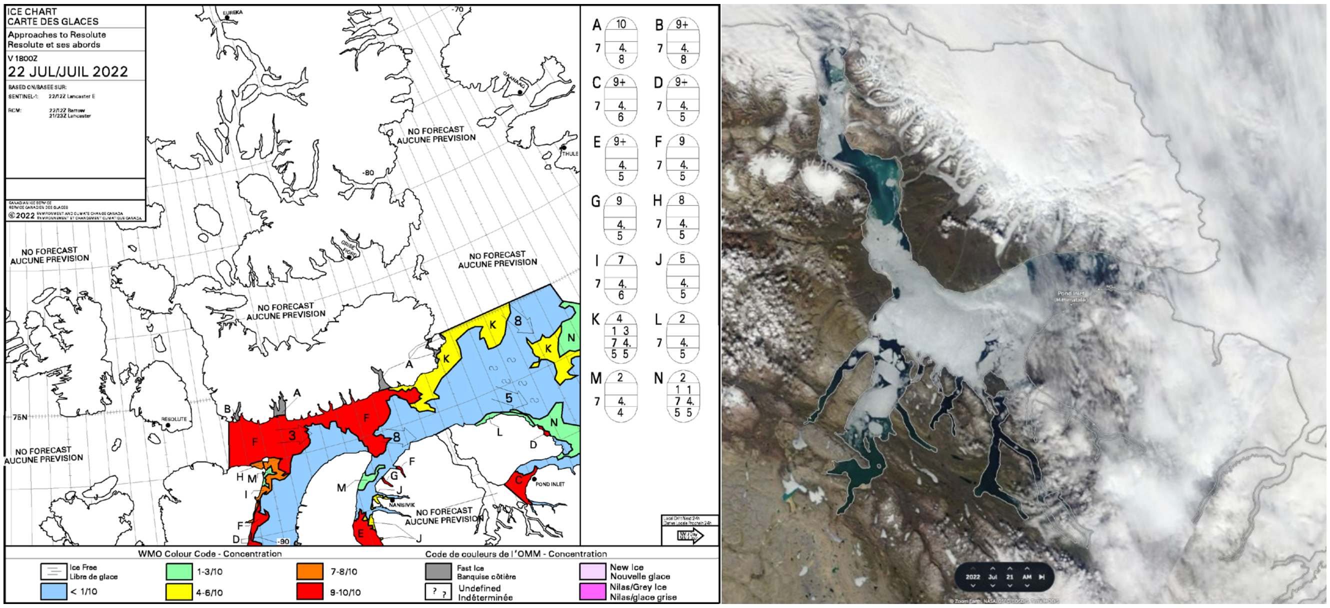


Figure 5: Ice chart for 22 July 2022 (left; Canadian Ice Services) and satellite image for 21 July 2022 (right; Zoom Earth; https://zoom.earth) showing ice conditions in Eclipse Sound area at the start of Leg 1 aerial surveys.

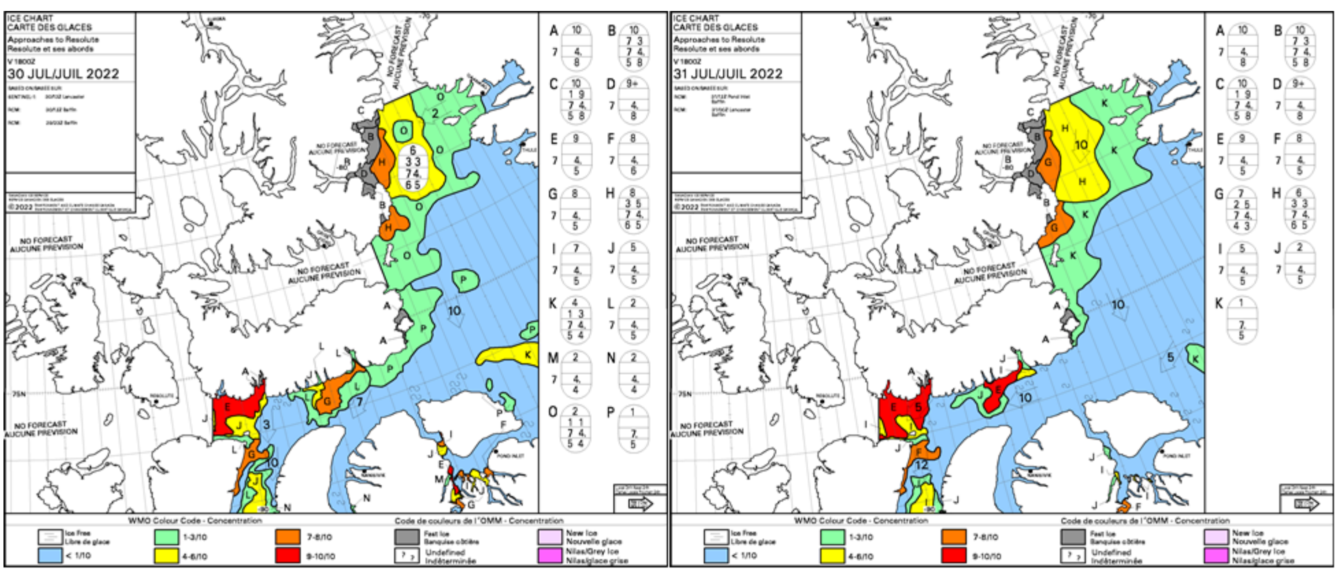


Figure 6: Ice chart for 30 and 31 July 2022 (Canadian Ice Services) showing ice concentrations in Eclipse Sound at the start of Baffinland shipping.

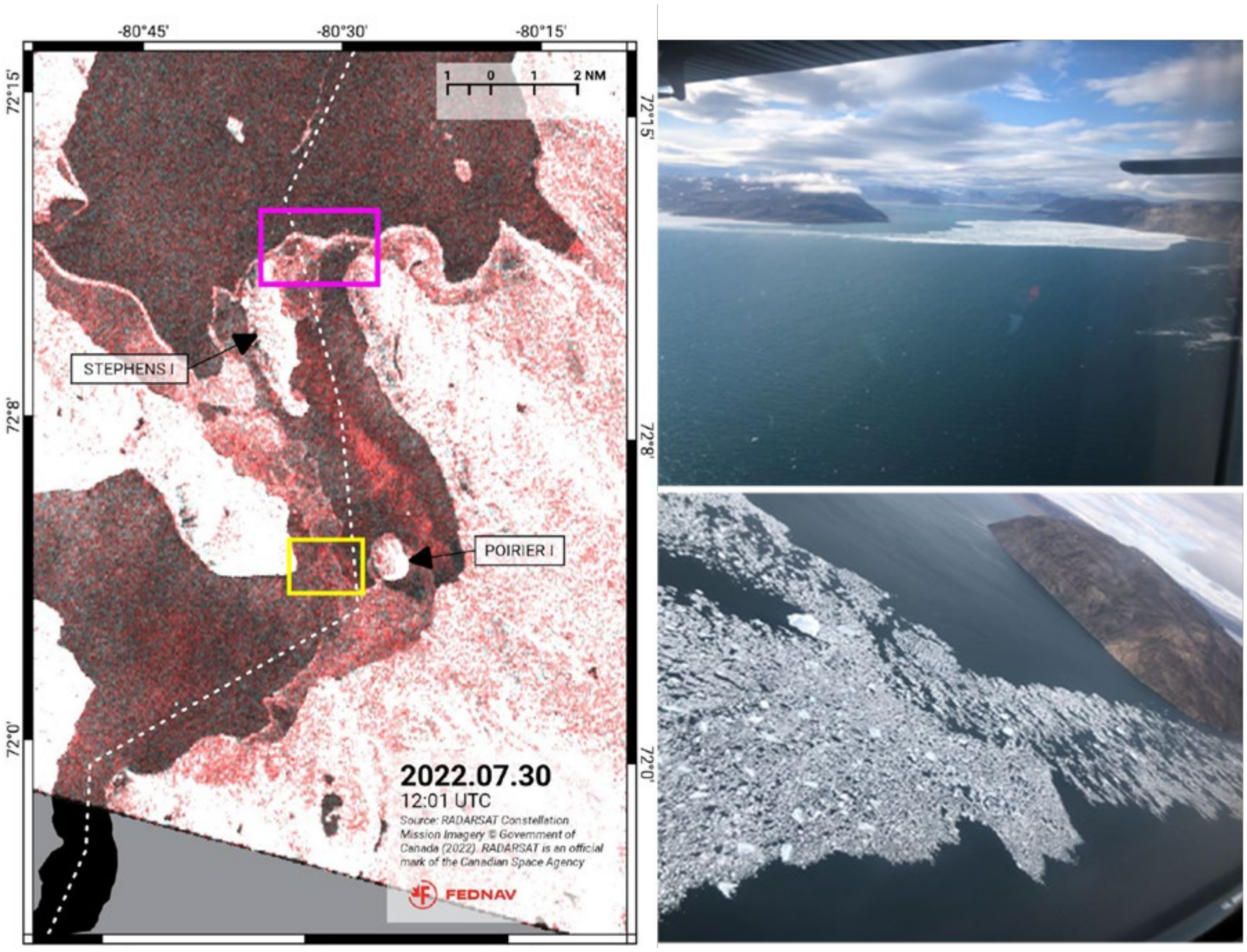


Figure 7: Satellite imagery of remaining ice in Milne Inlet provided by Fednav for 30 July 2022 (left); photo of ice belt at Stephens Island highlighted in fushia rectangle on satellite image (top right); photo of ice belt highlighted in yellow rectangle on satellite image (bottom right).

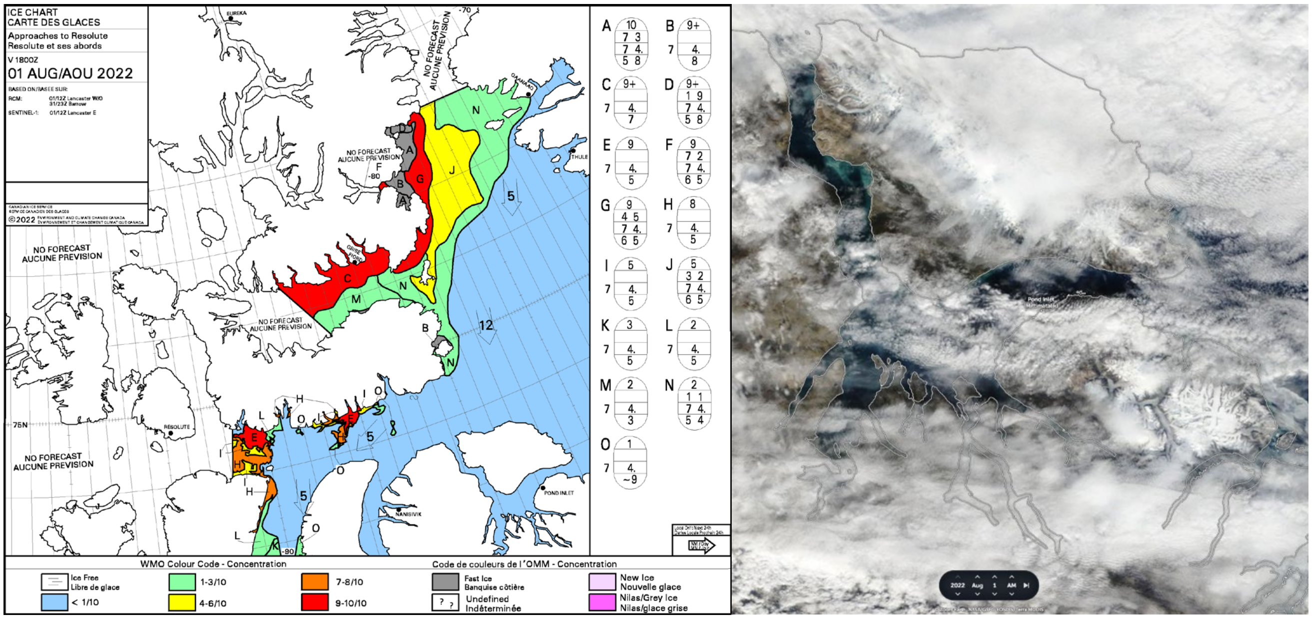


Figure 8: Ice chart for 1 August 2022 (left; Canadian Ice Services) and satellite image (right; Zoom Earth; https://zoom.earth) showing ice conditions in Eclipse Sound area at the end of Leg 1 aerial surveys.

2.5.2 Survey Coverage

Eight surveys were flown over 12 days during Leg 1 (see Appendix B; Figures B-1 to B-8). Over the course of the eight surveys, a total of 3,891.92 km of survey effort was conducted. This effort included systematic transect lines, dedicated transects (i.e., the Northern Shipping Route), and reconnaissance flights (Table 1). Systematic transects (i.e., pre-planned transects; see Figure 4) were flown in areas with ice floes (i.e., any type of sea ice not attached to land, drift ice) to open water and dedicated transects were flown along the ship route and in ice leads. Systematic transect lines totaled 3,384.69 km, dedicated transect totaled 318.50 km and reconnaissance flights totaled 188.73 km of total effort.

Table 1: Summary of 2022 Leg 1 survey flights. Systematic transect lines (S), dedicated transect lines (D), and reconnaissance (R) were flown over five surveys in nine strata

Survey Stratum	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Survey 7	Survey 8
	21 July	22 July	23 July	24 July	26 July	27 July	30 July	1 Aug
Pond Inlet (PI)	S	—	S	S	—	—	—	—
Eclipse Sound East (ESE)	S&D	—	S	—	—	—	D	—
Eclipse Sound West (ESW)	D	—	—	S	—	S	S&D	S
Milne Inlet North (MIN)	S	—	—	S	—	S	D	S
Milne Inlet South (MIS)	S	—	—	S	—	S	D	S
Tremblay Sound (TB)	—	—	—	S	—	S	S	S
Navy Board Inlet (NB)	—	S&D	S	—	—	S	S	—

Survey Stratum	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Survey 7	Survey 8
	21 July	22 July	23 July	24 July	26 July	27 July	30 July	1 Aug
Lancaster Sound (LAN)	—	—	S	—	—	—	—	—
Fjords	—	—	—	S	—	—	—	S
Admiralty Inlet North	—	—	—	—	S&R	—	—	—
Admiralty Inlet South	—	—	—	—	R	—	—	—
Systematic transects (km)	**239.75**	**141.82**	**504.67**	**685.13**	**406.73**	**587.76**	**290.17**	**528.65**
Dedicated transects (km)	**40.87**	**13.03**	**0**	**0**	**0**	**0**	**264.60**	**0**
Reconnaissance (km)	**0**	**0**	**0**	**0**	**188.73**	**0**	**0**	**0**
Total Effort (km)	**280.62**	**154.85**	**504.67**	**685.13**	**595.46**	**587.76**	**554.77**	**528.65**

2.5.3 Sighting Conditions

MMOs recorded environmental sighting conditions during visual surveys at the beginning and end of each transect and when conditions changed along the track. Sighting conditions were recorded within the MMO field of view (1 km of the transect line; see Appendix A) and were evaluated based on survey effort when each condition was observed.

Ice Cover

Ice cover ranged from 0/10 to 10/10concentrationsduring Leg 1 of the 2022 MMASP (Figure 9). Ice conditions changed, with ice cover decreasing, from the first survey on 21 July to the last survey on the 1 August (see Figure 5 to 8; see Appendix B, Figures B-1 to B-8). Landfast ice (i.e., fast ice) was present in the RSA on the 18 July (Canadian Ice Service) before the start of Leg 1, although complete ice coverage of the RSA (see Figure 5) was not available from CIS until 27 July 2022. Areas of <1/10 ice concentrations represented 56% of the total survey effort flown, whereas areas of 9-10/10 ice concentrations represented 10% of the total survey effort flown. During the flight on the 30 July >3/10 ice concentrations were present northwest of the shipping corridor in Eclipse Sound, the central portion of Tremblay Sound and the central portion of Navy Board Inlet. In Milne Inlet, two ice belts were observed along the shipping route; one at Stephens Island and one at Bruce Head spanning from shore to shore. During the second flight on 30 July, both ice belts had dispersed and were pushed up against shore.

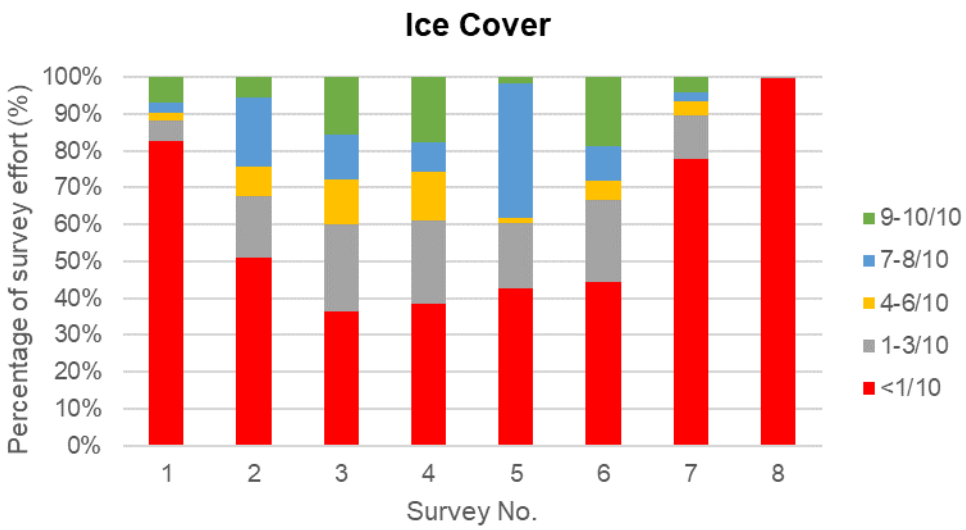


Figure 9: Ice cover during Leg 1 of the 2022 MMASP.

Fog

Two measurements of fog were used as sighting conditions. Fog cover was assessed as the percent (0–100%) of fog obscuring the viewing area and fog intensity (four levels: "none" when there was no fog, "light" fog that animals were visible through, "moderate" when animals were likely missed in the fog, and "thick" when animals were certainly missed in the fog). Areas that were forecasted to be foggy were avoided when daily surveys were planned. Fog was present during Surveys 1 to 6 for 7% of the total effort flown in 2022 (Figure 10). Most of the fog that was present on the survey was primarily of light and moderate thickness (Figure 11).

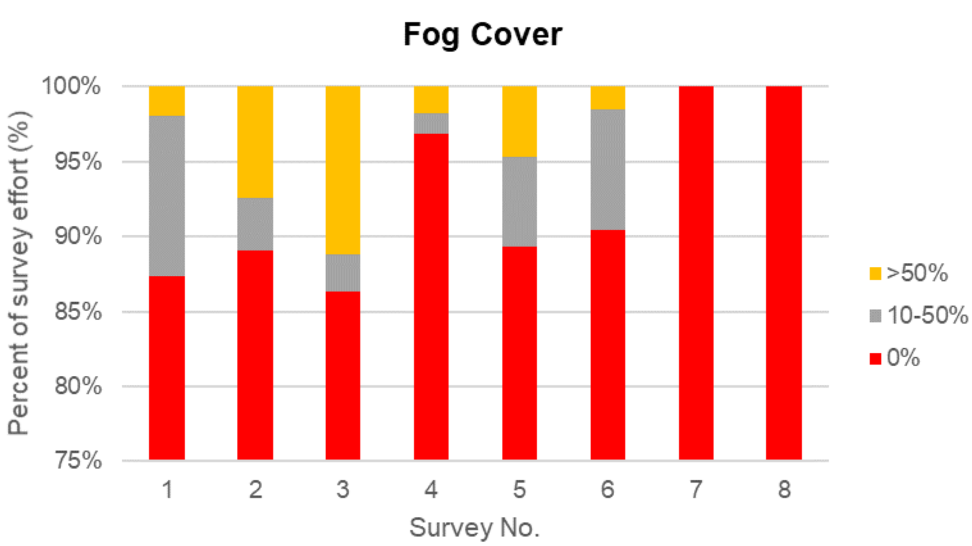


Figure 10: Fog cover during Leg 1 of the 2022 MMASP.

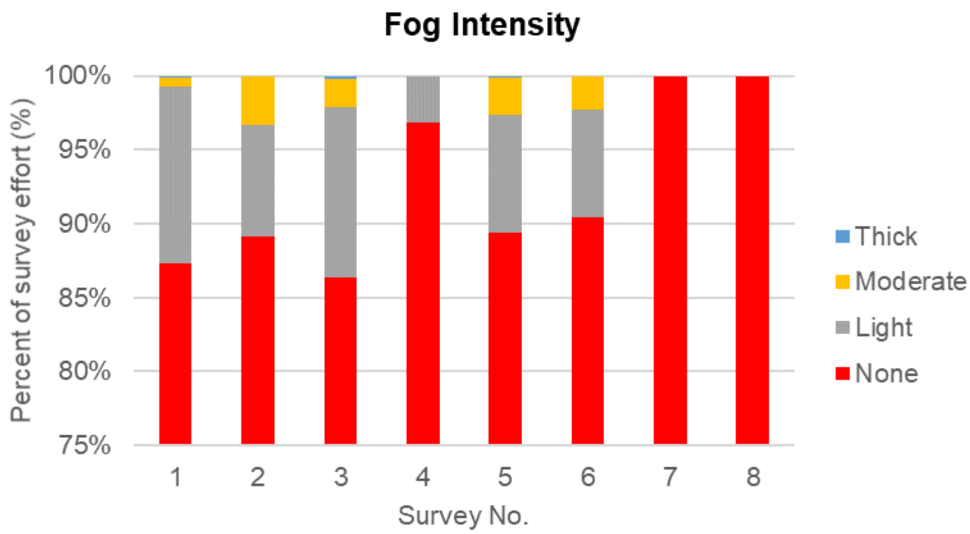


Figure 11: Fog intensity during Leg 1 of the 2022 MMASP.

Beaufort Sea State

On a scale of 0 to 12 (see Appendix A, Table 1), the Beaufort Sea State (BF) ranged from BF 0 (glassy mirror) to BF 6 (large waves) during Leg 1 of the 2022 MMASP (Figure 12). Sea state conditions were recorded between BF 0 (glassy mirror) and BF 4 (small, fairly frequent, whitecaps) for 96% of the total effort flown. Areas that were forecasted to have high sea states (>BF 4) were avoided when daily surveys were planned. If sea state conditions exceeded BF 4, the area was generally abandoned, and the survey was resumed in an area with more favorable environmental sighting conditions.

High sea states have a negative effect on cetacean counts (DeMaster et al. 2001; Gosselin et al. 2007). DeMaster et al. (2001) found the probability of sightings beluga whales in BF sea state 1 is significantly greater than that for sighting beluga whales in BF sea state 2, 3, and 4. Gosselin et al. (2007) stated that abundance estimation tends to be lower as BF increases. The lower estimates are driven by a reduction in encounter rate associated with increasing average daily BF condition. Another effect that might intuitively be expected with increasing BF is a reduction in effective strip half width as whales may not be visible as far away from the plane in bad sea conditions. During DFO surveys in Eclipse Sound and Admiralty Inlet in 2016, five surveys were terminated due to high sea states of BF 4–5 (DFO 2017). Surveys flown in areas of high sea states have a high probability of negatively biasing the number of animals present and will be excluded from the analysis if a statistically significant difference is found between two abundance estimates.

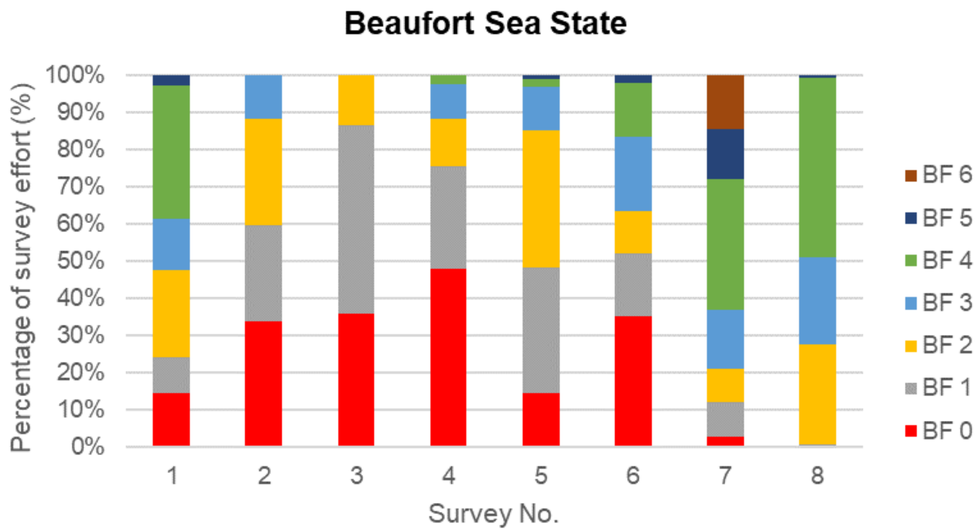


Figure 12: Beaufort Sea State during Leg 1 of the 2022 MMASP.

Glare Cover and Intensity

Two measurements of glare were used as sighting conditions. Glare cover was assessed as the percent (0–100%) of the viewing area affected by sun reflection and glare intensity (four levels: "none" when there was no reflection, "low" when animals were likely detected in center of reflection angle, "moderate" when animals were likely missed in the center of reflection angle, and "intense" when animals were certainly missed in the center of reflection angle. Glare was present during 43% of the total effort flown in 2022 (Figure 13). Intense glare was present during 11% of the total effort flown in 2022 (Figure 14).

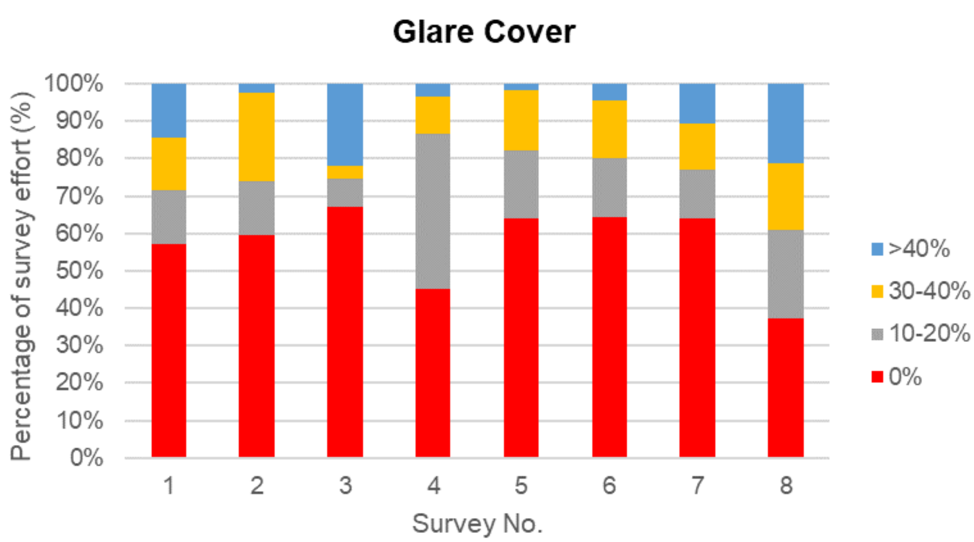


Figure 13: Glare cover during Leg 1 of the 2022 MMASP.

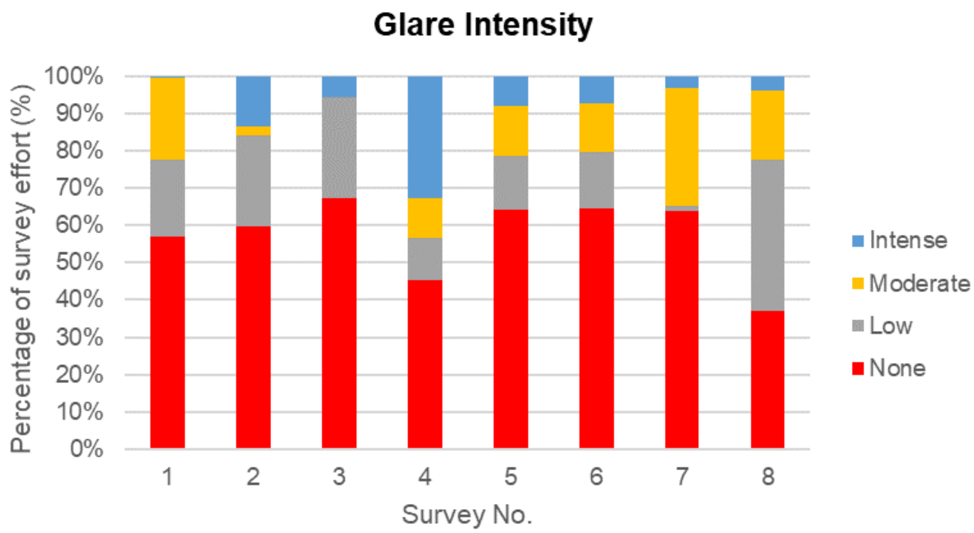


Figure 14: Glare intensity during Leg 1 of the 2022 MMASP.

2.5.4 Survey Sightings

Seven different marine mammal species were observed during Leg 1 of the 2022 MMASP: narwhal, bowhead whale, beluga whale, ringed seal, harp seal, bearded seal, and polar bear. Unidentified whales and seals were also recorded during the surveys. Table 2 and Table 3 summarize the number of marine mammal sightings and animals, respectively, recorded during surveys for each species by survey number. A total of 1,681 sightings totalling 4,382 marine mammals were recorded during Leg 1 surveys. One survey was flown in Admiralty Inlet on the 26 July, with the remaining surveys flown in the Eclipse Sound. The survey flown on the 30 July was completed prior to the first vessel entering the RSA.

Table 2: Number of sightings (including off-effort) in Eclipse Sound and Admiralty Inlet grids during Leg 1

Survey Date	Narwhal	Bowhead Whale	Beluga Whale	Unidentified Whale	Ringed Seal	Harp Seal	Bearded Seal	Unidentified Seal	Polar Bear	Total
21 July	57	3	0	1	7	2	0	5	0	**75**
22 July	210	0	0	1	8	7	0	3	0	**229**
23 July	370	1	1	0	9	28	0	0	2	**411**
24 July	74	0	0	0	50	8	1	2	2	**137**
26 July[a]	328	1	1	0	6	6	0	5	1	**348**
27 July	131	5	11	0	31	35	1	4	0	**218**
30 July	69	1	1	0	13	24	1	0	0	**109**
1 August	129	1	1	0	20	2	0	1	0	**154**
Total	**1,368**	**12**	**15**	**2**	**144**	**112**	**3**	**20**	**5**	**1,681**

[a] Flown in Admiralty Inlet.

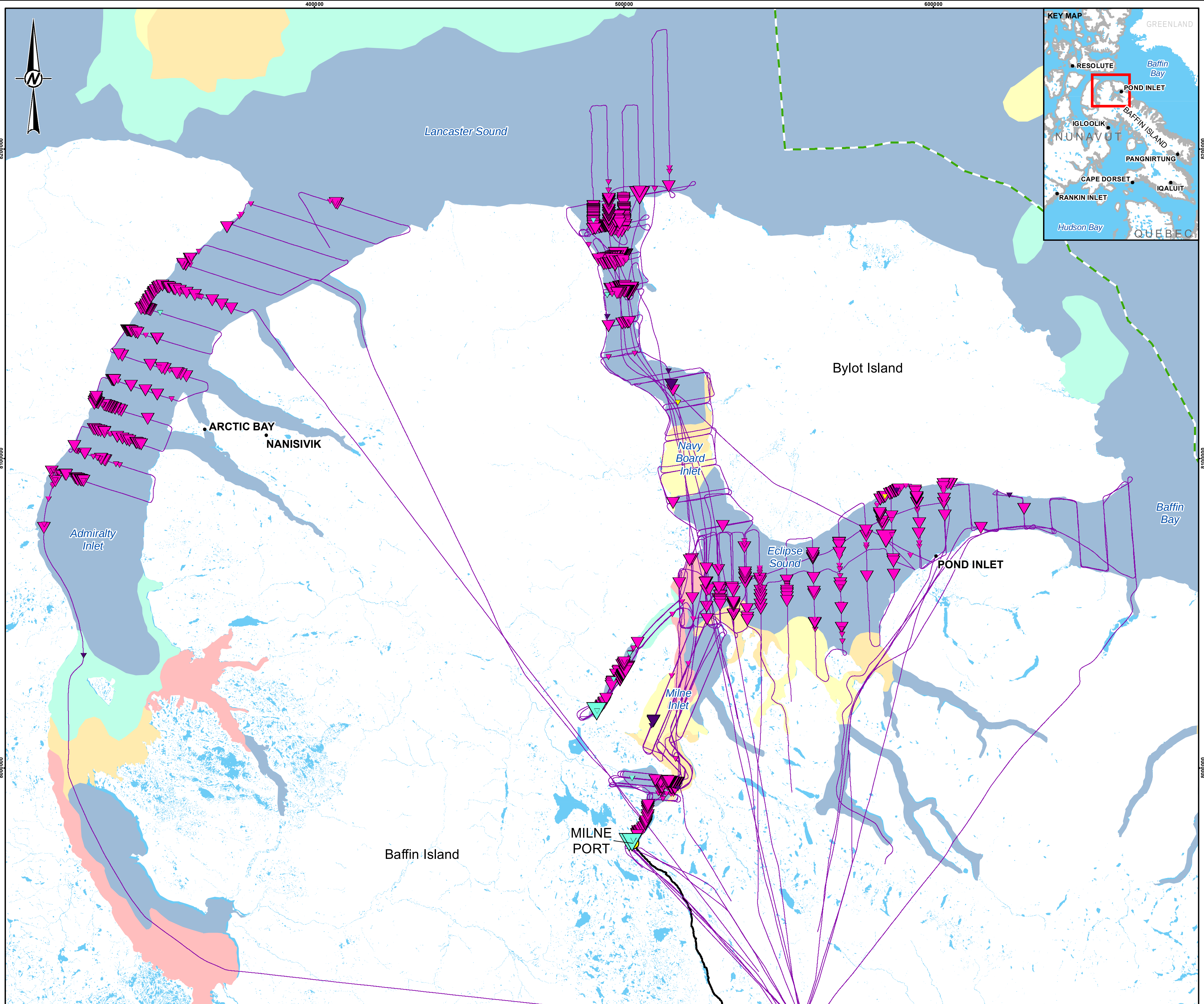
Table 3: Number of animals (including off-effort) in Eclipse Sound and Admiralty Inlet grids during Leg 1

Survey Date	Narwhal	Bowhead Whale	Beluga Whale	Unidentified Whale	Ringed Seal	Harp Seal	Bearded Seal	Unidentified Seal	Polar Bear	Total
21 July	145	3	0	1	7	32	0	9	0	**197**
22 July	412	0	0	1	8	75	0	5	0	**501**
23 July	749	1	1	0	13	233	0	0	2	**999**
24 July	149	0	0	0	53	67	1	2	2	**274**
26 July[a]	608	1	1	0	7	16	0	5	1	**639**
27 July	381	9	148	0	42	359	1	4	0	**944**
30 July	215	1	1	0	15	302	1	0	0	**535**
1 August	257	1	1	0	25	8	0	1	0	**293**
Total	**2,916**	**16**	**152**	**2**	**170**	**1,092**	**3**	**26**	**5**	**4,382**

[a] Flown in Admiralty Inlet.

Narwhal

Narwhal were observed throughout the survey area during the Leg 1 surveys with greatest concentrations in the Northern Navy Board Inlet, Eastern and Western Eclipse Sound, Tremblay Sound, and South Milne Inlet strata (Figure 15). Narwhal were observed in the northern half of Admiralty Inlet during a survey conducted on 26 July 2022 (Figure 15). A total of 1,040 sightings and 2,308 individual narwhal were recorded in Eclipse Sound grid and 328 sightings and 608 individual narwhal were recorded in Admiralty Inlet grid during the Leg 1 surveys (Table 2 and Table 3). Narwhal group sizes ranged from single animals to a group size of 30, with mean and median group sizes of 2.1 and 2.0, respectively. A total of 189 mother/calf pairs (128 mother/calf pairs in Eclipse Sound grid and 61 mother/calf pairs in Admiralty Inlet grid) and 12 lone calves (nine lone calves in Eclipse Sound grid and three lone calves in Admiralty Inlet grid) were recorded during the Leg 1 surveys.



LEGEND

- COMMUNITY
- MILNE PORT

VISUAL SURVEY CETACEAN SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1
- 2-10
- 10+

BOWHEAD WHALE
- 1
- 2-10

NARWHAL
- 1
- 2-10
- 10+

UNIDENTIFIED CETACEAN
- 1

- MILNE INLET TOTE ROAD
- AERIAL SURVEY TRACK
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

ICE CONCENTRATION (JULY 30, 2022)
- < 1/10
- 1-3/10
- 4-6/10
- 7-8/10
- 9-10/10

0 25 50

1:1,250,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF CETACEANS DURING LEG 1 – JULY AND AUGUST 2022

CONSULTANT

wsp

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	15

Bowhead whale

Few bowhead whales were observed during Leg 1 surveys in 2022. A total of 12 sightings and 16 individual bowhead whales were recorded during the Leg 1 surveys (Table 2 and Table 3). Bowhead whale were observed in Navy Board Inlet, Eastern Eclipse Sound, Pond Inlet, Milne Inlet North and South, and Admiralty Inlet North strata (Figure 15). Three bowhead sightings were observed along the south shore of Bylot Island on 21 July (see Appendix B, Figure B-1). On 23 July, only one bowhead whale sighting of an individual whale was observed, again along the south shore of Bylot Island (see Appendix B, Figure B-3). On 26 July, one bowhead sighting of an individual whale was observed in the central portion of Admiralty Inlet (see Appendix B, Figure B-5). Five bowhead whale sightings were observed on 27 July; two in Navy Board Inlet and three in Milne Inlet North (see Appendix B, Figure B-4). One bowhead whale sighting was observed on 30 July in Navy Board Inlet (see Appendix B, Figure B-7). One bowhead whale sighting was observed on 1 August in Milne Inlet South (see Appendix B, Figure B-8). Bowhead whale group sizes ranged from single animals to a group of three animals, with mean and median group sizes of 1.3 and 1.0, respectively. No mother/calf or lone calves were observed during Leg 1 surveys in 2022.

Beluga whale and Killer whale

During the Leg 1 surveys, there were 15 beluga sightings totalling 152 individuals with group sizes ranging from one to 120 animals (Figure 15; Table 2 and Table 3), with mean and median group sizes of 10.1 and 1.0, respectively. Beluga whale were observed in Navy Board Inlet, Tremblay Sound, Milne Inlet South, and Admiralty Inlet North strata (Figure 15). The first sighting of a single beluga was observed during the Leg 1 survey on 23 July in the northern portion of Navy Board Inlet (Appendix B, Figure B-3) and the second sighting of a single beluga was observed on 26 July in the northern portion of Admiralty Inlet (Appendix B, Figure B-5). On 26 July, a large concentration of beluga were also sighted by Milne Port staff in Assomption Harbour close to the Port Site. The aerial survey team flew over the area and photograph the beluga concentration. Approximately 150 beluga were recorded by visual observers in the Assomption Harbour concentration. After reviewing video footage of the beluga concentration, three separate counts averaged 233 beluga (including seven calves) in Assomption Harbour on 26 July (Figure 16). This sighting was not included in Tables 2 or 3 as aerial surveys were not being flown in Eclipse Sound at the time. Survey effort was focused in Admiralty Inlet on the day in question. On 25 July, killer whale sightings were reported by the community of Pond Inlet and relayed to the aerial survey team through the Inuit observers. It is possible that the beluga whales in Assomption Harbour were trying to evade the killer whales in Eclipse Sound. On 27 July, the beluga concentration was still present at the same location. The concentration was estimated at 120 beluga on 27 July (Appendix B, Figure B-6). An additional ten beluga sightings for a total of 28 beluga whales were also sighted on 27 July, with eight of the ten sightings being observed in Tremblay Sound (Appendix B, B-6). One beluga whale was observed on 30 July in Navy Board Inlet (see Appendix B, Figure B-7). One beluga whale was observed during on 1 August in Tremblay Sound (see Appendix B, Figure B-8).

Killer whales were not observed by the aerial survey team during the Leg 1 surveys in 2022.

Figure 16: Beluga whale concentration in Assomption Harbour on 26 July 2022.

Unidentified whale

There were two sightings of individual unidentified whales during the Leg 1 surveys (Figure 15; Table 2 and 3). An unidentified whale was observed in the Eastern Eclipse Sound strata along the south shore of Bylot Island on 21 July and another was observed in Navy Board Inlet on 22 July (see Appendix B, Figures B-1 and B-2).

Ringed seal

Ringed seal were observed throughout the survey area during the Leg 1 surveys with the highest numbers recorded in the Milne Inlet North, Milne Inlet South, and Eclipse Sound West strata (Figure 17). One hundred and forty-four sightings totalling 170 ringed seal were recorded during Leg 1 surveys (Table 2 and 3). Most of the ringed seal sightings observed in the water were of single animals (97 of 104 sightings). The remaining seven ringed seal groups observed in the water consisted of groups of two to six seals. The remaining forty ringed seal sightings were observed on ice. Ringed seals on the ice were observed in groups ranging from one to four seals and with mean and median group sizes of 1.4 and 1.0, respectively.

Harp seal

One hundred and twelve sightings totalling 1,092 harp seals were recorded during Leg 1 surveys (Table 2 and 3). Most harp seal were observed in northern Navy Board Inlet during Leg 1 surveys (Figure 17). All harp seal were observed in the water in groups ranging from one to 100 seals and with mean and median group sizes of 9.8 and 8.0, respectively.

Bearded seal

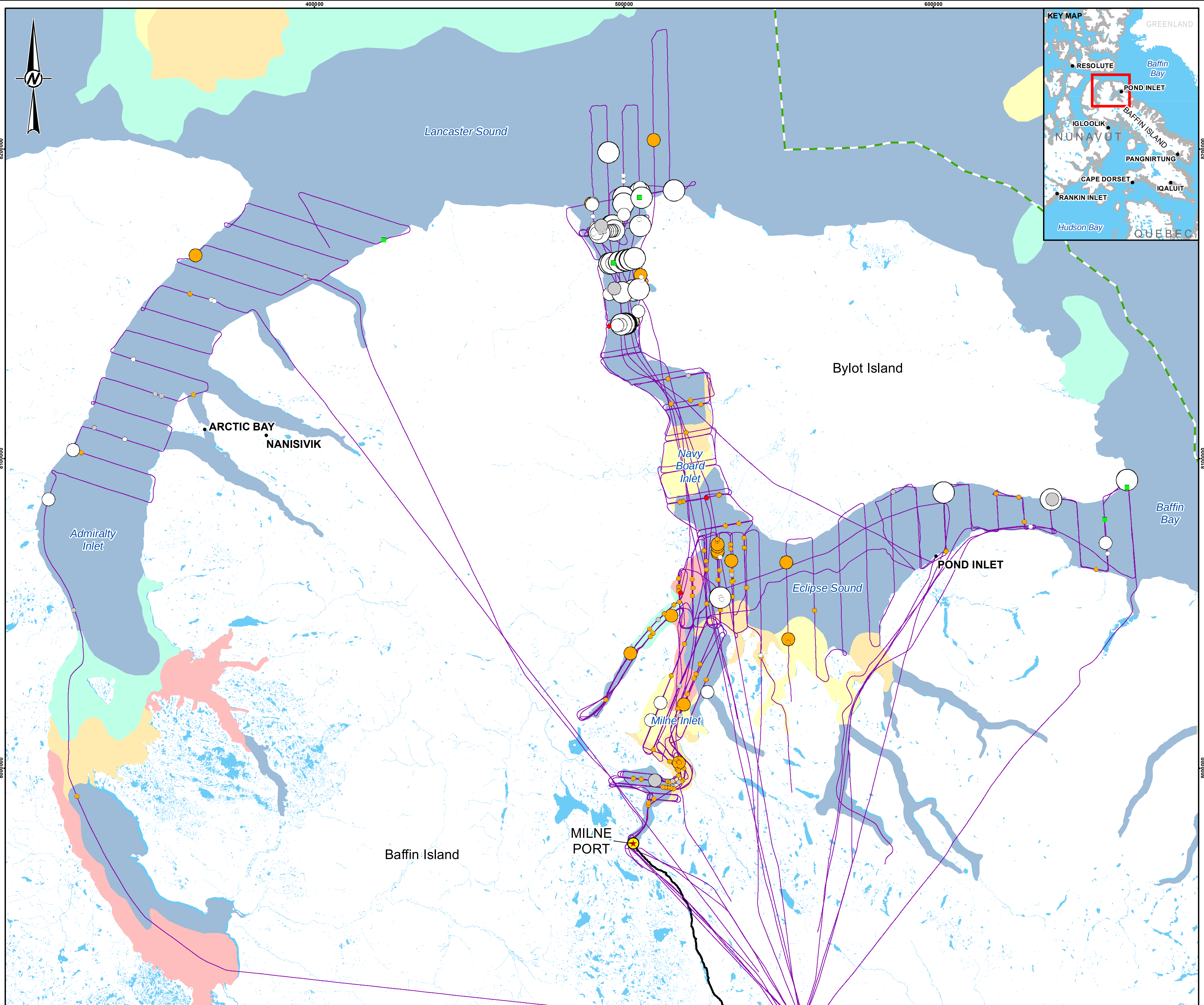
There were three sightings of individual bearded seals during the Leg 1 surveys (Figure 17; Table 2 and 3). The first sighting of bearded seal was observed in the Eclipse Sound West stratum on 24 July; the second and third bearded seal were observed in Navy Board Inlet on 27 and 30 July (see Appendix B, Figures B-4, B-6, and B-7).

Unidentified seal

Unidentified seal were observed throughout the survey area during Leg 1 surveys (Figure 17). There were 20 sightings totalling 26 seals (Table 2 and Table 3).

Polar bear

Five sightings of individual polar bears were recorded during Leg 1 surveys (Figure 17; Table 2 and Table 3). Two polar bears were observed in northern Navy Board Inlet and two polar bears were observed in the Pond Inlet stratum on 23 and 24 July, respectively (see Appendix B; Figure B-3 and B-4). All four sightings were of swimming animals. The fifth sighting was observed in Admiralty Inlet on 26 July (see Appendix B; Figures B-5). The polar bear was resting on the shore.



LEGEND

- COMMUNITY
- MILNE PORT
- MILNE INLET TOTE ROAD
- AERIAL SURVEY TRACK
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

VISUAL SURVEY PINNIPED SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

HARP SEAL
- 1
- 2-10
- 10+

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

ICE CONCENTRATION (JULY 30, 2022)
- < 1/10
- 1-3/10
- 4-6/10
- 7-8/10
- 9-10/10

0 25 50
1:1,250,000 KILOMETRES

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF PINNIPEDS AND POLAR BEAR DURING LEG 1 – JULY AND AUGUST 2022

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	17

2.5.5 Relative Abundance of Marine Mammals

In 2022, a total of 3,703.19 km of effort (3,384.69 km during systematic transects and 318.50 km during dedicated transects) were flown over eight surveys during Leg 1 (not including reconnaissance flights). The relative abundance of marine mammals in the RSA, expressed as the animal detection rate (no. of animals relative to survey effort in km) and sighting rate (no. of sightings relative to survey effort in km) were calculated. Table 4 provides a summary of sighting rates and animal detection rates by species and according to survey effort types (systematic transects vs. dedicated transects). All species were more abundant in the areas where systematic transects were flown compared to areas where dedicated transects were flown (ice lead, floe edge and along the nominal shipping corridor) (Table 4). All seven species were observed during systematic transect surveys while only narwhal (0.4867 animals/km) and ringed seal (0.0031 animals/km) were observed during dedicated surveys. Narwhal had the highest relative abundance for systematic transects (0.6970 animals/km). Harp seal had the second highest relative abundance (0.2668 animals/km). Narwhal relative abundance was higher during systematic transects than in areas where dedicated transects were flown (0.6970 animals/km and 0.4867 animals/km, respectively).

In the Eclipse Sound grid, narwhal relative abundance varied among the seven surveys flown ranging from 0.0959 to 2.8134 animals/km along systematic transects (Table 5). Admiralty Inlet had the third highest narwhal relative abundance along systematic transects during Survey 5 (1.0670 animals/km) (Table 5).

Table 4: Marine mammal sighting and animal detection rates (relative abundance) during Leg 1

Species	No. of Sightings		Sighting Rate (sightings/km)			No. of Animals		Animal Detection Rate (no. animals/km)		
	Sys.[a] Tran.	Ded.[b] Tran.	Sys. Tran.	Ded. Tran.	Combined	Sys. Tran.	Ded. Tran.	Sys. Tran.	Ded. Tran.	Combined
Narwhal	1148	44	0.3392	0.1381	0.3219	2359	155	0.6970	0.4867	0.6789
Bowhead Whale	4	0	0.0012	—	0.0011	7	0	0.0021	—	0.0019
Beluga Whale	15	0	0.0044	—	0.0041	151	0	0.0446	—	0.0408
Unknown Whale	1	0	0.0003	—	0.0003	1	0	0.0003	—	0.0003
Ringed Seal	135	1	0.0399	0.0031	0.0367	158	1	0.0467	0.0031	0.0429
Harp Seal	101	0	0.0298	—	0.0273	903	0	0.2668	—	0.2438
Bearded Seal	3	0	0.0009	—	0.0008	3	0	0.0009	—	0.0008
Unknown Seal	16	0	0.0047	—	0.0043	20	0	0.0059	—	0.0054
Polar Bear	3	0	0.0009	—	0.0008	3	0	0.0009	—	0.0008

[a] Systematic Transects

[b] Dedicated Transects

Table 5: Narwhal detection rates (relative abundance) during Leg 1 surveys

Date	Survey #	No. of Animals		Animal Detection Rate (animals/km)	
		Sys.[a] Tran.	Ded.[b] Tran. (Leads, Floe Edge and Ship Track)	Sys. Tran.	Ded. Tran. (Leads, Floe Edge, and Ship Track)
21 July	1	23	53	0.0959	1.2968
22 July	2	399	0	2.8134	—
23 July	3	622	0	1.2325	—
24 July	4	149	0	0.2175	—
26 July	5[c]	434	0	1.0670	—
27 July	6	374	0	0.6363	—
30 July	7	113	102	0.3894	0.3855
1 Aug	8	245	0	0.4372	—
	Total	**2359**	**155**	**0.6970**	**0.4867**

[a] Systematic Transects

[b] Dedicated Transects

[c] Flown in Admiralty Inlet

2.5.6 Comparison with Previous Surveys

The relative abundance for this section only included data from systematic transects because dedicated transect would bias the data due to the varying numbers of dedicated transects flown each year. Survey 5 flown on 26 July 2022 was removed from the analysis because it was flown in Admiralty Inlet and would bias the comparisons with previous years. The relative abundance of marine mammals in the RSA during Leg 1 surveys was higher in 2022 (1.060 animals/km) than in 2021 (0.839 animals/km), 2020 (0.564 animals/km), and 2019 (0.371 animals/km; Table 6).

Narwhal relative abundance increased by 93% in 2022 (0.6464) from 2021 (0.3356; Table 6). Much of this increase was likely attributed to a large number of narwhal in the northern portion of Navy Board Inlet during Surveys 2 and 3. Bowhead whale relative abundance decreased by 87% in 2022 (0.0024) from 2021 (0.0189). Beluga whale relative abundance increased by 9980% in 2022 (0.0504) from 2021 (0.0005). Ringed seals and harp seals were observed in lower relative abundance in 2022 compared to 2021, but in higher relative abundance in 2022 compared to 2019 and 2020. The seal data should be interpreted with caution due to the difficulty of observing and identifying seals at survey altitudes of 305 m (1,000 ft) above sea level (ASL), especially as sea state increases.

Table 6: Relative abundance (animal detection rate) of marine mammals for systematic transects in RSA during Leg 1 in 2019, 2020, 2021, and 2022

Species	2019		2020		2021		2022	
	No. of Animals	Relative Abundance (animals/km)	No. of Animals	Relative Abundance (animals/km)	No. of Animals	Relative Abundance (animals/km)	No. of Animals	Relative Abundance (animals/km)
Narwhal	1,187	0.2952	1,431	0.3333	2,091	0.3356	1,925	0.6464
Bowhead Whale	94	0.0234	39	0.0091	118	0.0189	7	0.0024
Beluga Whale	1	0.0002	4	0.0009	3	0.0005	150	0.0504
Killer Whale	10	0.0025	0	0.0000	20	0.0032	0	0.0000
Unknown Whale	4	0.0010	1	0.0002	4	0.0006	1	0.0003
Ringed Seal	71	0.0199	154	0.0359	568	0.0912	156	0.0524
Harp Seal	102	0.0286	680	0.1584	2,306	0.3701	895	0.3005
Bearded Seal	2	0.0006	2	0.0005	5	0.0008	3	0.0010
Walrus	0	0.0000	0	0.0000	1	0.0002	0	
Unknown Seal	19	0.0053	107	0.0249	107	0.0172	16	0.0054
Polar Bear	1	0.0002	2	0.0005	2	0.0003	3	0.0010
Total	**1,491**	**0.3709**	**2,420**	**0.5637**	**5,225**	**0.8387**	**3,156**	**1.0598**

Note: Relative abundance = animals/km (corrected for survey effort in km)

2.6 Discussion

2.6.1 Narwhal

The main focus of the Leg 1 marine mammal aerial surveys in 2022 was to obtain data on the presence/absence and distribution of marine mammals in the open water areas and in the ice throughout the Eclipse Sound survey grid prior to and immediately following the start of shipping activities. By the time aerial surveys began on 21 July 2022, ice conditions ranged from areas of open water to 9-10/10 ice concentrations, with no landfast ice along the shipping corridor (see Figure 5; Appendix B, Figure B-1). The first Project vessels to enter the RSA on the evening of the 30 July 2022 was a convoy consisting of three ore carriers and two tugs which transited directly to Milne Port, although other non-Baffinland vessels had entered and exited the RSA via Baffin Bay since 21 July 2022.

Throughout Leg 1 surveys, narwhal distribution shifted westward from Eclipse Sound East and Pond Inlet to Milne Inlet and Tremblay Sound. On 21 July, narwhal were distributed in ice concentrations ranging from <1/10 to 9-10/10 in the Pond Inlet and Eclipse Sound East strata. Concentrations of narwhal were highest along the shore of Bylot Island and floe edge in Eclipse Sound East with lower numbers scattered throughout the area north of Pond

Inlet (see Appendix B, Figure B-1). On 22 July, narwhal were observed in high concentrations in the open water at the north end of Navy Board Inlet. A survey was flown on 23 July in the central portion of Eclipse Sound and in the northern portion of Navy Board Inlet. Narwhal were distributed evenly throughout the central portion of Eclipse Sound where ice concentrations varied considerably from 0-10/10. Narwhal were again observed in high concentrations in the open water at the north end of Navy Board Inlet. Ice concentrations ranged from 0-10/10 in the central and southern portion of Navy Board Inlet. On 24 July, narwhal were distributed evenly throughout western Eclipse Sound where ice conditions varied considerably from 1-10/10 concentrations. Narwhal were not observed in Tremblay Sound or Milne Inlet South on 24 July even though both areas were primarily free of ice.

A survey was flown on 26 July in Admiralty Inlet. It consisted of a reconnaissance survey in southern Admiralty Inlet and a systematic survey in northern Admiralty Inlet (see Appendix B, Figure B-5). Ice concentrations during the reconnaissance survey ranged from open water in the far south to 9-10/10 in the central region of the Admiralty Inlet North stratum. In Admiralty Inlet North, ice concentrations ranged from open water to 9-10/10 where systematic transect lines were flown. Narwhal were distributed throughout the open water area in Admiralty Inlet North with highest concentrations along the west side of the Inlet. Although there was an open passage along the west shore from Admiralty Inlet North to Admiralty Inlet South, narwhal had not yet started to move south of the ice concentrations.

A survey flown in the Eclipse Sound grid on 27 July covered the Milne Inlet South, Milne Inlet North, Tremblay Sound, Eclipse Sound West, and Navy Board Inlet strata. Ice concentrations ranged from 0-9/10 in Navy Board Inlet, 1-10/10 in Eclipse Sound West, 0-10/10 in Milne Inlet North, 0-9/10 in Tremblay Sound, and open water in Milne Inlet South. Narwhal were observed in Eclipse Sound West, northern Navy Board Inlet, and one in Milne Inlet South (see Appendix B, Figure B-6). In northern Navy Board Inlet, narwhal occurred in lower numbers than observed on 22 and 23 July. A survey on 30 July covered the same strata as the 27 July survey. With the exception of a sighting in Navy Board Inlet, most narwhal sightings were observed in Tremblay Sound and Milne Inlet South (see Appendix B, Figure B-7). The only survey flown after the start of shipping operations was on 1 August. During this survey, narwhal were again, mainly concentrated in Tremblay Sound and Milne Inlet South (see Appendix B, Figure B-8).

Leg 1 narwhal distribution in 2022 was similar to the distribution observed in 2021. Not long after aerial surveys started in both years, narwhal distribution shifted from the Pond Inlet and Eclipse Sound East strata to the Eclipse Sound West stratum and then the Tremblay Sound and Milne Inlet South strata (Golder 2020a, 2021a, 2022c). By the start of the shipping season in both 2021 (24–26 July) and 2022 (30 July), narwhal had progressed further into the RSA than the two years prior with most narwhal concentrated in Milne Inlet South and Tremblay Sound. In 2019 and 2020, narwhal were primarily distributed in Eclipse Sound strata and Milne Inlet at the start of the shipping season with some differences in dispersal patterns of groups between those years. Ice concentration was likely the main factor driving both the differences in distribution and dispersal patterns between the years.

In 2019, the sea ice remaining in the RSA when icebreaking started (17 July) was fragmented in a loose, pack ice formation allowing narwhal to disperse throughout the Eclipse Sound area somewhat evenly (Golder 2020a). In 2020, the sea ice present in the RSA at the start of icebreaking (21 July) was largely intact (i.e., large, consolidated ice field) with a few ice leads running through it (Golder 2021a). As a result, narwhal were highly concentrated in the ice leads in Eclipse Sound in 2020, forming a more clumped distribution compared to 2019, 2021, and 2022. There was no Project-related icebreaking in 2021 and 2022 and shipping didn't start until ice concentrations were no greater than 3/10 along the entire Northern Shipping Route. In 2021, project vessels entered the RSA on 24–25 July (two tugs) and 26 July (MSV *Botnica* and one ore carrier) (Golder 2022c).

In 2022, project vessels entered the RSA on the evening of 30 July and were preceded by non-Baffinland vessels that entered and exited the RSA since as early as 21 July 2022. By the time shipping started in both years (2021 and 2022), narwhal had already traveled through the RSA and were concentrated in the Tremblay Sound and Milne Inlet South strata (Appendix B, Figures B-7 and B-8).

Eight aerial surveys (systematic and dedicated surveys) were conducted during the 2022 Leg 1 surveys (see Table 1). Relative abundance estimates were calculated for all marine mammals observed during the early shoulder season for both systematic and dedicated transects (see Table 4). Narwhal had the highest relative abundance (0.646 animals/km) of all marine mammals observed during systematic transects. The lowest relative abundance of narwhal was observed on 21 July (0.0959 animals/km) (see Table 5). The highest relative abundance was on 22 July with 2.8134 animals/km in Navy Board Inlet. This decreased to 1.2325 animals/km in Navy Board Inlet and Eclipse Sound on 23 July and to 0.2175 animals/km in western Eclipse Sound, Tremblay Sound and Milne Inlet on 24 July before increasing again to 0.6363 animals/km in western Eclipse Sound, Tremblay Sound, Milne Inlet and Navy Board Inlet on 27 July, 0.3894 animals/km in western Eclipse Sound, Tremblay Sound, Milne Inlet and Navy Board Inlet on 30 July (survey completed prior to the start of shipping in 2022), and 0.4634 animals/km in western Eclipse Sound, Tremblay Sound, and Milne Inlet on 1 August (see Table 5). The aerial survey conducted on 26 July was flown in Admiralty Inlet and is not further discussed here. The peak in narwhal numbers early during Leg 1 suggests that some narwhal were migrating through the RSA while others remained. Relative abundance during Leg 1 would be expected to be higher when counts include both narwhal migrating into the RSA to stay for the summer and narwhal migrating through the RSA to other areas for the summer, e.g., Admiralty Inlet.

In the Eclipse Sound grid, narwhal relative abundance in 2022 varied between systematic surveys ranging from 0.096 to 2.813 animals/km (see Table 5). In previous years, narwhal relative abundance ranged between surveys from 0.030 to 0.500 animals/km in 2019 (Golder 2020a), 0.000 to 0.773 animals/km in 2020 (Golder 2021a), and 0.000 to 0.685 animals/km in 2021 (Golder 2022c).

Calculations from systematic (open water) surveys were used to compare combined relative abundance between years from 2019 to 2022 (see Table 6). The combined relative abundance estimates from Leg 1 systematic surveys suggested that narwhal were more abundant in the RSA in 2022 (0.646) compared to 2019, 2020, and 2021 (0.295, 0.333, and 0.336 animals/km respectively) (see Table 6). However, the 2020 relative abundance may be higher or comparable to 2022 when considering the relative abundance estimate from dedicated survey in leads (2.09 animals/km). When combining both systematic and dedicated surveys conducted in 2020, the relative abundance of narwhal in in the RSA during Leg 1 surveys would be higher than 0.33 animals/km.

It is problematic to compare dedicated surveys between all four years because 2020 was the only year when the sea ice was largely intact within the RSA and leads were flown as dedicated surveys. Therefore, these relative abundance results should be interpreted with caution due to a variety of factors that would influence relative abundance estimates including uneven coverage effort between surveys, exclusion of dedicated surveys when comparing all years, and the variability in the timing of the surveys each year. For example, Leg 1 surveys in both 2021 and 2022 started later (19 and 21 July, respectively) than in 2019 (12 July) and 2020 (10 July). Prior to the start of shipping in 2021 and 2022, narwhal had already migrated and concentrated in Tremblay Sound and Milne Inlet which differed from 2019 and 2020 when narwhal were more evenly distributed throughout the RSA at the start of shipping. Compared to 2020, there were no ice leads to fly during Leg 1 surveys in 2019, 2021 and 2022, and all surveys were flown as systematic surveys over open water making it difficult to directly compare relative abundances.

For all survey years combined, the relative abundance calculation was not considered to be an accurate estimate of abundance because of uneven aerial coverage effort between surveys. Abundance calculations are considerably impacted if coverage in the survey area is not the same for all surveys. Leg 1 surveys focused on presence/absence and distribution of marine mammals prior to and during initial shipping operations. Complete and equal survey effort coverage of the RSA was not the main goal of Leg 1 surveys. This was often not achieved due to ice or other weather conditions. Therefore, relative abundance results from these surveys should be interpreted as a snapshot of abundance in the specific area surveyed at a particular time and does not represent an estimate of stock abundance. Additionally, in the spring and early summer, narwhal may migrate through the RSA to Admiralty Inlet or other summering areas, and it is not possible to determine which narwhal stay, and which simply migrate through. When narwhal do stay in the RSA, they tend to concentrate in either Koluktoo Bay or Tremblay Sound. As a result, relative abundance numbers will be higher during surveys that focus on surveying locations where narwhal are concentrated rather than flying all areas equally.

In summary, the comparison of the relative abundance results from Leg 1 surveys across 2019, 2020, 2021, and 2022 are to be interpreted with caution and understood that the results for each survey represent the relative abundance of narwhal for the specific locations surveyed on a specific date and for systematic surveys only. Relative abundance for comparison between years could be affected by factors such as unequal distribution of survey effort through the survey area, narwhal aggregating in large numbers in certain areas and surveys targeting those areas, as well as the timing of Leg 1 surveys.

2.6.2 Other Marine Mammals

2.6.2.1 Cetaceans

Bowhead Whale

Bowhead whales were observed in similar numbers throughout the RSA during Leg 1 surveys in 2022 compared to 2019, and lower numbers compared to 2020 and 2021(Golder 2020a, 2021a, 2022c). During 2022 Leg 1 surveys, bowhead whales were broadly distributed throughout the RSA with observations in Pond Inlet, Eclipse Sound East, Milne Inlet North, and Navy Board Inlet (see Figure 15). The distribution of bowhead whales was more extensive in 2022 compared to 2019, but less extensive compared to 2020 and 2021. In 2019, bowhead whales were only observed in Pond Inlet and Eclipse Sound West. In 2020 and 2021 bowhead whales were observed in the same strata as those observed in 2022, as well as in Tremblay Sound and Milne Inlet. Bowhead whale concentrations for 2022 were highest in the Milne Inlet North and Navy Board Inlet strata.

The bowhead relative abundance in the RSA in 2022 was the lowest recorded since the start of Leg 1 aerial surveys at 0.0024 animals/km compared to 0.0230 animals/km in 2019, 0.0091 animals/km in 2020, and 0.0189 animals/km in 2021. The higher number of bowhead whales observed in 2019 and 2021 may represent anomalous years compared to historical numbers. It was noted by many local residents in Pond Inlet that bowhead whale numbers observed in 2019 were higher than those observed in previous years. The relative abundance of bowhead in 2022 may be representative of typical numbers prior to 2019. Ongoing monitoring will help determine whether 2019 and 2021 were anomalous years with high bowhead whale abundance or whether bowhead whale use of the RSA may be increasing.

Beluga Whale

Prior to 2022, beluga numbers were consistently low in the RSA. There were three, four, and five beluga sightings during Leg 1 surveys in 2019, 2020, and 2021, respectively, (Golder 2020a, 2021a, 2022c). There were 15 sightings during the 2022 Leg 1 surveys alone. Most of the sightings (11) recorded in 2022, however, occurred on 27 July when a large aggregation of multiple groups of beluga whales was observed near Milne Port in Assomption Harbour prior to the start of Baffinland's shipping activities.

A total of 152 beluga whales were observed in the RSA during 2022 Leg 1 surveys. One hundred and fourty-eight of these were observed in Assomption Harbour on 27 July. Prior to 2022, all beluga sightings were of single whales during Leg 1 of the 2019, 2020, and 2021 aerial surveys (Golder 2020a, 2021a, 2022c). In 2007 and 2008, beluga whales were observed in the RSA in small numbers (three animals in 2007 and 59 animals in 2008; Baffinland 2012). Beluga whales were not observed during Baffinland aerial surveys from 2013 to 2015 (Elliott et al. 2015; Thomas et al. 2015, 2016). 2022 may have been a unique year for beluga numbers in the RSA, specifically the observation of 148 whales on 27 July. Beluga relative abundance in the RSA in 2022 was the highest of all Leg 1 survey years with 0.0504 animals/km compared to 0.0002 animals/km in 2019, 0.0009 animals/km in 2020, and 0.0005 animals/km in 2021.

Killer Whale

Killer whale were not observed during the 2022 Leg 1 surveys. However, on 25 July, killer whale sightings were reported by the community of Pond Inlet and relayed to the aerial survey team through the Inuit observers. The following day (26 July), a large concentration of beluga were sighted by Milne Port staff in Assomption Harbour close to the Port Site. This was an incidental sighting and numbers were not included in the survey results. Video footage of the beluga concentration yielded a beluga count of 233 beluga (including seven calves) in Assomption Harbour on 26 July (Figure 16). It is possible that the beluga whales in Assomption Harbour were trying to evade the killer whales in Eclipse Sound.

The relative abundance of killer whales was higher in 2019 and 2021 (0.0025 animals/km and 0.0032 animals/km, respectively) compared to 2020 and 2022 (0.0000 animals/km for both years). Though killer whale were not observed during Leg 1 surveys in 2019 and 2020, killer whale presence during Leg 2 survey in 2020 was higher in the Eclipse Sound grid than in 2019. Relative abundance and sightings of killer whale during Legs 1 and 2 in previous surveys suggested that killer whale presence in the RSA may be increasing. However, killer whale were not observed during either Leg 1 or Leg 2 of 2022 and ongoing monitoring of killer whale occurrence in the RSA is needed to determine trends in the RSA.

2.6.2.2 Pinnipeds

Pinniped data collected in 2019, 2020, 2021, and 2022 should be interpreted with caution due to the difficulty in observing seals at survey altitudes of 305 m (1,000 ft) ASL. Apparent differences in sighting data may result from changes in survey conditions and the ability of MMOs to identify species rather than actual changes in pinniped species numbers or distribution.

Ringed Seal

Ringed seals were distributed throughout the survey area during Leg 1 of the 2019, 2020, 2021, and 2022 MMASPs, similar to what was observed in previous aerial surveys (Elliott et al. 2015; Thomas et al. 2015, 2016; Golder 2020a, 2021a, 2022c). In 2020, 2021, and 2022 ringed seal were more concentrated in the Eclipse Sound West and Milne Inlet strata while being more sporadically distributed throughout the survey area in 2019.

Ringed seal relative abundance was highest in 2021 (0.09 animals/km), followed by 2022 (0.052 animals/km), 2020 (0.036 animals/km), and 2019 (0.020 animals/km). Ringed seal distribution in all years was greatest where ice remained concentrated in the Eclipse Sound West and Milne Inlet strata or where there was open water in the Milne Inlet South stratum.

Ringed seal observations provide relative abundance and distribution information. However, this information cannot be used to reliably assess the effects of Project shipping or obtain accurate abundance estimates. Results from the 2021 ringed seal aerial survey program indicated that ringed seal densities had remained stable with some annual variations since the onset of shipping and icebreaking activities in the RSA (Golder 2022b).

Harp Seal

Harp seals were observed throughout northern Navy Board Inlet, Baffin Bay, Pond Inlet, Eclipse Sound, and Milne Inlet North strata during Leg 1 of the 2022 MMASP. This is similar to what had been observed during previous aerial surveys for the Project (Elliott et al. 2015; Thomas et al. 2015, 2016; Golder 2020a, 2021a, 2022c). Harp seal were dispersed throughout these areas in 2019 and 2020. In 2021 and 2022, harp seal concentrations were greatest in northern Navy Board Inlet.

During Leg 1 in 2022, harp seal relative abundance was a lower (0.300 animals/km) than the 2021 relative abundance (0.370 animals/km) and higher than the 2019 and 2020 relative abundances (0.0290 animals/km and 0.160 animals/km, respectively). The differences in relative abundance between years may be attributable to the different environmental conditions observed between the years (2019, 2021 and 2022 had less ice in the survey area compared to 2020), where the surveys were flown (only one of the five surveys was flown in the very north end of Navy Board Inlet in 2019 where the highest concentrations of harp seal were observed in other years), or it is possible that there was a greater number of harp seals in the RSA in July 2020 and 2021. Harp seal numbers in the RSA were variable during aerial surveys from 2013 to 2020 (Elliott et al. 2015; Thomas et al. 2015, 2016; Golder 2020a, 2021a, 2022c). The highest count of harp seals recorded on a survey was 80 sightings totalling 1,005 individuals on 16–17 September 2014 (Thomas et al. 2015).

Bearded Seal

Similar to previous years, only a few bearded seals were observed during the 2022 MMASP. There were three sightings recorded during the 2022 Leg 1 in the Eclipse Sound Grid, compared to two in each of 2019 and 2020, and five in 2021. Relative abundance was highest in 2022 with 0.0010 animals/km compared to 2019, 2020, and 2021 (0.0006 animals/km, 0.0005 animals/km, and 0.0008 animals/km, respectively). Limited IQ has been collected regarding the overall abundance of bearded seal. Some Elders in the Baffin region have observed a decrease in bearded seal abundance since the advent of firearms and motorized transportation (Baffinland 2010). In contrast, one Elder noted that bearded seal were rare near Pond Inlet in the past but are now more frequently observed. Five of ten bearded seal observed during Leg 1 surveys were observed in the Pond Inlet stratum.

Walrus

No walrus were recorded during 2022 Leg 1 surveys in Eclipse Sound. Walrus have rarely been observed during the Baffinland aerial survey programs. In 2014, three sightings totalling four individuals were recorded during a survey on 3–4 August (Thomas et al. 2015). In 2015, one walrus was recorded during a survey on 31 August (Thomas et al. 2016). During Leg 1 in 2021, one walrus was observed in the Pond Inlet stratum (Golder 2022c). IQ indicates that small numbers of walrus occur near the mouth of Navy Board Inlet and in Lancaster Sound to the west of Admiralty Inlet (Baffinland 2010). During 2015 workshops, IQ indicated the Navy Board Inlet floe edge had more walrus present than the Pond Inlet floe edge (JPCS 2017).

2.6.2.3 Polar Bear

Five sightings of individual polar bears were recorded during Leg 1 surveys (Figure 17; Table 2 and Table 3). Two polar bears were observed in northern Navy Board Inlet and two polar bears were observed in the Pond Inlet stratum on 23 and 24 July, respectively (see Appendix B; Figures B-3 and B-4). All four sightings were of swimming animals. The fifth sighting was observed in Admiralty Inlet on 26 July (see Appendix B; Figure B-5). The polar bear was resting on the shore.

Polar bear sightings have been regularly recorded during the Baffinland aerial survey programs. The distribution of polar bears in 2022 was similar to what was observed during previous aerial surveys. In the Eclipse Sound grid, polar bears were more likely to be recorded in the Navy Board Inlet and Pond Inlet strata; all polar bear observed during 2022 Leg 1 surveys were in these strata. Because most polar bear sightings are of polar bears on shore (i.e., when in transit), they are not included in the relative abundance estimates. Relative abundance estimates include only sightings seen in the water while on transect. Polar bear observations provide relative distribution information but cannot be used to assess effects of Project shipping or provide reliable abundance estimates.

3.0 LEG 2: OPEN-WATER SURVEYS IN ECLIPSE SOUND AND ADMIRALTY INLET

3.1 Introduction

3.1.1 Objectives

The 2022 MMASP was staged in two separate survey legs. Leg 2 targeted a 15-day window in August corresponding with the peak open-water period identified by DFO (Watt et al. 2015). The objective of Leg 2 surveys was to obtain an updated (2022) abundance estimate for the Eclipse Sound and Admiralty Inlet narwhal summer stocks. Survey design and data collection methodology previously developed by DFO (Asselin and Richard 2011; Doniol-Valcroze et al. 2015a; Marcoux et al. 2016; Matthews et al. 2017) and implemented by Golder Associates Ltd. (amalgamated under WSP Canada Inc. in January 2023) in 2019, 2020, and 2021 (Golder 2020a, 2021a, 2022c) enabled for a comparison to previously reported abundance estimates.

3.2 Survey Team and Training

Leg 2 of the 2022 aerial surveys took place over one 15-day period (9–23 August) with two aircraft. The survey team consisted of four WSP biologists, three contracted marine biologists and four Inuit researchers with previous marine mammal experience as MMOs, four pilots, and one mechanic (Figure 18 and 19). Four local Inuit researchers, two from Pond Inlet and two from Arctic Bay, participated in the Leg 2 surveys. All Inuit researchers had previous experience as MMOs on either the aerial survey program, the ship-based observer program, or the Bruce Head shore-based monitoring program in previous years.

A one-day data collection and safety training workshop was held at Mary River on 10 August 2022. The training and orientation session was led by a WSP senior marine mammal biologist. The safety component of the workshop aimed to familiarize team members with the Health and Safety Plan that was developed for the program, to review WSP's and Baffinland's health and safety policies and requirements, and to discuss general expectations for the program. The technical component of the workshop including practical (hands-on) training in observational survey procedures, data collection techniques, proper use of equipment, data recording and data entry, and post-processing of the survey data. During the training, all participants were provided with a training manual (see Appendix A) and obtained practical experience using the surveying equipment including recorders, clinometers, and geometer.

Figure 18: 2022 Marine Mammal Aerial Survey Team — Leg 2 CKB Aircraft.

Figure 19: 2022 Marine Mammal Aerial Survey Team — Leg 2 BBV Aircraft

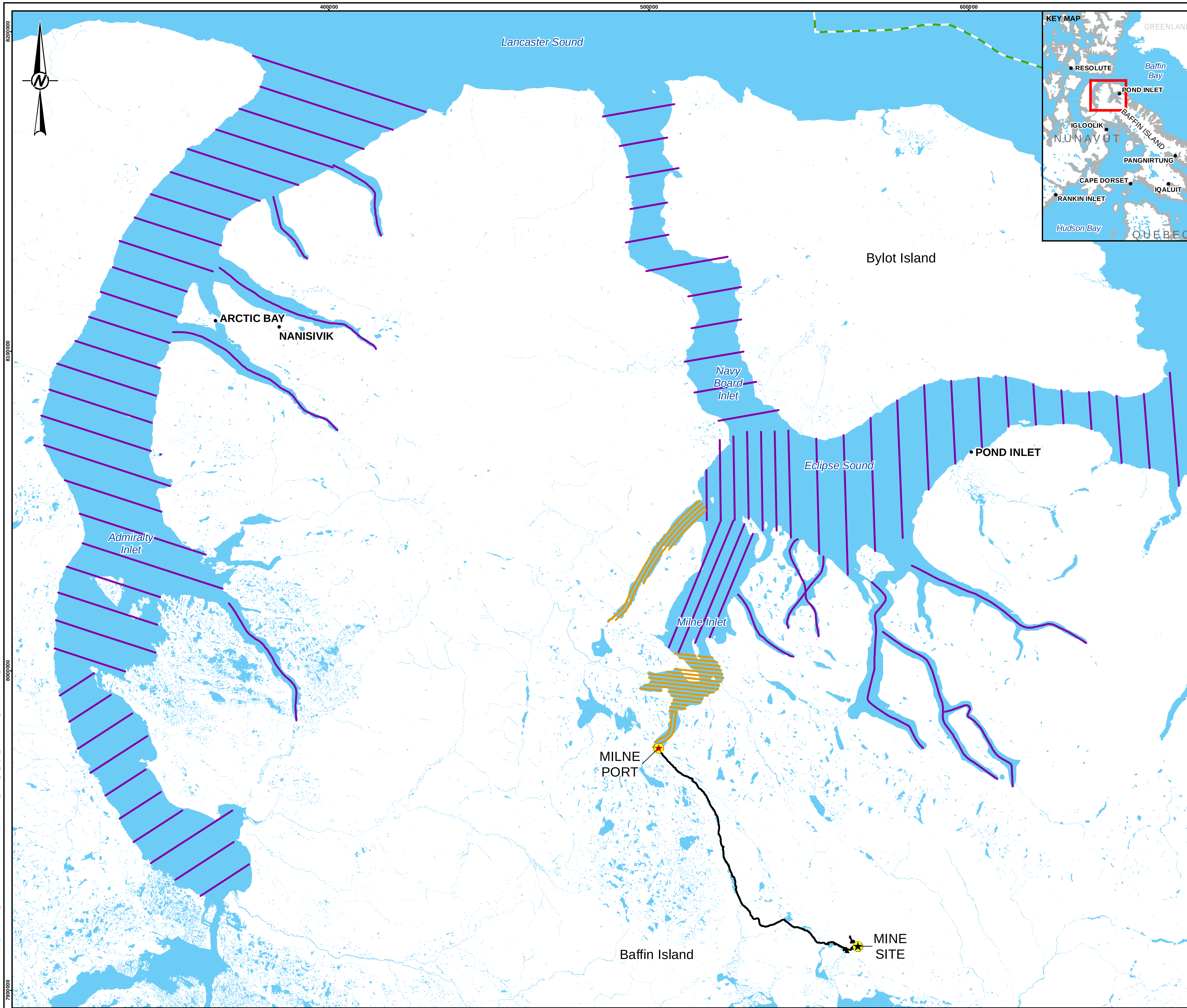
3.3 Study Area and Design

Leg 2 surveyed Eclipse Sound and Admiralty Inlet within a two-day period to obtain an estimate of narwhal abundance in the combined areas. The boundaries for the Eclipse Sound grid during Leg 2 were the same as those for Leg 1 with the Baffin Bay stratum removed (see Figure 3). As during Leg 1, systematic random visual line-transect surveys were flown for all strata (except Tremblay Sound and Milne Inlet South where photographic surveys were conducted) with the location of the first line chosen at random (Figure 20). Transect spacing was the same as those flown during Leg 1 in the Eclipse Sound grid (see Section 2.3). A photographic survey with complete coverage was flown for the Tremblay Sound and Milne Inlet South strata because IQ indicates that these are areas of high narwhal concentration (JPCS 2017) and past surveys (Doniol-Valcroze et al. 2015a; Elliott et al. 2015; Golder 2020a, 2021a; Marcoux et al. 2019; Thomas et al. 2015; 2016) recorded high concentrations of narwhal in these areas. Transect spacing of 1,200 m for the photographic survey allowed lateral overlap of approximately 30% between photos from adjacent transects (see Section 3.4.1.2 for details).

Through consultation with the MEWG prior to the 2019 MMASP (Golder 2020a), the boundaries for Admiralty Inlet were divided into three strata (Admiralty Inlet North, Admiralty Inlet South, and Admiralty Fjords; see Figure 3). Systematic random visual line-transect surveys were flown for the North and South strata with the location of the first line chosen at random. An east-west parallel line design, with an 8.5 km transect line spacing, was used to provide uniform coverage probability (Buckland et al. 2001; Figure 20).

The survey design consisted of systematically placed and evenly distributed (when possible) line transects across the survey area (Figure 20). Transects were generally straight and uniformly spaced across large waterbodies but were occasional skewed to follow the shoreline contour. This was necessary in areas where the survey aircraft could not safely perform the turns necessary to cross waterbodies perpendicular to shorelines.

For navigation during the survey to follow the survey track lines and to log the flight tracks, an iPad was connected to a Bluetooth GPS (Bad Elf GPS Pro+) which provided information to a navigation app (Foreflight). Foreflight utilizes current and routinely updated digital aeronautical maps. The iPad was used by the navigator/camera operator to coordinate with the flight crew. The flight crew had their own iPad (with Foreflight application) which was synced with the other iPad each time modifications to the planned survey flights were made.



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

TRANSECT LINES

- PHOTOGRAPHIC SURVEY
- VISUAL SURVEY

0 25 50

1:1,200,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE

TRANSECT LINES FOR ECLIPSE SOUND AND ADMIRALTY INLET GRIDS DURING LEG 2

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

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3.4 Materials and Methods

3.4.1 Field Methodology

3.4.1.1 Visual Survey

Surveys were flown in a de Havilland Twin Otter (DH-6) equipped with bubble windows and an optical glass covered camera hatch at the rear. Visual line transect surveys were conducted at an altitude of 305 m (1,000 ft) and a ground speed of 185 km/h (100 kn) with four experienced MMOs. MMOs were stationed at the front and rear bubble windows that provide a view of the track line directly below the aircraft. MMOs were instructed to focus their attention on the area closest to the track line and to use their peripheral vision for sightings farther afield. Observers counted all sightings of marine mammals by speaking into a handheld digital recorder. Using a geometer (or clinometer), the perpendicular declination angle to the center of each sighting was measured once it was abeam of the observer. MMOs noted the species and number of animals in the sighting. A ‘sighting was defined as animals within one or a few body lengths of each other and oriented or moving in a similar direction. When time permitted, observers were instructed to give additional details on the sightings, such as the presence of calves, tusked narwhal, behaviour and direction of travel. The visual surveys were conducted as a double-platform experiment with independent observation platforms at the front (primary observer) and rear (secondary observer) of the survey plane. The two MMOs stationed on the same side of the aircraft were separated acoustically to achieve independence of their conditional detections. A fifth member of the survey team was responsible for overseeing navigation along the survey grid, monitoring the camera system and entering additional sighting data obtained from the primary observers into the database.

Two MMOs were designated as ‘Primary’ observers and two were designated as ‘Secondary’ observers. In addition to counting animals, all observers were responsible for dictating the following environmental conditions throughout the surveys into the recorders: ice concentrations (in tenths), sea state (Beaufort scale), fog (% of field of view and intensity) and glare (% of field of view and intensity). These environmental conditions were recorded at the start and end of each transect, at regular intervals (every 2 minutes) along the transect or sooner if changes were detected throughout the transect.

The area directly below the aircraft was photographed continuously throughout each visual survey using the camera system described in Section 3.4.1.2. Photographs taken during the visual surveys were used to supplement visual sightings for missed geometer angles and group sizes.

Sightings from observers were automatically entered into the Mysticetus program by the observers using geometers during the survey. Geometers were linked to the Mysticetus program, allowing observer data (i.e., date, time, location and declination angles) to be enter electronically into the Mysticetus program in real time. Additional sighting data and environmental conditions recorded on audio recorders were transcribed into the Mysticetus program after the flight. Sightings were georeferenced and transect lengths were calculated in Mysticetus. Strata areas were determined in ArcGIS. Sightings where angles of declinations were not recorded were compared to the photographic records. The perpendicular distance was retrieved from the pixel position of the sighting on the photo if a visual sighting was identified without ambiguity on the corresponding photo. If the sighting was not made within the swath width of the picture, could not be found, or could not be identified from other sightings unambiguously, the sighting was coded as missing distance (these sightings were not used in fitting the detection function, but were added to the total count per transect, as described in Doniol-Valcroze et al. 2015a). Sightings where group size were not recorded, or were coded as ‘uncertain’, were compared to the photographic records, and group size was retrieved if a match could be made based on perpendicular distance.

Otherwise, sightings with missing group size were given the average group size in that stratum (posterior to estimation of the expected group size so that it does not affect the estimation of its variance).

During visual line-transect surveys, if large aggregations (e.g., >50 narwhal or when observers indicated that they could not accurately keep up with narwhal counts) were identified during visual transects, the aircraft continued collecting visual line-transect data along transects until narwhal numbers decreased to smaller (e.g., <50) aggregations. The aircraft then ended visual line-transect survey data collection and a photographic survey was flown with complete coverage over the group to allow for accurate counts of animals. Using pre-planned survey grids, the aggregation would be photographed using a systematic grid with complete coverage as seen in Figure 20 (yellow transect lines) for the Milne inlet South and Tremblay Sound strata.

3.4.1.2 Photographic Survey

The aircraft was equipped with two identical camera systems. The systems used Canon EOS 5DS R DSLR (digital single-lens reflex) cameras fitted with 35 mm lens (three Sigma 35 mm f/1.4 DG HSM and one Zeiss 35 mm f1.4 Milvus ZE). The cameras were connected to a laptop computer to control exposure settings and photo interval. The cameras were installed within the optical glass covered camera hatch on a custom-made mount. Images were saved directly to internal camera cards. Photos were georeferenced (using GPicSync 1.32) at the end of the field season using saved GPS logs from a Bluetooth GPS receiver (Bad Elf GPS Pro+). Cameras and computers were synched with the GPS receiver, and the GPS receiver was calibrated to barometric data provided by the pilots when available.

The cameras were oriented widthwise (long side perpendicular to the track line) and angled obliquely: one to the port side and the other to the starboard side. Each camera provided an oblique image starting at the track line, the viewing angle of each camera (α = 27°) equal to half its field of view (shown as β in Figure 21), calculated using (Covington 1985):

$$\alpha = \beta = \arctan\left(\frac{sensorwidth}{focallength \times 2}\right)$$

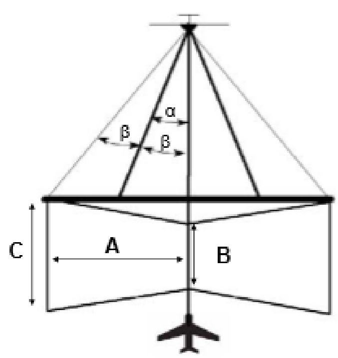


Figure 21: Geometry of oblique aerial photos (modified from Grendzdörffer et al. 2008).

Photographic surveys were conducted at an altitude of 610 m (2,000 ft) and a ground speed of 185 km/h (100 kn). Surveys were flown at an altitude of 305 m (1,000 ft) or 457 m (1,500 ft) if conditions did not allow surveying at higher altitude (610 m). The aircraft maintained appropriate altitude when flying in Simirlik National Park. Using the methods described in Grendzdörffer et al. (2008), the photograph dimensions of the two-camera system (see Figure 21) and the necessary photographic interval were calculated to allow overlap of the photos while flying at 100 knots (Table 7). The photographic interval was set to maintain an overlap (on the inside edge) of approximately 15% between consecutive photos, and with a transect spacing of 600 m (for 1,000 ft surveys) and 1,200 m (for 2,000 ft surveys), the lateral overlap between photos from adjacent transects was approximately 30%.

Table 7: Dimensions of images at three possible altitudes and image interval needed for 15% endlap

	Altitude (m)		
	305	457	610
A (m)	423	629	846
B (m)	186	279	372
C (m)	318	475	636
Interval (sec)	3	5	6

Three sets of grid lines (one for 305 m, a second for 457 m and a third for 610 m altitudes) were prepared prior to field work so a photographic survey could be coordinated within minutes of spotting an aggregation of animals.

All photographs were orthorectified at the end of the field season to create an orthophotograph prior to analysis (Figure 22). An orthophotograph is an aerial photograph that has been geometrically corrected such that the scale is an accurate representation of the earth’s surface, having been adjusted for topographic relief, lens distortion, and camera tilt.

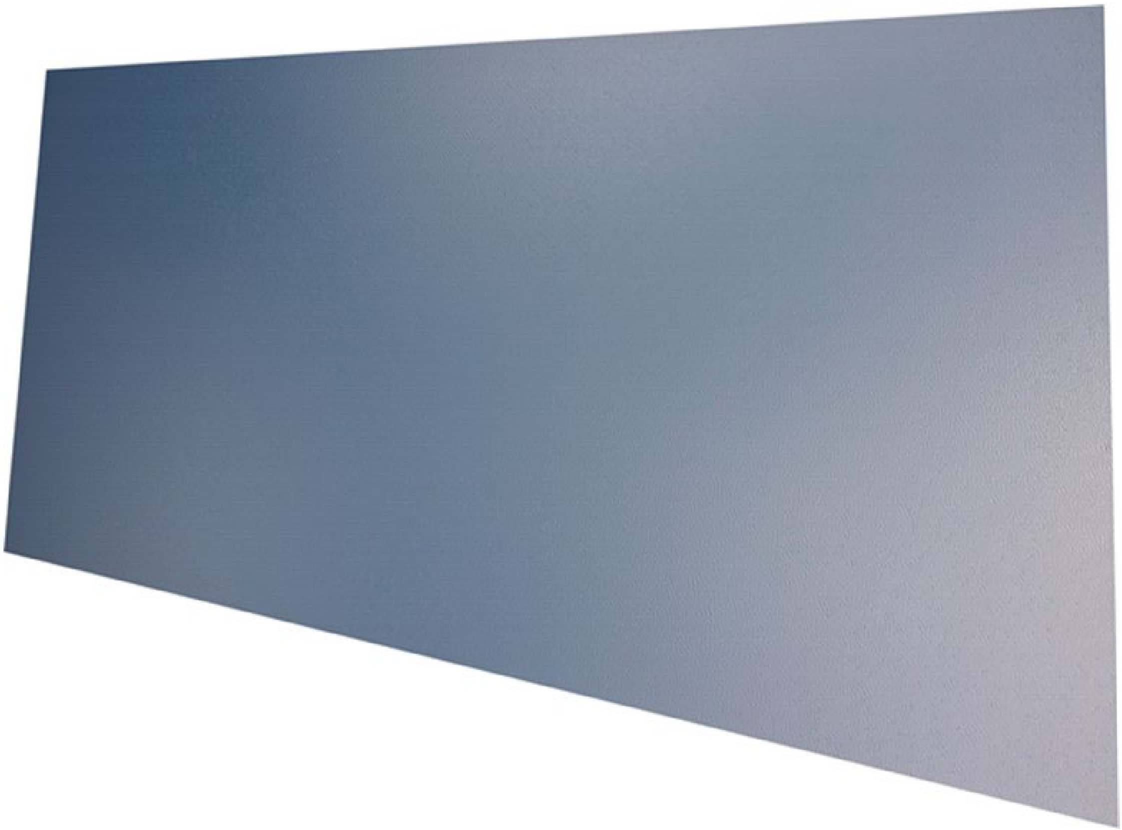


Figure 22: Orthophotograph of an image taken at 610 m (2,000 ft) in Eclipse Sound on 20 August 2020.

3.4.2 Data Analysis

An adaptive sampling plan to estimate narwhal abundance that combines visual line-transect sampling of the survey area and aerial photographic surveys of designated strata was used (Asselin and Richard 2011; Marcoux et al. 2016; Matthews et al. 2017). Animal detection rates were also calculated for other marine mammal species and expressed as number of sightings/km and number of animals/km (used as a proxy for relative abundance).

3.4.2.1 Visual Survey

3.4.2.1.1 Distance Analysis

The standard analysis method of this design assumed that on average, over multiple replications of the survey, each point within the survey area had an equal likelihood of being sampled (uniform coverage probability). Given that the locations of the transect lines were considered random with respect to the location of marine mammals, the average density of marine mammals was considered to be the same irrespective of distance from the transect line. Subsequently, observed changes in marine mammal sightings with increasing distance from the transect line was considered a change in the probability of detection, rather than a true change in animal density. The change in detection probability with respect to sighting distance from the track line (flight path) was measured to provide an estimate of the average probability of detection of an animal, which was, in turn, used to estimate the density of marine mammals in the survey area.

Density was calculated by using the line transect estimation method (Buckland et al. 2001). In the standard approach, animal density (D) was estimated using the following equation:

$$\frac{n * f(0) * \hat{E}(s)}{2 * L * g(0)}$$

Where n is the number of observed objects (single or clusters of animals), f (0) is the estimated probability density function at zero distance, $\hat{E}(s)$ is the estimate of expected value of cluster size (estimated group size), L (effort) is the total length of transect lines surveyed and g (0) is the probability of detection on the transect line. Effort was calculated as total length of transect lines surveyed using trackline GPS data. Transits between transects were not included in effort calculations.

An implicit assumption of this method was that the probability of detection depended solely on an animal's perpendicular distance from the transect line. Line transect theory assumes that all animals on the transect line were detected with certainty (g(0)=1). In reality, this is an unrealistic assumption for animals that spend considerable time underwater where observers may fail to detect animals due to availability bias (animal was not detected because it was diving) (Marsh and Sinclair 1989). Correcting for availability bias requires published dive profile data to reliably estimate the proportion of time different marine mammal species spend diving (Laake et al. 1997). The most current time-series dive data collected from tagged narwhal near Arctic Bay and Pond Inlet were used to apply a correction factor for availability bias in photographic data (Watt et al. 2015; Table 8), as was used in the previous DFO narwhal abundance estimates (Doniol-Valcroze et al. 2015a; Marcoux et al. 2019). Mid-August included the period from 13 August (the earliest tagging date) until 24 August and late August included the period from 25–31 August (Watt et al. 2015). For narwhal visual surveys, correction factors (Cα) from Watt et al. (2015) tagging data were used with an additional correction for time in view and animal dive cycle applied from Doniol-Valcroze et al. (2015a) measurements (Table 8).

Table 8: Availability bias correction factors

Species	Survey Type/Date	Correction Factor	CV	Source
Narwhal	Photo / Mid-Aug	3.18	0.03	Watt et al. 2015
	Photo / Late Aug	3.16	0.03	Watt et al. 2015
	Visual / Mid-Aug	2.94	0.03	Watt et al. 2015; Doniol-Valcroze et al. 2015a
	Visual / Late Aug	2.92	0.03	Watt et al. 2015; Doniol-Valcroze et al. 2015a

Encounter rate [$\frac{n}{L}$ from the equation above] was calculated as the number of marine mammal sighting per transect kilometre and was specific to each survey area. Although encounter rate was calculated (not estimated), there was a degree of variability in its value since encounter rate may vary among individual transects. Encounter rate variance was estimated using the S2 estimator available within Distance 7.3 (Fewster et al. 2009).

Group size [$\hat{E}(s)$ from equation above] was estimated to correct for observer size-bias whereby larger groups were more likely to be seen at long distances than smaller groups (or individuals). The regression of the natural log of cluster size was tested against the estimated g(x) and considered significant at an alpha level of 0.1; the value of mean group size was used for non-significant results. Distance truncation of the data was performed to remove sightings past a selected distance to remove outliers from the dataset that would otherwise inflate density and abundance estimates, and to eliminate hard-to-fit portions of the dataset.

3.4.2.1.2 Perception Bias

Distance sampling (DS) methods can be used to estimate detection probability away from the track line while assuming that detection on the track line is certain (denoted by g(0)=1). However, aerial survey observers miss some of the narwhal visible at the surface (Richard et al. 2010). This "perception bias" (Marsh and Sinclair 1989) can be corrected for by using mark-recapture (MR) methods on the sighting data from two observers on the same side of the plane (Laake and Borchers 2004). Thus, the combination of MR and DS (MRDS) methods can be used to estimate abundance without assuming that g(0)=1. The two observers in the front of the plane were considered to be the first platform and referred to as "primary observers", and the two observers in the rear were considered to be the second platform ("secondary observers").

To conduct MRDS analysis, duplicate sightings (those seen by both the primary and secondary observer) must be identified. The following criteria, based on previous DFO surveys (Asselin and Richard 2011; Doniol-Valcroze et al. 2015a), were used to identify sightings:

- Timing of sightings within 10 seconds
- Perpendicular declination angle within 10°

As MRDS analysis in Distance requires that duplicate sightings be identical, when this was not the case, the following adjustments to the data were made:

- Used the average perpendicular declination angle as measured by the two observers
- Used the largest group size as measured by the two observers
- Used group differentiation as measured by the primary observer

Although primary and secondary observers were acting independently, detection probabilities of observers can be correlated because of factors such as group size (for example, both observers are more likely to see only large groups at long distances). Buckland et al. (2009) developed a point-independence model, which assumes that detections were independent only on the track line. This model is usually more robust than a model assuming that detections were independent at all perpendicular distances.

Line-transect analyses to estimate density and abundance were performed with the MRDS package in R. A point-independence model involved estimating two functions: a multiple covariate DS detection function for detections pooled across platforms, assuming certain detection on the track line, and a MR detection function to estimate the probability of detection on the track line.

3.4.2.2 Photographic Survey

Whale Seeker, Inc. (Whale Seeker) was contracted for the post season photographic analysis. The photo analyst from Whale Seeker is experienced in analysing aerial photos from previous DFO narwhal surveys in 2013 and the 2019, 2020, and 2021 photographic surveys. Photographs were orthorectified prior to being analysed. All narwhal within the top 2 m of the water column were counted. Water clarity was subjectively evaluated in each photo and classified as either murky (water in which narwhal could only be observed at the surface) or clear (water in which narwhal could be observed down to 2 m).

A randomly selected photo survey was re-analyzed by a second experienced photo analyst to evaluate reliability and repeatability. A simple linear regression was run on the comparison of the photo survey readings. Photographic readings from the original photo readers were used in the photo analysis.

Some photographic surveys have observed a decrease in marine mammal detectability with increasing distance from the track line (Golder 2018b). To assess if this was occurring on the photographic surveys, a survey was selected with no glare or land, to assess if a decrease in detectability with increasing distance from the track line was occurring. Removing re-sightings from subsequent photographs on a track line and measuring the distance from the track line for each sighting allowed assessment of detectability with increasing distance from the track line. The Distance program was used to measure a change in marine mammal sightings with increasing distance from the transect line, referred to as detection probability. The change in detection probability with respect to sighting distance from the track line (flight path) was measured to provide an estimate of the average probability of detection of an animal, which was, in turn, used to estimate the density of narwhal in the photographic survey area.

The area covered by each photograph was calculated in ArcMap (Esri) based on the orthophotograph which accounted for survey altitude, focal length of the camera sensor (35 mm), the length of the camera sensor (35.9 mm), the width of the camera sensor (24 mm), angle of the camera (27°), and the tilt of the aircraft. The area of land was subtracted from each photograph. On some photos, a proportion of the photo was masked by sun glare, which made it impossible for the reader to evaluate if narwhal were present. Therefore, the area of the photo covered by sun glare was measured for each photo in ArcMap (Esri) and subtracted from the photograph. When ice was present in concentrations greater than 10%, the proportion of ice was estimated and deducted from the area left after subtracting the land and glare.

Based on the methodology used in past DFO surveys (Asselin and Richard 2011; Marcoux et al. 2016; Matthews et al. 2017), the total area of a photograph A_{total} examined to detect narwhal was calculated by subtracting the area of each photograph A_{photo} from the area on land A_{land}, the area covered in sun glare A_{glare}, and area covered in ice A_{ice}.

$$A_{tot} = A_{photo} - A_{land} - A_{glare} - A_{ice}$$

The area covered by each photographic survey (A_{survey}) was determined by calculating the area of a polygon made of all the photographs merged together and removing the areas that were on land. Due to photograph sidelap and endlap, some narwhal were photographed more than once. To estimate the total number of narwhal at the surface in each survey (N_{tot}) (i.e., exclude the positive bias of double-counts), the within-photo animal density was calculated and multiplied by the total area covered by photos:

$$N_{tot} = A_{survey} * \sum_{i=1}^{I} \frac{N_{surface}}{A_{tot_i}}$$

Where:

$N_{surface}$ is the total number of narwhal detected near or at the surface in a photograph

A_{tot} = area of photo i (excluding land, sun glare and ice cover on water)

A_{survey} = total area covered by merged photos (excluding land)

I is the number of photographs per survey

The total number of narwhal in each survey was corrected for the instantaneous availability bias and detectability bias:

$$N_{cor} = N_{tot} * C_{a} * C_{d}$$

Where:

N_{tot} = is the total number of narwhal detected near or at the surface in each survey (excluding the positive bias of double-counts)

C_a = is the availability correction factor taken from Watt et al. (2015)

C_d= is the detection correction factor accounting for decreasing detectability from trackline (i.e., 1/p where p=probability of observing a narwhal in a defined area in Distance analysis)

N_{cor} = number of narwhal in the survey corrected for availability bias

The variance of the surface abundance of narwhal (N_{tot}) was calculated:

$$var(N_{tot}) = \frac{\sum(x_i - \bar{x})^2}{N_{photos}}$$

Where x̄ is the average number of narwhal per photo, x_i is the number of narwhal for each photo and N_{photos} is the number of photographs. The coefficient of variation (CV) of the photographic count estimate (N_{tot}) was calculated (Marcoux et al. 2016; Marcoux, Pers. Comm. 2020):

$$CV(N_{tot}) = \frac{\sqrt{var(N_{tot})}}{N_{tot}}$$

The total variance of the estimate from the photographic survey was calculated following the delta method (Buckland et al. 2001):

$$var(N_{cor}) = N_{cor}^2 * \left\{\frac{var(N_{tot})}{(N_{tot})^2} + \frac{var(C_a)}{{C_a}^2} + \frac{var\ (C_d)}{{C_d}^2}\right\}$$

The CV of the estimate from the photographic survey was calculated:

$$CV(N_{cor}) = \frac{\sqrt{var(N_{cor})}}{N_{cor}}$$

3.4.2.3 Abundance Estimates

The total estimate for each Survey (N_i) was calculated by summing the estimate from the visual survey, corrected for availability bias, detectability bias and perception bias (N_{iV}), with the estimate from the photographed area, also corrected for availability bias and detectability bias (for narwhal) (N_{iP}):

$$N_i = N_{iV} + N_{iP}$$

Where N_{iP} is the abundance of whales in the photographic survey previously referred to as N_{tot} for narwhal

With variance calculated (e.g., Asselin and Richard 2011; Matthews et al. 2017):

$$var(N_i) = var(N_{i1}) + var(N_{i2})$$

The CV of the estimate from the total estimate was calculated:

$$CV = \frac{\sqrt{var(N_i)}}{N_i}$$

Confidence intervals (95%) were calculated using the lognormal method of Buckland et al. (2001):

$$(N_i / C, N_i * C)$$

Where: $C = exp\left[z_{\alpha} * \sqrt{var(log_e N_i)}\right]$

and: $var(log_e N^*) = log_e\left[1 + \frac{var(N_i)}{N^{*2}}\right]$

The final averaged abundance estimate ($\hat{N}_{avg}$) was calculated by combining the estimates from two surveys (Visual and Photo) using a mean weighted by effort (Buckland et al. 2001 eqn. 8.7):

$$\hat{N}_{avg} = \frac{L_1 \hat{N}_1 + L_2 \hat{N}_2}{L_1 + L_2}$$

Where L_i is the effort calculated as the area covered by the survey i

The variance of the mean estimate is calculated as follows (Buckland et al. 2001 eqn. 8.8):

$$var(\hat{N}_{avg}) = \frac{L_1^2 \widehat{var}(\hat{N}_1) + L_2^2 \widehat{var}(\hat{N}_2)}{(L_1 + L_2)^2}$$

3.4.2.4 Trend Analysis

3.4.2.4.1 Aerial Abundance Estimate Trend Over Time

A resampling simulation method was used to estimate the trend in stock abundance estimates over the past twenty years for three areas: Eclipse Sound, Admiralty Inlet, and the combined Eclipse Sound and Admiralty Inlet. The annual estimates of abundance, provided as mean and 95% confidence intervals, were assumed to have come from a lognormal distribution. This assumption was tested by assessing whether the lower and upper confidence limits provided were estimated using a single standard deviation value and a lognormal distribution. The assumption was found to be accurate for abundance estimates post-2005 (since they were generated using the Distance Sampling software) but did not hold for 2003–2004 estimates provided by DFO. The distribution used to generate these estimates was not detailed in the report (Richard et al. 2010). This may have resulted in reduced resampling variability for 2003–2004 data but is not likely to affect the overall results.

A total of 5,000 iterations were used for the analysis. In each iteration, for each sampling year, a random number was drawn from a lognormal distribution with the mean and standard deviation that were used to generate the annual abundance estimate. This resulted in a single time series of abundances in each of the three areas. These values were used to run a linear model where the response value was a natural log-transformed abundance and the predictor variable was sampling year (as a continuous variable). The model was run separately for each area. The significance of the effect of year (alpha = 0.05) and the effect size of year (i.e., the increase or decrease in abundance between each two consecutive years) were recorded for each iteration. This resulted in an array of 5,000 P-values and effect sizes for each area. The median and 95% confidence interval around the effect size were calculated from the 5,000 iterations for each area, and the proportion of iterations that had a significant effect of slope out of all 5,000 iterations was recorded and was interpreted as the probability of a significant temporal effect.

3.4.3 Quality Management

To confirm data integrity, validity, and reliability, the following Quality assistance/Quality control (QA/QC) measures were undertaken:

- Data was collected and entered into the MMASP database by qualified experienced MMOs following standard field data collection methods (see Appendix A).
- Field data entries were reviewed by a different member of the MMO team for completeness and accuracy.
- Effort and area calculations were reviewed by a WSP biologist to ensure accuracy.
- A final QA/QC of the data results was done by the senior WSP biologist.

3.5 Leg 2 Survey Results

Leg 2 aerial surveys for narwhal were conducted in the North Baffin area during August 2022. The objectives of the surveys were to obtain abundance estimates of narwhal during the open-water season and within the time frame identified by DFO for the Eclipse Sound and Admiralty Inlet summer stock areas. Open-water surveys (Leg 2) were flown in the Eclipse Sound grid and Admiralty Inlet grid from 13–21 August. A total of four surveys were attempted in the Eclipse Sound survey grid and two surveys were attempted in the Admiralty Inlet survey grid during Leg 2. Complete coverage was obtained on three of the four surveys in Eclipse Sound and both of the surveys in Admiralty Inlet.

3.5.1 Survey Coverage

Four surveys were attempted over nine days during the open-water season in the Eclipse Sound and Admiralty Inlet grids (see Appendix B; Figures B-9 to B-14). Over the course of the four surveys, a total of 7,771.89 km of survey effort was conducted which included both visual and photographic surveys (Table 9).

Eclipse Sound Grid: Visual surveys totaled 3,963.11 km and photographic surveys totaled 1,222.87 km of survey effort (Table 9). Three of the four surveys (Surveys 2, 3, and 4) achieved complete coverage of the survey grid (see Appendix B; Figures B-11, B-8, B-12 and B-14). Due to deteriorating conditions (i.e., fog causing low visibility) at the Mary River site Survey 1 had to be terminated early resulting in an incomplete survey. Survey 2 was flown during high sea states and was latter removed from the abundance estimate.

Admiralty Inlet Grid: Visual surveys totaled 2,281.63 km and photographic surveys totaled 304.29 km of survey effort (Table 9). Two surveys (Surveys 3 and 4) were flown in Admiralty Inlet in 2022 and both obtained complete coverage of the survey grid (see Appendix B; Figures B-10 and B-13).

Table 9: Visual (V) and photographic (P) survey effort undertaken during Leg 2

	Survey 1	Survey 2	Survey 3	Survey 4
Survey Stratum	**13 Aug**	**14–16 Aug**	**17–18 Aug**	**21 Aug**
Pond Inlet (PI)	V	V	V	V
Eclipse Sound East (ESE)	V	V	V	V
Eclipse Sound West (ESW)	—	V	V	V
Milne Inlet North (MIN)	V	V	V&P	V
Milne Inlet South (MIS)	P	P	P	P
Tremblay Sound (TS)	—	P	P	P
Navy Board Inlet (NBI)	—	V	V	V
Eclipse Fjords	V	V	V	V
Eclipse Visual Effort (km)	507.08	1,140.60	1,190.78	1,124.64
Eclipse Photographic Effort (km)	84.44	374.84	394.60	368.99
Eclipse Total Effort (km)	591.52	1,515.44	1,585.38	1,493.63
Admiralty Inlet North (AIN)	—	V	V&P	—
Admiralty Inlet South (AIS)	—	V&P	V	—
Admiralty Fjords	—	V	V	—
Admiralty Visual Effort (km)	—	1,147.00	1,134.63	—
Admiralty Photographic Effort (km)	—	63.39	240.90	—
Admiralty Total Effort (km)	—	1,210.39	1,375.53	—
Combined Total Effort (km)	591.52	2,725.83	2,960.91	1,493.63

3.5.2 Sighting Conditions

MMOs recorded environmental sighting conditions during visual surveys at the beginning and end of each transect and anytime conditions changed along the track. All sighting conditions were recorded within the MMO field of view (1 km of the transect line). Sightings conditions were evaluated based on survey effort when each condition was observed. For calculating abundance estimates, distance analyses used the sighting conditions as covariates in the model.

Ice Cover

Ice cover ranged from 0/10 to 1/10 ice concentrations during Leg 2 of the 2022 MMASP (Figure 23). The first two surveys in the Eclipse Sound grid had less than 1% of the survey effort flown in 1/10 ice concentrations. The remaining four survey flown had no ice present in the survey grids.

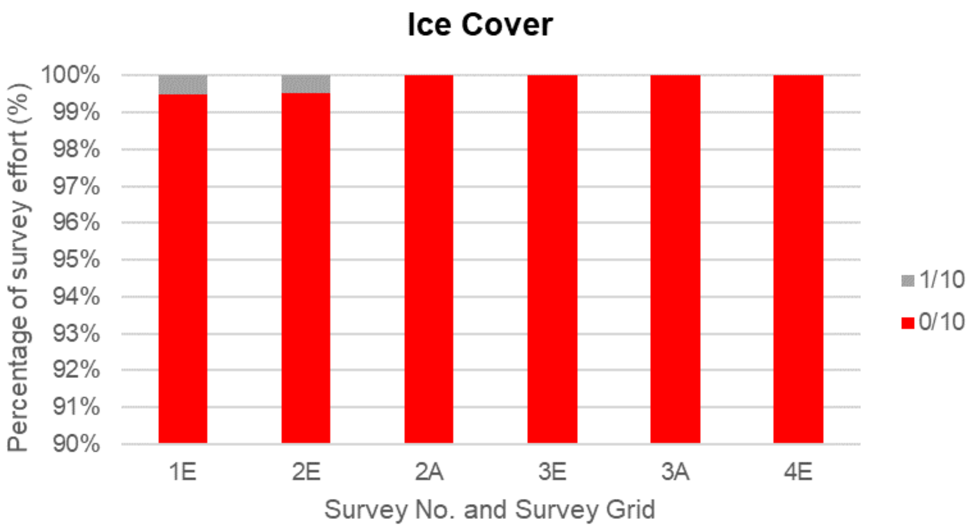


Figure 23: Ice cover during Leg 2 of the 2022 MMASP. Survey grid denoted with ‘E’ for Eclipse Sound and ‘A’ for Admiralty Inlet.

Fog

Two measurements of fog were used as sighting conditions. Fog cover was assessed as the percent (0–100%) of fog obscuring the viewing area and fog intensity (four levels: “none” when there was no fog, “light” fog that animals were visible through, “moderate” when animals were likely missed in the fog, and “thick” when animals were certainly missed in the fog). Areas that were forecasted to be foggy were avoided when daily surveys were planned. Fog cover ranged from None to 100% cover during Leg 2 of the 2022 MMASP. Fog was present during Surveys 2 and 4 in the Eclipse Sound grid and accounted for 1% of the effort of each survey (Figure 24). Most of the fog that was present on the survey was primarily of light and moderate thickness (Figure 25).

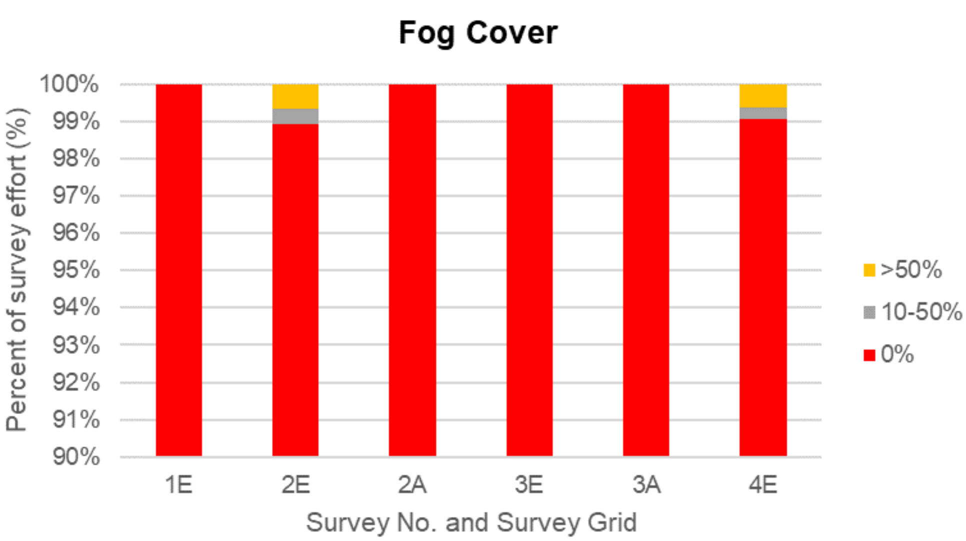


Figure 24: Fog cover during Leg 2 of the 2022 MMASP. Survey grid denoted with ‘E’ for Eclipse Sound and ‘A’ for Admiralty Inlet.

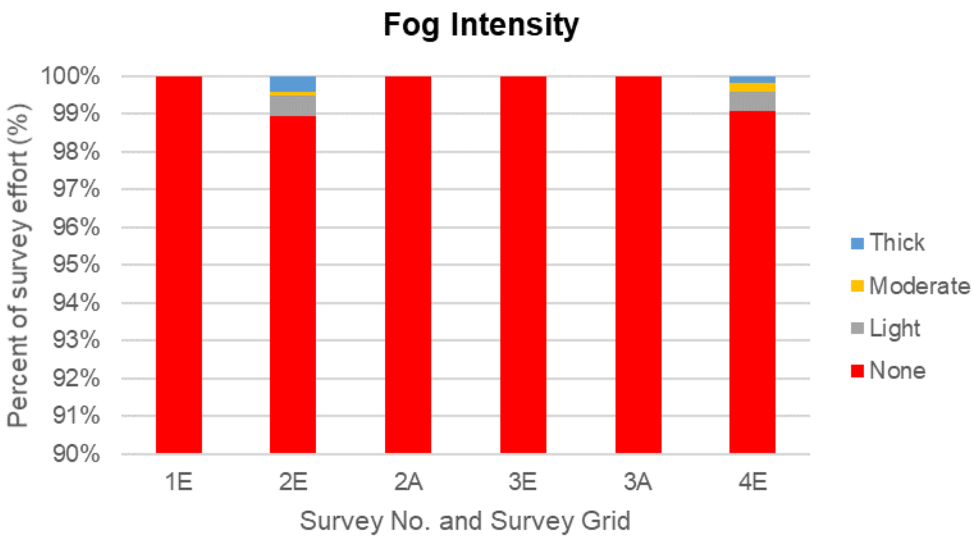


Figure 25: Fog intensity during Leg 2 of the 2022 MMASP. Survey grid denoted with 'E' for Eclipse Sound and 'A' for Admiralty Inlet.

Beaufort Sea State

On a scale of 0 to 12 (see Appendix A, Table 1), the Beaufort Sea State (BF) ranged from BF 0 (glassy mirror) to BF 6 (large waves) during Leg 2 of the 2022 MMASP (Figure 26). Most sea state conditions were recorded between BF 0 (glassy mirror) and BF 3 (large wavelets, scattered whitecaps) for both survey grids. Areas that were forecasted to have high sea states (> BF 4) were avoided when daily surveys were planned. If sea state conditions exceeded BF 4, the area was generally abandoned, and the survey was resumed in an area with more favorable environmental sighting conditions.

High sea states have a negative effect on cetacean counts (DeMaster et al. 2001; Gosselin et al. 2007). DeMaster et al. (2001) found the probability of sightings beluga whales in BF sea state 1 is significantly greater than that for sighting beluga whales in BF sea state 2, 3, and 4. Gosselin et al. (2007) stated that abundance estimation tends to be lower as BF increases. The lower estimates are driven by a reduction in encounter rate associated with increasing average daily BF condition. Another effect that might intuitively be expected with increasing BF is a reduction in effective strip half width as whales may not be visible as far away from the plane in bad sea conditions. During DFO surveys in Eclipse Sound and Admiralty Inlet in 2016, five surveys were terminated due to high sea states of BF 4–5 (DFO 2017). Surveys flown in areas of high sea states have a high probability of negatively biasing the number of animals present and should be excluded from the analysis if a statistically significant difference is found between two abundance estimates.

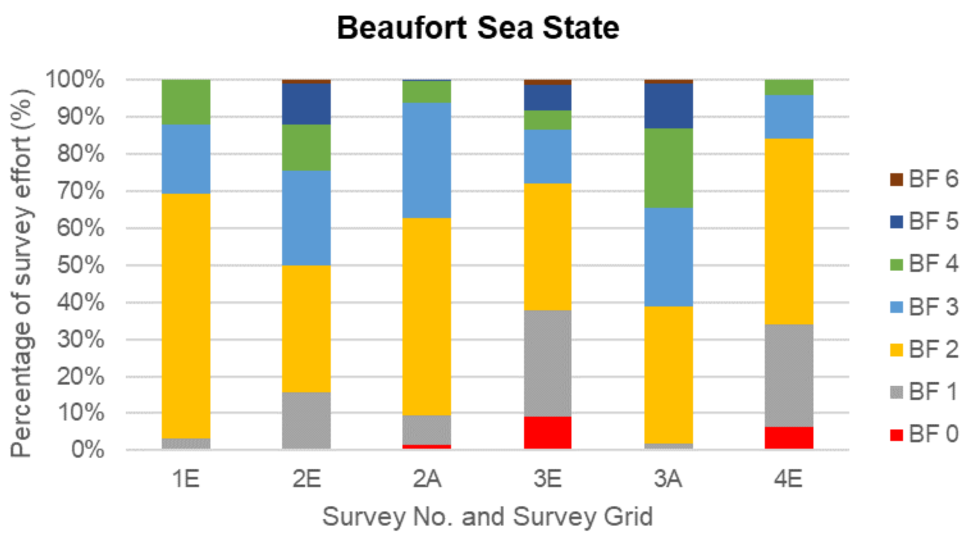


Figure 26: Beaufort Sea State during Leg 2 of the 2022 MMASP. Survey grid denoted with 'E' for Eclipse Sound and 'A' for Admiralty Inlet.

Glare Cover and Intensity

Two measurements of glare were used as sighting conditions. Glare cover was assessed as the percent (0–100%) of the viewing area affected by sun reflection and glare intensity (four levels: "none" when there was no reflection, "low" when animals were likely detected in center of reflection angle, "moderate" when animals were likely missed in the center of reflection angle, and "intense" when animals were certainly missed in the center of reflection angle). All surveys were flown during partial cloudy conditions with glare recorded as "none" for 71% to 81% of the survey effort in each survey (Figure 27). When glare was present intensity was denoted as intense for 4% to 15% of the survey effort in each survey (Figure 28).

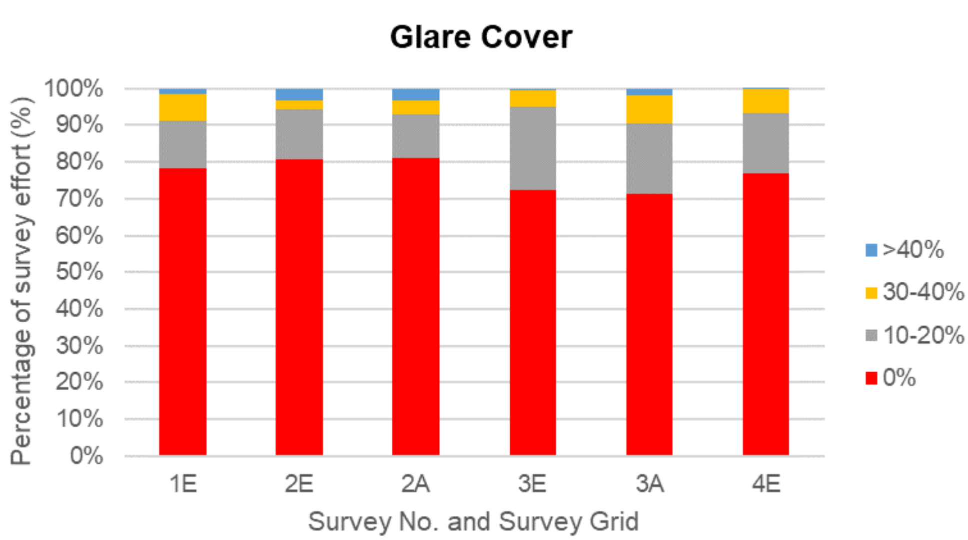


Figure 27: Glare cover during Leg 2 of the 2022 MMASP. Survey grid denoted with 'E' for Eclipse Sound and 'A' for Admiralty Inlet.

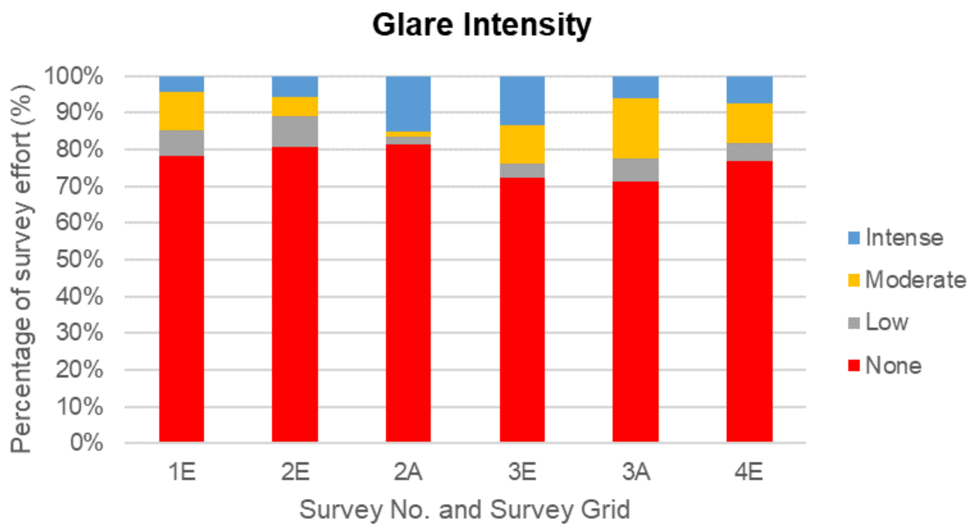


Figure 28: Glare intensity during Leg 2 of the 2022 MMASP. Survey grid denoted with 'E' for Eclipse Sound and 'A' for Admiralty Inlet.

3.5.3 Visual Survey Sightings

Eclipse Sound Grid: Six different species of marine mammals were observed during the four Leg 2 visual surveys of the 2022 MMASP in the Eclipse Sound grid: narwhal, beluga whale, ringed seal, harp seal, bearded seal, and polar bear. Unidentified whales and seals were also recorded during the visual surveys. Visual sightings that were duplicates (i.e., sighted by both the primary and secondary observer) were only counted once and visual sightings observed in photographic areas are not included in this section. Table 10 summarizes the number of marine mammal sightings and animals recorded for each species in each of the four Leg 2 surveys. A total of 417 sightings and 679 animals were recorded during Leg 2 visual surveys in the Eclipse Sound grid.

The most commonly sighted species was ringed seal (208 sightings totalling 226 animals), followed by narwhal (84 sightings totalling 138 animals), harp seal (24 sightings totalling 203 animals), polar bear (six sightings of single animals), bearded seal (six sightings of single animals), and beluga whale (three sightings of single animal). There were also 85 unidentified seal sightings totalling 96 animals and one sighting of a single unidentified whale

Table 10: Marine mammal sightings (including off-effort) in Eclipse Sound grid during Leg 2

	Survey 1		Survey 2		Survey 3		Survey 4	
Species	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals
Narwhal	6	11	1	3	1	1	76	123
Beluga	0	0	0	0	2	2	1	1
Unidentified Whale	0	0	0	0	0	0	1	1
Ringed Seal	10	12	35	37	98	106	65	71
Harp Seal	5	26	4	64	6	62	9	51

Species	Survey 1		Survey 2		Survey 3		Survey 4	
	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals
Bearded Seal	0	0	0	0	3	3	3	3
Unidentified Seal	16	18	6	8	43	49	20	21
Polar Bear	0	0	1	1	1	1	4	4
Total	**34**	**67**	**47**	**113**	**154**	**224**	**179**	**275**

Admiralty Inlet Grid: Seven different species of marine mammals were observed during the two Leg 2 visual surveys of the 2022 MMASP in the Admiralty Inlet grid: narwhal, bowhead whale, beluga whale, ringed seal, harp seal, walrus, and polar bear. Unidentified whales and seals were also recorded during the surveys. Visual sightings that were duplicates (i.e., sighted by both the primary and secondary observer) were only counted once and visual sightings observed in photographic areas are not included in this section. Table 11 summarizes the number of marine mammal sightings and animals recorded for each species during each of the Leg 2 surveys. A total of 1,264 sightings and 2,560 animals were recorded during Leg 2 visual surveys in the Admiralty Inlet grid.

The most commonly identified species was narwhal (945 sightings totalling 1,809 animals), followed by ringed seal (125 sightings totalling 145 animals), harp seal (107 sightings totalling 458 animals), beluga whale (10 sightings totalling 53 animals), bowhead whale (seven sightings totalling 11 animals), polar bear (five sightings totalling seven animals), and walrus (one sighting of a single animal). There were also 62 sightings of unidentified seal totalling 74 animals and one sighting of a pair of unidentified whales.

Table 11: Marine mammal sightings (including off-effort) in Admiralty Inlet grid during Leg 2

Species	Survey 2		Survey 3	
	No. Sightings	No. Animals	No. Sightings	No. Animals
Narwhal	568	1,063	377	746
Bowhead Whale	5	7	2	4
Beluga	9	52	1	1
Unidentified Whale	2	2	0	0
Ringed Seal	90	106	35	39
Harp Seal	70	255	37	203
Walrus	0	0	1	1
Unidentified Seal	36	46	26	28
Polar Bear	4	5	1	2
Total	**784**	**1,536**	**480**	**1,024**

Narwhal

Eclipse Sound Grid: During the open-water season (Leg 2) narwhal were primarily sighted in Milne Inlet South, Milne Inlet North, and Tremblay Sound strata as evident in the photographic coverage of the areas (see Appendix B, Figures B-9, B-11, B-12 and B-14). Relatively few narwhal were recorded in Eclipse Sound, Navy Board Inlet or the Fjords during the four Leg 2 surveys conducted in August.

A total of 84 sightings and 138 individual narwhal were recorded during the Leg 2 visual survey of the Eclipse Sound grid (Table 10). Narwhal group sizes ranged from single animals to a group size of six, with mean and median group sizes of 1.6 and 1.0, respectively. Ten mother/calf pairs and two lone calves were recorded during the surveys. One mother/calf pair was observed during Survey 2 (16 August) in Milne Inlet North stratum. The remaining mother/calf pair were observed during Survey 4 (21 August), in Milne Inlet North, Eclipse Sound West and White Bay Fjord strata.

Admiralty Inlet Grid: During Survey 2, narwhal were observed dispersed through the central portion of the Admiralty Inlet North and concentrated along the western shore of Admiralty Inlet South (see Appendix B; Figure B-10). During Survey 4, narwhal were observed dispersed through the central portion of the Admiralty Inlet North and concentrated along the western shore (see Appendix B, Figure B-13).

A total of 945 sightings and 1,809 individual narwhal were recorded during the two Leg 2 visual surveys of the Admiralty Inlet grid (Table 11). Narwhal group sizes ranged from single animals to a group size of 20, with mean and median group sizes of 2.0 and 1.0, respectively. One hundred and thirteen mother/calf pairs and 50 lone calves were recorded during the surveys.

Bowhead Whale

Eclipse Sound Grid: No bowhead whale was observed in Eclipse Sound during Leg 2 visual surveys.

Admiralty Inlet Grid: Bowhead whale were observed in Admiralty Inlet during Leg 2 surveys flown in August. Bowhead whale sightings were located primarily in the same areas that narwhal were sighted (see Appendix B, Figures B-10 and B-13). A total of seven sightings totalling 11 bowhead whales were recorded during the Leg 2 visual surveys of the Admiralty Inlet grid (Table 11). Bowhead group sizes ranged from single animals to pairs, with mean and median group sizes of 1.6 and 2.0, respectively. Two mother/calf pairs were observed on the 14 August.

Beluga Whale

Eclipse Sound Grid: There were three sightings of a single beluga observed in Eclipse Sound during Leg 2 visual surveys. Two sightings were observed on 17 August (Survey 3); one in the Milne Inlet North stratum and the other in the Navy Board Inlet stratum. The third sighting was observed on 21 August (Survey 4) in the Pond Inlet stratum (see Appendix B, Figures B-12 and B-14).

Admiralty Inlet Grid: Beluga were observed in Admiralty Inlet during Leg 2 surveys flown in August. During Survey 2 (14 August), nine beluga sightings of varying group sizes were observed in Admiralty Inlet South (see Appendix B; Figure B-10). During Survey 4 (18 August), one beluga whale was observed in Baillarge Bay (see Appendix B, Figure B-13).

A total of ten sightings and 53 individual beluga were recorded during the Leg 2 visual surveys of the Admiralty Inlet grid (Table 11). Beluga group sizes ranged from single animals to a group size of 16, with mean and median group sizes of 5.3 and 3.0, respectively.

Unidentified Whale

Eclipse Sound Grid: A single unidentified whale was observed in Eclipse Sound East stratum on 16 August (Survey 4) (Table 10; see Appendix B, Figure B-14).

Admiralty Inlet Grid: There were two sightings of a single unidentified whale observed on 14 August (Survey 2) in the Admiralty North stratum during the Leg 2 visual surveys (Table 11; see Appendix B, Figure B-10).

Ringed Seal

Eclipse Sound Grid: Ringed seals were observed during all Leg 2 visual surveys throughout the Eclipse Sound grid (see Appendix B, Figures B-9, B-11, B-12 and B-14). There was a total of 208 sightings totalling 226 individual ringed seals recorded during Leg 2 visual surveys (Table 10). Ringed seal sightings were primarily of single animals (195 of 208 sightings). The remaining ringed seal sightings observed consisted of eleven sightings of pairs, one sighting of four animals, and one sighting of five animals.

Admiralty Inlet Grid: Ringed seals were observed during both surveys flown during Leg 2 visual surveys of the Admiralty Inlet grid (see Appendix B, Figures B-10 and B-13). There was a total of 125 sightings totalling 145 individual ringed seals recorded during Leg 2 visual surveys (Table 11). Ringed seal sightings were primarily of single animals (108 of 125 sightings). The remaining ringed seal sightings observed consisted of fourteen sightings of pairs and three sightings of three animals.

Harp Seal

Eclipse Sound Grid: Harp seal were observed on all Leg 2 visual surveys. They were observed primarily at the top of Navy Board Inlet and in the Pond Inlet stratum (see Appendix B, Figures B-9, B-11, B-12 and B-14). A total of 24 sightings and 203 individual harp seals were recorded during Leg 2 visual surveys (Table 10). Harp seal were observed with group sizes that ranged from one to 50 animals with mean and median group sizes of 8.5 and 2.0, respectively.

Admiralty Inlet Grid: Harp seal were observed on both Leg 2 visual surveys in Admiralty Inlet grid (see Appendix B, Figures B-10 and B-13). A total of 107 sightings and 458 individual harp seals were recorded during Leg 2 visual surveys (Table 11). Harp seals were observed throughout the survey area with group sizes ranging from one to 50 animals with mean and median group sizes of 4.3 and 2.0, respectively.

Walrus

Eclipse Sound Grid: No walrus was observed in Eclipse Sound during Leg 2 visual surveys

Admiralty Inlet Grid: One walrus sighting of a single animal was observed in Admiralty Inlet during Leg 2 visual surveys. It was sighted on 18 August (Survey 3) in the northern portion of Admiralty Inlet close to the western shore (see Appendix B, Figure B-13).

Unidentified Seal

Eclipse Sound Grid: Unidentified seals were observed throughout the survey area during Leg 2 visual surveys (see Appendix B, Figures B-9, B-11, B-12 and B-14). A total of 85 sightings and 96 seals were recorded with mean and median group sizes of 1.1 and 1.0, respectively (Table 10).

Admiralty Inlet Grid: Unidentified seals were observed throughout the survey area during Leg 2 visual surveys in the Admiralty Inlet grid (Appendix B, Figures B-10 and B-13). A total of 62 sightings and 74 seals were recorded with mean and median group sizes of 1.2 and 1.0, respectively (Table 11).

Polar Bear

Eclipse Sound Grid: Six polar bear sightings of single animals were made during Leg 2 visual surveys in the Eclipse Sound grid (Table 10). All sightings occurred in Navy Board Inlet stratum, with one sighting seen during Surveys 2 and 3 and the remaining four sightings during Survey 4 (see Appendix B, Figures B-11, B-12 and B-14). Three of the sightings were identified as adults and one sighting was identified as a juvenile.

Admiralty Inlet Grid: Five polar bear sightings totalling seven individuals were made during Leg 2 visual surveys in the Admiralty Inlet grid (Table 11). Three of the sightings were of single animals identified as adults and located in Admiralty Inlet North stratum on 14 August (Appendix B, Figure B-10). The two remaining sightings were of mothers with a cub on the 14 August in Admiralty Inlet South (Appendix B, Figure B-10) and on the 18 August in Elwin Inlet (Appendix B, Figure B-13).

3.5.4 Photographic Survey Sightings

Photographic analyses were only completed for surveys with complete survey (transect) coverage and adequate sighting conditions in the photo area. For the Eclipse Sound survey grid, this included Surveys 2, 3 and 4. Survey 1 was incomplete due to poor visibility conditions at Mary River causing the survey to be terminated early for safety reasons. Surveys 2, 3 and 4 were completed in one day with good sighting conditions. Survey 2 was eventually excluded from the abundance estimate due to poor sighting conditions during large portions of the visual survey. For the Admiralty Inlet survey grid, analysis of the aerial photographic data for Leg 2 included Surveys 2 and 3. Both surveys were completed in one day with good sighting conditions. No other surveys were attempted in Admiralty Inlet. All photographic surveys were flown at 610 m (2,000 ft), except the one photographic survey flown in Tremblay Sound during Survey 4 which was flown at 457 m (1,500 ft) due to low ceilings.

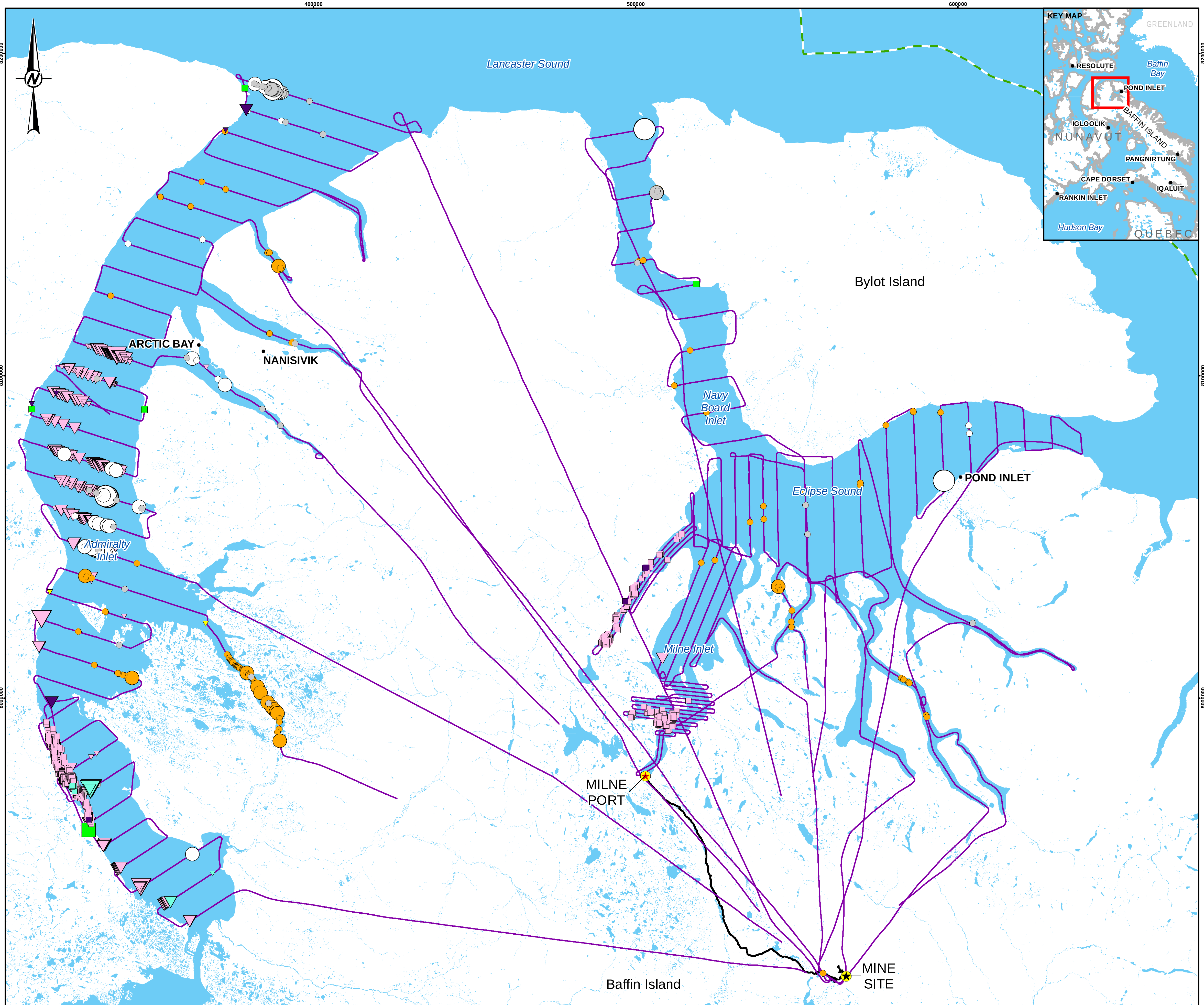
Eclipse Sound Grid: During the open-water season (Leg 2), narwhal were primarily sighted in Milne Inlet South, Milne Inlet North, and Tremblay Sound strata as evident in the photographic coverage of the areas (Figure 29A–B, Figure 30A–B, and Figure 31A–B). A total of 2,591 sightings and 4,300 narwhal were recorded for photographic surveys in Eclipse Sound grid (Table 12). Narwhal group sizes ranged from single animals to a group size of 13, with mean and median group sizes of 1.7 and 1.0, respectively. Four bowhead whale sightings of single animals were recorded during the Leg 2 photographic surveys (Table 12). One sighting of three beluga whales was recorded during Survey 3 in the Milne Inlet North stratum (Table 12; Figure 28B).

Admiralty Inlet Grid: In Admiralty Inlet, two of the three photographic surveys were conducted in the northern stratum and one was conducted in the southern stratum (Figure 29A–B and Figure 30A–B). A total of 7,139 sightings and 11,636 narwhal were recorded for the photographic surveys in the Admiralty Inlet grid (Table 12). Narwhal group sizes ranged from single animals to a group size of 11, with mean and median group sizes of 1.6 and 1.0, respectively. One bowhead whale sighting of a single animal was recorded during Survey 2 in the Admiralty Inlet South stratum (Table 12; Figure 27B). A total of four sightings and 22 beluga whales were recorded during the photographic surveys in the Admiralty Inlet grid (Table 12). Beluga group sizes ranged from a pair of animals to a group size of 10, with mean and median group sizes of 5.5 and 5.0, respectively.

Table 12: Photographic survey sightings in the Eclipse Sound and Admiralty Inlet grids during Leg 2

Grid	Survey #	Stratum	Narwhal		Bowhead[b]		Beluga[b]	
			No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals
Eclipse	2	MIS	104	119	0	0	0	0
Eclipse	2	TS	229	405	2	2	0	0
Eclipse	3	MIN	735	1,385	0	0	1	3
Eclipse	3	MIS	284	451	1	1	0	0
Eclipse	3	TS	572	945	1	1	0	0
Eclipse	4	MIS	662	986	0	0	0	0
Eclipse	4	TS	5	9	0	0	0	0
Admiralty	2	AIS	1,690	3,127	1	1	4	22
Admiralty	3	AIN1	1,294	1,806	0	0	0	0
Admiralty	3	AIN2	4,155	6,703	0	0	0	0

[a] MIN=Milne Inlet North, MIS=Milne Inlet South, TS=Tremblay Sound, AIN=Admiralty Inlet North, AIS=Admiralty Inlet South
[b] Not including re-sightings



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE
- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BELUGA
- BOWHEAD WHALE
- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1
- 2-10
- 10+

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

POLAR BEAR
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

UNIDENTIFIED WHALE
- 1

0 25 50

1:1,200,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF MARINE MAMMALS RECORDED DURING LEG 2 - SURVEY 2 ON 14-16 AUGUST 2022 IN ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT

wsp

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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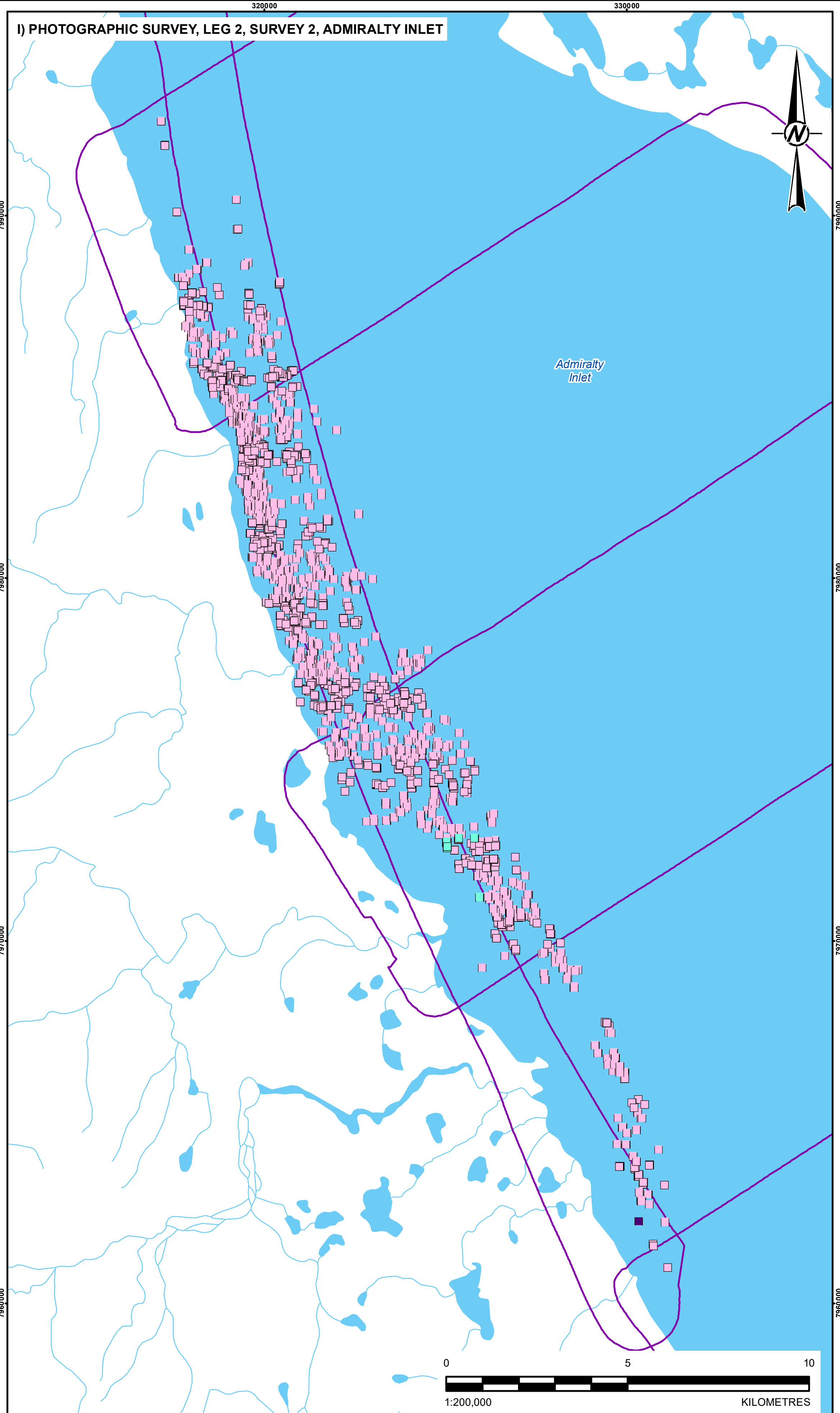
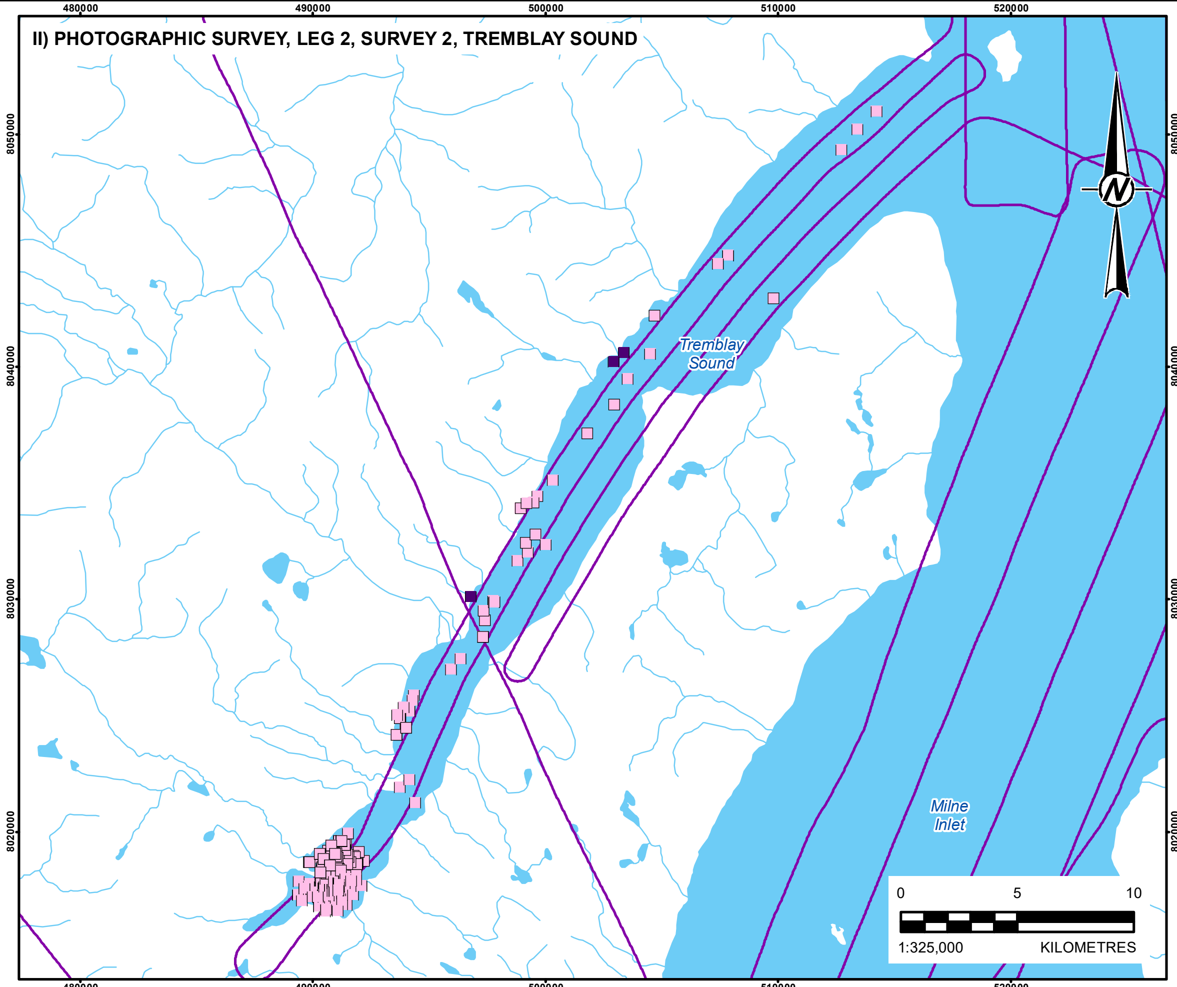
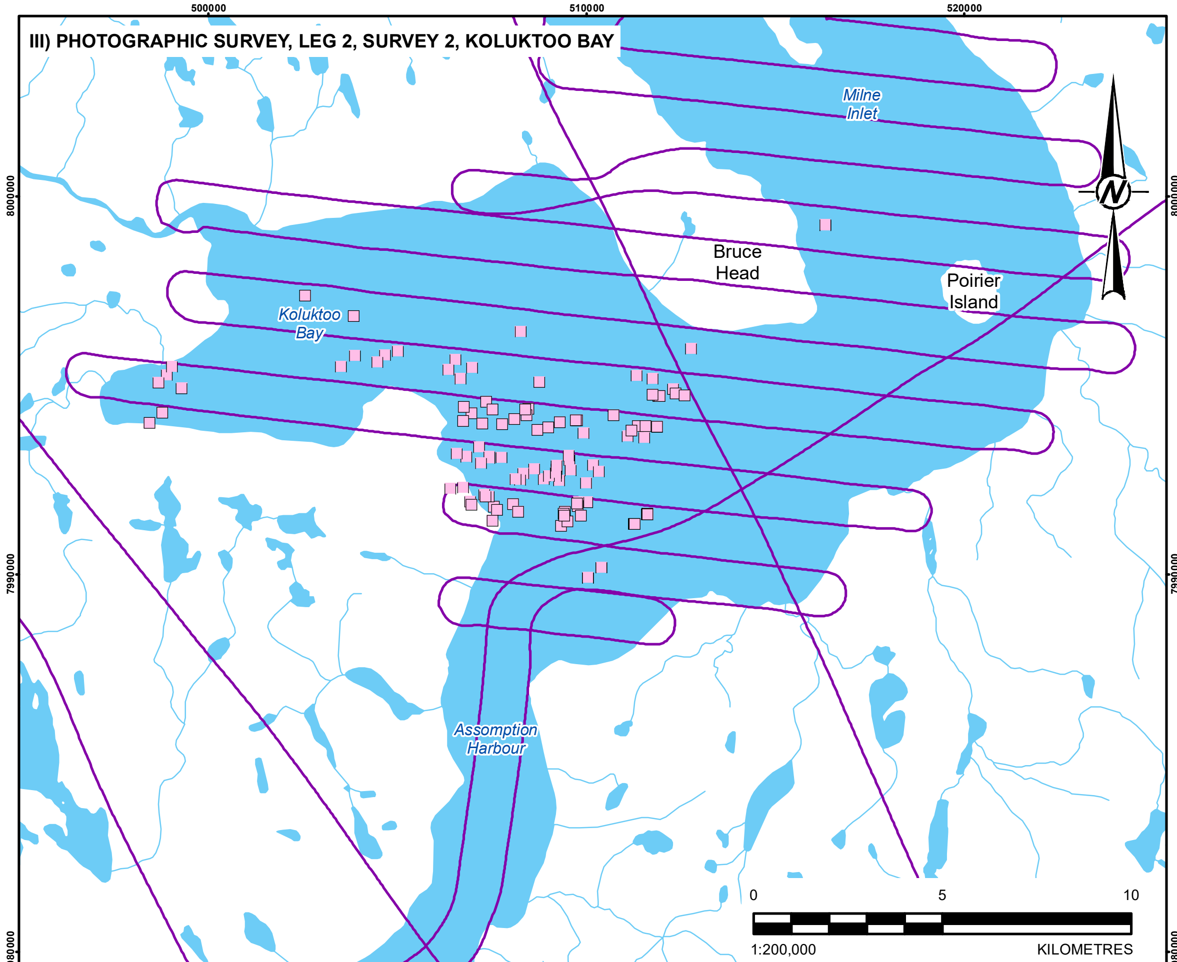




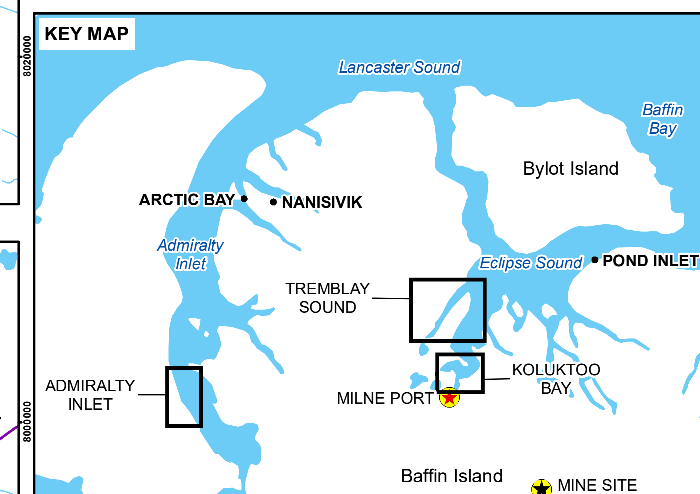


LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE
- AERIAL SURVEY TRACK
- WATERCOURSE
- WATERBODY

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BELUGA
- BOWHEAD WHALE
- NARWHAL



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PROJECTION: UTM ZONE 17 DATUM: NAD 83

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BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE

PHOTOGRAPHIC SURVEYS DURING LEG 2 - SURVEY 2 ON 14-16 AUGUST 2022 IN ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT

wsp

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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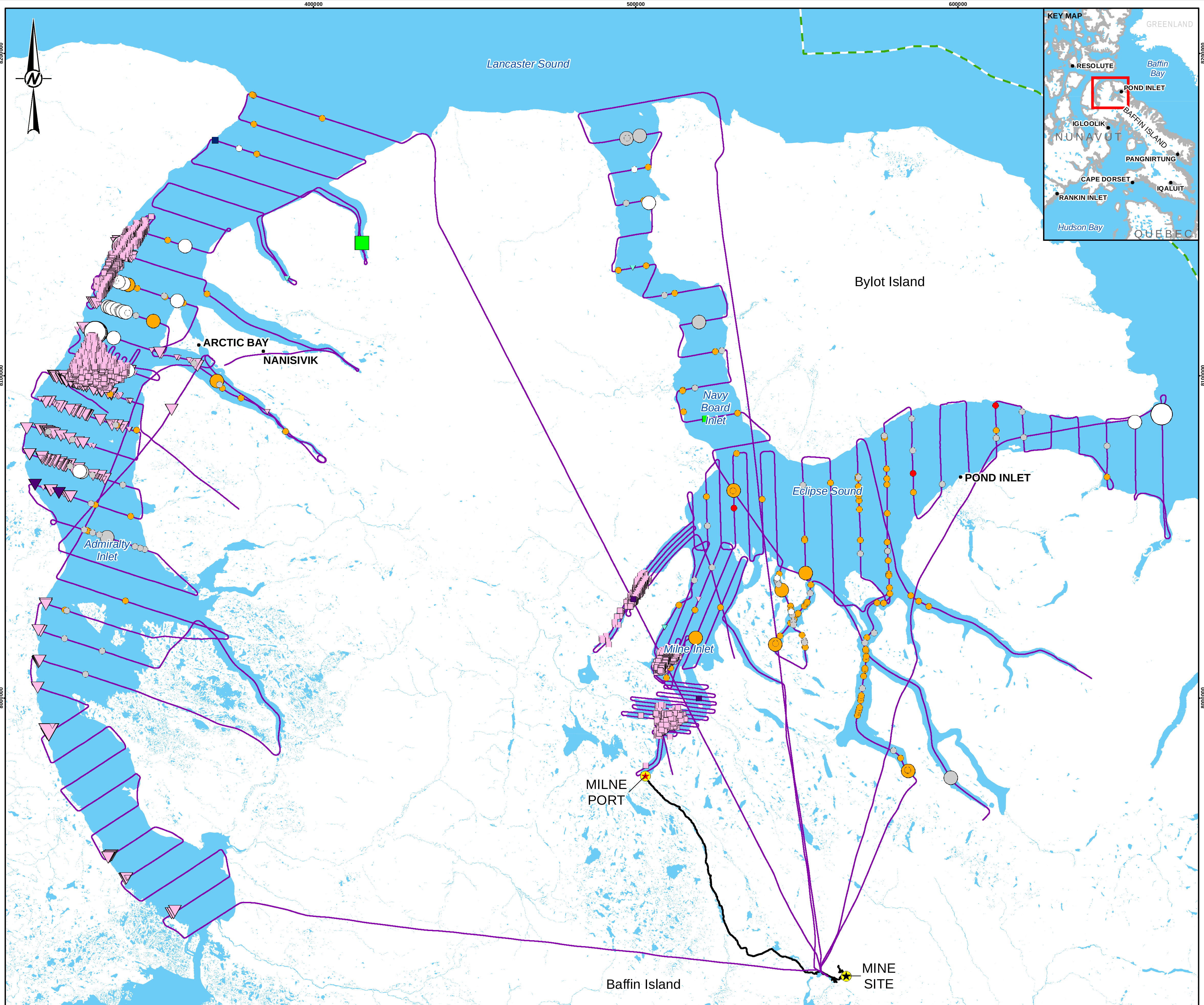

LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE
- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BELUGA
- BOWHEAD WHALE
- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BELUGA
- 1

BOWHEAD WHALE
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

POLAR BEAR
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

WALRUS
- 1

UNIDENTIFIED SEAL
- 1
- 2-10

0 25 50
1:1,200,000 KILOMETRES

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF MARINE MAMMALS RECORDED DURING LEG 2 - SURVEY 3 ON 17-18 AUGUST 2022 IN ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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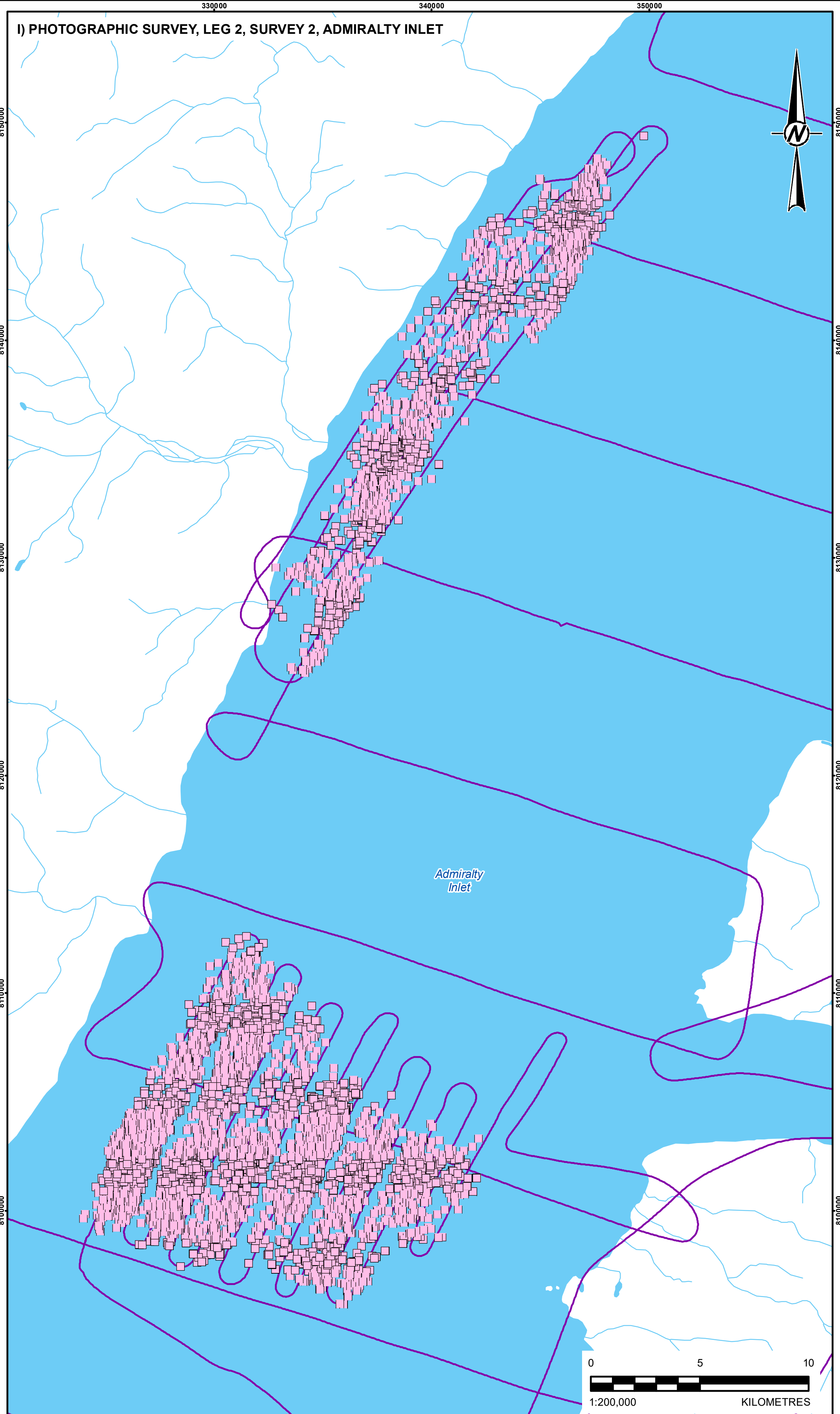
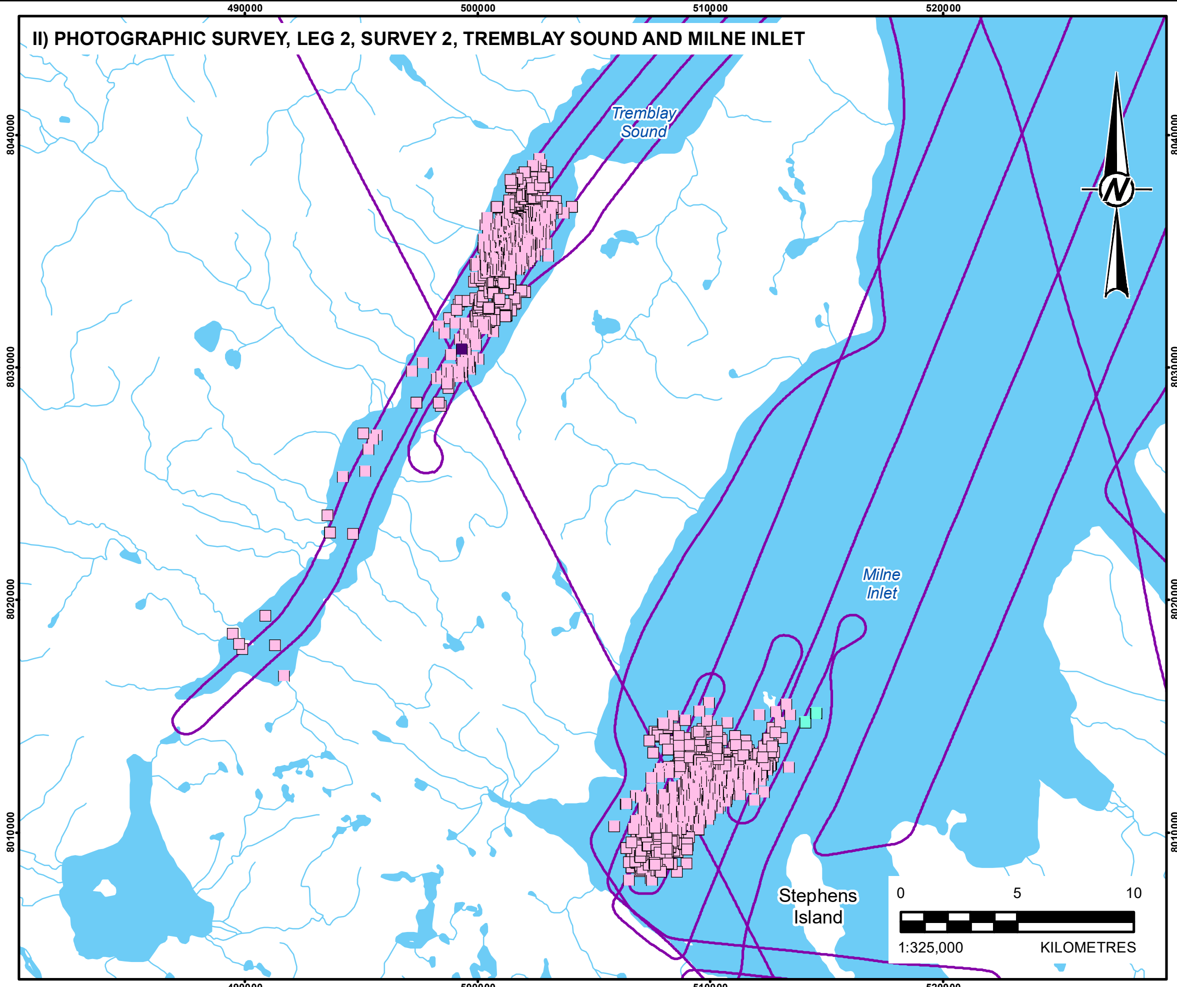
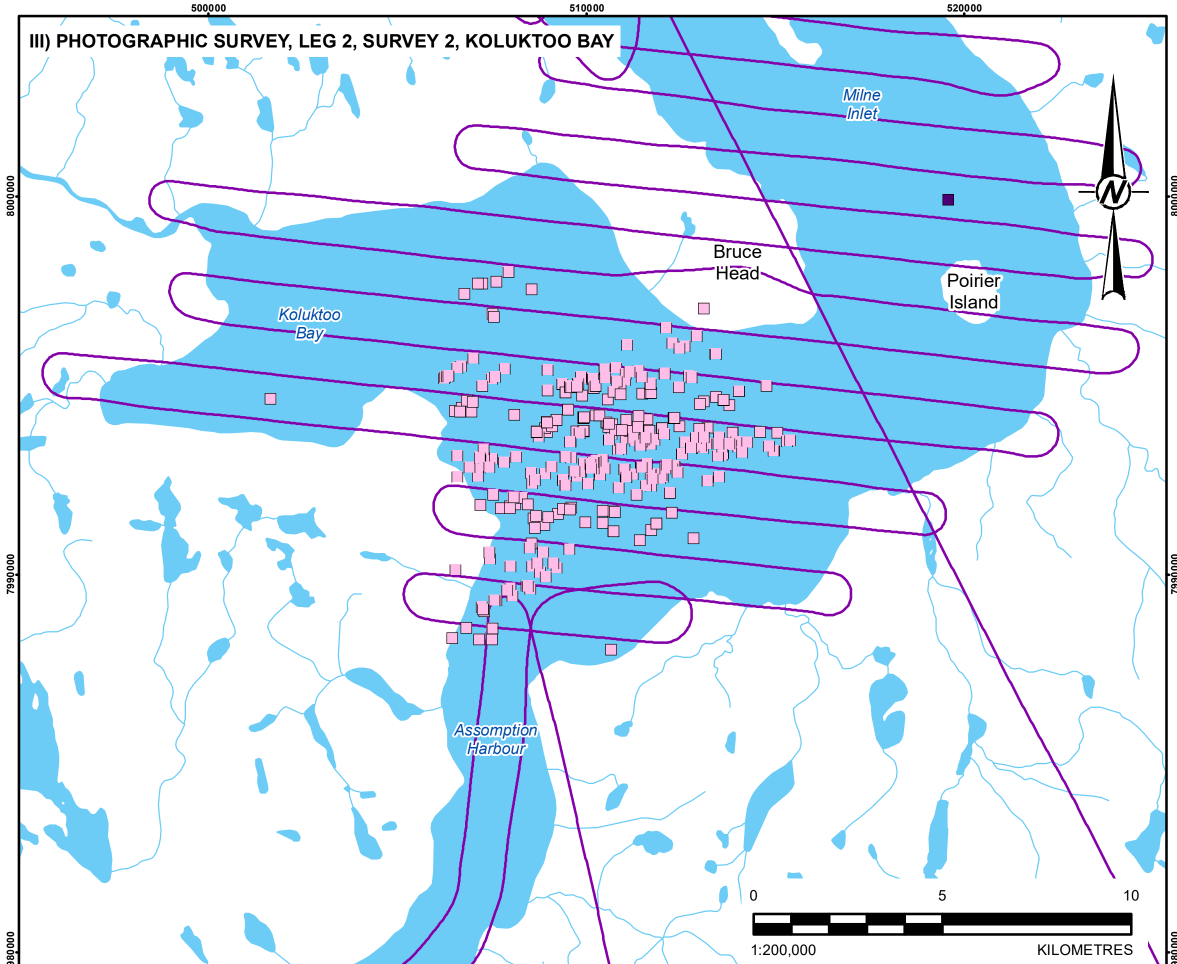






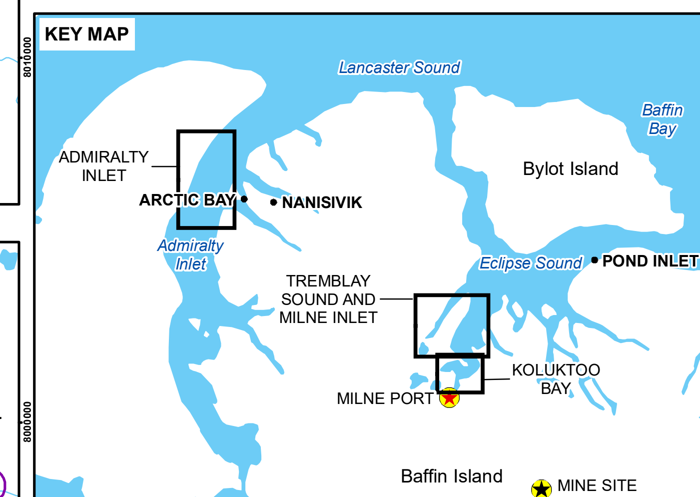
LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE
- AERIAL SURVEY TRACK
- WATERCOURSE
- WATERBODY

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BELUGA
- BOWHEAD WHALE
- NARWHAL

KEY MAP



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PROJECT

MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE

PHOTOGRAPHIC SURVEYS DURING LEG 2 - SURVEY 3 ON 17-18 AUGUST 2022 IN ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT

wsp

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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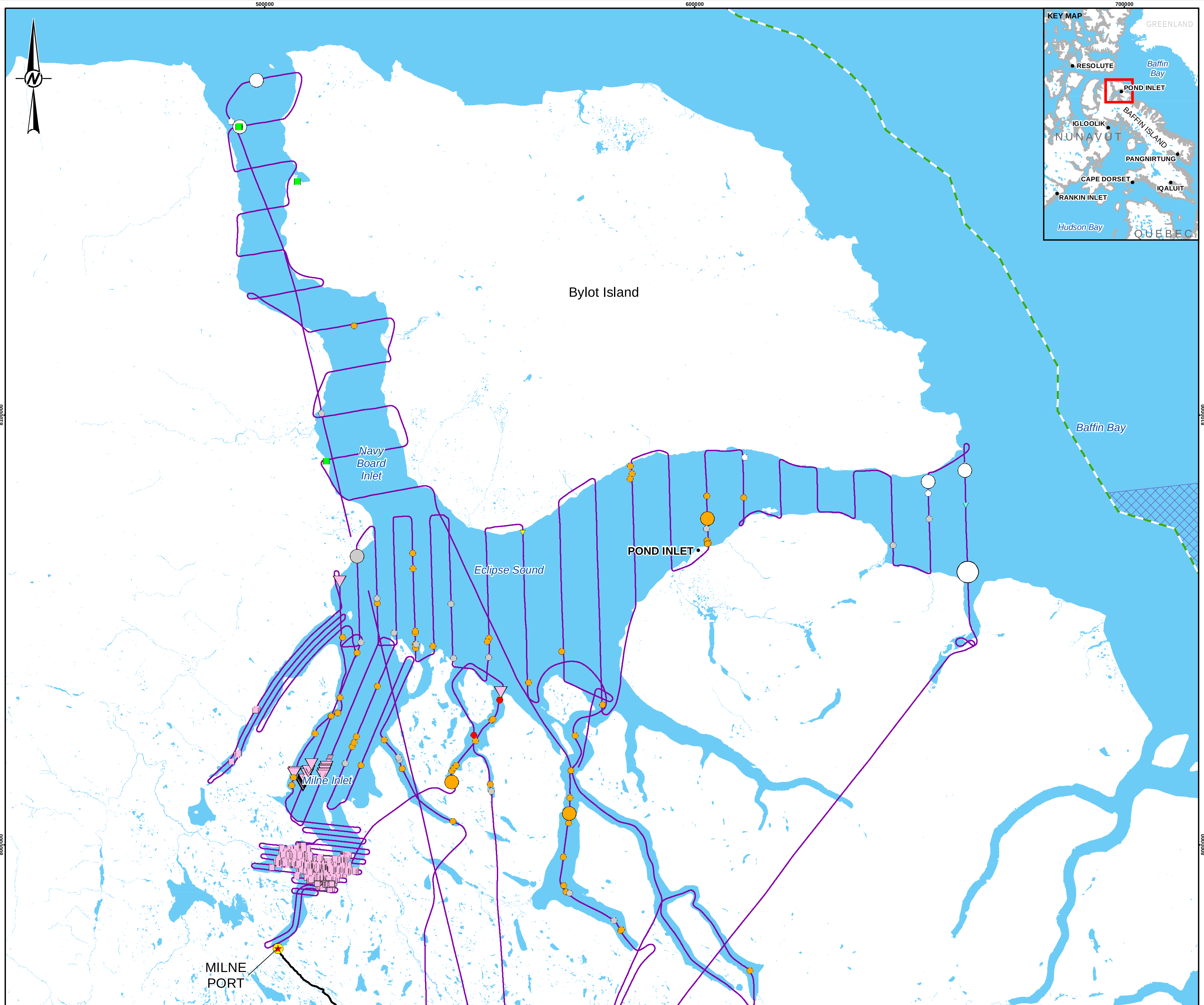

LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE
- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BELUGA
- 1

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

UNIDENTIFIED WHALE
- 1

0 25 50

1:900,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF MARINE MAMMALS RECORDED DURING LEG 2 - SURVEY 4 ON 21 AUGUST 2022 IN ECLIPSE SOUND GRID

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	31A

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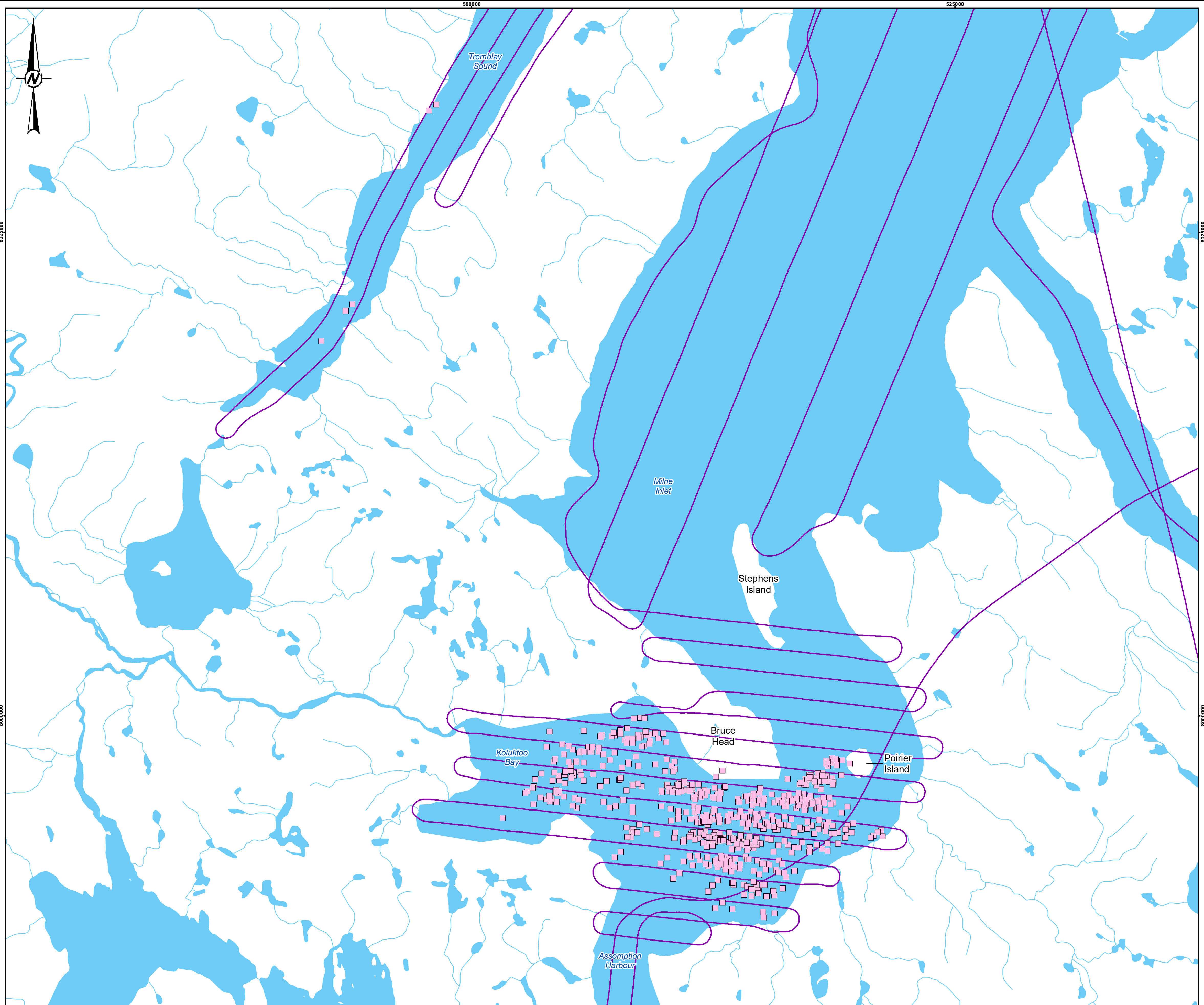
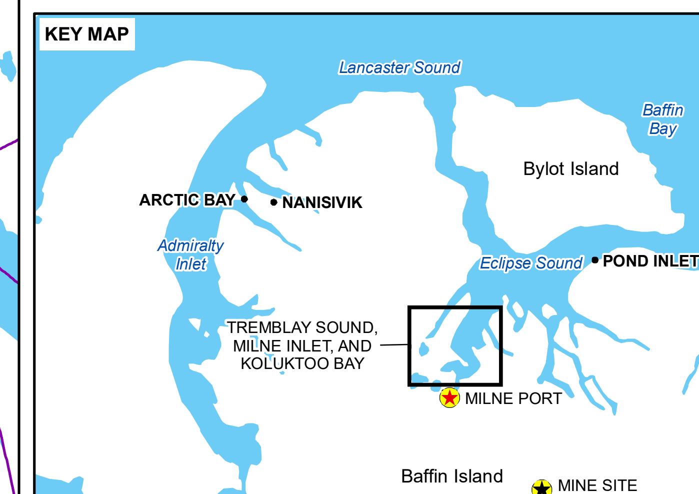


LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE
- AERIAL SURVEY TRACK
- WATERCOURSE
- WATERBODY

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL



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BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
PHOTOGRAPHIC SURVEYS DURING LEG 2 - SURVEY 4 ON 21 AUGUST 2022 IN ECLIPSE SOUND GRID

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	31B

3.5.5 Narwhal Abundance Estimates

Narwhal abundance estimates were calculated for Surveys 2, 3, and 4 in the Eclipse Sound survey grid. Survey 1 was incomplete due to deteriorating conditions at Mary River causing the survey to be terminated early for safety reasons. Survey 2 was completed in one day although sighting conditions during visual surveys in two strata (Navy Board Inlet and Eclipse Sound West) were poor, possibly resulting in missed narwhal sightings. Surveys 3 and 4 were completed in one day with good sighting conditions throughout the visual and photographic surveys.

For the Admiralty Inlet survey grid, narwhal abundance estimates were calculated for Surveys 2 and 3. Survey 2 was completed in one day with good sighting conditions. Survey 3 was completed in one day although sighting conditions during visual surveys in the Admiralty Inlet South stratum were poor. No other surveys were attempted in Admiralty Inlet.

3.5.5.1 Visual Survey Data Characteristics

Sightings data from both the Eclipse Sound and Admiralty Inlet survey grids supplemented one another to provide for a more robust model of probability detection function. The same marine mammal observers flew both the Eclipse Sound and Admiralty Inlet grids and were incorporated into the model as a covariate. Re-sightings were not used for the estimation of any variables.

One detection function was created for narwhal for the combined Eclipse Sound and Admiralty Inlet grids. Sightings data was pooled between dates to increase sample size in order to meet the assumptions of the detection probability model, but only if the spatial distribution of species detections (sightings) were similar between those days (i.e., the ability to detect animals at a distance did not change under the available sighting conditions, including altitude). Combining survey data for days with apparent variability in detectability can skew findings and result in either an over- or under-estimation of true animal density for a specific date. Location (i.e., Eclipse Sound vs Admiralty Inlet) was included as a covariate in the detection function model but it did not lower Akaike's Information Criterion (AIC) values and consequently, location specific models were not created.

The number of narwhal sightings during fjord transects was too small (n=9) to appropriately perform abundance estimations using the Density Surface Modelling technique (Doniol-Valcroze et al. 2015b). Individual fjord surveys were instead treated as separate transects within a fjord-based stratum and analyzed the same as transects within the other regional strata.

Analysis of sightings data was performed using the MRDS analysis package (Laake et al. 2018) within R version 4.1.2 (R Core Team 2021). The shape of the histogram suggested that some animals were missed close to the track line despite the bubble windows. There was a risk that hazard-rate and half-normal distributions would overestimate the probability of detection and the resulting effective strip width. The gamma key function does not assume a 100% detection on the track line (g(0)=1). A horizontal offset value can be applied to the gamma detection function data since that key function assumes zero detections at zero distance. However, offsetting the data for the gamma key function does bias the results, with larger offsets creating a greater bias. Environmental and observer covariates were included for fitting the detection function and mark-recapture models. Models were selected using the minimum AIC. Although four gamma key function models had AIC scores lower than that of the best half-normal model (see Appendix C), there were issues with model convergence issues for mark-recapture models when they included distance as a covariate. This convergence issue, combined with concerns regarding how mark-recapture models were combined by the R-package with gamma key function models, led to the selection of the half-normal model with AIC = 12730.029 (see Appendix C). The top half-normal and gamma key function models both included the same covariates and had similar detection probabilities (47.0 vs. 46.3% probability, respectively). The potential issues with the MRDS R-package have been raised with its development team but no answers were available at the time of reporting.

The combined narwhal sightings (n=992) for the Eclipse Sound and Admiralty Inlet survey grids from the open-water season survey (Leg 2) were used for estimating the detection function and mark-recapture detection probabilities for narwhal in Eclipse Sound and Admiralty Inlet (Figure 32). This was because the same observers were used for both the Eclipse Sound and Admiralty Inlet grids and location (i.e., Eclipse Sound or Admiralty Inlet) did not affect the model. Examination of the histogram of the perpendicular distances of unique sightings suggested right-truncating the data at 900 m (i.e., discarding sightings beyond 900 m).

Model selection was performed on the three key functions and all the combinations of environmental covariates. A half normal key function model, including 2nd order Cosine adjustment term with covariates GlareCover : GlareIntensity + ObserverTeam had the lowest AIC for detection function models: (g(x)=0.47 and CV=0.05%; see Appendix C).

Selection among mark-recapture models was performed on all combinations of environmental covariates. The lowest AIC was a model with covariates for observer + ObserverTeam : observer + ObserverTeam : distance + ObserverTeam (see Appendix C). It resulted in a p(0) of 0.78 for observers 1 (Figure 33) and 0.29 for observers 2 (Figure 34), and a combined p(0) of 0.83 and (CV=0.06). The combined models resulted in a detection probability of 0.39 (CV=0.08).

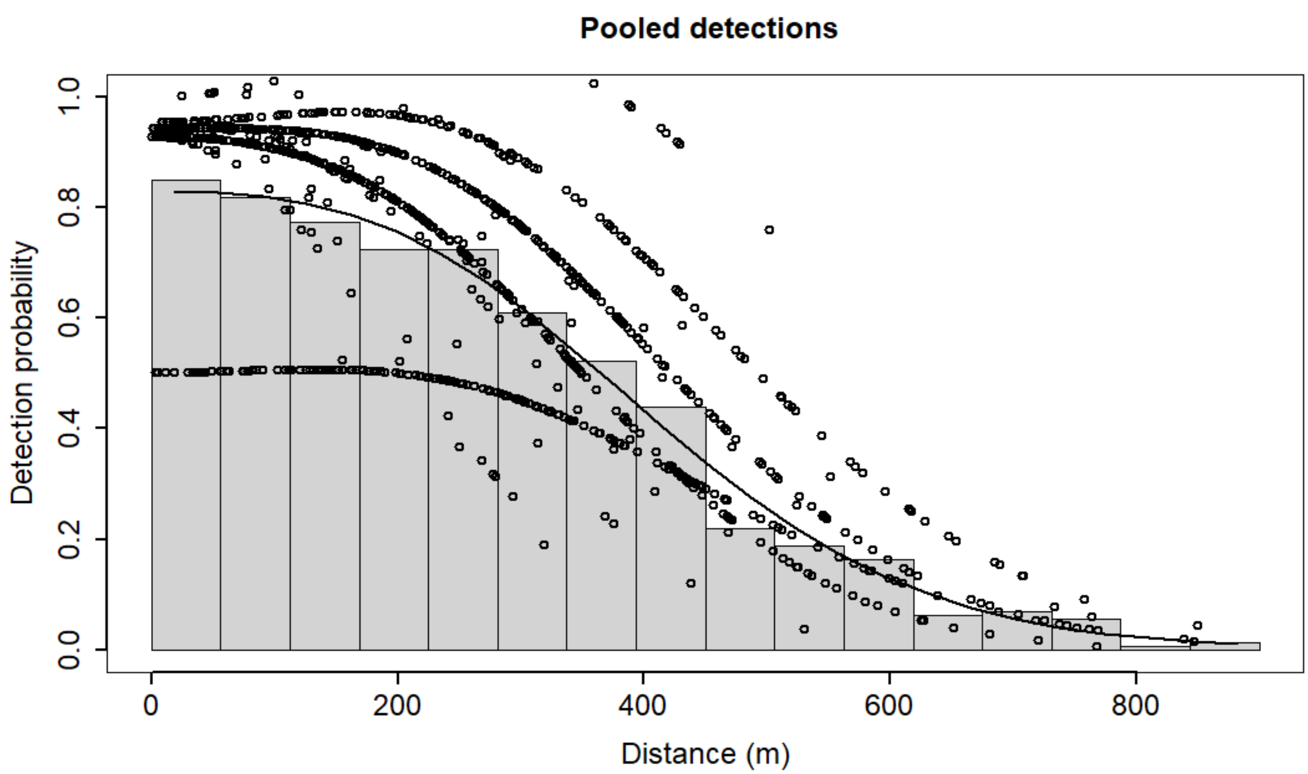

Figure 32: Perpendicular distances of narwhal sightings in Eclipse Sound and Admiralty Inlet survey grids.

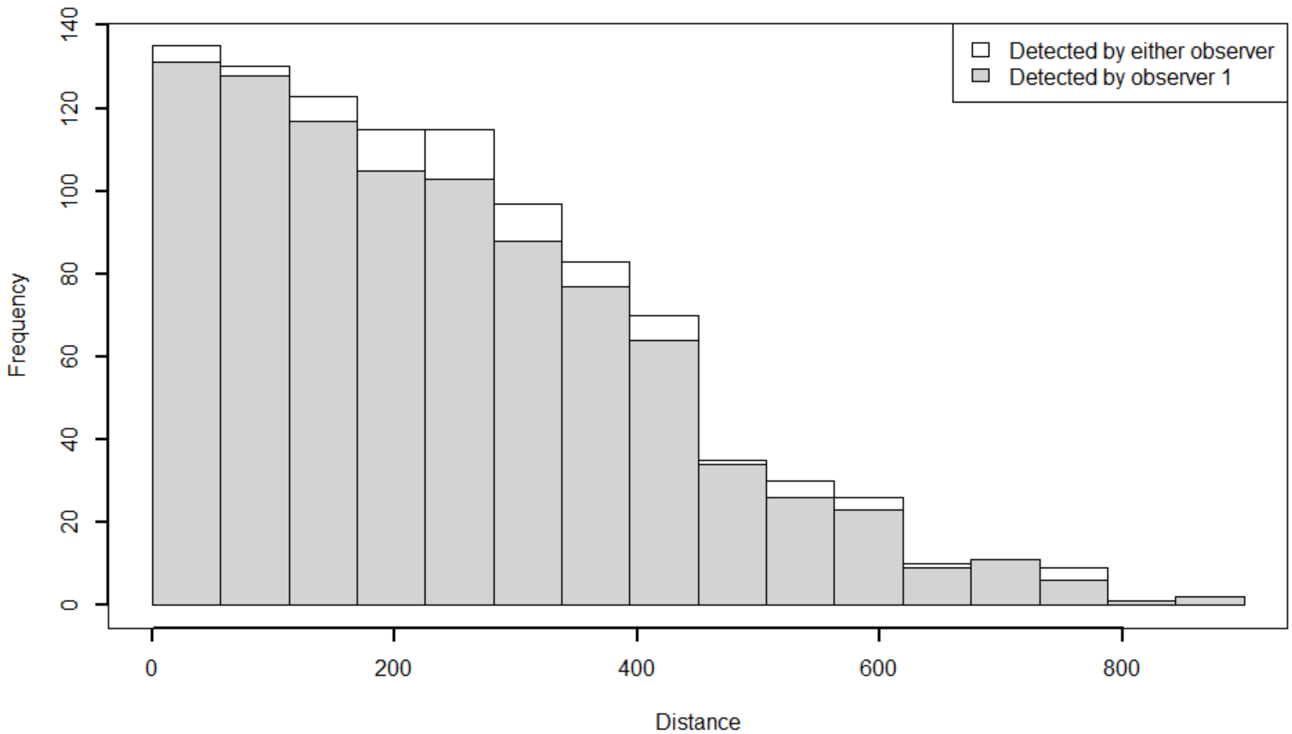

Figure 33: Distribution of narwhal sighting distances for Observer 1 and both observers combined (Observers 1 and 2) in Eclipse Sound and Admiralty Inlet survey grids. Distance is measured in meters.

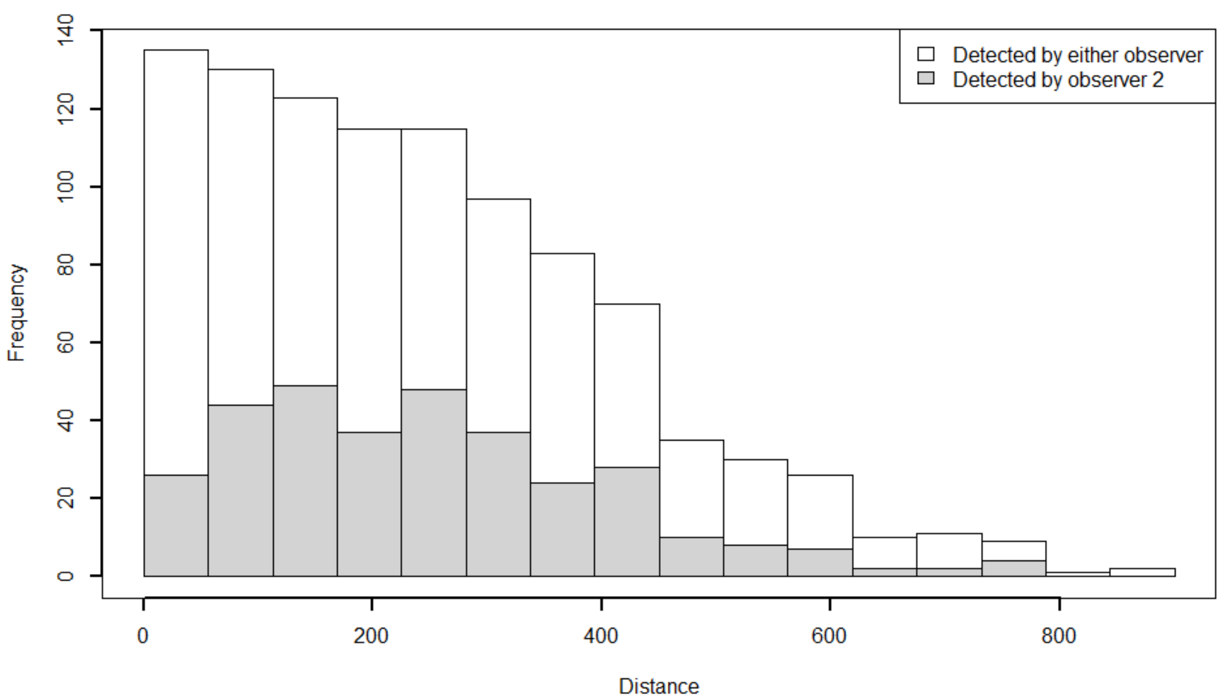

Figure 34: Distribution of narwhal sighting distances for Observer 2 and both observers combined (Observers 1 and 2) in Eclipse Sound and Admiralty Inlet survey grids. Distance is measured in meters.

The availability bias component of g(x), where an animal is diving and is thus out of visual range of the observers, requires species, and area-specific dive profile data to estimate proportion of time spent underwater (e.g., Barlow et al. 1988). A correction factor (2.94, CV=0.03 for mid-August) was applied to the data to account for potential availability bias for this species, adjusted for the specific observation platform. This correction factor is based on previously reported narwhal dive and aerial survey results (Doniol-Valcroze et al. 2015a; Watt et al. 2015).

3.5.5.2 Photographic Survey Data Characteristics

For the assessment of reliability and repeatability of the photographic data, a simple linear regression of the comparison of two experienced photo readers was run. Repeat counts of 933 photos were highly correlated (simple linear regression; R^2 = 0.926, $F_{1,931}$ = 11.667 x 10^3, p < 0.0001). Counts for the first and repeat reads varied between zero and nine (Table 13). The original counts were kept for the abundance analysis. The same photo analyst has been used since 2019 to analyse the photographs, which further reduces bias with photographic surveys.

Table 13: Count difference between first and repeat reads of the photographs

Difference in count between readers	Count	Higher original count	Higher secondary count
Same	388		
One	237	138	99
Two	112	64	48
Three	87	47	40
Four	47	34	13
Five	32	24	8
Six	15	8	7
Seven	8	5	3
Eight	5	3	2
Nine	2	2	0

With ideal sightings conditions for photographic data, one would expect a slight decrease in animal detectability with increasing distance from the track line. The data showed a slight decrease in sightings with increased distance from the track line (Figure 35). Possible factors affecting the detectability bias include camera angle, aircraft crab angle (cross wind), imprecise aircraft altitudes, obscurity of subsurface animals, photo observer bias, and animal behaviour. A detection function was created for narwhal in the photographic surveys. Surveys were selected for the analysis that had no land or glare which would skew the results.

A detection model fitted to the photographic data for one survey flown at 610 m (2,000 ft) resulted in a probability of detection of 0.8586 (C_d = detectability bias correction factor of 1.17, n=2,508), CV=0.02 (Figure 35). A hazard rate key function with no adjustments and a right truncation of 810 m had the lowest AIC of 33450.82 for the detection function model.

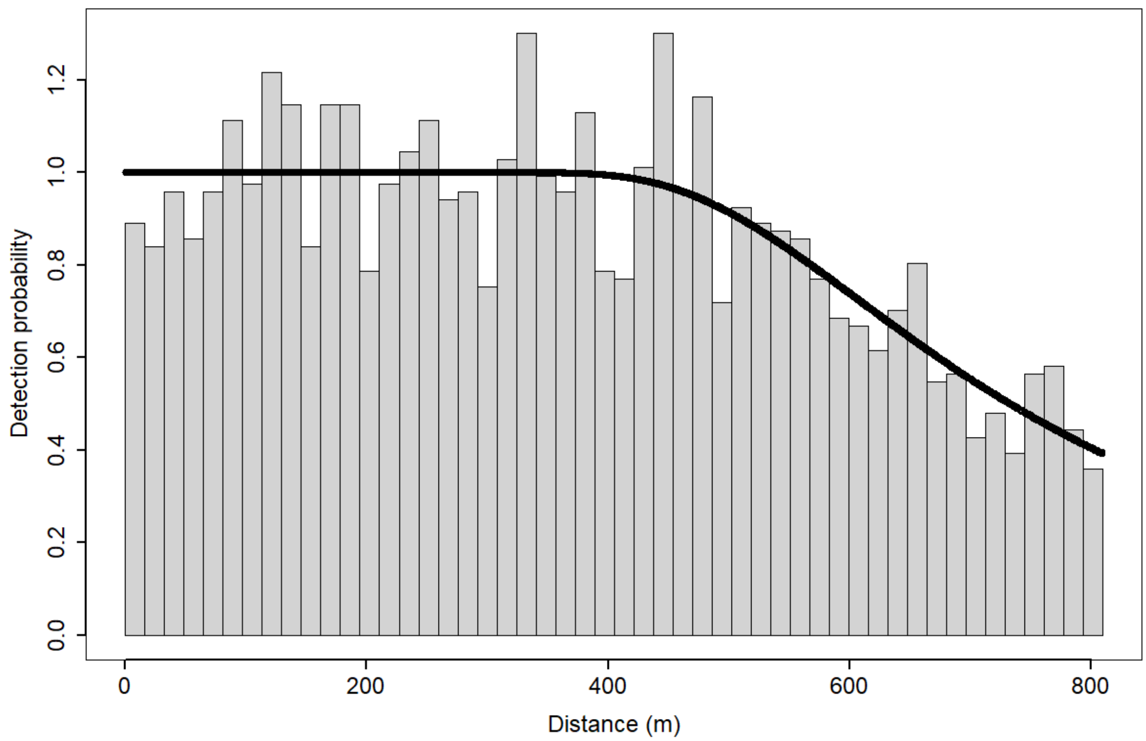

Figure 35: Detection Function for Photographic Survey Data at 610 m (2,000 ft).

3.5.5.3 2022 Narwhal Abundance

3.5.5.3.1 Eclipse Sound Stock

Overall, there were 76 narwhal visual sightings during Surveys 2, 3, and 4 (Table 14). All sightings had perpendicular distances recorded during flight.

During Survey 2 (16 August), a total of 1,140.6 km of transects were visually surveyed (Table 14). The total count of narwhal sightings observed on-effort in the visual survey area was one sighting before and after truncation (Table 14). Variation of the abundance estimate was a combination of the variation of detection function, encounter rate, cluster size, and availability bias. Although variation of the abundance estimate was a combination of the variation from detection function and encounter rate, the overall variation in abundance estimates came primarily from the encounter rate component (Table 14). The total narwhal abundance for Survey 2 combined visual surveys was estimated at 54 narwhal (CV=0.88) (Table 14).

The total length of transect lines visually surveyed during Survey 3 (17 August) was 1,190.7 km (Table 14). The total count of narwhal sightings observed on-effort in the visual survey area was one sighting before and after truncation (Table 14). For this survey, the overall variation in abundance estimates came primarily from the encounter rate component. The total narwhal abundance for Survey 3 visual surveys was estimated at 18 narwhal (CV=1.11) (Table 14).

During Survey 4 (21 August), a total of 1,124.7 km of transects were visually surveyed (Table 14). The total count of narwhal sightings observed on-effort in the visual survey area was 74 sightings before and after truncation (Table 14). For this survey, the overall variation in abundance estimates came primarily from the encounter rate component (Table 14). The total narwhal abundance for Survey 4 visual surveys was estimated at 2,092 narwhal (CV=0.46) (Table 14).

Table 14: Narwhal abundance estimates from visual surveys in Eclipse Sound grid during Leg 2

Survey #	Stratum[a]	Area (km^2)	Effort (km)	No. Sight. Before Trunc.	No. Sight. After Trunc.	Corrected Abundance	CV	% CV contributed by Encounter Rate	% CV contributed by Cluster Size
2	PI	1,381.3	61.7	0	0	-	-	-	-
2	ESE	2,066.5	254.4	0	0	-	-	-	-
2	ESW	841.0	179.0	0	0	-	-	-	-
2	MIN	681.3	158.8	1	1	54	0.88	99.1	0
2	NBI	2,007.8	163.5	0	0	-	-	-	-
2	Fjords	957.5	323.2	0	0	-	-	-	-
2	***Total***	**7,935.5**	**1,140.6**	**1**	**1**	**54**	**0.88**		
3	PI	1,381.3	154.0	0	0	-	-	-	-
3	ESE	2,066.5	230.7	0	0	-	-	-	-
3	ESW	841.0	180.9	0	0	-	-	-	-
3	MIN	626.6	144.2	1	1	18	1.11	99.4	0
3	NBI	2,007.8	204.2	0	0	-	-	-	-
3	Fjords	957.5	276.7	0	0	-	-	-	-
3	***Total***	**7,880.7**	**1,190.8**	**1**	**1**	**18**	**1.11**		
4	PI	1,381.3	152.1	0	0	-	-	-	-
4	ESE	2,066.5	227.2	0	0	-	-	-	-
4	ESW	841.0	182.6	1	1	116	0.88	99.1	0
4	MIN	681.3	160.0	72	72	1,944	0.50	94.5	2.6
4	NBI	2,007.8	149.0	0	0	-	-	-	-
4	Fjords	957.5	253.8	1	1	32	0.89	99.1	0
4	***Total***	**7,935.5**	**1,124.6**	**74**	**74**	**2,092**	**0.46**		

[a] PI=Pond Inlet, ESE= Eclipse Sound East, ESW=Eclipse Sound West, MIN=Milne Inlet North, NBI=Navy Board Inlet.

During Survey 2 (16 August), two photographic surveys were undertaken, one in Milne Inlet South (MIS) stratum and one in the Tremblay Sound (TS) stratum (see Figure 29B). A total of 2,273 photographs were taken to capture the narwhal aggregations in the two areas. The total area photographed was 406.08 km^2 (251.45 km^2 in MIS and 154.63 km^2 in TS; Table 15). The total count of narwhal in the photographed areas was 524 narwhal (119 in MIS and 405 in TS; see Table 12). The sum of the area of the individual photographs totaled 531.9 km^2 in

MIS and 321.1 km^2 in TS, resulting in an average density of 0.224 narwhal/km^2 in MIS and 1.261 narwhal/km^2 in TS. Multiplying the average density by the total area photographed resulted in a surface estimate of 56 narwhal in MIS and 195 narwhal in TS. The surface estimate was then corrected for availability bias using Cα=3.18 (correction from Watt et al. 2015) and detectability bias of 1.17, resulting in a total narwhal estimate for the photographed areas of 209 narwhal (CV=0.04) in MIS and 727 narwhal (CV=0.04) in TS (Table 15).

During Survey 3 (17 August), three photographic surveys were undertaken in the Eclipse Sound study area, one in the MIS stratum, one in the Milne Inlet North (MIN) stratum, and one in the TS stratum (see Figure 30B). A total of 2,546 photographs were taken to capture the narwhal aggregations in the three areas. The total area photographed was 465.86 km^2 (255.26 km^2 in MIS, 54.74 km^2 in MIN, and 155.86 km^2 in TS; Table 15). The total count of narwhal in the photographed areas was 2,781 narwhal (451 narwhal in MIS, 1,385 in MIN, and 945 narwhal in TS; see Table 12). The sum of the area of the individual photographs totaled 534.0 km^2 in the MIS, 106.6 km^2 in the MIN, and 309.0 km^2 in TS, resulting in an average density of 0.845 narwhal/km^2 in MIS, 12.997 narwhal/km^2 in MIN, and 3.058 narwhal/km^2 in TS. Multiplying the average density by the total area photographed resulted in a surface estimate of 216 narwhal in MIS, 712 narwhal in MIN, and 477 narwhal in TS. The surface estimate was then corrected for availability bias using Cα = 3.18 (correction from Watt et al. 2015) and detectability bias of 1.17, resulting in a total narwhal estimate for the photographed areas for Survey 3 of 806 narwhal (CV=0.04) in MIS, 2,656 narwhal (CV=0.04) in MIN, and 1,779 narwhal (CV=0.04) in TS (Table 15).

During Survey 4 (21 August), two photographic surveys were undertaken, one in the MIS stratum and one in the TS stratum (see Figure 31B). A total of 2,419 photographs were taken to capture the narwhal aggregations in the two areas. The total area photographed was 405.48 km^2 (255.48 km^2 in MIS and 150.00 km^2 in TS; Table 15). The total count of narwhal in the photographed areas was 995 narwhal (986 in MIS and nine in TS; see Table 12). The sum of the area of the individual photographs totaled 533.6 km^2 in MIS and 232.5 km^2 in TS, resulting in an average density of 1.848 narwhal/km^2 in MIS and 0.039 narwhal/km^2 in TS. Multiplying the average density by the total area photographed resulted in a surface estimate of 472 narwhal in MIS and six narwhal in TS. The surface estimate was then corrected for availability bias using Cα=3.16 (correction from Watt et al. 2015) and detectability bias of 1.17, resulting in a total narwhal estimate for the photographed areas for Survey 4 of 1,760 narwhal (CV=0.04) in MIS and 22 narwhal (CV=0.04) in TS (Table 15).

Table 15: Narwhal abundance estimates from photographic survey in Eclipse Sound grid during Leg 2

Survey #	Stratum[a]	# Photos	# Photos with Murky Water	# Photos with Glare	Photo Area (km^2)	Surface Count	Corrected Abundance	CV
2	MIS	1,414	0	2	251.45	56	209	0.04
2	TS	859	0	163	154.63	195	727	0.04
3	MIN	262	0	0	54.74	712	2,656	0.04
3	MIS	1,458	0	30	255.26	216	806	0.04
3	TS	826	0	93	155.86	477	1,779	0.04
4	MIS	1,397	0	0	255.48	472	1,760	0.04
4	TS	1022	0	66	150.00	6	22	0.04

[a] MIN=Milne Inlet North, MIS=Milne Inlet South, TS=Tremblay Sound.

For the Eclipse Sound stock, the narwhal abundance estimates calculated for the three survey replicates (Surveys 2, 3, and 4) ranged from 990 to 5,259 narwhal (Table 16). Survey 2 had high sea states in Navy Board Inlet (BF of 4–6 for 80% of effort) and western portions of Eclipse Sound (BF of 4–6 for 35% of effort). High sea states have a negative effect on cetacean counts (see Section 3.5.2). The abundance estimate for Survey 2 (990 narwhal, CV = 0.06, 95% CI of 885–1,107) was statistically different than the abundance estimate for Survey 3 (5,259 narwhal, CV = 0.02, 95% CI of 5,008–5,523) (t-test = 29.87, $p < 0.0001$) and statistically lower than the abundance estimate for Survey 4 (3,874 narwhal, CV = 0.25, 95% CI of 2,387–6,287) (t-test = 2.96, $p = 0.030$). Survey 2 was thus deemed an inaccurate representation of the Eclipse Sound narwhal abundance and was excluded from the averaged estimate of the Eclipse Sound stock.

The abundance estimate for Survey 3 (5,259 narwhal, CV = 0.02, 95% CI of 5,008–5,523) was not significantly different than the abundance estimate for Survey 4 (3,874 narwhal, CV = 0.25, 95% CI of 2,387–6,287) (t-test = 1.41, $p = 0.25$). Surveys 3 and 4 were averaged, resulting in an overall abundance estimate of 4,592 narwhal, CV = 0.10, 95% CI of 3,754–5,617 for the Eclipse Sound summer stock (Table 16).

Table 16: Narwhal abundance estimates from combined visual and photographic surveys in Eclipse Sound grid during Leg 2

Survey #	Survey Type	Estimate	CV	95% CI
2	Visual	54	0.88	12–240
2	Photographic	936	0.03	879–997
2	**Combined**	**990**	**0.06**	**885–1,107**
3	Visual	18	1.11	3–104
3	Photographic	5,241	0.02	4,993–5,501
3	**Combined**	**5,259**	**0.02**	**5,008–5,523**
4	Visual	2,092	0.46	881–4,967
4	Photographic	1,782	0.04	1,656–1,918
4	**Combined**	**3,874**	**0.25**	**2,387–6,287**
3 and 4	**Combined Average**	**4,592**	**0.10**	**3,754–5,617**

3.5.5.3.2 Admiralty Inlet Stock

Overall, there were 929 narwhal sightings while on-effort during Surveys 2 and 3 (Table 17). Initially, 26 of the sightings were missing perpendicular distances. After photo-verification of sightings with missing measurements, 15 perpendicular distances were recovered from the photographs, with the remaining 11 left as missing values.

During Survey 2 (14 August), a total of 1,147.0 km of transects were visually surveyed (Table 17). The total count of narwhal sightings observed on-effort in the visual survey area was 567 sightings before truncation and after truncation (Table 17). Variation of the abundance estimate was a combination of the variation of detection function, encounter rate, cluster size, and availability bias. For Survey 2 the variation in abundance estimates came primarily from the encounter rate and the cluster size components. The total narwhal abundance for Survey 2 visual surveys was estimated at 39,581 narwhal (CV=0.29) (Table 17).

The total length of transect lines visually surveyed during Survey 3 (18 August) was 1,134.6 km (Table 17). The total count of narwhal sightings observed on-effort in the visual survey area was 362 sightings before truncation and 359 after truncation (Table 17). The overall variation in abundance estimates came primarily from the encounter rate and cluster size components. The total narwhal abundance for Survey 3 visual surveys was estimated at 25,365 narwhal (CV=0.23) (Table 17).

Table 17: Narwhal abundance estimates from visual surveys in Admiralty Inlet grid during Leg 2

Survey #	Stratum[a]	Area (km^2)	Effort (km)	No. Sight. Before Trunc.	No. Sight. After Trunc.	Corrected Abundance	CV	% CV contributed by Encounter Rate	% CV contributed by Cluster Size
2	AIN	6,835.4	782.1	510	510	32,512	0.36	93.1	1.3
2	AIS	1,540.8	166.2	56	56	7,067	0.21	58.5	24.7
2	Fjords	756.2	198.7	1	1	2	0.42	95.9	0
2	**Total**	**9,132.4**	**1,147.0**	**567**	**567**	**39,581**	**0.29**		
3	AIN	6,515.4	740.7	334	332	22,991	0.25	86.5	2.3
3	AIS	1,651.7	191.8	21	20	2,344	0.54	81.3	16.3
3	Fjords	756.2	202.1	7	7	30	0.52	58.7	38.6
3	**Total**	**8,923.3**	**1,134.6**	**362**	**359**	**25,365**	**0.23**		

[a] AIN=Admiralty Inlet North, AIS=Admiralty Inlet South.

During Survey 2 (14 August), one photographic survey was undertaken in the Admiralty Inlet South (AIS) stratum (see Figure 30B). A total of 405 photographs were taken to capture the narwhal aggregations in the area. The total area photographed was 110.96 km^2 (Table 18). The total count of narwhal in the photographed areas was 3,127 narwhal (see Table 12). The sum of the area of the individual photographs totaled 235.1 km^2, resulting in an average density of 13.302 narwhal/km^2. Multiplying the average density by the total area photographed resulted in a surface estimate of 1,476 narwhal. The surface estimate was then corrected for availability bias using $C\alpha$=3.18 (correction from Watt et al. 2015), and detectability bias of 1.17, resulting in a total narwhal estimate for the photographed area for Survey 2 of 5,505 narwhal (CV=0.04) in AIS (Table 18).

During Survey 3 (18 August), two photographic surveys were undertaken in the Admiralty Inlet study area, both in Admiralty Inlet North (AIN) stratum (Figure 31B). A total of 1,546 photographs were taken to capture the narwhal aggregations in the two areas, with a total area photographed of 320.02 km^2 (128.81 km^2 in AIN1 and 191.21 km^2 in AIN2; Table 18). The total count of narwhal in the photographed areas was 8,509 narwhal (1,806 in AIN1 and 6,703 in AIN2; see Table 12). The sum of the area of the individual photographs totaled 128.8 km^2 in AIN1 and 390.4 km^2 in AIN2, resulting in an average density of 7.373 narwhal/km^2 in AIN1 and 17.165 narwhal/km^2 in AIN2. Multiplying the average density by the total area resulted in a surface estimate of 950 narwhal in AIN1 and 3,282 narwhal in AIN2. The surface estimate was then corrected for availability bias using $C\alpha$=3.18 (correction from Watt et al. 2015), and detectability bias of 1.17, resulting in a total narwhal estimate for the photographed areas for Survey 3 of 3,543 narwhal (CV=0.04) in AIN1 and 12,241 narwhal (CV=0.04) in AIN2 (Table 18).

Table 18: Narwhal abundance estimates from photographic surveys in Admiralty Inlet during Leg 2

Survey #	Stratum[a]	# Photos	# Photos Murky Water	# Photos with Glare	Area (km^2)	Surface Count	Corrected Abundance	CV
2	AIS	405	0	11	110.96	1,476	5,505	0.04
3	AIN1	613	0	0	128.81	950	3,543	0.04
3	AIN2	933	0	2	191.21	3,282	12,241	0.04

[a] AIN=Admiralty Inlet North, AIS=Admiralty Inlet South.

For the Admiralty Inlet stock, the narwhal abundance estimates calculated for the two survey replicates (Survey 2 and 3) ranged from 41,149 to 45,086 narwhal (Table 19). The abundance estimate for Survey 2 (45,086 narwhal, CV = 0.26, 95% CI of 27,396–74,200) was not significantly different than the abundance estimate for Survey 3 (41,149 narwhal, CV = 0.14, 95% CI of 31,038–54,554) (t-test = 0.30, p = 0.76). Survey 2 and 3 were therefore averaged, resulting in an overall abundance estimate of 43,042 narwhal, CV = 0.15, 95% CI of 32,218–57,502 for the Admiralty Inlet summer stock (Table 19).

Table 19: Narwhal abundance estimates from combined visual and photographic surveys in Admiralty Inlet grid during Leg 2

Survey #	Survey Type	Estimate	CV	95% CI
2	Visual	39,581	0.29	22,502–69,623
2	Photographic	5,505	0.04	5,106–5,935
2	**Combined**	**45,086**	**0.26**	**27,396–74,200**
3	Visual	25,365	0.23	16,137–39,870
3	Photographic	15,784	0.04	14,868–16,756
3	**Combined**	**41,149**	**0.14**	**31,038–54,554**
2 and 3	**Combined Average**	**43,042**	**0.15**	**32,218–57,502**

3.5.5.3.3 Combined Eclipse Sound and Admiralty Inlet Stocks

For the combined Eclipse Sound and Admiralty Inlet stock, the narwhal abundance estimates calculated for the two survey replicates (Survey 2 and 3) ranged from 46,076 to 46,408 narwhal (Table 20). The portion of Survey 2 flown in the Eclipse Sound grid was considered to be an inaccurate representation of the Eclipse Sound narwhal abundance (see Section 3.5.5.3.1), therefore Survey 3 was selected as the best abundance estimate of the combined Eclipse Sound and Admiralty Inlet stock with an abundance estimate of 46,408 narwhal (CV = 0.13, 95% CI of 36,129–59,611).

Table 20: Narwhal abundance estimates for the combined Eclipse Sound and Admiralty Inlet stocks during Leg 2

Survey #	Stock	Estimate	CV	95% CI
2	Eclipse Sound	990	0.06	885–1,107
2	Admiralty Inlet	45,086	0.26	27,396–74,200
2	Combined Stock	46,076	0.25	28,289–75,047
3	Eclipse Sound	5,259	0.02	5,008–5,523
3	Admiralty Inlet	41,149	0.14	31,038–54,554
3	**Combined Stock**	**46,408**	**0.13**	**36,129–59,611**

3.5.6 Abundance Comparison with Previous Years

During Leg 2, three surveys were flown in the Eclipse Sound grid and two surveys were flown in the Admiralty Inlet grid. Surveys 3 and 4 were combined to come up with an overall abundance estimate of 4,592 narwhal, CV = 0.10, 95% CI of 3,754–5,617 for the Eclipse Sound summer stock. Surveys 2 and 3 were combined to come up with an overall abundance estimate of 43,042 narwhal, CV = 0.15, 95% CI of 32,218–57,502 for the Admiralty Inlet summer stock. Survey 3 was selected as the best abundance estimate of the combined Eclipse Sound and Admiralty Inlet stock with an abundance estimate of 46,408 narwhal (CV = 0.13, 95% CI of 36,129–59,611) (Table 21).

Table 21: Comparison of narwhal abundance estimates for Eclipse Sound, Admiralty Inlet, and combined stocks

Stock	Year	Survey Dates (Survey #)	Abundance	CV	95% CI	Source
Eclipse Sound	2004	August	20,225	0.36	9,471–37,096	Richard et al. 2010
Eclipse Sound	2013	18–19 Aug	10,489	0.24	6,342–17,347[b]	Doniol-Valcroze et al. 2015a
Eclipse Sound	**2016**	**7–10 Aug**	**12,039**	**0.23**	**7,768–18,660**	**Marcoux et al. 2019**
Eclipse Sound	2016	15 Aug	20,093	0.57	6,449–104,339	Golder 2018b
Eclipse Sound	2016	21 Aug	12,955	0.16	7,245–23,166	Golder 2018b
Eclipse Sound	2019	21–22 Aug (#3)	7,765	0.04	7,182–8,396	Golder 2020a
Eclipse Sound	2019	25–27 Aug (#4)	12,088	0.08	10,388–14,066	Golder 2020a
Eclipse Sound	**2019**	**21–27 Aug (#3&4)**	**9,931**	**0.05**	**9,009–10,946**	**Golder 2020a**
Eclipse Sound	2019	29–30 Aug (#5)	4,879[a]	0.06	4,322–5,507	Golder 2020a
Eclipse Sound	2020	20 Aug (#1)	3,519	0.03	3,308 – 3,743	Golder 2021a
Eclipse Sound	**2020**	**29 Aug (#3)**	**5,018**	**0.03**	**4,736 – 5,317**	**Golder 2021a**
Eclipse Sound	2021	8 &10 Aug (#1&2)	2,172	0.04	2,005 – 2,353	Golder 2022b
Eclipse Sound	**2021**	**20–21 Aug (#4)**	**2,595**	**0.33**	**1,369 – 4,919**	**Golder 2022b**

Stock	Year	Survey Dates (Survey #)	Abundance	CV	95% CI	Source
Eclipse Sound	2021	26 Aug (#5)	1,410	0.03	1,329 – 1,496	Golder 2022b
Eclipse Sound	2022	17 Aug (#3)	5,259	0.02	5,008–5,523	Current report
Eclipse Sound	2022	21 Aug (#4)	3,874	0.25	2,387–6,287	Current report
Eclipse Sound	**2022**	**17–21 Aug (#3&4)**	**4,592**	**0.10**	**3,754–5,617**	Current report
Admiralty Inlet	2003	August	5,362	0.50	1,920–12,199	Richard et al. 2010
Admiralty Inlet	2010	7–11 Aug	18,049	0.23	11,613–28,053	Asselin and Richard 2011
Admiralty Inlet	**2013**	**12–17 Aug**	**35,043**	**0.42**	**14,188–86,553**[b]	**Doniol-Valcroze et al. 2015a**
Admiralty Inlet	2019	21–22 Aug (#3)	27,436	0.14	20,860–36,084	Golder 2020a
Admiralty Inlet	2019	25–26 Aug (#4)	30,638	0.29	17,668–53,129	Golder 2020a
Admiralty Inlet	**2019**	**21–26 Aug (#3&4)**	**28,746**	**0.15**	**21,545–38,354**	**Golder 2020a**
Admiralty Inlet	2019	29–30 Aug (#5)	18,976	0.20	12,963–27,779	Golder 2020a
Admiralty Inlet	2020	21 Aug (#1)	17,244	0.18	12,056–24,664	Golder 2021a
Admiralty Inlet	**2020**	**28 Aug (#3)**	**31,026**	**0.14**	**23,406–41,126**	**Golder 2021a**
Admiralty Inlet	2021	15-16 Aug (#3)	*24,047*	*0.12*	*18,989 – 30,452*	Golder 2022b
Admiralty Inlet	**2021**	**19 Aug (#4)**	***72,582***	***0.09***	**61,333–85,895**	**Golder 2022b**
Admiralty Inlet	2022	14 Aug (#2)	45,086	0.26	27,396–74,200	Current report
Admiralty Inlet	2022	18 Aug (#3)	41,149	0.14	31,038–54,554	Current report
Admiralty Inlet	**2022**	**14–18 Aug (#2&3)**	**43,042**	**0.15**	**32,218–57,502**	Current report
Combined	**2013**	**12–19 Aug**	**45,532**	**0.33**	**22,440–92,384**[b]	**Doniol-Valcroze et al. 2015a**
Combined	2019	21–22 Aug (#3)	35,201	0.11	28,401–43,629	Golder 2020a
Combined	2019	25–27 Aug (#4)	42,726	0.21	28,620–63,786	Golder 2020a
Combined	**2019**	**21–27 Aug (#3&4)**	**38,677**	**0.11**	**31,155–48,015**	**Golder 2020a**[c]
Combined	2019	29–30 Aug (#5)	23,855	0.16	17,581–32,368	Golder 2020a
Combined	2020	20–21 Aug (#1)	20,763	0.15	15,410–27,976	Golder 2021a
Combined	**2020**	**28–29 Aug (#3)**	**36,044**	**0.12**	**28,267–45,961**	**Golder 2021a**
Combined	**2021**	**19-21 Aug (#4)**	**75,177**	**0.08**	**63,795–88,590**	**Golder 2022b**
Combined	**2022**	**17–18 Aug (#3)**	**46,408**	**0.13**	**36,129–59,611**	Current report

Bolded values are considered the most accurate abundance estimate for that year.

[a] Possible narwhal aggregation missed during survey personal comms. local hunters.

[b] T. Doniol-Valcroze, Pers. Comm. 2020.

[c] T. Number has been revised from the Golder 2020a report to correct an error.

For the Eclipse Sound stock alone, the narwhal abundance estimate was 4,592 narwhal (CV = 0.10, 95% CI of 3,754–5,617; Table 21) based on an average of Baffinland's aerial surveys conducted on 17 and 21 August 2022. The 2022 estimate is statistically higher than the 2021 estimate of 2,595 (CV = 0.33, 95% CI of 1,369–4,919; Golder 2022c) (t-test = 2.017, p = 0.049) (Table 22), indicating that narwhal numbers appear to be increasing from the 2021 numbers. The 2022 estimate remains statistically lower than the 2016 estimate of 12,039 (CV = 0.23, 95% CI of 7,768–18,660; Marcoux et al. 2019) (t-test = 2.651, p = 0.038) and the 2019 abundance estimate of 9,931 (CV = 0.05, 95% CI of 9,009–10,946; Golder 2020a) (t-test = 7.808, p < 0.001) (Table 22), indicating that narwhal numbers did not reach 2016 and 2019 levels. The 2022 estimate is not statistically different than the 2013 abundance estimate of 10,489 (CV = 0.24, 95% CI of 6,342–17,347; Doniol-Valcroze et al. 2015a) (t-test = 2.302, p = 0.104) or the 2020 abundance estimate of 5,018 (CV = 0.03, 95% CI of 4,736–5,317; Golder 2021a) (t-test = 0.859, p = 0.438) (Table 22).

Table 22: Test statistics for comparison between years

Region	Year	Abundance	Year	Abundance	T-statistic	P-value (two-tailed)	P-value (one-tailed)	Statistical Significance
Eclipse Sound	2013	10,489	2022	4,592	2.302	0.104	0.052	Not Sig
	2016	12,039			2.651	0.077	**0.038**	**Sig Decr**
	2019	9,931			7.808	**<0.001**	**<0.001**	**Sig Decr**
	2020	5,018			0.859	0.438	0.219	Not Sig
	2021	2,595			2.017	0.100	**0.049**	**Sig Incr**
Admiralty Inlet	2013	35,043	2022	43,042	0.498	0.623	0.311	Not Sig
	2019	28,746			1.861	0.067	**0.033**	**Sig Incr**
	2020	31,026			1.538	0.129	0.064	Not Sig
	2021	72,582			3.304	**0.002**	**0.001**	**Sig Decr**
Eclipse Sound & Admiralty Inlet	2013	45,532	2022	46,408	0.054	0.957	0.479	Not Sig
	2019	38,771			1.011	0.316	0.158	Not Sig
	2020	36,044			1.390	0.170	0.085	Not Sig
	2021	75,177			3.317	**0.002**	**0.001**	**Sig Decr**

The 2020, 2021, and 2022 Eclipse Sound stock abundance estimate exceeded the ‘High Risk’ trigger identified in the Marine Mammal TARP (i.e., a >25.0% decrease in the Eclipse Sound stock size (abundance) relative to the 2019 aerial survey abundance) (Baffinland 2023). These results suggest a decrease in the Eclipse Sound stock abundance estimates relative to the 2019 abundance estimate, and therefore warranted further investigation.

A decreasing trend in the estimated abundance of narwhal in the Eclipse Sound stock can be observed since 2004 (Figure 36). This decreasing trend started well before Baffinland shipping in the region. A resampling simulation method was used to estimate the trend in abundance estimates in Eclipse Sound over the past 19 years. A subset of 100 iterations was used to generate a plot showing the individual trends calculated during the resampling process (Figure 37). The orange line shows the fitted trend based on only mean annual abundance estimates, and the red line shows extrapolation for 2023 based on the estimated trends (Figure 37). For Eclipse Sound, 74% of the iterations had a significant temporal trend, which suggests moderate evidence of a significant decrease in abundance over time in the area, with an effect size of -9% (95% CI of -12% to -5%). The analysis estimated that narwhal abundance in Eclipse Sound decreased by 9% between each two consecutive years.

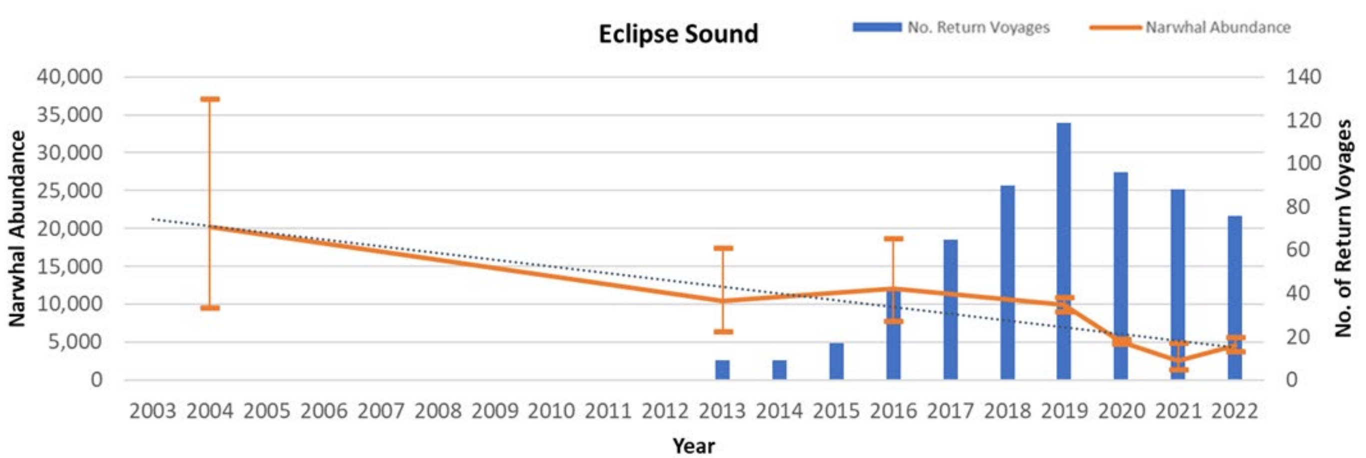

Figure 36: Narwhal abundance estimates in Eclipse Sound over a span of 19 years along with Baffinland shipping activities for all vessel types (ore carriers, fuel tankers, sea lifts, tugs, and ice breaker).

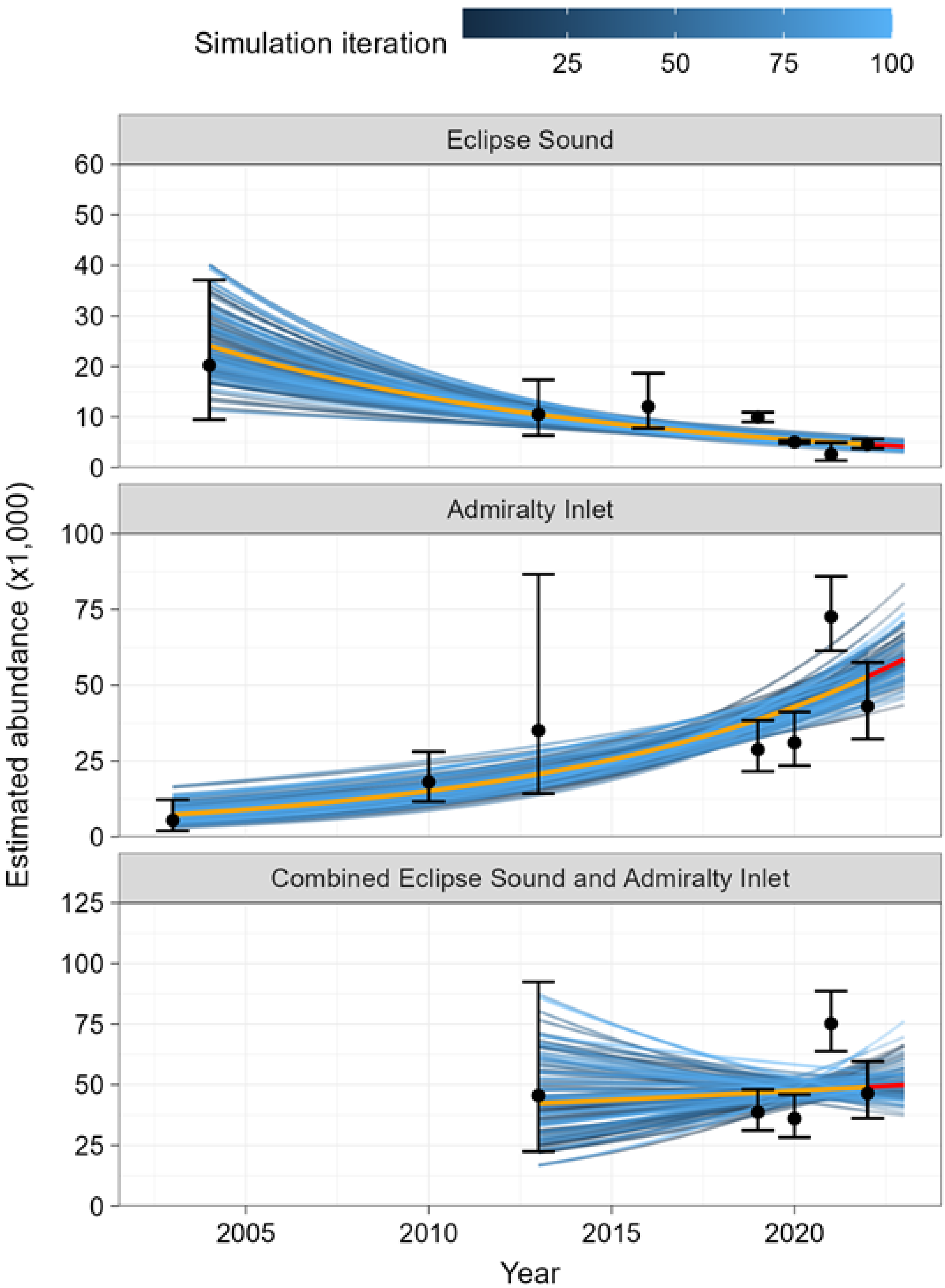

Figure 37: Trend analysis for Eclipse Sound, Admiralty Inlet, and the combined Eclipse Sound and Admiralty Inlet stock estimates using a resampling simulation method.

For Admiralty Inlet stock alone, the narwhal abundance estimate was 43,042 narwhal (CV = 0.15, 95% CI of 32,218–57,502; Table 21) based on an average of Baffinland's aerial surveys conducted on 14 and 18 August 2022. This estimate was not statistically different than the abundance calculated during the previous DFO survey conducted in August 2013 (35,043 narwhal, CV = 0.42, 95% CI of 14,188–86,553; Doniol-Valcroze et al. 2015a) (t-test = 0.498, p = 0.623) and the 2020 Baffinland estimate of 31,026 (CV = 0.14, 95% CI of 23,406–41,126) (t-test = 1.538, p = 0.129) (Table 22). The 2022 estimate was statistically higher than the 2019 Baffinland estimate of 28,746 (CV = 0.15, 95% CI of 21,545–38,354) (t-test = 1.861, p = 0.033), (Table 22). The 2022 estimate was statistically lower than the 2021 Baffinland estimate of 72,582 (CV = 0.09, 95% CI of 61,333–85,895) (t-test = 3.304, p = 0.001) (Table 22).

A increasing trend in the estimated abundance of narwhal in the Admiralty Inlet stock can be observed since 2003 (Figure 38). A resampling simulation method was used to estimate the trend in abundance estimates in Admiralty Inlet over the past 20 years (Figure 37). Results of the simulation found 91% of the iterations for Admiralty Inlet had a significant temporal trend, which suggest strong evidence of a significant increase in abundance estimates over time in the area, with an effect size of 11% (95% CI of 7% to 16%). The analysis estimated that narwhal abundance in Admiralty Inlet increased by 11% between each two consecutive years.

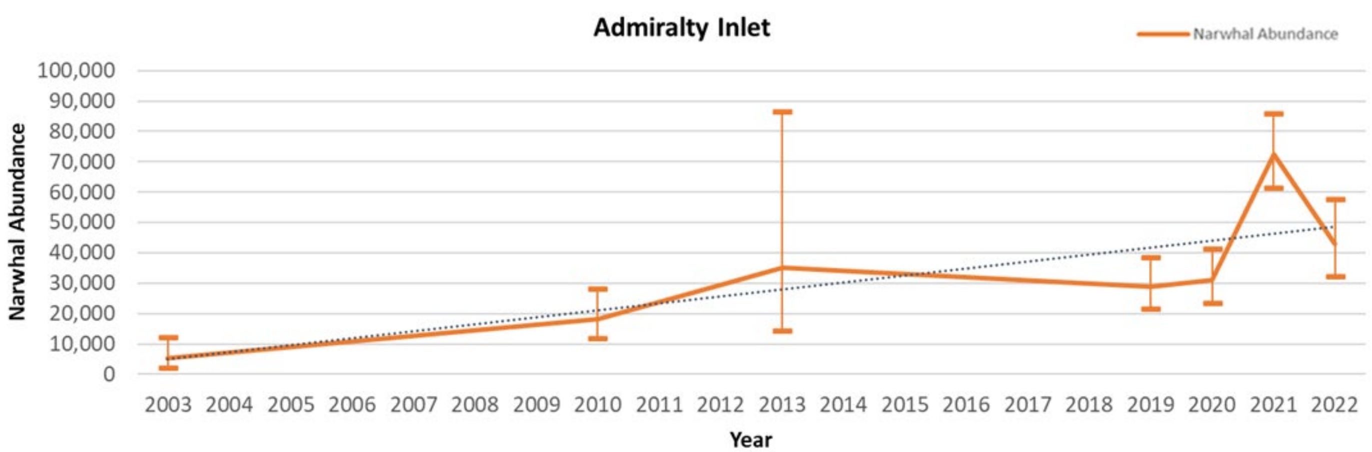

Figure 38: Narwhal abundance estimates in Admiralty Inlet over a span of twenty years.

The abundance estimate for the combined Eclipse Sound and Admiralty Inlet stocks was 46,408 narwhal (CV = 0.13, 95% CI of 36,129–59,611; Table 21) based on aerial surveys conducted on 17–18 August 2022. This estimate was not statistically different than the abundance calculated during the previous DFO survey conducted in August 2013 (45,532 narwhal, CV = 0.33, 95% CI of 22,440–92,384; Doniol-Valcroze et al. 2015a) (t-test = 0.054, p = 0.957), the 2019 Baffinland estimate of 38,677 (CV = 0.11, 95% CI of 31,155–48,015) (t-test = 1.011, p = 0.316), and the 2020 Baffinland estimate of 36,044 (CV = 0.12, 95% CI of 28,267–45,961) (t-test = 1.390, p = 0.170) (Table 22). The 2022 estimate was statistically lower than the 2021 Baffinland estimate of 75,177 (CV = 0.08, 95% CI of 63,795–88,590) (t-test = 3.317, p = 0.001) (Table 22).

A stable trend in the estimated abundance of narwhal in the combined Eclipse Sound and Admiralty Inlet stocks can be observed since 2013 (Figure 39). A resampling simulation method was used to estimate the trend in abundance estimates in the combined Eclipse Sound and Admiralty Inlet over the past 10 years. Results of the simulation found only 1% of the iterations had a significant temporal trend, which suggests no evidence of a temporal trend. The estimated effect size was 2% (95% CI of -7% to 11%).

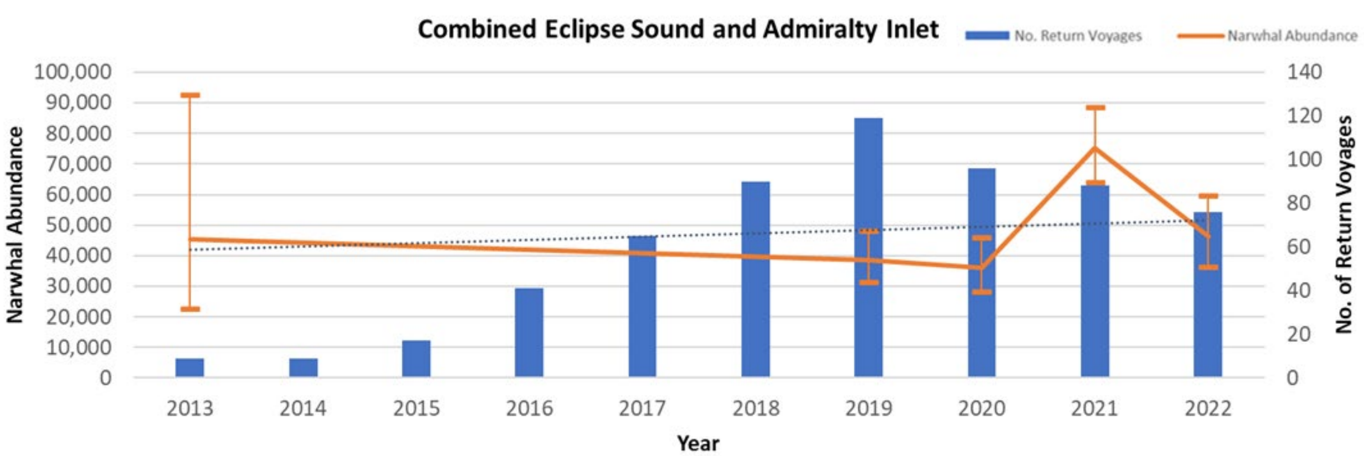

Figure 39: Narwhal abundance estimates in the combined Eclipse Sound and Admiralty Inlet over a span of ten years along with Baffinland shipping activities.

The sample sizes used to generate narwhal abundance estimates for DFO's previous surveys (Doniol-Valcroze et al. 2015a; Marcoux et al. 2019) were not reported, thus degrees of freedom for the DFO surveys were assumed to be the same as the corresponding Baffinland estimate for t-test analysis. The use of a Z-statistic was recommended for surveys with unknown sample sizes although this may represent a higher precision than is warranted by the DFO data. Calculations of a Z-statistic for the combined Eclipse Sound and Admiralty Inlet stocks resulted in similar significance values as the t-statistic (2022 vs 2013: Z-test = 0.054, p = 0.957, 2022 vs 2019: Z-test = 1.011, p = 0.156, 2022 vs 2020: Z-test = 1.390, p = 0.164, 2022 vs 2021: Z-test = 3.317, p = < 0.001). Calculations of a Z-statistic for the Eclipse Sound only stock was not done due to insufficient degrees of freedom to run the statistics.

3.6 Discussion

3.6.1 Narwhal Abundance and Distribution

***High-level Summary**: Results from the 2022 narwhal abundance survey (i.e., Leg 2 survey) indicated that: i) narwhal abundance in Eclipse Sound was statistically higher in 2022 than that observed in the previous year (2021) although statistically lower than 2016 and 2019 levels, and ii) the combined narwhal abundance in Eclipse Sound and Admiralty Inlet was similar in 2022 to what was observed in previous years (2013, 2019 and 2020). These results suggest a portion of the Eclipse Sound stock continued to occupy the Admiralty Inlet summering ground again during the summer of 2022.*

The 2022 abundance estimate for the Eclipse Sound narwhal stock was 4,592 narwhal (CV = 0.10, 95% CI of 3,754–5,617) which is statistically higher than the 2021 estimate of 2,595 (CV = 0.33, 95% CI of 1,369–4,919; Golder 2022a) (t-test = 2.017, p = 0.049), indicating that narwhal numbers in Eclipse Sound appear to be increasing from the low numbers observed in 2021. However, the 2022 estimate remains statistically lower than the 2016 estimate of 12,039 (CV = 0.23, 95% CI of 7,768–18,660; Marcoux et al. 2019) (t-test = 2.651, p = 0.038) and the 2019 abundance estimate of 9,931 (CV = 0.05, 95% CI of 9,009–10,946; Golder 2020a) (t-test = 7.808, p < 0.001), indicating that narwhal numbers in Eclipse Sound have not yet rebounded to 2016 and 2019 levels.

The 2022 abundance estimate for the combined Eclipse Sound and Admiralty Inlet stocks was 46,408 narwhal (CV = 0.13, 95% CI of 36,129–59,611), which was not statistically different than the 2013 DFO estimate of 45,532 (CV = 0.33, 95% CI of 22,440–92,384; Doniol-Valcroze et al. 2015a) (t-test = 0.054, p = 0.957), the 2019 Baffinland estimate of 38,677 (CV = 0.11, 95% CI of 31,155–48,015) (t-test = 1.011, p = 0.316), or the 2020 Baffinland estimate of 36,044 (CV = 0.12, 95% CI of 28,267–45,961) (t-test = 1.390, p = 0.170) (Table 22). These findings support the theory that a portion of the Eclipse Sound stock continued to occupy the Admiralty Inlet summering ground during the summer of 2022.

These findings were compared with results from the 2022 Bruce Head Shore-based Monitoring Program in which the relative abundance of narwhal at Bruce Head (i.e., total number of narwhal corrected for survey effort) was shown to be higher in 2022 (84.9) than in 2020 and 2021 (47.5 and 29.4, respectively), and approaching the 2014 baseline level (98.2) (WSP 2023). However, narwhal relative abundance in 2022 was lower than levels observed in 2016 (178.0), 2017 (121.8) and 2019 (127.2). These findings indicate that narwhal numbers in the RSA appear to be increasing from the low numbers observed in 2020/2021 but have not yet reached levels observed during the initial shipping years (2016, 2017) or those observed in 2019 (WSP 2023). Over the combined 2014-2022 monitoring period at Bruce Head, the second highest relative abundance estimate at Bruce Head was recorded in 2019, when shipping levels in the RSA were the highest to date and Project icebreaking occurred during the early shoulder season for the third consecutive year (2018-2020). In contrast, the lowest relative abundance estimates at Bruce Head were recorded in 2020 and 2021, when shipping levels were similar to 2016. Icebreaking operations took place during the 2020 early shoulder season but not in 2021. These results suggest that the annual volume of Project shipping in the RSA is not a reliable predictor of narwhal relative abundance at Bruce Head in the same year (WSP 2023).

Collectively, the available data indicates that some degree of exchange occurs between the Eclipse Sound and Admiralty Inlet stock areas and that the reduced numbers observed in Eclipse Sound in 2020-2022 (Golder 2022a) may be temporary. Possible causes of the observed exchange of narwhal from Eclipse Sound to Admiralty Inlet include:

- Displacement from Eclipse Sound as a result of: i) acoustic disturbance from shipping operations, ii) acoustic disturbance from construction activities associated with the Pond Inlet Small Craft Harbour (SCH) Project, and/or iii) increased killer whale presence in the RSA (Golder 2021c).
- More favourable ecological conditions (e.g., prey availability, ice coverage, lower predation pressure) in Admiralty Inlet during the spring and/or summer seasons of 2020-2022 that served to draw in a larger influx of narwhal from Eclipse Sound, and potentially from other proximal summer stock areas (i.e., Somerset Island, East Baffin Island), with some individuals from the Eclipse Sound stock returning to the RSA in 2022.
- Natural exchange of narwhal between the two putative summer stock areas (i.e., Eclipse Sound and Admiralty Inlet) during the open-water season. This has been previously suggested by DFO based on historical aerial survey results (Doniol-Valcroze et al. 2015a, 2020; DFO 2020) and telemetry studies (DFO 2020). Natural exchange of narwhal between these stock areas during the open-water season is strongly supported by available IQ (NWMB 2016a, 2016b; QWB 2022).

As noted in Golder (2021c), the above factors may have independently or cumulatively contributed to the observed changes in narwhal numbers in Eclipse Sound in recent years. If it was determined that the changes in narwhal numbers in the RSA were a result of Project activities, this would be consistent with a high severity response and would be considered a significant alteration of natural behavioural patterns of narwhal in the RSA and/or disruption to their daily routine (WSP 2023; Southall et al. 2021). However, findings from the aerial surveys were consistent with results obtained via Bruce Head conducted in 2022, suggesting that narwhal numbers in the RSA appear to be increasing from the low numbers observed in 2021.

Other Considerations:

For the past four consecutive years (2019–2022), combined surveys of both Admiralty Inlet and Eclipse Sound summering stock areas have been undertaken. The primary impetus for running the combined stock surveys (as opposed to the Eclipse Sound summer stock only) was based on available IQ, which indicates that the geographic and genetic distinction between these two summering stocks may be invalid (NWMB 2016a; 2016b; QWB 2022). DFO has also been investigating the extent to which there is a natural exchange of narwhal between these stock areas during the open-water season (Doniol-Valcroze et al. 2015a, 2020; DFO 2020). Natural exchange between the two summering areas was proposed as a possible reason why the 2013 survey results for Admiralty Inlet (~35,000 narwhal) and Eclipse Sound (~10,000 narwhal) differed substantially from previous survey results for the same stocks (18,000 for Admiralty Inlet in 2010 and 20,000 for Eclipse Sound in 2004) (Doniol-Valcroze et al. 2015a). All of these surveys (i.e., 2004, 2010 and 2013) occurred prior to the start of Baffinland iron ore shipping operations.

Given that the combined stock estimate for Admiralty Inlet and Eclipse Sound indicated that the regional narwhal population remained stable relative to pre-shipping conditions, and in consideration of the available IQ regarding the degree of exchange between narwhal groups on their summering grounds, the observed changes in narwhal abundance in Eclipse Sound in recent years likely reflects a natural exchange between the two putative stock areas that began prior to Baffinland shipping operations, with animals shifting between Eclipse Sound and Admiralty Inlet based on where habitat conditions may be more favorable that season (e.g., ice coverage, prey availability, predation pressure). With the recent influence of rapidly warming ocean temperatures and longer open-water seasons due to climate change, more pronounced changes in habitat conditions are to be expected throughout the Arctic along with commensurate changes in animal distributions and migratory movements. For example, it is well documented that sea ice in the Arctic is presently undergoing rapid reduction due to climate warming (Stroeve et al. 2012; IPCC 2013; Overland and Wang 2013) and this has been directly associated with notable shifts in species distributions for both Arctic marine mammals (Laidre et al. 2008, 2015; Frederiksen and Haug 2015; Nøttestad et al. 2015; Víkingsson et al. 2015; Albouy et al. 2020; Chambault et al. 2022;) and their prey (Frainer et al. 2017; Steiner et al. 2019, 2021; Møller and Nielsen 2020). How this might be manifesting on a micro-geographic scale in the North Baffin region is presently unclear, although some insight is offered when considering changes reported in other Arctic environments in close proximity to Eclipse Sound.

Two major oceanographic changes have recently been observed in coastal areas of Southeast Greenland; a lack of pack ice in summer and increasing sea temperature (NAAMCO 2021). This has had cascading effects on the marine ecosystem, as observed through shifts in fish species assemblages in the region (i.e., change in fish community structure) and previously undocumented occurrences of temperate water cetaceans in Southeast Greenland in high abundances (e.g., humpback whales, fin whales, killer whales, pilot whales and white beaked dolphins). Traditional narwhal habitat in this area has become restricted by the warming oceans and the ability of narwhal to adapt to warming water temperatures is also limited due to their general physiology. Shifts in narwhal distribution in Greenland have also been documented in recent years, with multiple sightings of narwhal in locations well north of their traditional range (e.g., Dove Bay, Greenland Sea, Northeast water and Petermann glacier front) (NAAMCO 2021). Current evidence suggests that a combination of hunting and climate change is negatively impacting the long-term viability of populations in Southeast Greenland (NAAMCO 2021).

A recent study by Chambault et al. (2022) predicted the future distribution of Eastern Baffin Bay narwhal under two different climate change scenarios using narwhal satellite tracking data collected over two decades. The long-term predictive models suggested that the current distribution of Baffin Bay narwhal during summer will undergo a northward shift of more than 200 km by the end of the century to cope with climate change, and that summer narwhal habitats in this region were predicted to decline from 31 to 66% over this period, depending on the climate model. These changes may already be underway in the Eastern Canadian Arctic and may affect Eclipse Sound and Admiralty Inlet differently.

For the above reasons, the potential for climate-driven shifts in species distributions cannot be ignored as a potential driver of the recently observed changes in summer narwhal distribution in Eclipse Sound. To better understand what is occurring, additional engagement and monitoring with Inuit stakeholders and regulatory agencies are needed, inclusive of collaborative regional-scale monitoring to better understand how climate change is impacting the Baffin Bay narwhal population as a whole.

3.6.2 Other Marine Mammals

3.6.2.1 Bowhead Whale

Bowhead whale observations declined substantially prior to the start of the open-water season (Leg 2), suggesting that most bowhead whales seen during Leg 1 had migrated out of the RSA prior to 13 August (start of Leg 2). Four bowhead whales were observed in the RSA during the open-water surveys on 16–17 August. On 16 August, two sightings of individual bowhead whales were sighted in Tremblay Sound (see Appendix B, Figure B-11). On 17 August, one sighting of an individual bowhead whale was sighted in Tremblay Sound and another in Milne Inlet South (see Appendix B, Figure B-12). The Bruce Head team reported a single bowhead whale on five separate occasions approximately one to three weeks after the start of Baffinland shipping activities (7, 9, 10, 17, and 20 August) in the study area in 2022 (WSP 2023). During previous aerial surveys flown in August in the RSA, two bowhead whales were observed in 2021 (Golder 2022c), one bowhead whale was observed in 2020 (Golder 2021a), four bowhead whales were observed in 2019 (Golder 2020a), six were observed in 2014 (Thomas et al. 2015), and none were observed in 2013 or 2015 (Elliott et al. 2015; Thomas et al. 2016). The decline in bowhead sightings during Leg 2 was consistent with baseline conditions and did not suggest that Project shipping activities resulted in displacement of bowhead from their summering ground. Bowhead whales appeared to use Eclipse Sound and Navy Board Inlet as a migration corridor during the early shoulder season, with numbers in the RSA dropping during the open water season. Bowhead relative abundance in the Eclipse Sound grid was similar in 2022 (0.0006 animals/km) compared to the three previous years (0.0006 animals/km in 2021, 0.0003 animals/km in 2020, and 0.0003 animals/km in 2019) (see Appendix D), although bowhead relative abundance was lower during the 2022 Leg 2 surveys (0.0006 animals/km) compared to 2022 Leg 1 surveys (0.0024 animals/km). These results were consistent with IQ which included observations of bowhead migrating through the RSA in Aujaq (end of July to September) (JPCS 2017).

In Admiralty Inlet, bowhead whales were observed during both surveys flown in August. Bowhead sightings were dispersed throughout the Admiralty Inlet grid. Bowhead relative abundance in the Admiralty Inlet grid was lower in 2022 (0.0034 animals/km) than in the previous three years (0.0510 animals/km in 2021, 0.0087 animals/km in 2020, and 0.0313 animals/km in 2019) (see Appendix D). The Canadian High Arctic Cetacean Survey conducted by DFO in August 2013 calculated a bowhead abundance in Admiralty Inlet of 82 whales (CV=0.97; DFO 2015b). Bowhead whale abundance estimates calculated in 2019 were higher than previous estimates in Admiralty Inlet.

The highest estimate for the 2019 MMASP was obtained from the 25–27 August survey with an estimate of 834 bowhead whales (CV=0.50, 95% CI of 334–2,080). The lowest estimate for the 2019 MMASP was obtained two days later from the 29–30 August survey with an estimate of 472 bowhead whales (CV=0.35, 95% CI of 240–926). Bowhead numbers appear to fluctuate considerably from year to year in the Admiralty Inlet grid.

3.6.2.2 Killer Whale

In 2022, killer whale were not observed in the Eclipse Sound grid during the Leg 2 surveys or during the Bruce Head Shore-based Monitoring Program. It is not unusual to not see killer whales in the Eclipse Sound grid in August. During five consecutive years of shore-based monitoring conducted for Baffinland from 2013 to 2017, no killer whale were recorded (Thomas et al. 2014; Smith et al. 2015, 2016, 2017; Golder 2018c). Similarly, killer whale were not observed in the RSA during three consecutive years of aerial surveys conducted between 2013 and 2015 during the open water period (Elliott et al. 2015; Thomas et al. 2015, 2016). Killer whales were observed in the Eclipse Sound grid in August during the three previous years (2019, 2020, 2021).

In Admiralty Inlet, killer whale were not observed in 2022 during aerial surveys. However, on 16 August, killer whale sightings were reported by residents in Arctic Bay and relayed to the aerial survey team through the Inuit observers. Killer whales were observed during the Admiralty Inlet aerial surveys in 2021 but not in 2019 or 2020.

3.6.2.3 Beluga Whale

In 2022, beluga whales were observed in the Eclipse Sound grid during Leg 2 aerial surveys and the Bruce Head shore-based monitoring program. There were three sightings of individual beluga whales observed in Eclipse Sound during Leg 2 visual surveys. One sighting was observed in the Milne Inlet North stratum on 17 August, another was observed on the same day in the Navy Board Inlet stratum, and the third was observed in the Pond Inlet stratum on 21 August (see Appendix B, Figures B-9 and B-11). During a photographic survey on 17 August, one sighting of three beluga whales was recorded. During the 2022 Bruce Head Shore-based Monitoring Program, a large group of 120 beluga was present in the study area on 29 July when the survey crew was arriving to site. This is likely the same group of beluga whales that was observed on 26–27 July in Assomption Harbour during the Leg 1 aerial surveys. Beluga were frequently observed in the Bruce Head study area in groups of 1–3 between 1–16 August 2022, with one group of 10 being observed in the study area on 6 August 2022.

Beluga whales were observed in 2022 for the first time in Admiralty Inlet during aerial surveys flown for the Baffinland project. It is not known why there appears to be an increase in beluga whales in both Eclipse Sound and Admiralty Inlet.

3.6.2.4 Pinnipeds

Pinniped data collected in 2019, 2020, 2021, and 2022 should be interpreted with caution due to the relative difficulty in observing seals at survey altitudes of 305 m (1,000 ft) ASL. Apparent differences in sightings may be the result of changes in survey conditions and the ability of MMOs to identify species rather than actual changes in pinniped numbers or distribution.

Ringed Seal: Ringed seals were sporadically distributed throughout the survey area during Leg 2 of the 2022 MMASP, similar to what was observed in previous years (Elliott et al. 2015; Thomas et al. 2015, 2016; Golder 2020a; Golder 2021a; Golder 2022c). Ringed seal had the highest sighting count of all pinniped species sighted during the 2022 MMASP, accounting for 71% of all pinniped sightings identified to the species level (333 out of a total of 471). Ringed seal sightings were primarily observed as single animals. During Leg 2, ringed seal relative abundance in the Eclipse Sound grid was also similar in 2022 (0.0726 animals/km) to that observed in the previous two years (0.0702 animals/km in 2021 and 0.0736 animals/km in 2020) (see Appendix D). In the Admiralty Inlet grid ringed seal relative abundance was lower in 2022 (0.0615 animals/km) to that observed in 2021 (0.0920 animals/km) and 2020 (0.0830 animals/km) (see Appendix D). Ringed seal observations provide relative abundance and distribution information. However, this information cannot be used to reliably assess the effects of Project shipping or obtain accurate abundance estimates.

A summary of the 2021 ringed seal aerial survey program which indicated that ringed seal densities had remained stable in the RSA with some annual variations since the onset of shipping or icebreaking activities is provided in Golder (2022b).

Harp Seal: Harp seal were observed during all Leg 2 visual surveys in 2022. In the Eclipse Sound grid, harp seals were observed primarily at the top of Navy Board Inlet and in the Pond Inlet stratum, similar to what had been observed in previous years (Elliott et al. 2015; Thomas et al. 2015, 2016; Golder 2020a, 2021a, Golder 2022c). In the Admiralty Inlet grid, harp seals were observed throughout the survey area, although higher numbers were observed in the Admiralty Inlet North stratum. Harp seal sightings were primarily observed as groups of multiple animals. The largest group size observed in 2022 was 50 animals. During Leg 2, the 2022 harp seal relative abundance in the Eclipse Sound grid (0.0466 animals/km) was slightly higher compared to the previous two years (0.0331 animals/km in 2021 and 0.0448 animals/km in 2020) and lower compared to 2019 (0.0527 animals/km) (see Appendix D).

In the Admiralty Inlet grid, the 2022 harp seal relative abundance (0.1917 animals/km) was lower compared to the previous two years (0.9441 animals/km in 2021 and 0.3685 animals/km in 2020) and higher compared to 2019 (0.1495 animals/km) (see Appendix D). Harp seal observations provide relative abundance and distribution information. However, this information cannot be used to reliably assess the effects of Project shipping or obtain accurate abundance estimates.

Bearded Seal: Similar to previous years, only a few bearded seals were observed during the 2022 MMASP. Six sightings were recorded during Leg 2 surveys. All six sightings were observed in the Eclipse Sound grid; three in Eclipse Sound, two in White Bay, and one in Navy Board Inlet. Limited IQ has been collected regarding the overall abundance of bearded seal. Some Elders in the Baffin region have observed a decrease in bearded seal abundance since the advent of firearms and motorized transportation (Baffinland 2010). In contrast, one Elder noted that bearded seal were rare near Pond Inlet in the past but are now more frequently observed.

Walrus: Walrus were seldom seen in the Eclipse Sound or the Admiralty Inlet grid during the summer surveys. Walrus were not observed in the Eclipse Sound grid during 2022 Leg 2 surveys. A single juvenile walrus was observed on 12 August 2022 by the Bruce Head Shore-based Monitoring Program (WSP 2023). A single walrus was also observed in the northern portion of Admiralty Inlet during Survey 3 (18 August) of the 2022 MMASP.

3.6.2.5 Polar Bear

Polar bear sightings have been regularly recorded during the Baffinland aerial survey programs. The distribution of polar bears in 2022 was similar to what was observed during previous aerial surveys. In the Eclipse Sound grid, polar bears were more likely to be recorded in the Navy Board Inlet and Pond Inlet strata. In 2022, all polar bear sightings occurred in the Navy Board Inlet stratum, with one sighting observed during each of Surveys 2 and 3, and the remaining four sightings observed during Survey 4 (see Appendix B, Figures B-11, B-12 and B-14). All six sightings were of single animals. Three of the sightings were identified as adults, one sighting was identified as a juvenile and the remaining two were of unknown age classes.

In the Admiralty Inlet grid, polar bears were recorded throughout the study area, although sighting numbers were down from the previous year. Five polar bear sightings totalling seven individuals were made during the 2022 Leg 2 visual surveys in the Admiralty Inlet grid. Three of the sightings were of single animals identified as adults and located in the Admiralty Inlet North stratum on 14 August (Appendix B, Figure B-10). The two remaining sightings were of mothers with a cub on 14 August in Admiralty Inlet South (Appendix B, Figure B-10) and on 18 August in Elwin Inlet (Appendix B, Figure B-13).

4.0 LEG 3: CLEARANCE SURVEY

A third survey (Leg 3) at the end of the shipping season was proposed to occur over a three-day period (29–31 October), with three Inuit researchers and one Mittimatalik Hunters and Trappers Organization (MHTO) observer. The objective of the Leg 3 surveys would have been to conduct a visual clearance survey to confirm that no narwhal entrapment events occurred in Eclipse Sound and Milne Inlet following completion of Baffinland's 2022 shipping operations along the Northern Shipping Route.

The Leg 3 clearance aerial surveys did not take place in 2022 due to the shipping season ending early, on 13 October, as a result of the presence of multi-year ice entering the RSA (Figure 40). Landfast ice later started to form on 23 October (Figure 41).

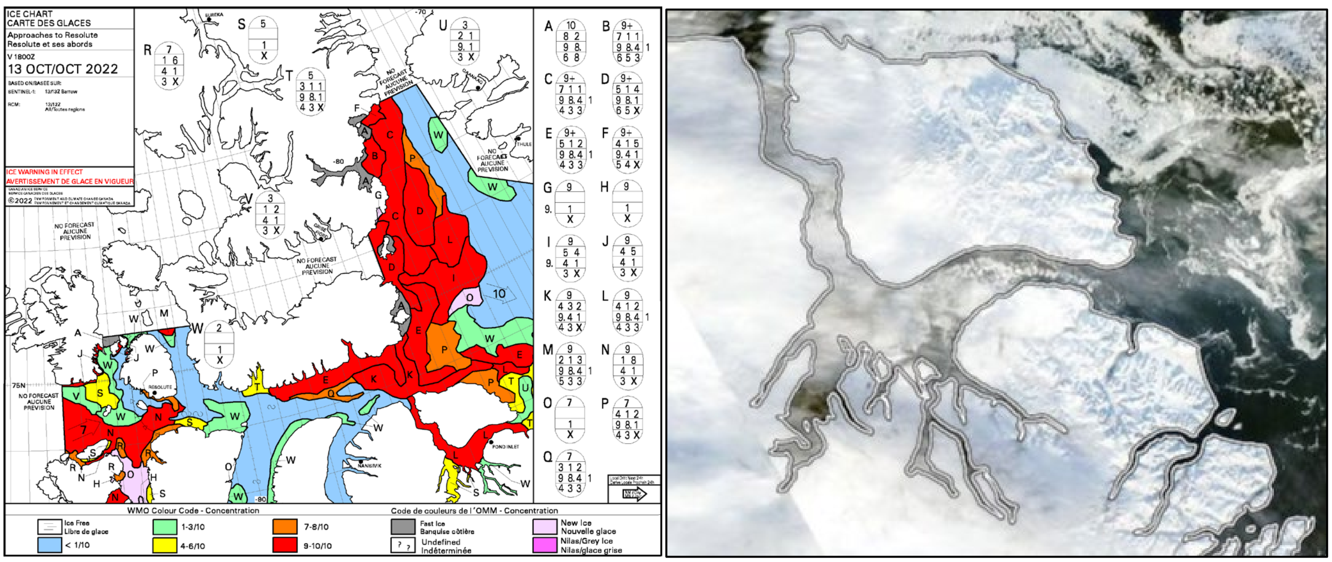

Figure 40: Ice chart for 13 October 2022 (left; Canadian Ice Services) and satellite image for 14 October 2022 (right; Zoom Earth; https://zoom.earth) showing ice conditions in Eclipse Sound area at the end of the shipping season.

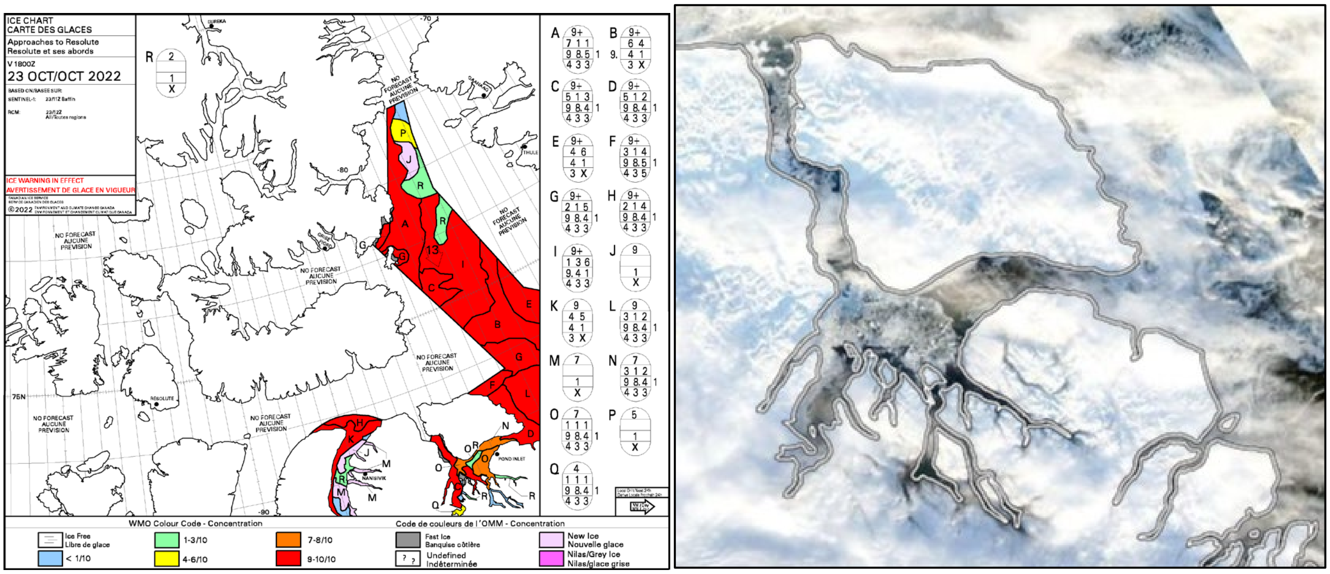

Figure 41: Ice chart for 23 October 2022 (left; Canadian Ice Services) and satellite image for 20 October 2022 (right; Zoom Earth; https://zoom.earth) showing ice conditions in Eclipse Sound area when land fast ice started forming.

5.0 SUMMARY

The 2022 MMASP addressed Project Certificate No. 005 Terms and Conditions 101, 109, 111, and 126. Table 23 demonstrates how Project Certificate Terms and Conditions were met through the 2022 MMASP.

Table 23: NIRB Project Certificate No. 005 Terms and Conditions relevant to the 2022 MMASP.

Project Certificate Terms and Conditions	Condition / Evidence of Conditions Met
101	Efforts to involve Inuit in monitoring studies at all levels: ■ Inuit researchers participated in Legs 1 and 2 of the 2022 MMASP. Monitoring protocols that are responsive to Inuit concerns: ■ Aerial surveys allow for evaluation of narwhal large-scale displacement effects, abandonment of the RSA, moderate to large changes in stock size. ■ Although not designed to assess ringed seal abundance in the RSA, the MMASP reports on values of relative abundance for ringed seals. Schedule for periodic aerial surveys as recommended by the MEWG: ■ Aerial surveys in support of the Project were conducted in 2006, 2007, 2008, 2012, 2013, 2014, 2015, 2019, 2020, 2021, and 2022.
109	Conduct a monitoring program to confirm the prediction in the FEIS: ■ Aerial survey can measure effects at the narwhal population and/or stock level including evaluation of large-scale displacement effects or abandonment of the RSA.
110	Develop a monitoring program that includes, but is not limited to, acoustical monitoring, to facilitate assessment of the potential short term, long term, and cumulative effects on marine mammals and marine mammal populations. The Proponent is expected to work with the Marine Environment Working Group to determine appropriate early warning indicator(s) that will ensure rapid identification of negative impacts along the southern and northern shipping routes. ■ Conducted dedicated EWI aerial surveys to collect proportion of immatures in the Eclipse Sound and Admiralty Inlet stocks
111	Develop clear thresholds for determining if negative impacts as a result of vessel noise are occurring: ■ Conducted statistical analyses to compare the values of the current aerial survey to past aerial surveys.
126	Design monitoring program to ensure that local users can assist with monitoring and evaluating potential impacts: ■ Inuit researchers participated in Legs 1 and 2 of the 2022 MMASP.

Results from the 2022 narwhal abundance aerial survey (Leg 2) indicated that: i) narwhal abundance in Eclipse Sound was statistically higher in 2022 than the previous year (2021), although still statistically lower than in 2016 and 2019, and ii) the combined narwhal abundance in Eclipse Sound and Admiralty Inlet was similar in 2022 to what was observed in recent years (2013, 2019 and 2020). These results suggest a portion of the Eclipse Sound stock continued to occupy the Admiralty Inlet summering ground during the summer of 2022.

Given that the combined stock estimate for Admiralty Inlet and Eclipse Sound indicated that the regional narwhal population remained stable relative to pre-shipping conditions, and in consideration of the available IQ regarding the degree of exchange between narwhal groups on their summering grounds, the observed changes in narwhal abundance in Eclipse Sound in recent years likely reflects a natural exchange between the two putative stock areas that began prior to Baffinland shipping operations, with animals shifting between Eclipse Sound and Admiralty Inlet based on where habitat conditions may be more favorable that season (e.g., ice coverage, prey availability, predation pressure). With the recent influence of rapidly warming ocean temperatures and longer open-water seasons due to climate change, more pronounced changes in habitat conditions are to be expected throughout the Arctic along with commensurate changes in animal distributions and migratory movements. For example, it is well documented that sea ice in the Arctic is presently undergoing rapid reduction due to climate warming (Stroeve et al. 2012; IPCC 2013; Overland and Wang 2013) and this has been directly associated with notable shifts in species distributions for both Arctic marine mammals (Laidre et al. 2008, 2015; Frederiksen and Haug 2015; Nøttestad et al. 2015; Víkingsson et al. 2015; Albouy et al. 2020; Chambault et al. 2022;) and their prey (Frainer et al. 2017; Steiner et al. 2019, 2021; Møller and Nielsen 2020). How this might be manifesting on a micro-geographic scale in the North Baffin region is presently unclear, although some insight is offered when considering changes reported in other Arctic environments in close proximity to Eclipse Sound.

Two major oceanographic changes have recently been observed in coastal areas of Southeast Greenland; a lack of pack ice in summer and increasing sea temperature (NAAMCO 2021). This has had cascading effects on the marine ecosystem, as observed through shifts in fish species assemblages in the region (i.e., change in fish community structure) and previously undocumented occurrences of temperate water cetaceans in Southeast Greenland in high abundances (e.g., humpback whales, fin whales, killer whales, pilot whales and white beaked dolphins). Traditional narwhal habitat in this area has become restricted by the warming oceans and the ability of narwhal to adapt to warming water temperatures is also limited due to their general physiology. Shifts in narwhal distribution in Greenland have also been documented in recent years, with multiple sightings of narwhal in locations well north of their traditional range (e.g., Dove Bay, Greenland Sea, Northeast water and Petermann glacier front) (NAAMCO 2021). Current evidence suggests that a combination of hunting and climate change is negatively impacting the long-term viability of populations in Southeast Greenland (NAAMCO 2021).

A recent study by Chambault et al. (2022) predicted the future distribution of Eastern Baffin Bay narwhal under two different climate change scenarios using narwhal satellite tracking data collected over two decades. The long-term predictive models suggested that the current distribution of Baffin Bay narwhal during summer will undergo a northward shift of more than 200 km by the end of the century in order to cope with climate change, and that summer narwhal habitats in this region are predicted to decline from 31 to 66% over this period depending on the climate model. These changes may already be underway in the Eastern Canadian Arctic and may affect Eclipse Sound and Admiralty Inlet differently.

For the above reasons, the potential for climate-driven shifts in species distributions cannot be ignored as a potential driver of the recently observed changes in summer narwhal distribution in Eclipse Sound. To better understand what is occurring, additional engagement and monitoring with Inuit stakeholders and regulatory agencies are needed, inclusive of collaborative regional scale monitoring that looks at the population dynamics of the entire Baffin Bay narwhal stock.

6.0 RECOMMENDATIONS

With respect to future monitoring initiatives for the Marine Mammal Aerial Survey Program, WSP provides the following recommendations for implementation in 2023:

- Conduct an early shoulder season survey to document narwhal movements and distribution in the RSA prior to the start of shipping operations.
- Given that the combined stock estimate for Admiralty Inlet and Eclipse Sound indicate that the regional narwhal population remained stable relative to pre-shipping conditions, and in consideration of the available IQ regarding the degree of exchange between narwhal groups on their summering grounds, the observed low narwhal abundance in Eclipse Sound most likely reflects natural exchange between the two putative stock areas, or alternatively, that animals, at this point in time, are finding more favourable ecological conditions in Admiralty Inlet. To better understand this process, additional engagement and monitoring is needed, inclusive of regional-scope monitoring that looks at population dynamics of the Baffin Bay narwhal stock as a whole. It is recommended that Baffinland support DFO in the Baffin Bay narwhal stock abundance survey in 2023, by flying the Admiralty Inlet and Eclipse Sound summer stock areas while DFO surveys the rother remaining summer stock areas belonging to the Baffin Bay narwhal population.
- Conduct an end-of-shipping-season visual clearance survey to confirm that no narwhal entrapment events occurred in Eclipse Sound and Milne Inlet following completion of shipping operations along the Northern Shipping Route.
- Conduct photo-analysis of 2023 aerial survey data collected at 305 m for early warning indicator (EWI) metrics to supplement the data on the proportion of immature narwhal in the population collected through the Bruce Head Shore-based Monitoring Program.

7.0 CLOSURE

We trust that this report meets your immediate requirements. If you have any questions regarding the content of this report, please do not hesitate to contact the undersigned.

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https://golderassociates.sharepoint.com/sites/11206g/deliverables (do not use)/issued to client_for wp/400-499/1663724-428-r-rev0-59000/1663724-428-r-rev0-59000 mmasp report_27apr_23.docx

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APPENDIX A

MMO Training Manual

2022 Marine Mammal Aerial Survey Program

Training Manual

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Distribution List

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1.0 INTRODUCTION

The Marine Mammal Aerial Survey Program (MMASP) represents one of several programs that were developed to support the Mary River Project (the Project). The MMASP is part of the Marine Monitoring Program (MMP) for marine mammals, in accordance with Project Certificate (PC) terms and conditions issued for the Project. This manual was developed by experienced marine mammal observers to help train other biologists who may or may not have aerial survey experience.

A marine mammal observer (MMO) is a person with training in marine mammal survey techniques. These survey techniques include spotting and identifying marine mammals, determining location of sightings and their movement, and recording environmental variables.

This MMASP training manual will cover the following:

- objectives of the MMASP
- health and safety
- field program overview and procedures
- survey equipment
- data collection, management, and backup

2.0 PROGRAM OBJECTIVES AND OVERVIEW

The 2022 MMASP is proposed to occur during two separate survey legs: Leg 1 (early shoulder season) and Leg 2 (open-water season). The Leg 1 surveys are proposed to occur over a 14-day window in mid-July, during the staging period when narwhal and other marine mammals await ice break-out prior to their entry into Eclipse Sound and Milne Inlet. The objective of the Leg 1 surveys is to collect data on the presence/absence and distribution of marine mammals prior to and during initial shipping operations in the RSA. These surveys aim to address identified data gaps for narwhal during ice break-up in the early shoulder season. Leg 2 surveys are proposed to occur over a 14-day window in August corresponding with the peak open-water period. The objective of Leg 2 surveys is to obtain an updated (2022) abundance estimate for the Eclipse Sound and Admiralty Inlet narwhal summer stocks, as well as for other marine mammal species in the Regional Study Area (RSA). Survey design and data collection methodology previously developed by Fisheries and Oceans Canada (DFO) (Matthews et al. 2017; Marcoux et al. 2016; Doniol-Valcroze et al. 2015; Asselin and Richard 2011; Golder 2020, 2021) will be used to allow for a comparison to previously reported abundance estimates.

3.0 HEALTH AND SAFETY

3.1 Aircraft

Leg 1 and 2 surveys will be flown in a de Havilland Canada DHC-6 Twin Otter aircraft operated by Kenn Borek Air Ltd. (Ken Borek; Figure 1). This short takeoff and landing utility aircraft seats 19 passengers, has a maximum range of approximately 4.5 hours or 1207 km (750 miles) and a cruise speed of 265 km/h (165 mph).

Kenn Borek's safety management system is consistent and aligned with Transport Canada's highest airline standard complete with Emergency Response Plan and Quality Assurance Program. Kenn Borek continuously monitors and develops the following safety objectives:

- Non-punitive Policy
- Proactive Reporting
- Annual Goal Setting
- Management of Change / Risk Management Program
- Corrective Action Planning and Quality Assurance Oversight
- Continuous promotion of a safe and just culture by all Kenn Borek Air management

Figure 1: Aircraft de Havilland Canada DHC-6 Twin Otter operated by Kenn Borek Air Ltd.

3.2 Personnel

MMOs are expected to familiarize themselves with aircraft exit locations and safety equipment on-board the aircraft. This information will be reviewed during the safety briefing prior to each flight. In addition to aircraft safety, all MMOs must read and understand the MMASP program-specific Health, Safety, Security and Environment (HSSE) Plan which will be reviewed prior to the start of MMASP related work. A major component of the HSSE Plan is the identification of potential health and safety hazards associated with the MMASP including environmental conditions and MMO activities and the implementation of the controls necessary to minimize the risk to people. The program specific HSSE Plan is based on the assessment of previous worksites and similar activities and is a dynamic document that can be modified if things change during the MMASP. The HSSE plan will typically cover the following information:

- personnel contact information
- emergency contact information

- Safe Work Practices and Procedures
- toolbox meetings (to be completed at the start of every day)
- incident reporting

4.0 FIELD PROGRAM

4.1 Survey Area

Two survey grids (Eclipse Sound and Admiralty Inlet) encompass the survey area for the 2022 MMASP. Eclipse Sound Grid is divided into nine strata (Baffin Bay, Pond Inlet, Eclipse Sound East, Eclipse Sound West, Navy Board Inlet, Tremblay Sound, Milne Inlet North, Milne Inlet South, and Fjords; Figure 2). Admiralty Inlet Grid is divided into three strata (Admiralty Inlet North, Admiralty Inlet South, and Fjords; Figure 2).

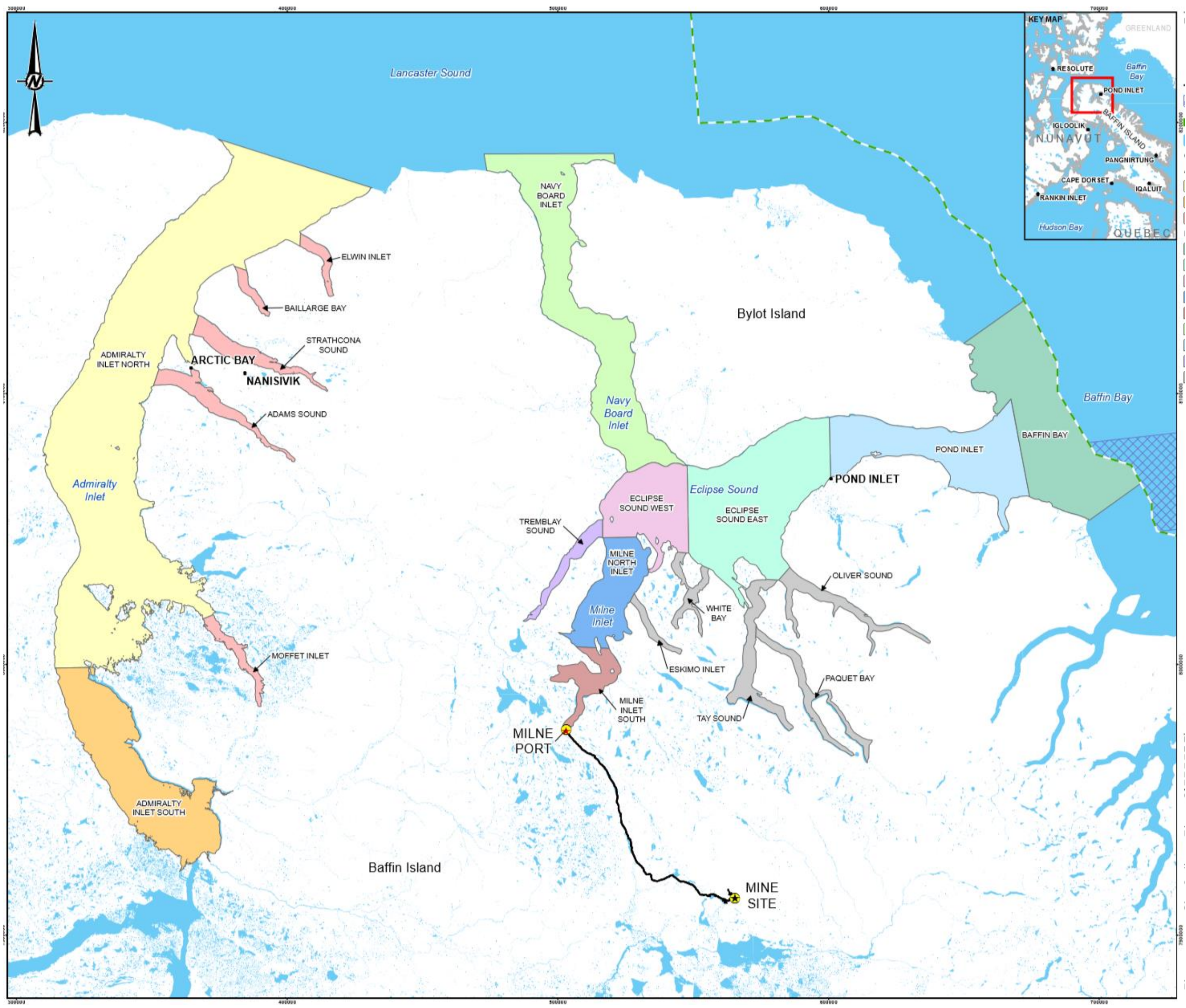


Figure 2: Geographic strata for Eclipse Sound Grid (on the right) and Admiralty Inlet Grid (on the left).

Leg 1 study area encompasses the Eclipse Sound Grid and is based on the boundaries flown in previous surveys from 2013–2016 (DFO 2017; Golder 2017), with the addition of a Baffin Bay stratum (Figure 2). Leg 1 is designed to focus in the open-water area around the floe edge (blue and yellow/orange lines in Figure 3) in the Baffin Bay or eastern Pond Inlet strata where narwhal are known to stage prior to entering Eclipse Sound. Reconnaissance flights will be flown periodically in Tremblay Sound, Eclipse Sound and Milne Inlet to verify narwhal presence/absence. If narwhal are observed in these strata, the entire survey grid will be flown, including all strata (switching from yellow/orange floe edge line and blue transect lines to red transect lines in Figure 3).

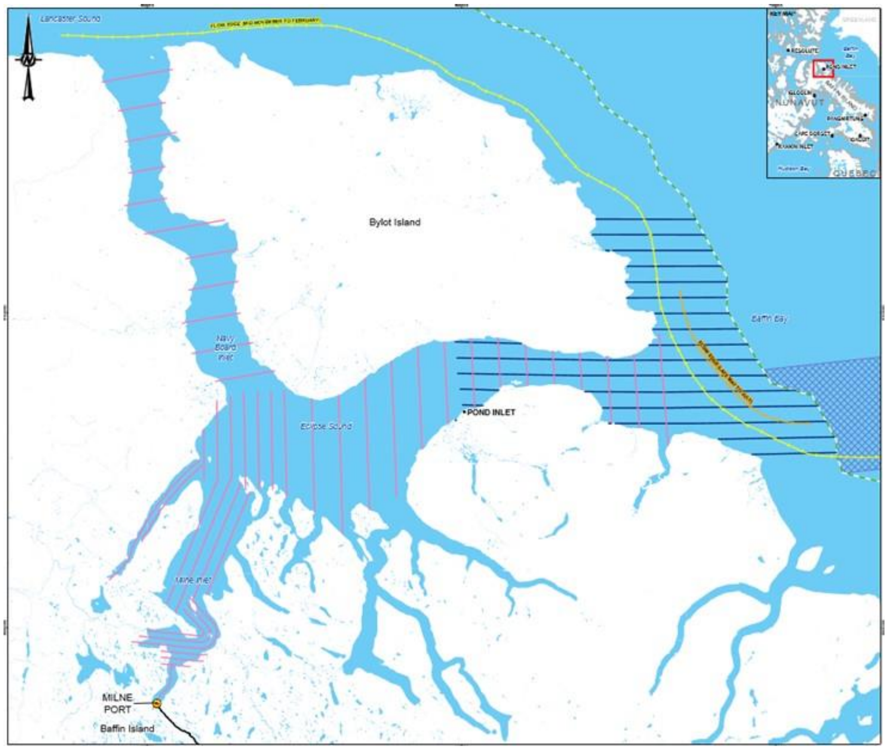


Figure 3: Leg 1 transect lines for the Eclipse Sound study area.

Leg 2 will survey Eclipse Sound Grid and Admiralty Inlet Grid within a two- to three-day period to obtain an estimate of narwhal abundance in the combined areas. The boundaries for the Eclipse Sound Grid are the same as those for Leg 1 with the exclusion of the Baffin Bay stratum (see Figure 2). As during Leg 1, systematic random visual line-transect surveys will be flown for all strata (except Tremblay Sound and Milne Inlet South where photographic surveys will be conducted) with the location of the first line chosen at random (Figure 4). A photographic survey with complete coverage will be flown for the Tremblay Sound and Milne Inlet South strata. Reconnaissance flights in Eclipse Fjords will be flown when time and weather permits.

The boundaries for Admiralty Inlet are divided into three strata (see Figure 4). Systematic random visual line-transect surveys will be flown for the North and South strata with the location of the first line chosen at random (Figure 4). Reconnaissance flights in the fjords will be flown when time and weather permits.

During visual line-transect surveys, if large aggregations (e.g., >50 narwhals or when observers indicated that they cannot accurately keep up with narwhal counts) are identified, a photographic survey will be flown with complete coverage over the group to allow for accurate counts of animals. To identify aggregations observed during visual surveys, all personnel on board the aircraft are instructed to look out for herds of narwhal and alert everyone when one was sighted. When such an aggregation is located, lines will be flown in a cross pattern over the group, to determine its spatial extent. Using pre-planned survey grids, the aggregation will be photographed using a systematic grid with complete coverage as seen in Figure 4 for the Milne Inlet South and Tremblay Sound strata.

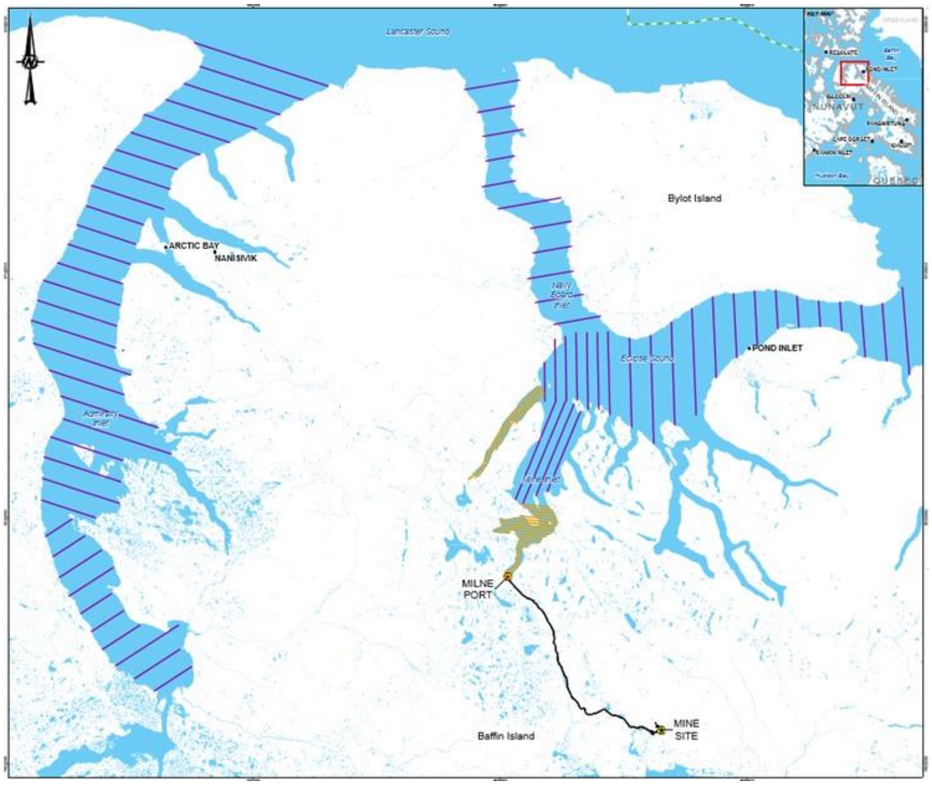


Figure 4: Leg 2 transect lines for the Eclipse Sound and Admiralty Inlet study areas.

4.2 Flight and Observational Procedures

Each survey will be flown along the transect lines at a target altitude of 305 m (1,000 feet) with a target speed of 185 km/h (100 knots). The survey aircraft for all survey Legs will consist of a de Havilland Twin Otter 300 equipped with four bubble windows on the sides and a large belly window used for cameras. MMOs will be stationed at the front and rear bubble windows that provide a view of the track line directly below the aircraft. Visual surveys will be conducted as a double-platform experiment with independent observation platforms at the front (primary) and rear (secondary) of the survey plane. The two observers stationed on the same side of the aircraft will be separated visually and acoustically to achieve independence of their conditional detections. A fifth member of the survey team will be responsible for overseeing camera operations, data entry, and navigation along the survey grid.

Observers will focus on the area closest to the track line and use their peripheral vision for sightings farther afield. Primary observers will record every marine mammal sighting by speaking into a hand-held audio recorder to supplement the data being collected in real time in Mysticetus. Secondary observers will also record every marine mammal sighting in a hand-held audio recorder, as well as enter partial observation records in Mysticetus.

Each sighting record will include information on time, species type, group size, group composition (presence of calves, mother/calf pairs, adults, number of tusks, etc.), direction of travel (heading), speed of travel, sighting cue, behaviour, and activity. A group is defined as animals within one to a few body lengths of each other and oriented or moving in a similar direction. Observers will give priority to estimating group size, especially when densities are high, followed by other variables (direction of movement, presence of young, number of tusks) if time permits. Geometers will automatically assign the perpendicular declination angle of each sighting in the Mysticetus program for the primary and secondary observers. Position and altitude of the plane will be recorded every second using a GPS connected to a laptop running Mysticetus. A dedicated Bluetooth GPS unit and iPad will also be used to track the aircraft location using specialized navigational mapping software (Foreflight pre-programmed with the survey transect grid).

Observational conditions (environmental data) will be recorded onto the audio recorders by the primary observers at the start of each transect and re-stated at any time a change was detected throughout the survey. Conditions will include sea state (Beaufort scale), ice concentration (in tenths), fog (% cover in field of view and intensity), and glare (% of forward field of view and intensity). Environmental data will be entered into Mysticetus after each flight.

4.3 Photographic Data

To supplement visual observations, the aircraft will collect continuous photographic records below the aircraft using dual oblique cameras pointing downwards towards either side of the track line. A three-second interval between photographs will allow for a target overlap of 20% between successive photographs along the direction of the aircraft at the survey altitude of 1,000 ft above sea level. The aircraft will be fitted with a camera belly port hatch to accommodate a custom camera frame and two Canon EOS 5DS R Digital Single Lens Reflex (DSLR) still cameras.

Each camera will be connected to a laptop and controlled remotely (settings, start and stop). Photographs will be stored in high-resolution RAW format. At the end of each survey photos will be transferred to an external hard drive.

4.4 Photographic Surveys

During visual line-transect surveys, if large aggregations (>50 narwhals or when observers indicate that they cannot accurately keep up with narwhal counts) are identified, a photographic survey will be flown with complete coverage over the group to allow for accurate counts of animals. To better quantify large narwhal aggregations observed on the visual surveys, all personnel on board the aircraft will be instructed to look out for herds of narwhal and alert everyone when one was sighted. When such an aggregation is located, two lines will be flown in a cross pattern over the group to determine its spatial extent. Using the pre-planned survey grid, the aggregation will be photographed using a systematic grid with complete coverage. A six-second interval between photographs will allow for a target overlap of ~15% between successive photographs along the direction of the aircraft at the survey altitude of 2,000 ft above sea level. During Leg 2 a dedicated photographic survey will be flown in the Milne Inlet South and Tremblay Sound strata where narwhal are known to concentrate at that time of the year.

5.0 DAILY ROUTINES

Every morning the aerial crew will meet at a designated area to take the bus to the Weather Haven where they will remain for the duration of the day awaiting a weather window for a survey. Upon arriving at the Weather Haven a daily toolbox session will be initiated with the aerial crew and a plan put into motion to either prepare for a survey or to check back in an allotted time if weather conditions are not favorable for a survey. Weather requirements for surveying include a ceiling of greater than 333 m (1,000 ft) and sea states of less than Beaufort level five.

Flight days—If the weather permits a flight, the lead MMO will set up a time for departure. Typical flight days range in length from 10-12 hours depending upon weather. *Punctuality is required*. Delays or missing crew members can force the survey to be canceled. Bring water and food for the flight, keeping in mind that the plane has no toilet. A small bag including toiletries and a coat are also good to bring, as sometimes poor weather may require the use of an alternate landing site. Each MMO will be supplied with a dry suit to wear while working on the aircraft and a headset. After a flight, it is important to enter and validate the data as soon as possible. Depending on the landing time, this could be either that evening or the next morning.

Non-flight days—Typical workdays range in length from 8–10 hours depending upon the number of trained staff members available, the weather, and how much data needs processing from the previous day. When no surveys are flown MMO's will be expected to do data entry and validation.

6.0 EQUIPMENT

Clinometer

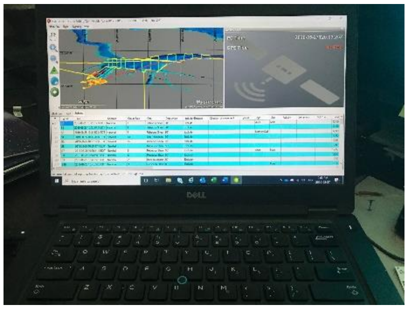
Depression angle from the horizon to the sighting is determined using a clinometer when the marine mammal is perpendicular to the aircraft. Use only one clinometer reading for the center of a group (no angle ranges). See Appendix B for instructions of use.

Geometer

When the marine mammal is perpendicular to the aircraft, sight the animal in the center of the scope and press the button on the front of the geometer. This will automatically record sighting time and declination angles of the sighting in the Mysticetus program. This device can be used instead of the clinometer.

Digital Recorder

Digital recorders will be used to record sighting data and environmental data to be transcribed to the Mysticetus database at the end of each flight.



Laptop with Mysticetus program

The Mysticetus program will be used to record GPS tracks and waypoints (transect start and stop, sightings, and environmental data) during each survey. After each survey, additional data will be entered on a laptop computer into the Mysticetus database. The database is programmed with data forms (drop-don menus) and data entry fields that are specific to the type of data being collected.

Bad Elf GPS

A Bad Elf GPS Pro device will be used to track the aircraft during marine mammal surveys at one second intervals.

Each GPS device should be turned on at the start of the flight by pressing the “ON” button located on the left side of the device. It may take a few minutes for the device to acquire satellites.

The MMO should check the GPS device regularly during the flight to ensure that it has not lost signal and is working properly.

Camera Equipment

Each aircraft will be equipped with two identical camera systems, using Canon EOS 5DS DSLR cameras fitted with 35 mm lenses. The cameras will be connected to a laptop computer to control exposure settings and photo interval. The cameras will be installed within the camera hatch on a custom-made mount. Images will be saved directly to the internal camera cards. The cameras will be oriented widthwise (long side perpendicular to the track line) and angled obliquely: one to the port side and the other to the starboard side. See Appendix A for detailed camera setup.

Personal Protective Equipment

Observers will be provided with a dry suit and a headset prior to each flight.

7.0 DATA COLLECTION

Each aerial survey crew consists of five positions: two primary observers (front observers), two secondary observers (rear observers), and the navigator/data manager (Figure 5). The positions are assigned prior to take-off and have different responsibilities, however during long flights positions can be rotated during refuelling to reduce fatigue.

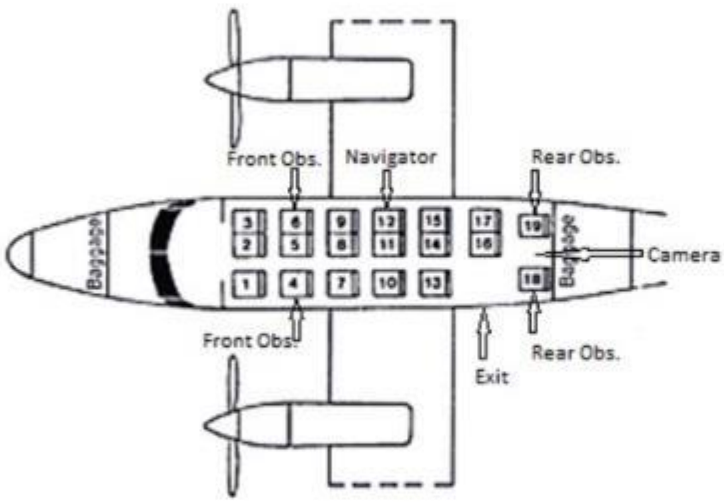


Figure 5: Twin Otter aircraft configuration with aerial crew locations

7.1 Navigator/Data Manger

A specially designed electronic database (Mysticetus) with mapping software will be downloaded with the survey track lines so the observers can be notified by the navigator of the start and stop point of the transects. Geometers will automatically populate Mysticetus with the date, time, location (i.e., GPS coordinates), observer and declination angle of the primary and secondary observer sightings. The data manager will supplement the sighting data for the primary observer sightings in real time with species and group size along with any additional data verbalized by the primary observers. A drop-down menu is available to facilitate recording data collected during the survey, but some data will be transcribed from the audio recorders into the database after the flight. Supplemental sighting data for the secondary observers will be entered after completion of the survey. Primary and secondary observers will be connected to separate computers each running their own version of Mysticetus. A portable GPS unit will be plugged into each computer to record GPS positions and waypoints during each flight with the Mysticetus program. The date, time, and GPS coordinates are automatically recorded with each one-second point on the track line.

The data manager will be responsible for keeping a flight log in the Mysticetus database connected to the primary observers. The flight log should have the date, flight number, start (aircraft starts moving) and stop (aircraft stops moving) times, and the survey number for each time the aircraft is flown.

7.2 Primary and Secondary Observers

At the start of the flight, each observer is issued a geometer, synchronized wristwatch, and digital voice recorder. Primary observers sit in the forward right and left seats and collect environmental and sightings data used for analyses. The two most experienced MMOs on the aircraft should be occupying the primary observer positions. Secondary observers sit in the rear right and left seats and are collecting sightings data to be used in the double-platform experiment. The double-platform experiment requires independent observation platforms at the front (primary) and rear (secondary) of the survey plane. The two observers stationed on the same side of the aircraft will be separated visually and acoustically to achieve independence of their conditional detections.

7.2.1 Environmental Data

Environmental conditions are recorded at the start and end of each transect and whenever conditions change within the viewing area (Table 1). The viewing area is estimated out to approximately 1 km from the aircraft (see Appendix B). Four environmental conditions are recorded:

- **Ice tenths cover**: Tenths of the viewing area covered in ice.
- **Beaufort wind force (Beaufort Sea State)**: Visual conditions of the wave height and froth.
- **Glare**: Percentage of searching area affected by sun reflection and intensity.
- **Fog**: Percentage of the viewing area obscured due to fog and level of intensity.

See Appendix B for examples of the various environmental conditions.

Table 1: Environmental Codes

Environmental Type	Code	Description
Ice Cover	0/10 – 10/10	Ice cover within viewing area
Beaufort Wind Force	0	Sea like a mirror
	1	Ripples with the appearance of scales are formed, but without foam crests
	2	Small wavelets, short but more pronounced. Crests have glassy appearance and don’t break.
	3	Smooth, large wavelets. Crests begin to break. Scattered whitecaps.
	4	Small waves, becoming longer. Fairly frequent whitecaps.
	5	Moderate waves, taking a pronounced long form. Many whitecaps.
	6	Large waves forming, white foam crests more extensive everywhere. Probably spray.
	7-12	Ranges from a gale to a hurricane.

Environmental Type	Code	Description
Percent Glare	0 -100%	Percent glare obscuring viewing area
Glare Intensity	Intense	When animals were certainly missed in the center of reflection angle
	Medium	When animals were likely missed in the center of reflection angle
	Low	When animals were likely detected in center of reflection angle
	None	No glare
Fog Cover	0 -100%	Percent fog obscuring viewing area
Fog Intensity	Thick	Dense thick fog that you cannot see through
	Moderate	Thick and light fog interspersed, can see through at times
	Light	Light fog that you can see through
	None	No fog

7.2.2 Sighting Data

Sighting data is recorded every time a marine mammal is sighted (Table 2). Examples with descriptions of each sighting type are provided in Appendix B.

Observers will trigger the geometer when a marine mammal is spotted **perpendicular** to the aircraft so the sighting along with the date, time, location, observer and declination angle is automatically entered in the Mysticetus program. Primary observers will notify the Mysticetus operator (i.e., data manager) of the species and group size.

Both primary and secondary observers will record the following additional information about the sighting on their digital voice recorder in order of importance:

- **Time:** hour, minute and second
- **Species**: name of species observed
- **Group size**: number of individuals in group
- **Included/excluded:** on transect or on transit
- **Direction of movement:** clockface direction of movement in relation to the aircraft
- **Speed:** relative speed of animal's movement
- **Age/sex:** apparent age of the animal and if tusk present
- **Behavior:** movements or biological processes in which animal is engaged
- **Activity:** a collection of behaviors that indicate the animal is working toward an overall goal (e.g., feeding, migrating)
- **Sighting cue:** What alerted you to the sighting?

Table 2: Sighting Data Codes

Sighting Type	Code	Description
Species	Species (e.g., narwhal)	Narwhal, bowhead, beluga, ringed seal, harp seal, walrus, etc.
Group Size	#	Number of individuals in group (group is defined as animals that are within one body length of each other and oriented or moving in a similar direction).
Clinometer angle	# degrees	Depression angle from the horizon to the sighting as determined using a clinometer when the marine mammal is perpendicular to the aircraft. Use only one clinometer reading for the center of a group (no angle ranges). If using a geometer, sighting time and depression angle are automatically stored on a laptop with the press of the button. Clinometers will only be used if needed.
Include/Exclude	Include	A sighting seen within the field of view on transect, at the surface or clearly visible just below surface, and at survey altitude.
	Exclude	If the sighting is seen on transit, or outside the field of view (i.e., behind the aircraft or well beyond 1 km), or barely visible below surface, or seen when flying above normal survey altitude (i.e., on transit flights).
Direction of movement	Clockface 1-12	Clockface direction of movement in relation to the aircraft. 12 o'clock means animal is moving in same direction as aircraft.
Speed	Fast	When animal is swimming rapidly through the water, often associated with splashes. Wake left behind.
	Moderate	When animal is swimming moderately through water, often associated with trail behind animal.
	Slow	When animal is swimming slowly through water, but trail barely visible in water.
	Not moving	Animal is stationary, no movement.
Age	# adults	Large whitish animals should be assumed to be adults. Dark animals that are 85% or larger than the length of whitish adults should be assumed to be adults. Code unknown if not sure.
	# juveniles	Dark in color and 15% smaller than adult. May have short tusk present. Code unknown if not sure.
	# calves	Whitish to grey in appearance and slightly less than half of the length of the adult female. Code unknown if not sure.
Sex	# males	If tusk visible code as male. Code unknown if not sure.
	# females # mother	If no tusk visible and not accompanied by a calf. Code as female. Code as mother if seen with a calf. Code unknown if not sure.
Activity	Feeding	Animal seen feeding or evidence of prey observed.
	Traveling	Moving in a distinct direction with a moderate to fast pace.
	Resting	Animal lying motionless at the surface of the water or on the ice/land.

Sighting Type	Code	Description
	Milling	Moving but net movement is near zero, e.g., swimming in circles.
	Socializing	Engaged in social activity (involving more than one animal).
	Unknown	Nothing recorded.
Behaviour	Hauled out	Hauled out on ice or land (pinnipeds). Primary behaviour to record for pinnipeds.
	Diving	Animal descends below the surface.
	Fluking	When a whale raises its fluke as it dives beneath the water.
	Surfacing	When a marine mammal is observed coming to the surface of the water.
	Swimming	Animal is swimming at the surface.
	Surface activity	Splashing, jumping, flipper or tail slapping, implies social interaction.
	Looking	When animal is in an upright position with its head out of the water and is actively looking at something (pinniped or polar bear).
	Blow	When whale releases air from its lungs at the surface of the water, observed as clouds of moist air. Can be visible at far distances.
	Breaching	When a whale leaps with its entire body out of the water.
	Spyhopping	When a whale raises its head vertically out of the water so that its eyes are clear of the surface.
	Walking/Running/Standing	Polar bear walking, running, or standing on ice or land.
	Dead	Observation of a dead marine mammal.
	Logging	When a marine mammal is on the surface and is neither swimming nor moving
	Unknown	Nothing recorded.
Sighting cue	Blow	Whale exhales breath at surface of water seen as a watery mist.
	Body	Body or marine mammal.
	Footprint	Surface of the water looks disturbed and are made when a marine mammal has just been on or near the surface of the water.
	Splash	Splashes may be a sign that a marine mammal is present.
	Birds	Aggregation of birds may be attracted to marine mammal when they are feeding.
	Unknown	Nothing recorded.

8.0 DATA MANAGEMENT

One of the most important parts of the work is to carefully record information on all sightings/observations during the survey onto the audio recorders and transcribe that data into the database after every flight. This information is critical to the success of the MMASP Program. A lot of time and mentorship will be spent on training to properly, efficiently, and consistently record information.

8.1 Data Transcription

Once the survey is complete, data from the voice recorders must be transcribed into the Mysticetus database for the primary observers or on data sheets for the secondary observers as soon as possible so that people may be able to accurately fill in any data not recorded during the survey. There will be prompts to enable the MMO to enter data efficiently and out-of-range error checking to ensure that only plausible values can be entered into the database. The Mysticetus database includes three types of data: flight data, environmental/effort data, and marine mammal sightings data.

8.1.1 Flight Data

Flight data is recorded by the data recorder during the flight and is assigned waypoints in the tracking program. Flight data includes the following data:

- Date
- Location (Eclipse Sound or Admiralty Inlet)
- Survey number
- Flight number (can take up to four flights to complete a survey)
- Observers and their locations on the aircraft

8.1.2 Environmental/Effort Data

Environmental/effort data are assigned waypoints in the database by the data recorder during the flight. Primary observers will fill in specific information associated with the waypoints after the flight from their audio recordings. Environmental/effort data include the following data:

- Start and stop transects (assigned a waypoint by data recorder during flight)
- Environmental record (assigned a waypoint by data recorder during flight)
- Ice cover for environmental record (filled in by primary observer audio recordings after flight)
- Beaufort wind force for environmental record (filled in by primary observer audio recordings after flight)
- Glare cover and intensity for environmental record (filled in by primary observer audio recordings after flight)
- Fog cover and intensity for environmental record (filled in by primary observer audio recordings after flight)

8.1.3 Sighting Data

Marine mammal sightings are assigned waypoints in the database by the data recorder during the flight. Primary and secondary observers will fill in specific information associated with the waypoints after the flight from their audio recorders. Sighting data include the following waypoints:

- Marine mammal sighting (assigned a waypoint by geometer during flight)
- Species (filled in by data recorder in real time for primary observer or by primary/secondary observer audio recordings after flight)
- Group size (filled in by data recorder in real time for primary observer or by primary/secondary observer audio recordings after flight)
- Clinometer angle (automatically entered by geometer)
- Observer (automatically entered by geometer)
- Include/exclude (filled in by primary/secondary observer audio recordings after flight)
- Direction of movement (filled in by primary/secondary observer audio recordings after flight)
- Speed (filled in by primary/secondary observer audio recordings after flight)
- Age (filled in by primary/secondary observer audio recordings after flight)
- Sex (filled in by primary/secondary observer audio recordings after flight)
- Activity (filled in by primary/secondary observer audio recordings after flight)
- Behaviour (filled in by primary/secondary observer audio recordings after flight)
- Sighting cue (filled in by primary/secondary observer audio recordings after flight)

Once all data have been entered, all electronic entries should be compared to digital recordings again, by a different observer, to check for errors. Backups of the database should be made regularly and stored on an external hard drive and another computer.

8.2 Data Editing

Check your own work at the end of each survey to ensure accuracy. If you note a mistake, and can remember the details, correct it and initial the changes. If you cannot remember, do not make a guess. Missing data are preferable to incorrect data. All columns should be filled out to the best of your ability; there should be no blank spaces in the spreadsheet. Additionally, if you note a mistake by another MMO, bring it to their attention as soon as possible, so it can be corrected.

8.3 Data Storage and Backup

MMOs are required to do the following measures after each survey is complete to help prevent collected data from being lost:

- Data recorded onto the digital recorders must be backed up onto the field computer.
- Mysticetus data should be backed up regularly in several places: external hard drive, lead MMO's laptop and on the field computer, as coordinated by the lead MMO. Backups should be double-checked to ensure that data were successfully transferred.

The photographic images will be backed up after every flight and a copy made for duplicates.

SIGNATURE PAGE

Golder Associates Ltd.

Tannis Thomas, MSc
Biologist

Patrick Abgrall
Senior Marine Biologist

TT/PA/syd

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APPENDIX A

Camera Setup

CAMERA SETUP

Camera Settings

- Mark each camera left or right (small piece of electrical tape with a "L" or "R" in silver permanent marker), mark media cards left or right.
- In playback menu, turn rotate tall and image review off.
- In shooting menu set image quality to RAW size large, 14 bit, image area to FX (36X24) 1.0 x with auto DX crop off, color space to RGB, and turn active D-lighting to off.
- In setup menu format both the SD and CF cards and set camera to write to one card then overflow to the next card. Set camera date and time to the precise GPS date and time, do this at the start of every day, check the date-time at the end of every flight when you're back in the hotel to see if there is any drift. If there is drift record it so that true camera times can be estimated to get an accurate match with GPS time.
- Connect cameras to a laptop running the camera control software. Using the camera control software, set cameras to shoot in manual settings, shutter priority of at least 1/1600 s, the aperture can be set on automatic if you expect a large variability in the brightness of the photos, particularly when ice in present in the survey area. Try to balance to keep an f stop that is not wide open as there is some clutter introduced to the pixels when shooting at wide open but do not close the aperture too much either. You can increase the ISO to increase shutter speed but there is some noise introduced to the pixels at the highest ISOs. Setting the ISO at 400 to 800 should be acceptable if you need to go that high to get 1/1600 sec shutter speed. We should do some tests in the aircraft when we get the chance to evaluate the tradeoff between ISO and shutter speed.
- Be careful with AF buttons, make sure they are set manual, if need be tape with electrical tape, remove tape after each flight so that glues do not adhere too much.

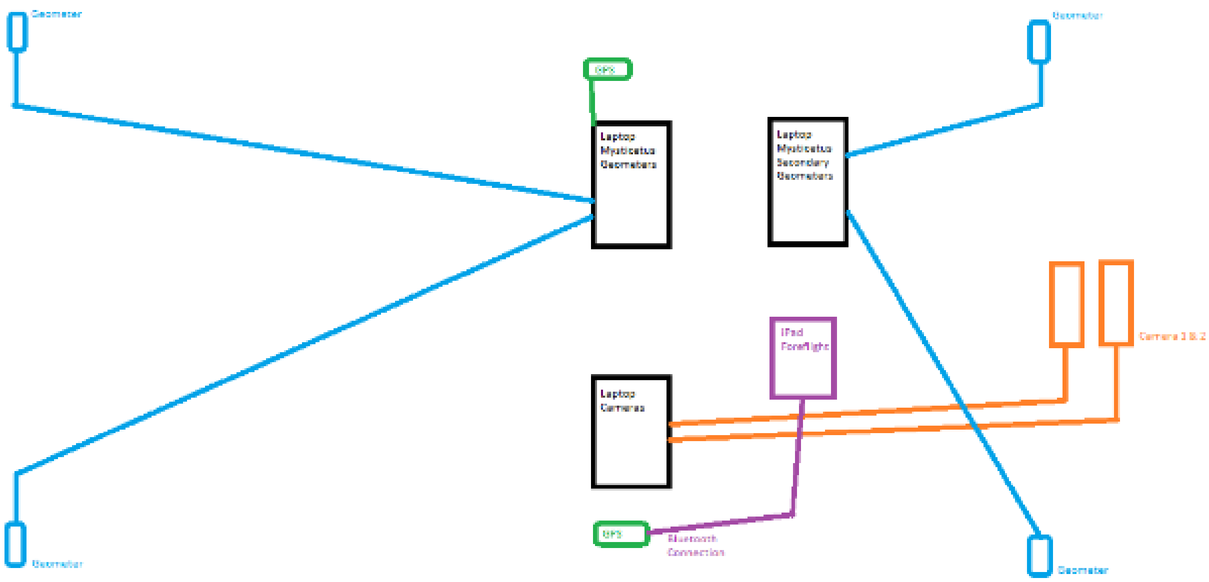
Inverter

- Bring plenty of extension cords, plan layout before flight.
- Careful with cords draped over seats and along floors, there are pinch points that can cut or damage cables (electrical, antenna, GPS, serial).
- Duct tape cords to the walls to keep them from getting in the way or being tripped over.
- Turned on inverter at start of flight before action starts, may have to ask pilot, they usually turn it off when starting aircraft, best to indicate when they look back to check on passengers before beginning taxiing, or after take-off during level flight.

Mounting Cameras on the Frames

- Frame, aircraft floor, camera port opening may have sharp edges, be careful.
- Setup frame, set camera angles depending on how many cameras you intend on using (e.g., 2, 3 or 4), 2 is usually one looking left and one looking right. If using a 35 mm lens, adjust angles to 27 degrees from centerline using a digital protractor.
- Camera image long axis is usually perpendicular to the flight direction to get the maximum strip width.
- Fit camera to frame before first flight, make sure that lenses are not touching camera port glass and that frame is setup for least vibration, set camera mount delimiters if they are available so that the camera will not touch parts of the aircraft when they are shooting (airframe vibration transferred to camera, damage to glass, damage to camera). Prevent the edges of the camera port from being included in the photos taken.
- Connect electrical.
- Tape connections if you can, especially between AC/DC power supply and dummy battery lead of camera.
- Carefully mount camera taking care to avoid stretching cables to prevent connectors from coming loose.
- Fire test shots to verify the centerline is covered in the images.

For connecting all equipment in the aircraft refer to image below.



APPENDIX B

Examples of Environmental and Sighting Data

This appendix contains examples of environmental and sighting data used in the data collection of the MMASP:

Environmental data includes:

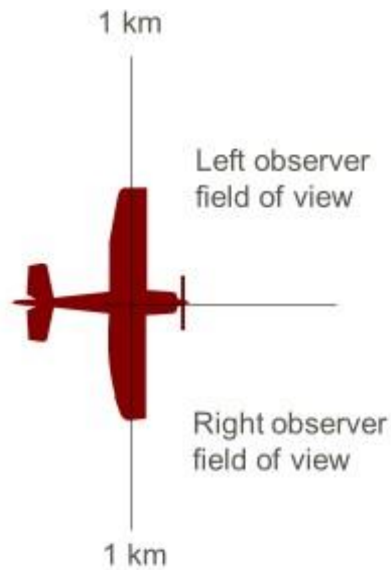
- Ice cover
- Wind force
- Glare
- Fog

Sighting data contains:

- Species
- Number
- Clinometer
- Include/exclude
- Heading
- Speed
- Age
- Sighting cue
- Behavior
- Activity

Field of View

- Looking forward and to out to the side of the aircraft
- 90 degrees and out to 1 km

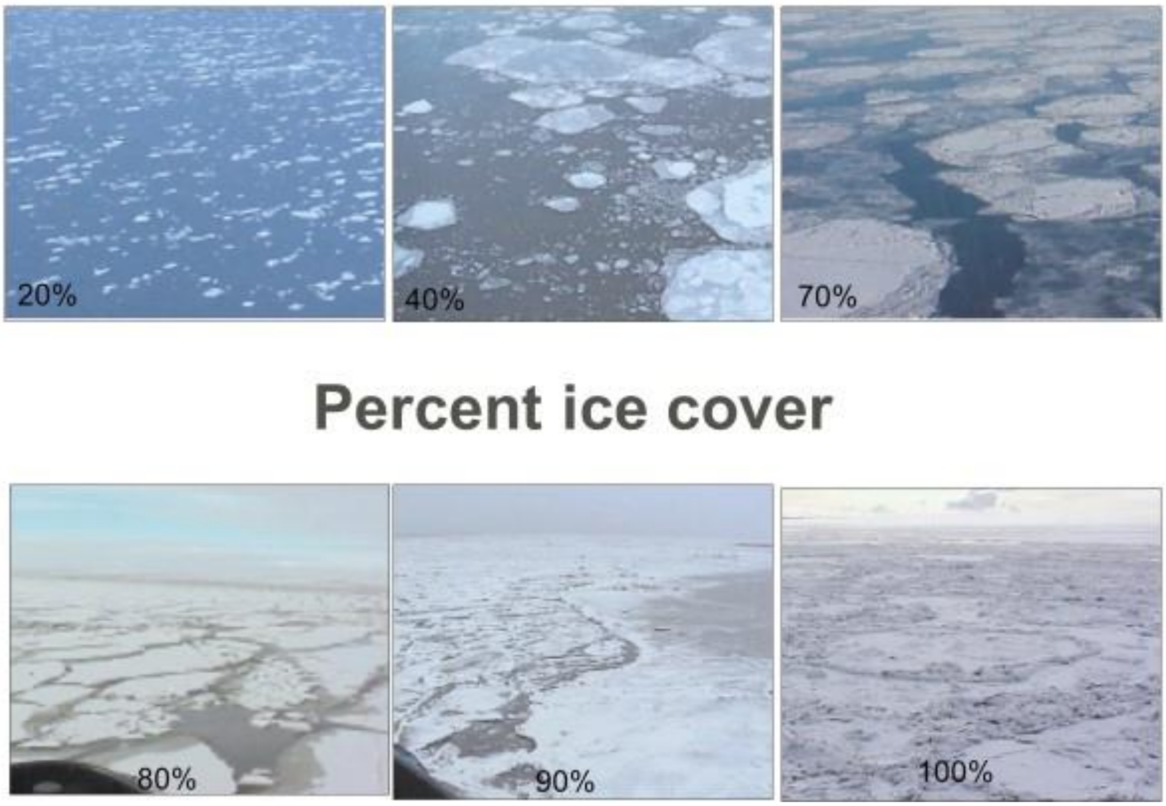


Environmental Data

- **Ice cover**
- Wind force
- Glare
- Fog

Subjective

Based on average of conditions

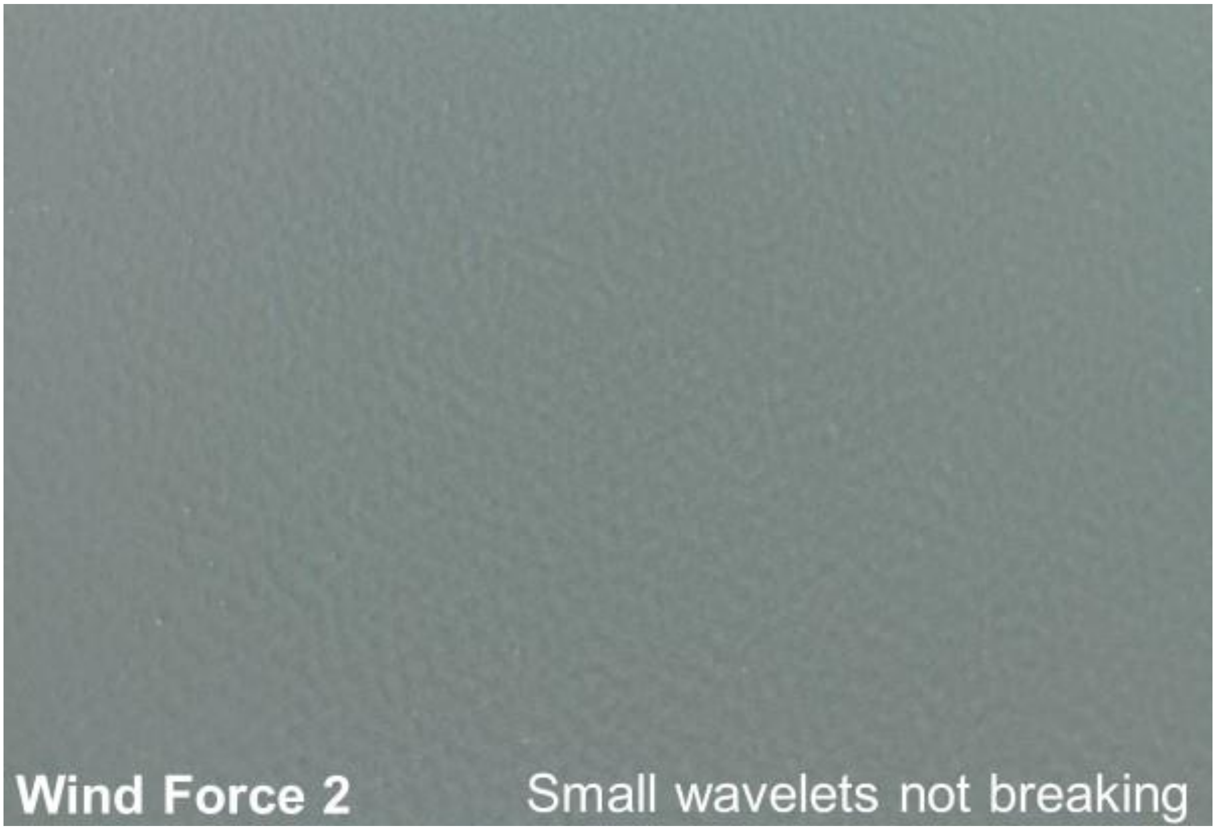


Beaufort Wind Force Chart

Wind Speed		Beaufort Wind Force	World Meteorological Organization Terms	Wave Height (m)	Description
Knots	m/s				
<1	<0.5	0	Calm	0	Glassy like a mirror
1-3	0.5-1.5	1	Light air	<0.1	Ripples with the appearance of scales but no whitecaps or foam crests
4-6	2.1-3.1	2	Light breeze	0-0.1	Small wavelets, crests have a glassy appearance but do not break (no whitecaps)
7-10	3.6-5.1	3	Gentle breeze	0.1-0.5	Smooth large wavelets, crests begin to break, occasional/scattered whitecaps
11-16	5.7-8.2	4	Moderate breeze	0.5-1.2	Slight; small fairly frequent whitecaps
17-21	8.7-10.8	5	Fresh breeze	1.2-2.4	Moderate waves becoming longer, some spray, frequent moderate whitecaps
22-27	11.3-13.9	6	Strong breeze	2.4-4	Rough, larger waves, longer-formed waves, many large whitecaps
28-33	14.4-17.0	7	Near gale	4-6	Very rough, large waves forming, white foam crests everywhere, spray is present
34-40	17.5-20.6	8	Gale		
41-47	21.1-24.2	9	Strong gale		
48-55	24.7-28.3	10	Storm	6-9	High
56-63	28.8-32.4	11	Violent storm	9-14	Very high


Wind Force 0
Glassy


Wind Force 1
Ripples


Wind Force 2
Small wavelets not breaking


Wind Force 3
Scattered white-caps


Wind Force 4
Frequent white-caps


Glare
Two measurements:
• Percent - percent glare obscuring viewing area (0 - 100 %)
• Intensity – intense, medium, low, or none


Medium and 50%


Intense and 25%

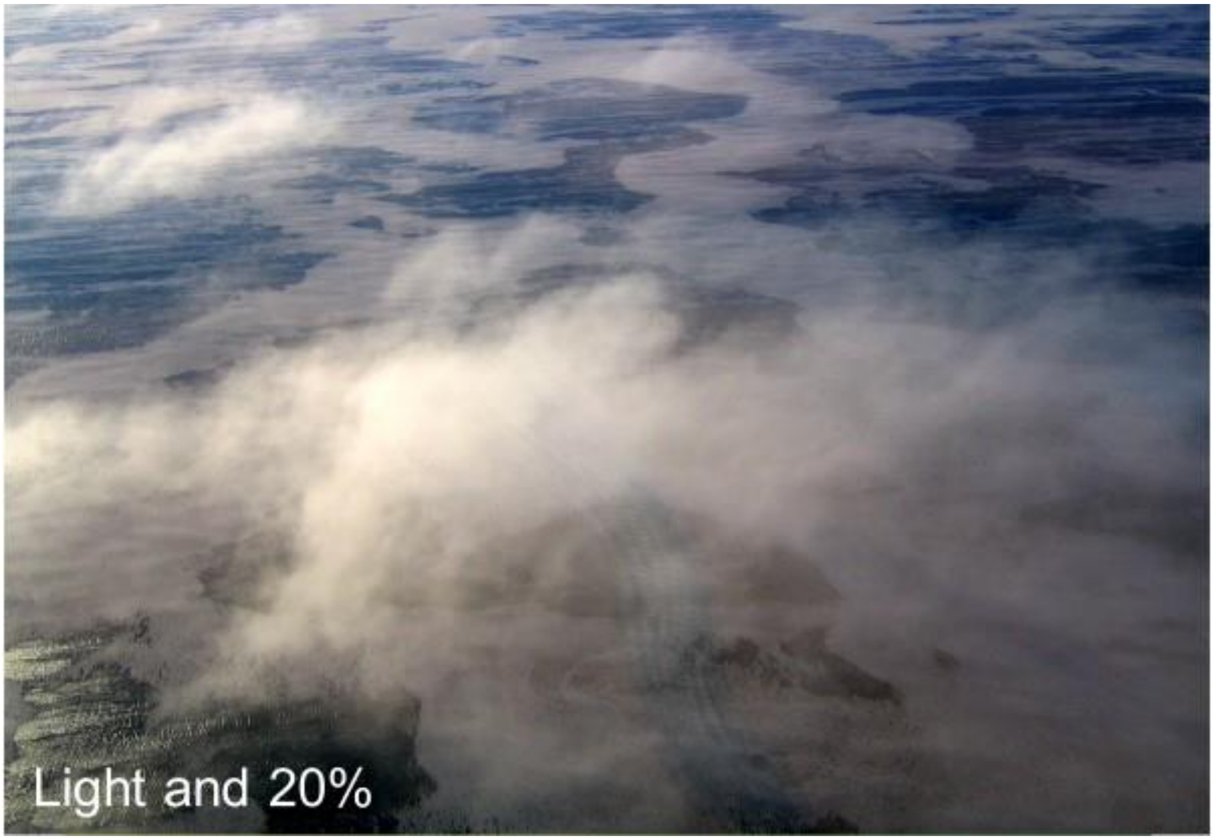
Fog

Two measurements:

- Percent - percent fog obscuring viewing area (0 - 100 %)
- Intensity – thick, moderate, light, or none


Thick and 100%


Moderate and 100%


Light and 20%


Sighting Data
Collected for each sighting:
Species
Number (group size)
Clinometer angle
Include/exclude
Collected if time:
Heading
Speed
Age
Sighting Cue
Activity/Behavior

Narwhal

- small whale 4.2 to 4.7 m
- low bushy blow
- spotted black and white coloration
- males have a tusk
- tail convex on trailing edge

Beluga

- small whale 4.3 to 4.9 m
- low bushy blow
- adults white and calves are gray


Bowhead
large whale
hump near blowhole
can have white on chin and tail
blows are v-shaped


Killer Whale
mid-sized whale 9 m
dorsal fin
black with white patches

Sperm Whale

- Large whale 12.5 to 19.2 m
- S-shaped blowhole at front of head and offset to left
- Thick, low dorsal fin followed by series of bumps on dorsal ridge

Seals

- Ringed Seal
- Harp Seal
- Bearded Seal
- Hooded Seal

Ringed Seal

- Small seal 1.1 to 1.6 m
- Short thick neck and fat body
- Color: light gray rings encircle spots on back

Harp Seal

- mid-sized seal 1.8 to 1.9 m
- old animals have harp pattern with black mask
- young animals have dark spots
- can be seen in large groups porpoising

Bearded Seal

- large seal 2.1 to 2.5 m
- color light to dark gray or brown
- small head to body ratio
- densely packed vibrissae (beard)

Hooded Seal

- large seal 2.0 to 2.6 m
- silver white with dark blotches
- face and muzzle very dark
- males with inflatable nasal cavity

Walrus

- large pinniped
- light to dark brown
- white tusks

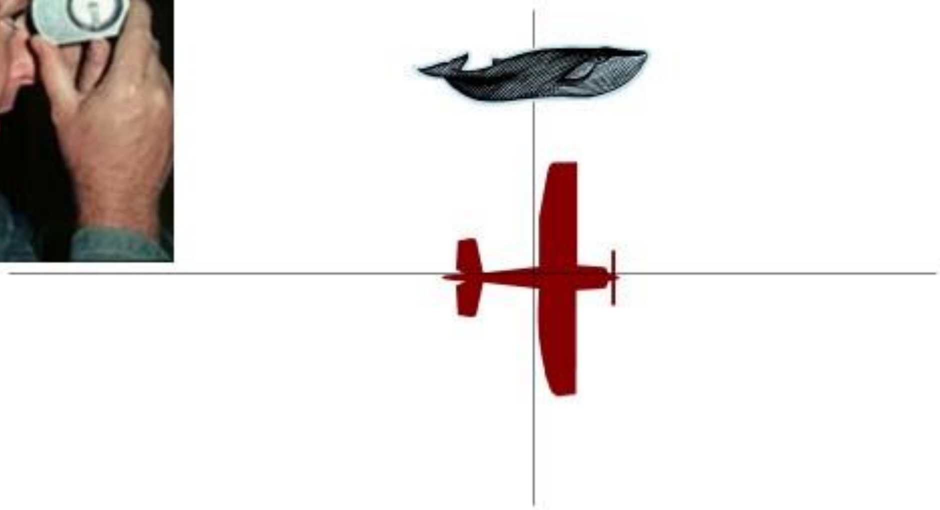
Polar Bear

Group Size

- Number of individuals in group (group is defined as animals that are within one or a few body lengths of each other and oriented or moving in a similar direction)

Using Clinometers

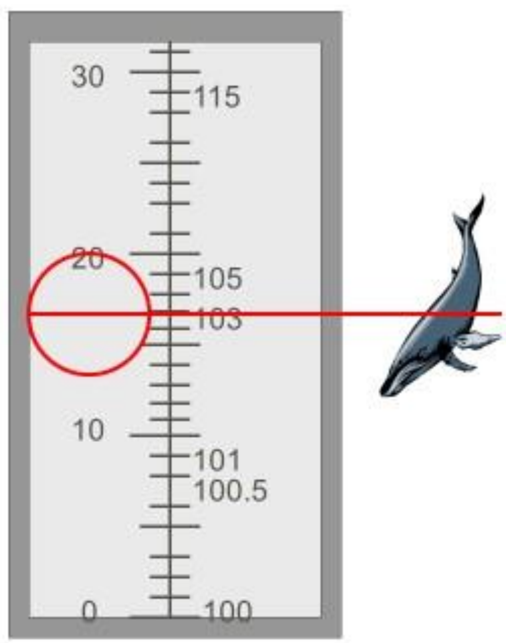
- Wait until the plane is perpendicular to the sighting. Then keep both eyes open and, looking though the inclinometer, line up the horizontal line with the center portion of the animal.
- Record the number on the **<u>left</u>** that the horizontal line passes through.
- If a group of several animals is sighted, measure from the center of the group.

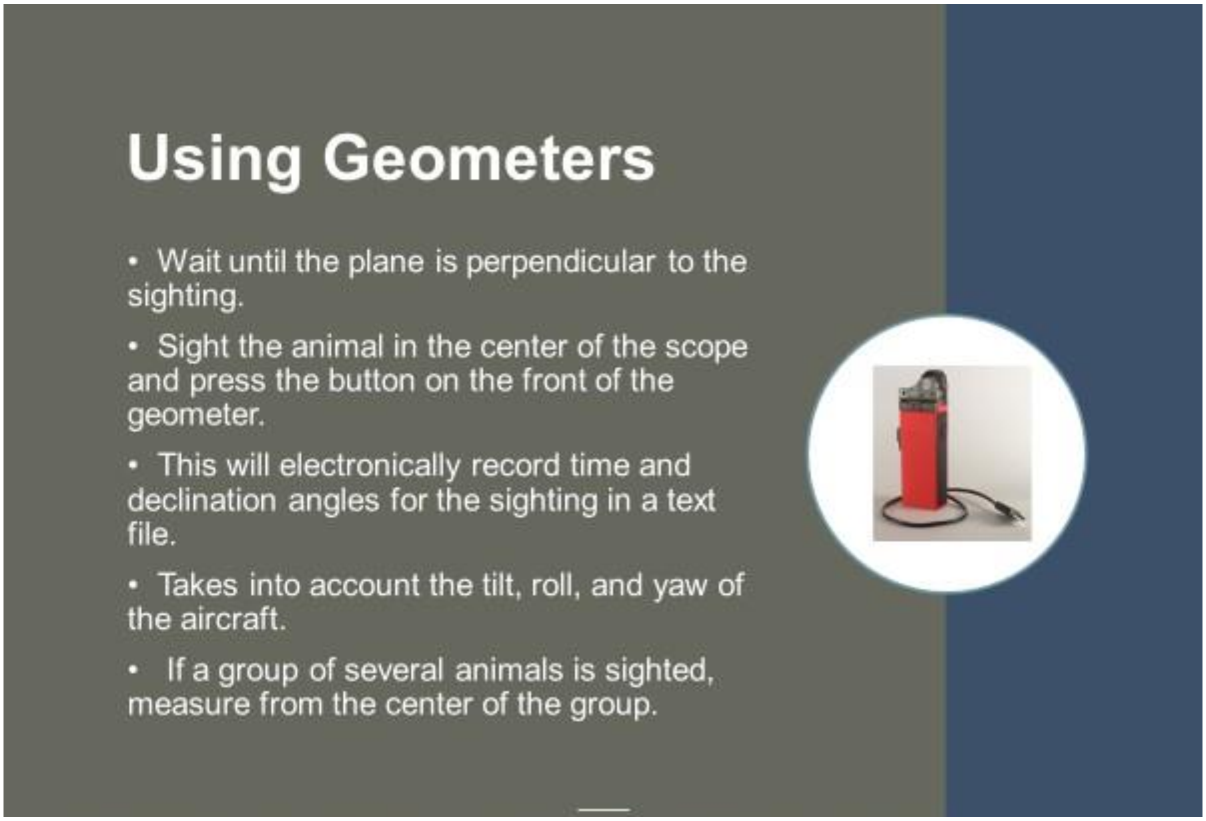


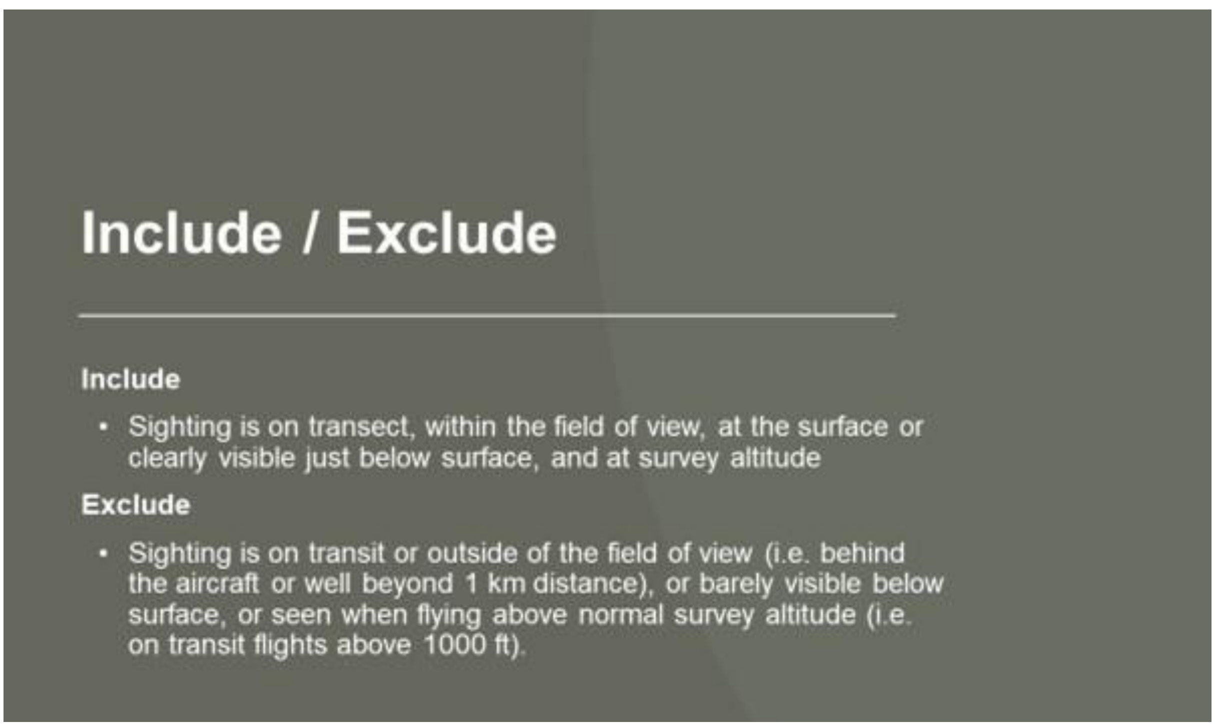
•**<u>Keep both eyes open!</u>**

•Line up mammal with horizontal line (use middle of mammal)

•Use scale on left = **17**



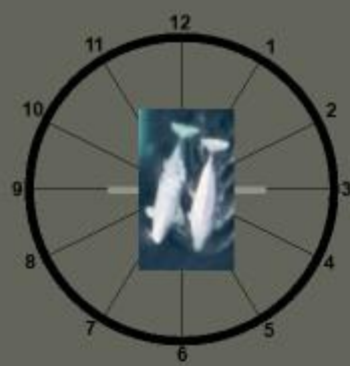

Using Geometers
• Wait until the plane is perpendicular to the sighting.
• Sight the animal in the center of the scope and press the button on the front of the geometer.
• This will electronically record time and declination angles for the sighting in a text file.
• Takes into account the tilt, roll, and yaw of the aircraft.
• If a group of several animals is sighted, measure from the center of the group.


Include / Exclude
Include
• Sighting is on transect, within the field of view, at the surface or clearly visible just below surface, and at survey altitude
Exclude
• Sighting is on transit or outside of the field of view (i.e. behind the aircraft or well beyond 1 km distance), or barely visible below surface, or seen when flying above normal survey altitude (i.e. on transit flights above 1000 ft).

Heading

- Assume aircraft is always pointing to 12:00
- Record clock face direction of animal (1 to 12)

Belugas heading towards 6:00



Speed

Fast

- White water streaming off bodies, wake left behind

Moderate

- Definite heading, steady motion, small amount of white water

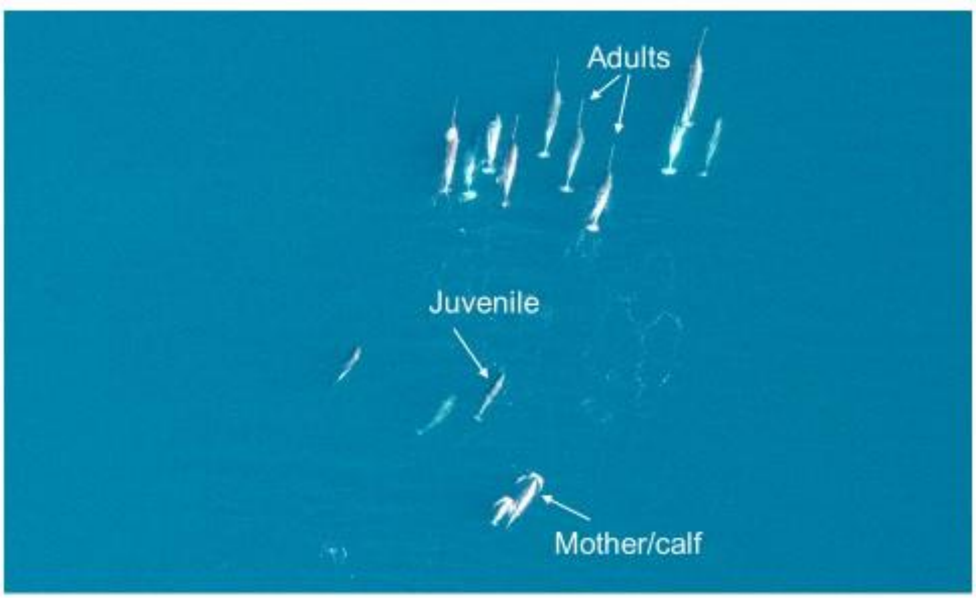
Slow

- Definite heading, forward motion observable, no white water visible

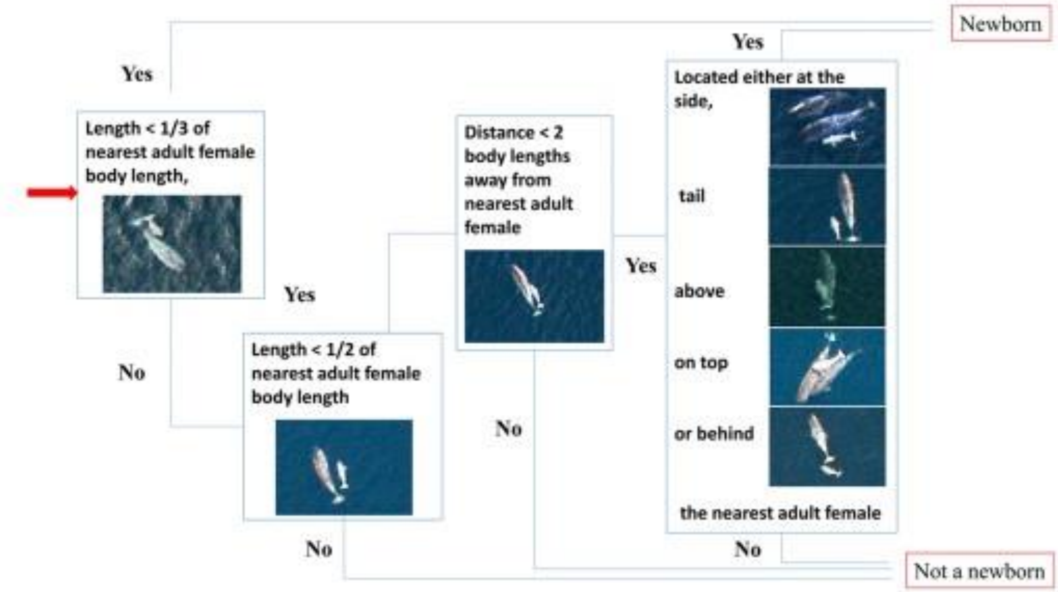
Not Moving

- Marine mammal is stationary, no movement

Narwhal age classes

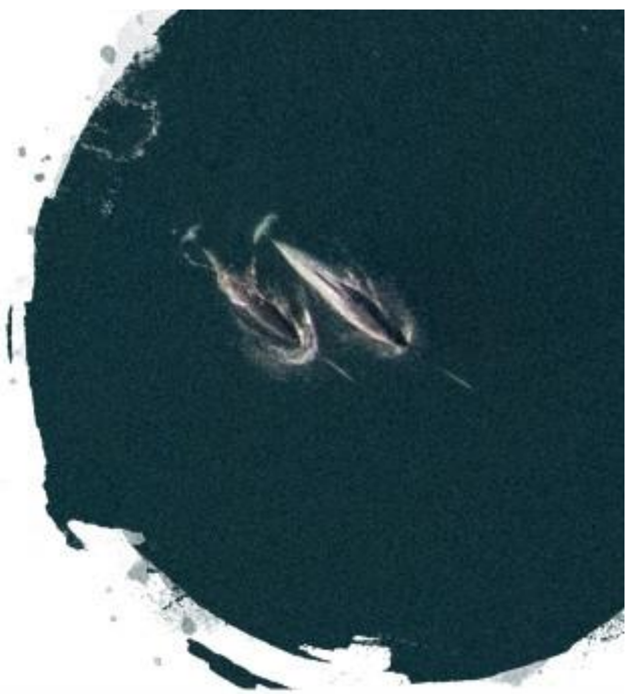


Narwhal Calf Key



Sighting Cue

- Body
- Blow
- Footprint
- Splash
- Birds




Footprint


Splash


Blow


Birds


Behaviour
Hauled Out
Diving
Fluke
Surfacing
Swimming
Surface Activity
Looking
Blow
Breaching
Spyhopping
Walking, Running, Standing (i.e. Polar Bear)
Dead
Logging

Hauled Out

Hauled out on ice or land (pinnipeds)

Diving

Marine mammal descends below the surface.

Fluke

Whale shows its fluke as it dives beneath the water.

Surfacing

Marine mammal observed coming to the surface of the water.

Swimming

Marine mammal swimming at the surface of the water

Surface Activity

Marine mammal splashing, jumping, flipper or tail slapping, implies social interaction

Looking

When animal is in an upright position with its head out of the water and is actively looking at something (pinniped or polar bear)

Blow

Marine mammal releases air from its lungs at the surface of the water, observed as clouds of moist air. Can be visible at far distances.

Breach

When a whale leaps with its entire body out of the water.

Spyhop

Marine mammal raises its head vertically out of the water so that its eyes are clear of the surface.

Walk, Run, Stand

Polar bear walking, running, or standing on ice or land.

Logging

When a marine mammal is on the surface and is neither swimming nor moving.

Dead

When a marine mammal is identified deceased on land or in water

Activity

An activity is composed of several behaviors and cannot always be determined

- Feeding
- Traveling
- Resting
- Milling
- Socializing
- Unknown

Feeding

Marine mammal seen feeding or evidence of prey observed.

Travelling

Moving in a distinct direction with a moderate to fast pace

Resting

Marine mammal lying motionless at the surface of the water or on the ice/land

Milling

Moving but net movement is near zero, eg. swimming in circles.

Socializing

Engaged in social activity (involving more than one animal)

APPENDIX C

Hard Copy Datasheets for Secondary Observers

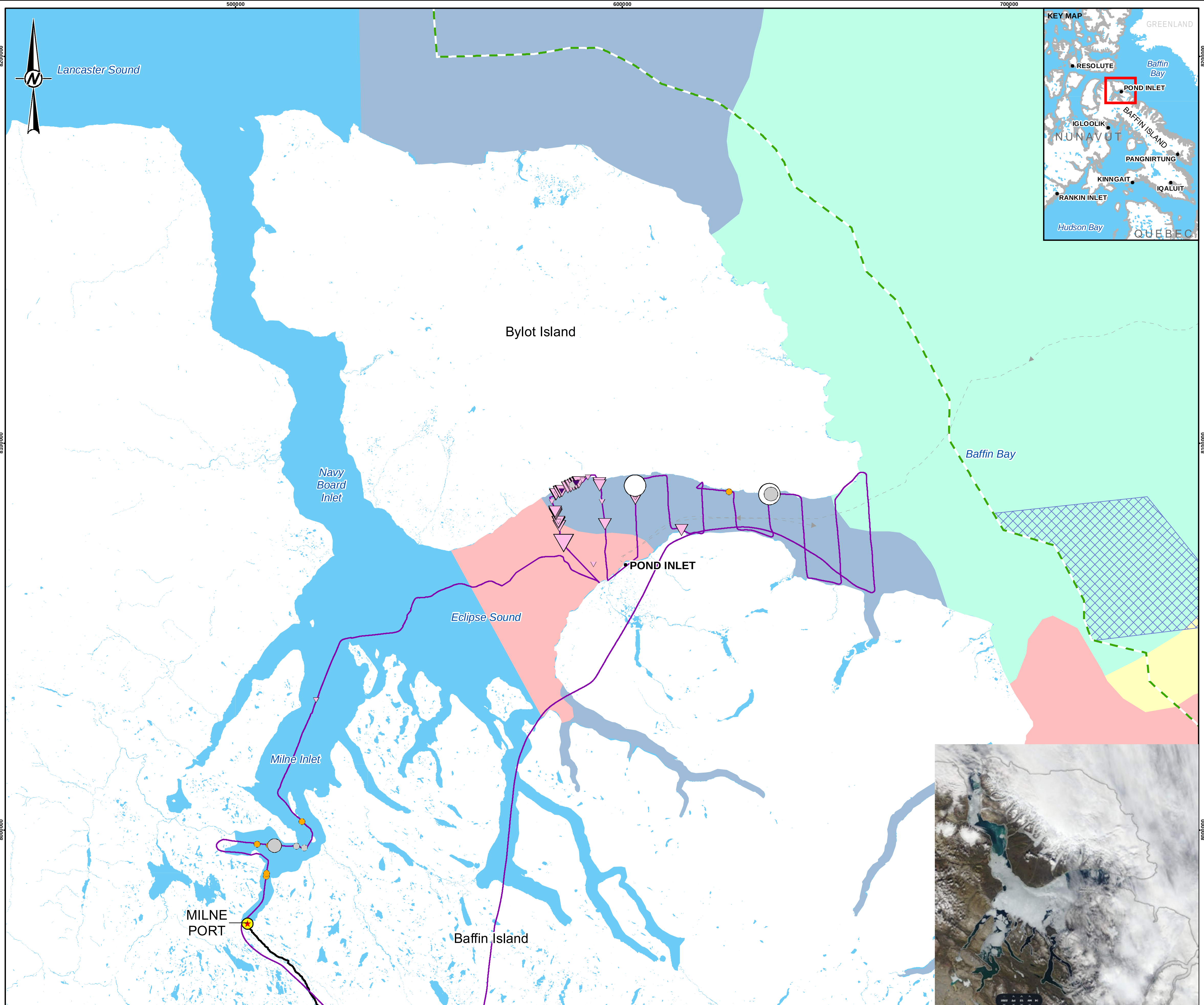
Date: ____________________ Observer name: _________________________________

Time	Species	Group size	Dec. angle	Include / exclude	Dir. of Travel	Speed	Age	Sex	Activity	Beh.	Sight.cue

golder.com

APPENDIX B

Mapbook



LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1

HARP SEAL
- 10+

NARWHAL
- 1
- 2-10
- 10+

RINGED SEAL
- 1

UNIDENTIFIED SEAL
- 1
- 2-10

UNIDENTIFIED WHALE
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

AIS_2022_AllCompiled_Tracks_20...

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10
- 1-3/10
- 4-6/10
- 9-10/10

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE

ECLIPSE SOUND LEG 1 SURVEY 1 - JULY 21, 2022

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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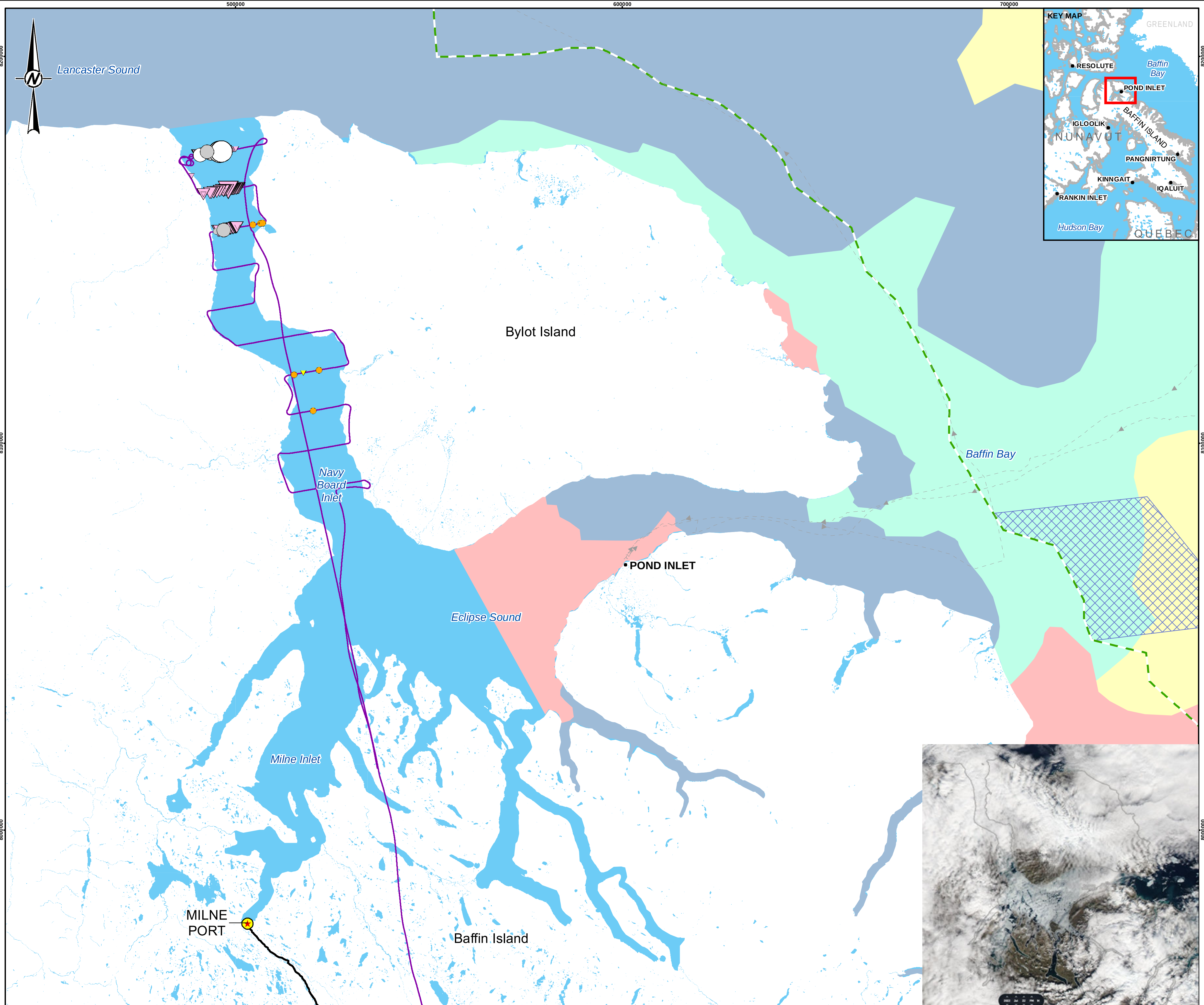

LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

RINGED SEAL
- 1

UNIDENTIFIED SEAL
- 1
- 2-10

UNIDENTIFIED WHALE
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

AIS_2022_AllCompiled_Tracks_20...

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10
- 1-3/10
- 4-6/10
- 9-10/10

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 2 - JULY 22, 2022

CONSULTANT

wsp

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	B-2

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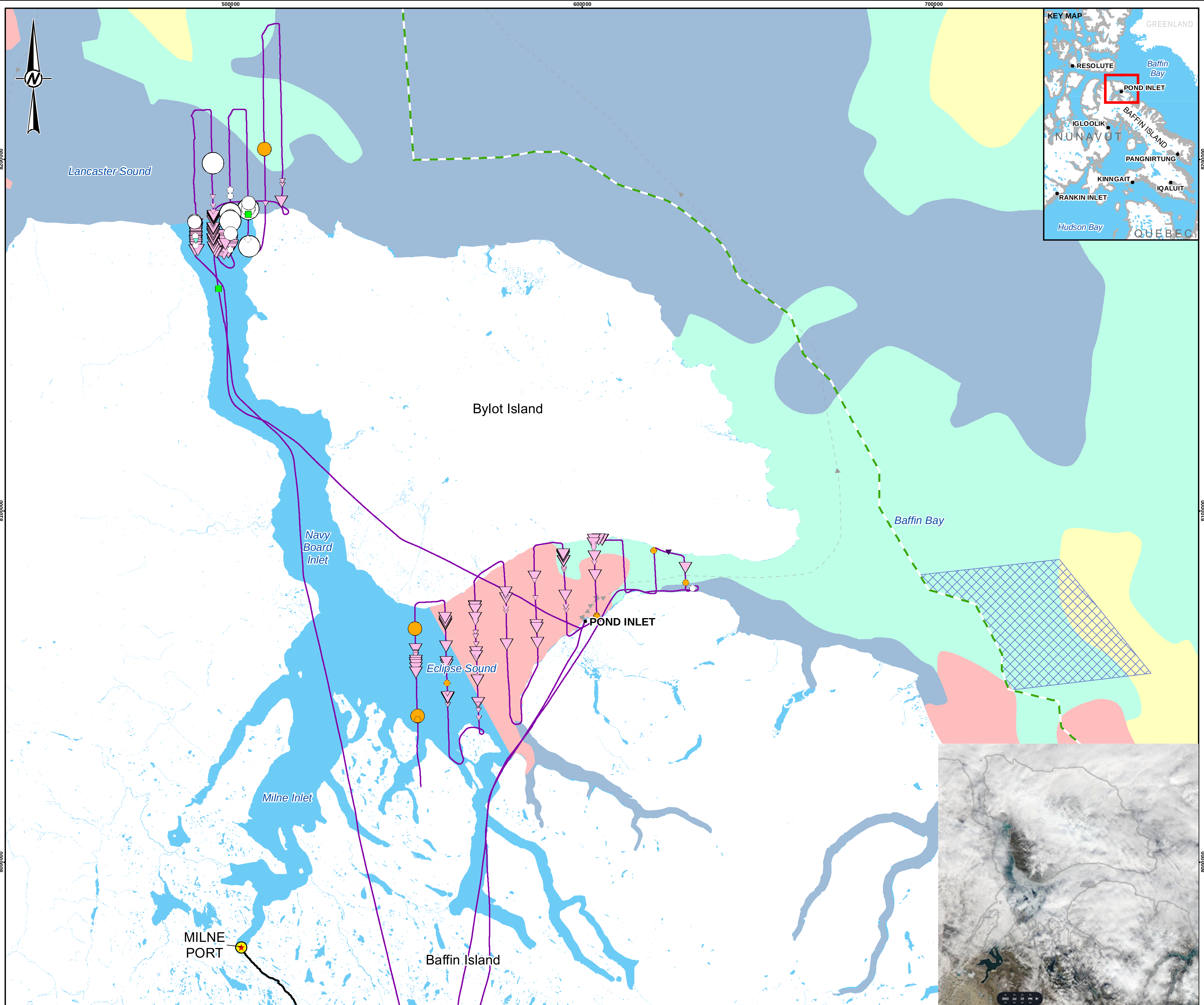

LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2-10

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

AIS_2022_AllCompiled_Tracks_20...

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10
- 1-3/10
- 4-6/10
- 9-10/10

0 30 60

1:1,100,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

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PROJECT

MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

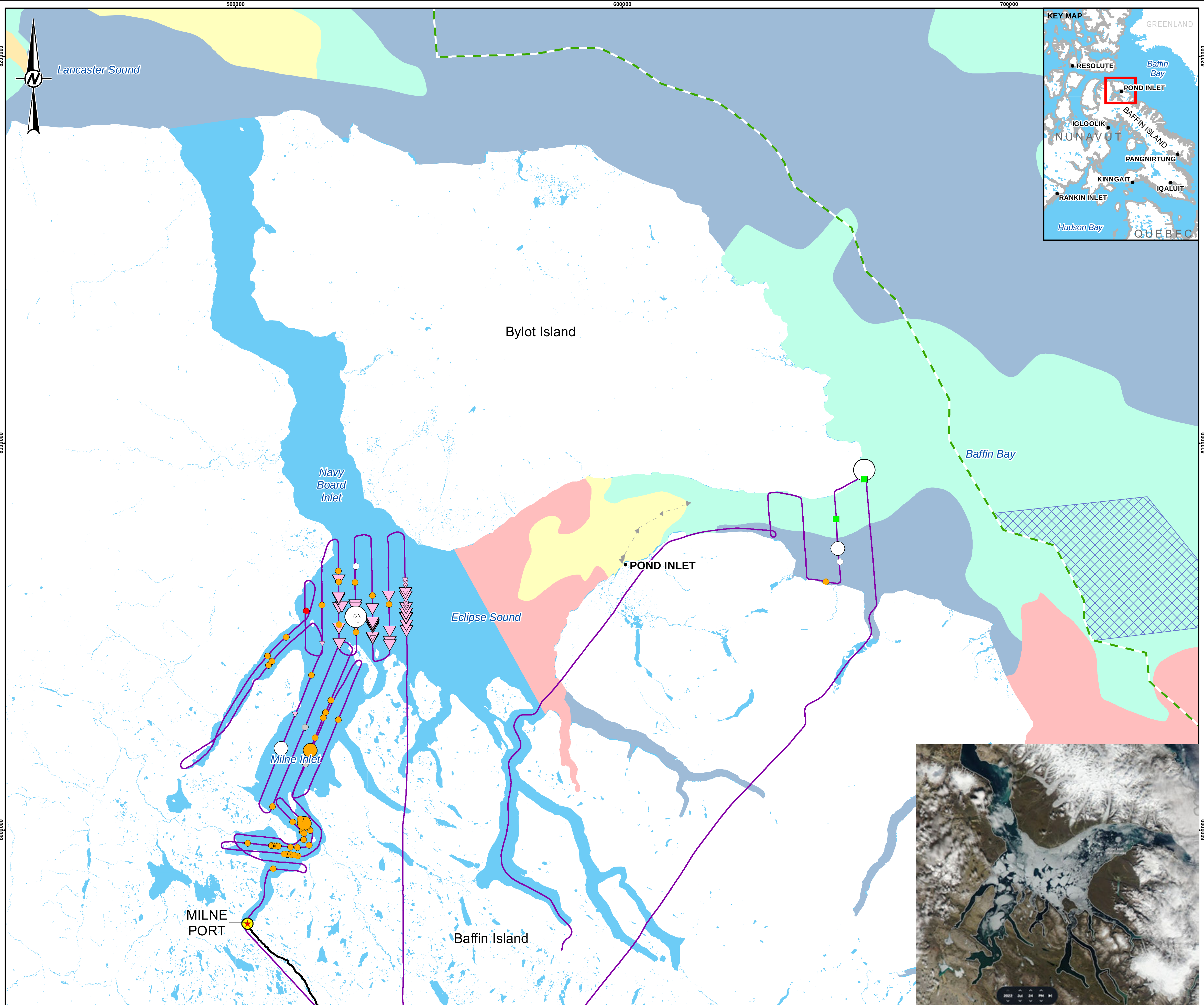
TITLE

ECLIPSE SOUND LEG 1 SURVEY 3 - JULY 23, 2022

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	B-3



LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

AIS_2022_AllCompiled_Tracks_20...

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10
- 1-3/10
- 4-6/10
- 7-8/10
- 9-10/10

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

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PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 4 - JULY 24, 2022

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	B-4

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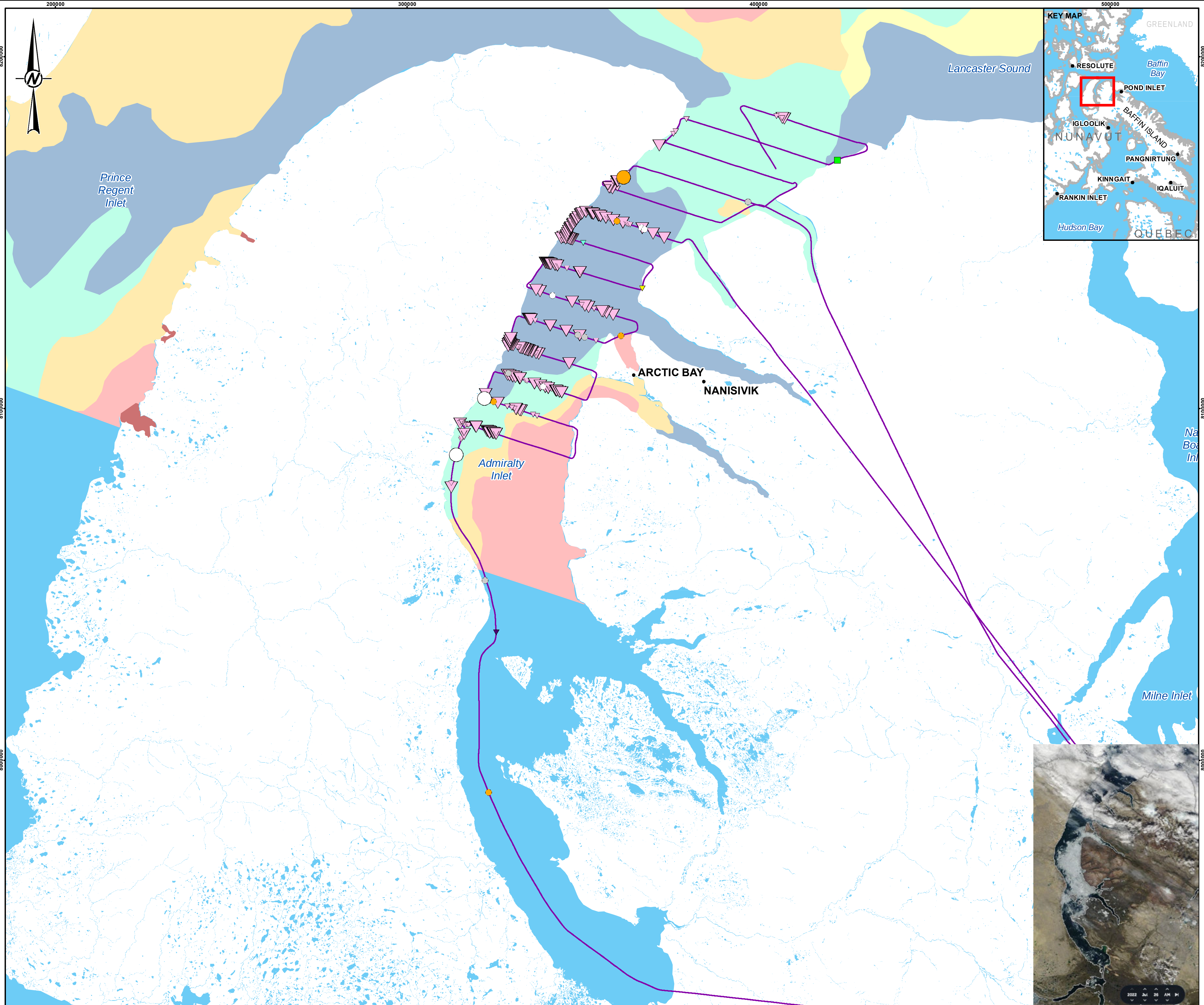

LEGEND

- COMMUNITY
- MILNE PORT
- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1
- 10+

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2-10

NARWHAL
- 1
- 2-10

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1

UNIDENTIFIED WHALE
- 1

ICE CONCENTRATION
- < 1/10
- 1-3/10
- 4-6/10
- 7-8/10
- 9-10/10
- LANDFAST ICE

0 30 60

1:1,100,000 KILOMETRES

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

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PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ADMIRALTY INLET LEG 1 SURVEY 5 – JULY 26, 2022

CONSULTANT

wsp

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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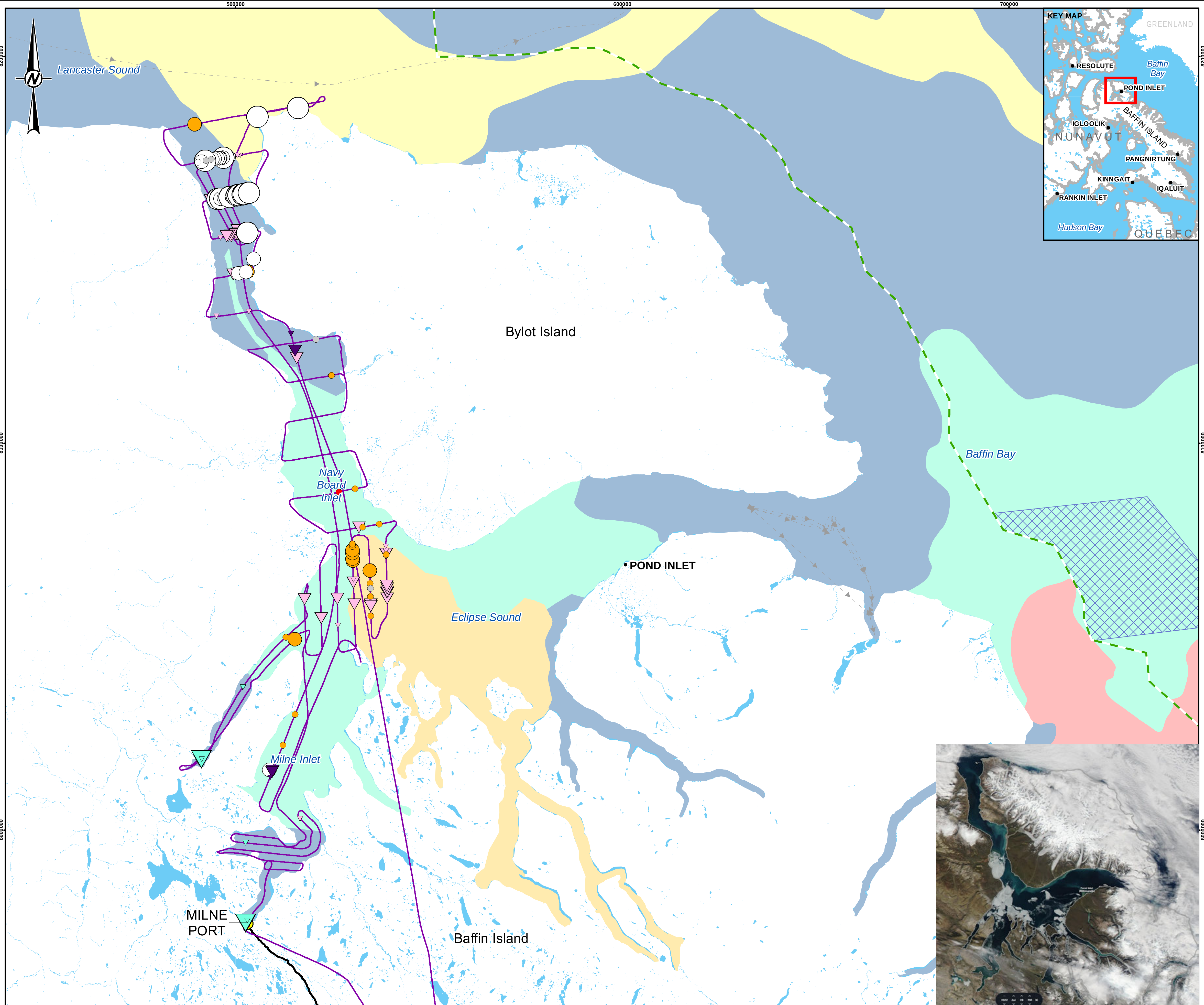

LEGEND

- COMMUNITY
- MILNE PORT
- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD
- AIS_2022_AllCompiled_Tracks_20...

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BELUGA
- 1
- 2-10
- 10+

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10
- 1-3/10
- 4-6/10
- 7-8/10
- 9-10/10

0 25 50
1:1,000,000 KILOMETRES

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

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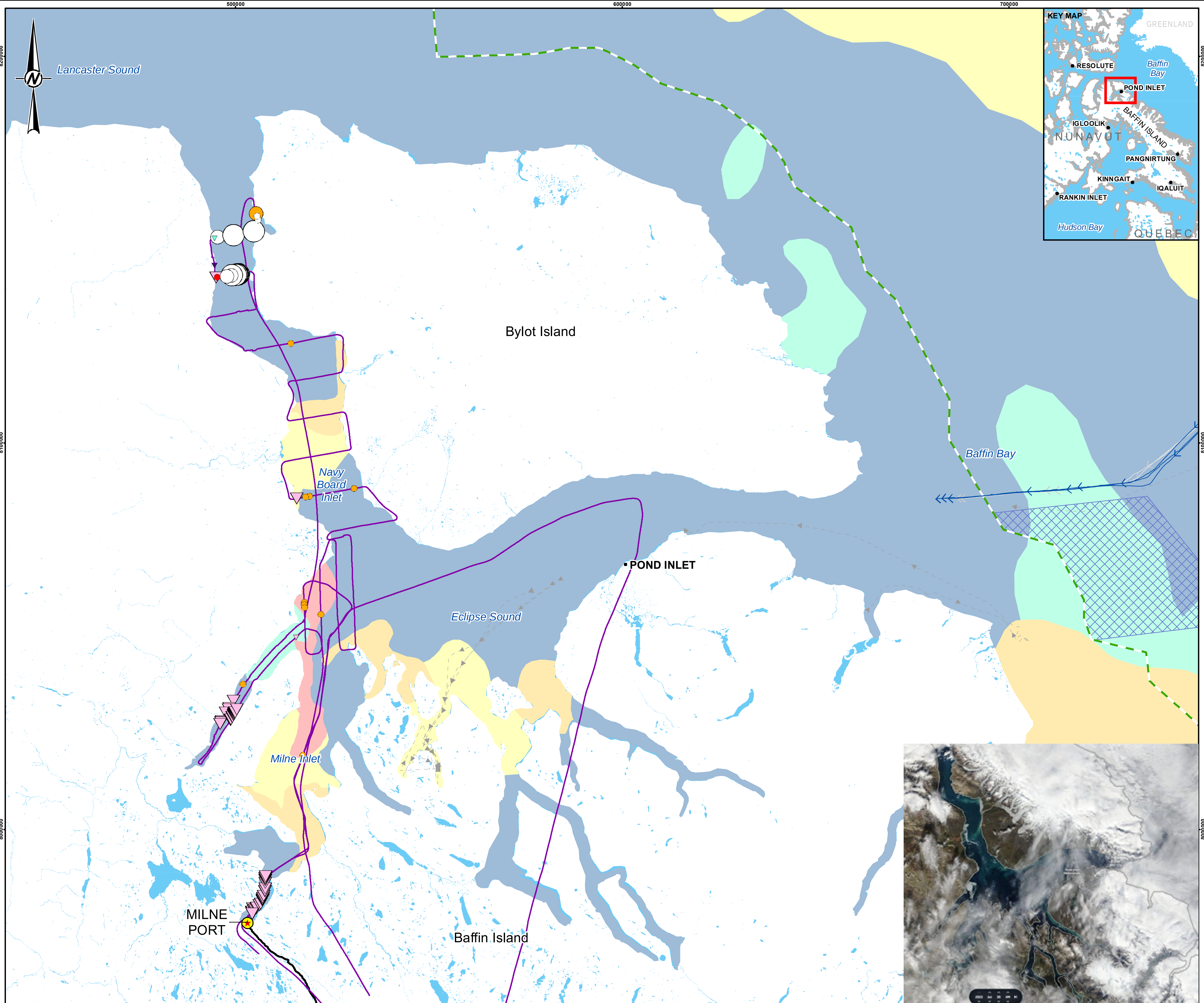
PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 6 - JULY 27, 2022

CONSULTANT
wsp

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	B-6



LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BELUGA
- 1

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

AIS_2022_AllCompiled_Tracks_20...

PROJECT VESSEL SHIP TRACKS
- BULK (ORE) CARRIER
- SERVICE VESSEL

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10
- 1-3/10
- 4-6/10
- 7-8/10
- 9-10/10

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

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PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 7 – JULY 30, 2022

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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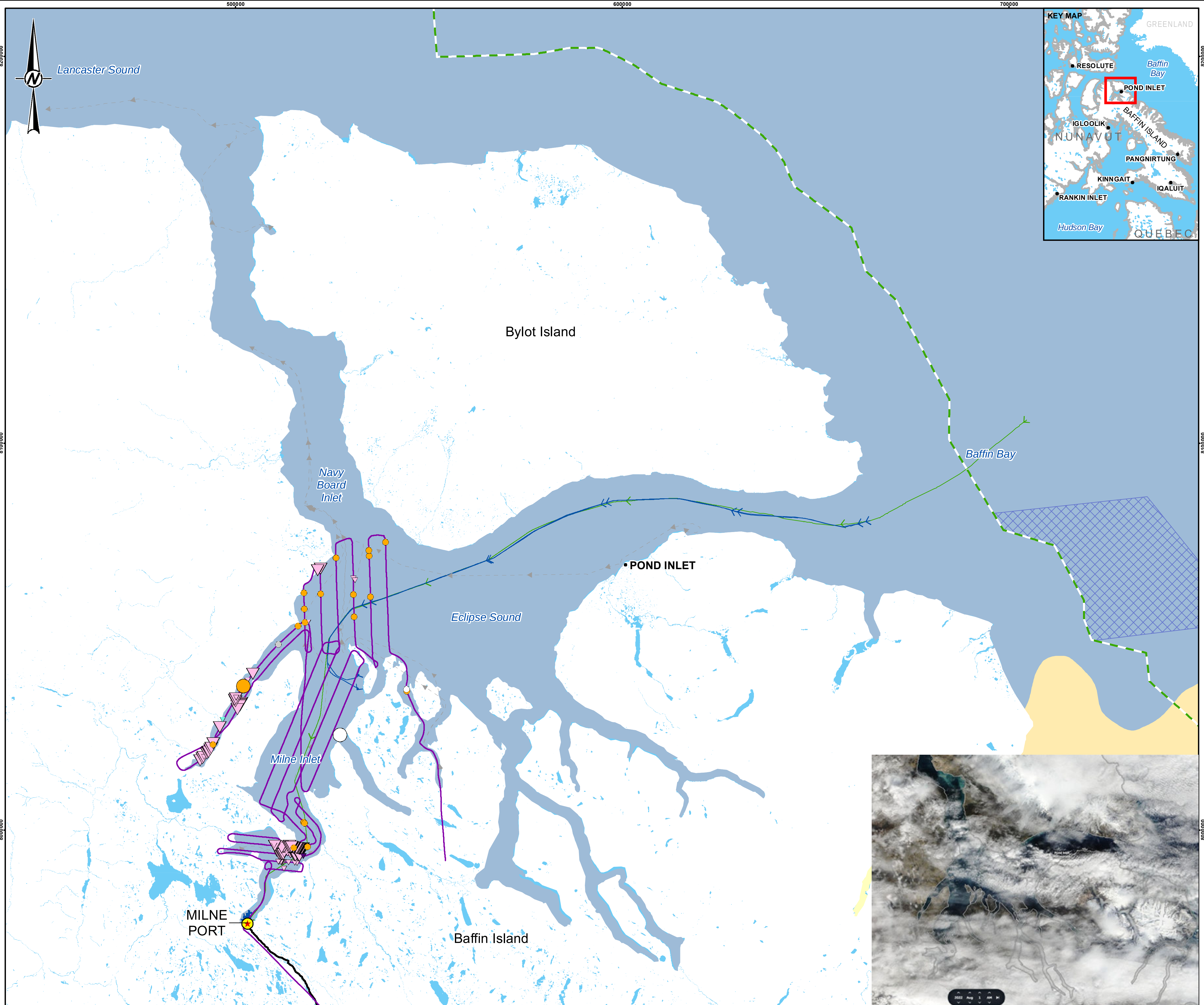

LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2-10

NARWHAL
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

AIS_2022_AllCompiled_Tracks_20...

PROJECT VESSEL SHIP TRACKS
- BULK (ORE) CARRIER
- OIL TANKER
- SERVICE VESSEL

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10
- 1-3/10
- 4-6/10
- 7-8/10

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED AUGUST 9, 2022. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 8 – AUGUST 1, 2022

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	B-8

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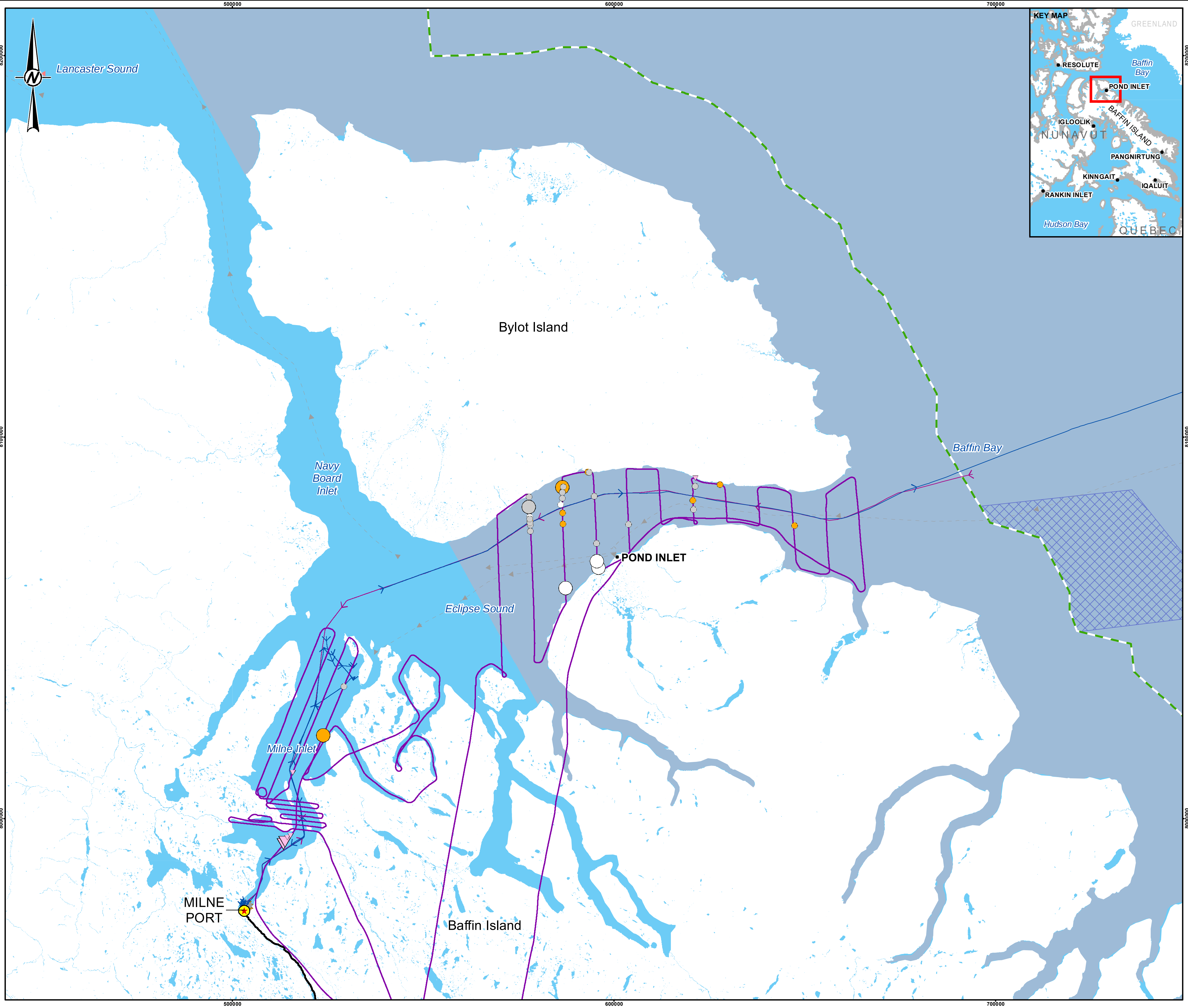


LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL
- 1
- 2-10

NARWHAL
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

PROJECT VESSEL SHIP TRACKS
- BULK (ORE) CARRIER
- GENERAL CARGO VESSEL
- ICEBREAKER (BOTNICA)
- SERVICE VESSEL

NON-PROJECT VESSEL SHIP TRACKS
- ICEBREAKER (TERRY FOX)
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED JANUARY 20, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

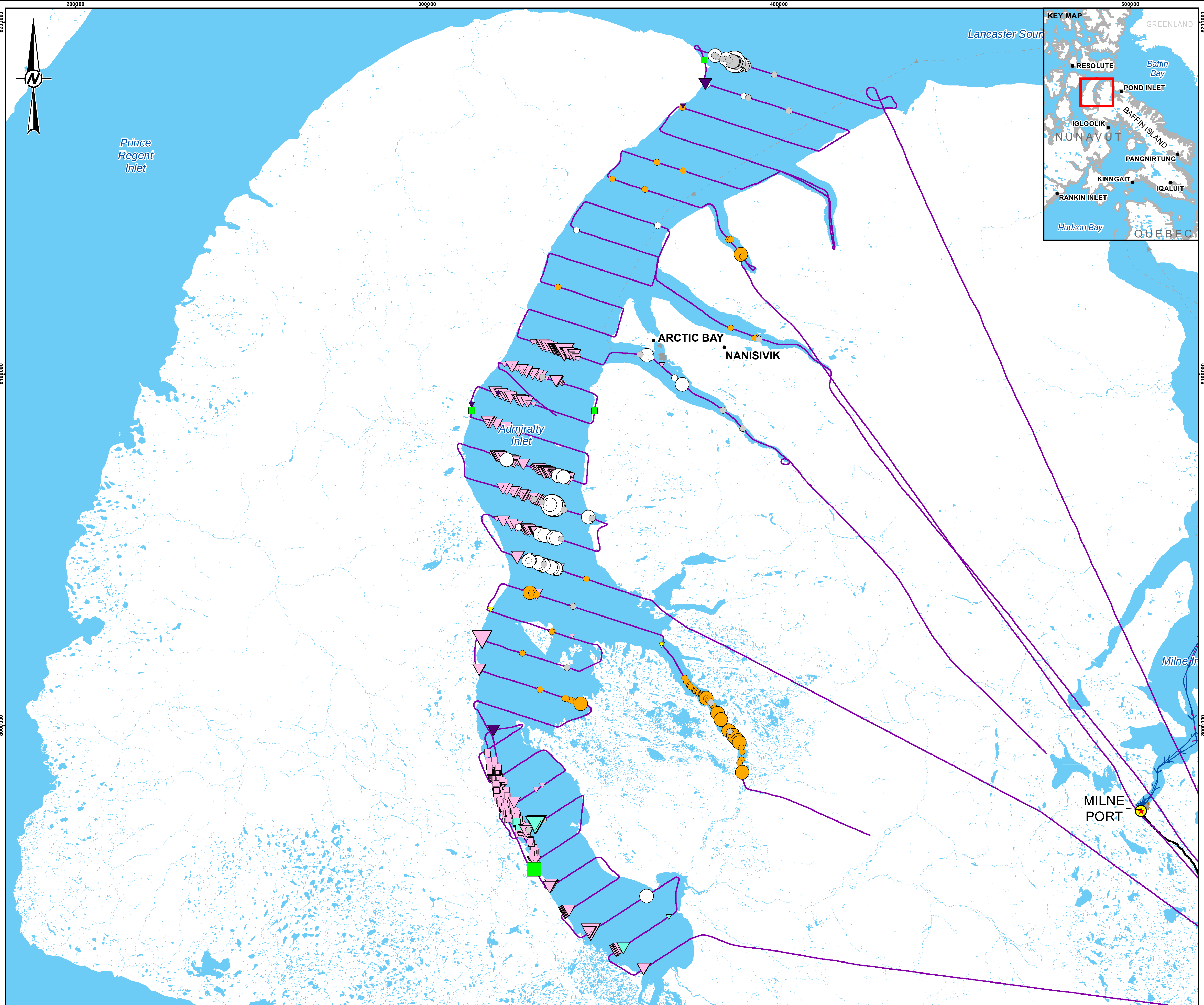
TITLE
ECLIPSE SOUND LEG 2 SURVEY 1 – AUGUST 13, 2022

CONSULTANT

wsp

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	B-9



LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BELUGA
- BOWHEAD WHALE
- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1
- 2-10
- 10+

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

POLAR BEAR
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

UNIDENTIFIED WHALE
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

PROJECT VESSEL SHIP TRACKS

- BULK (ORE) CARRIER
- GENERAL CARGO VESSEL
- ICEBREAKER (BOTNICA)
- SERVICE VESSEL

NON-PROJECT VESSEL SHIP TRACKS

- OTHER
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

- < 1/10

0 30 60

1:1,100,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED JANUARY 20, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ADMIRALTY INLET LEG 2 SURVEY 2 – AUGUST 14, 2022

CONSULTANT

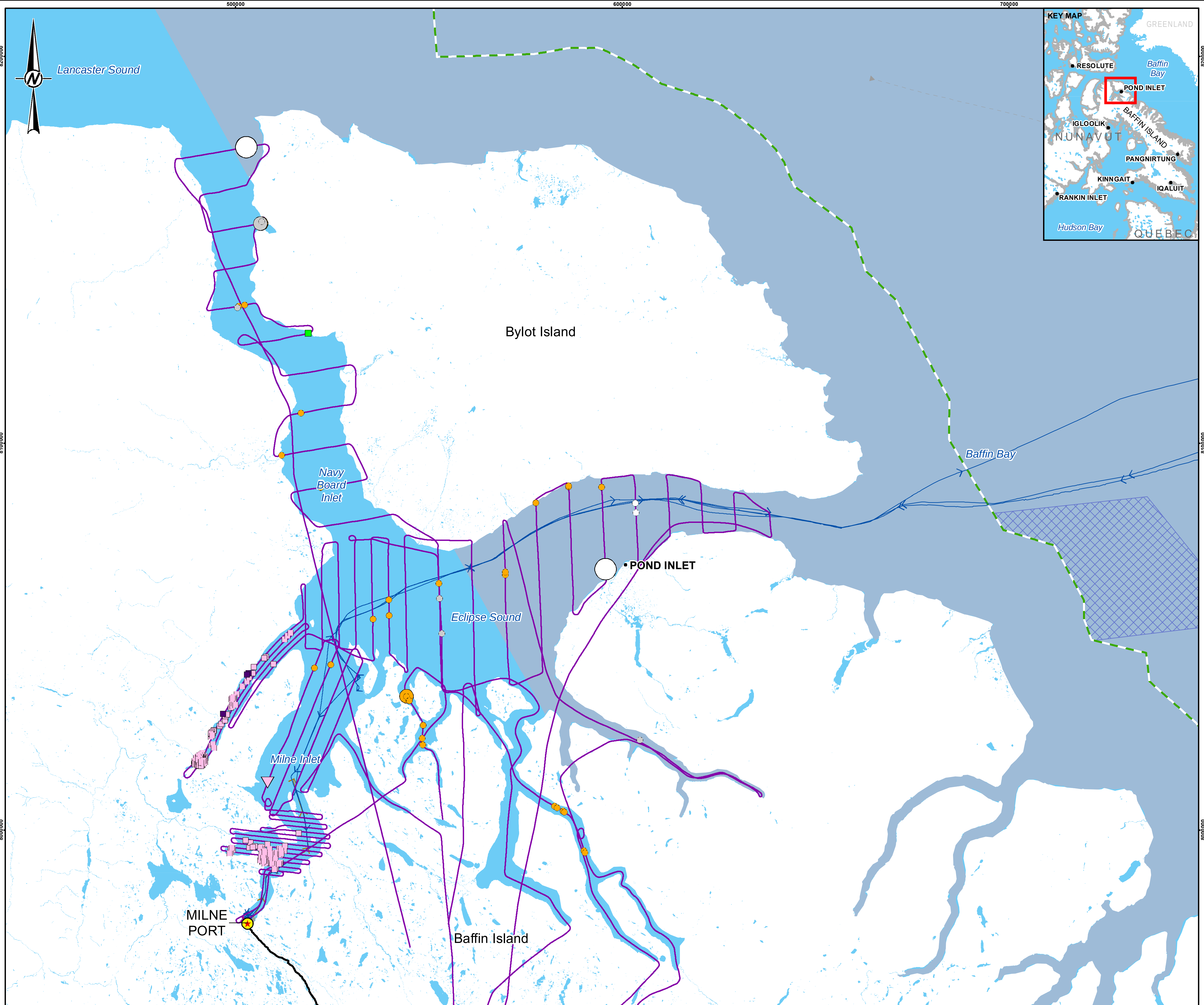
YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	B-10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0



LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD WHALE
- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL

- 1
- 10+

NARWHAL

- 2-10

POLAR BEAR

- 1

RINGED SEAL

- 1
- 2-10

UNIDENTIFIED SEAL

- 1
- 2-10

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

PROJECT VESSEL SHIP TRACKS

- BULK (ORE) CARRIER
- GENERAL CARGO VESSEL
- ICEBREAKER (BOTNICA)
- SERVICE VESSEL

NON-PROJECT VESSEL SHIP TRACKS

- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

- < 1/10

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED JANUARY 20, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

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BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 2 SURVEY 2 – AUGUST 16, 2022

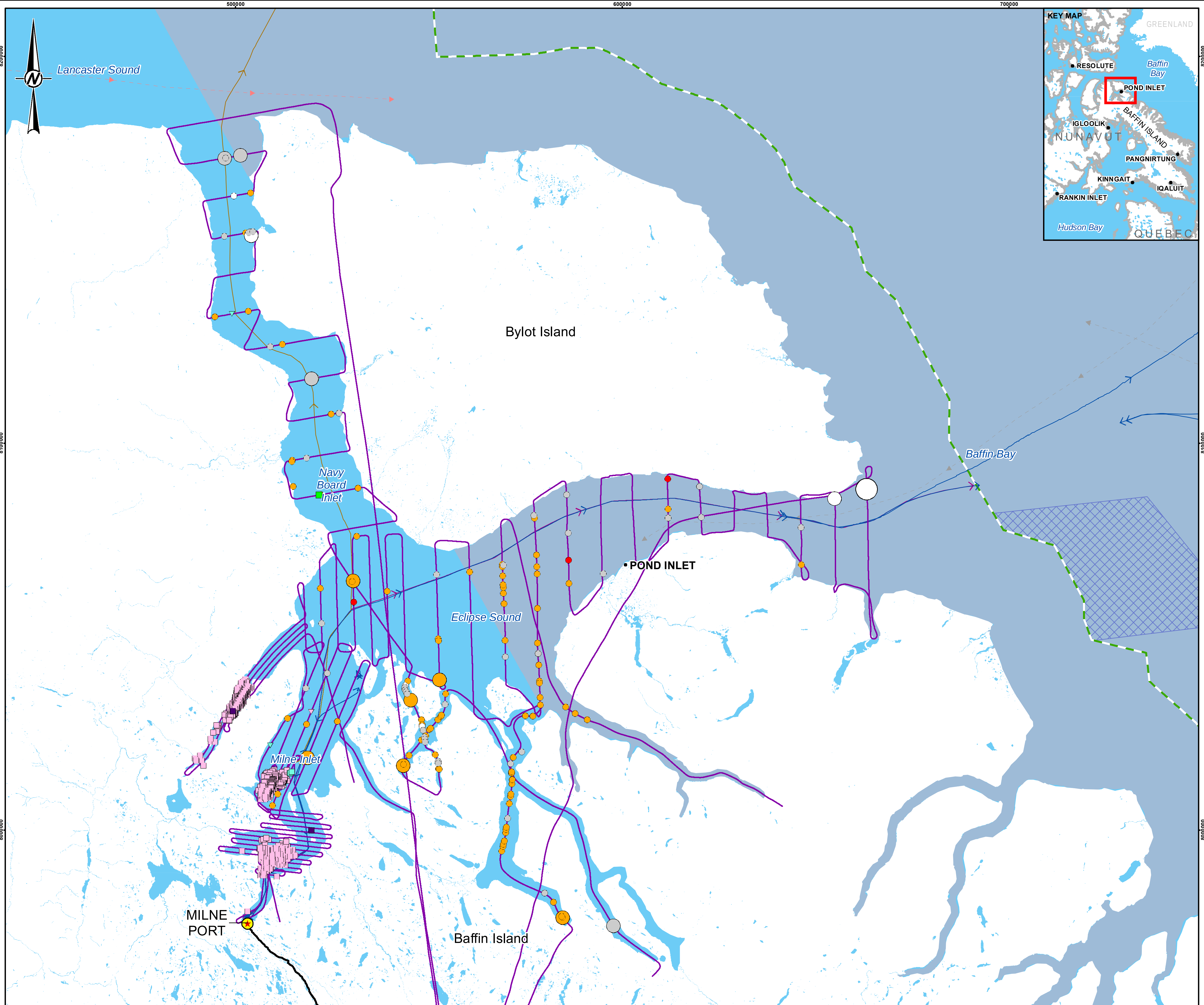
CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	B-11

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm



REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED JANUARY 20, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 2 SURVEY 3 – AUGUST 17, 2022

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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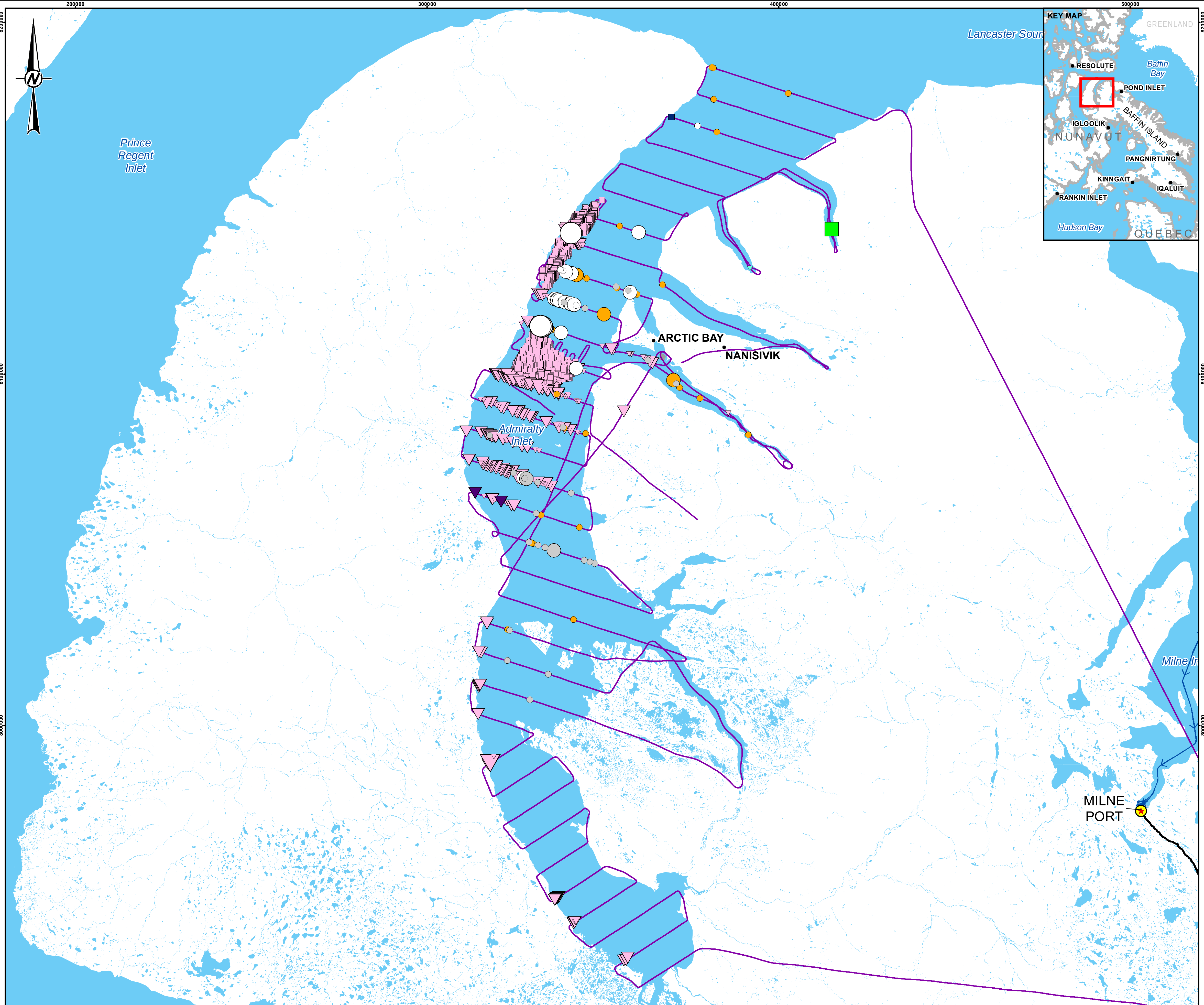

LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1

BOWHEAD WHALE
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

POLAR BEAR
- 2-10

RINGED SEAL
- 1
- 2-10

WALRUS
- 1

UNIDENTIFIED SEAL
- 1
- 2-10

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

PROJECT VESSEL SHIP TRACKS
- BULK (ORE) CARRIER
- SERVICE VESSEL

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10

0 30 60

1:1,100,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED JANUARY 20, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ADMIRALTY INLET LEG 2 SURVEY 3 – AUGUST 18, 2022

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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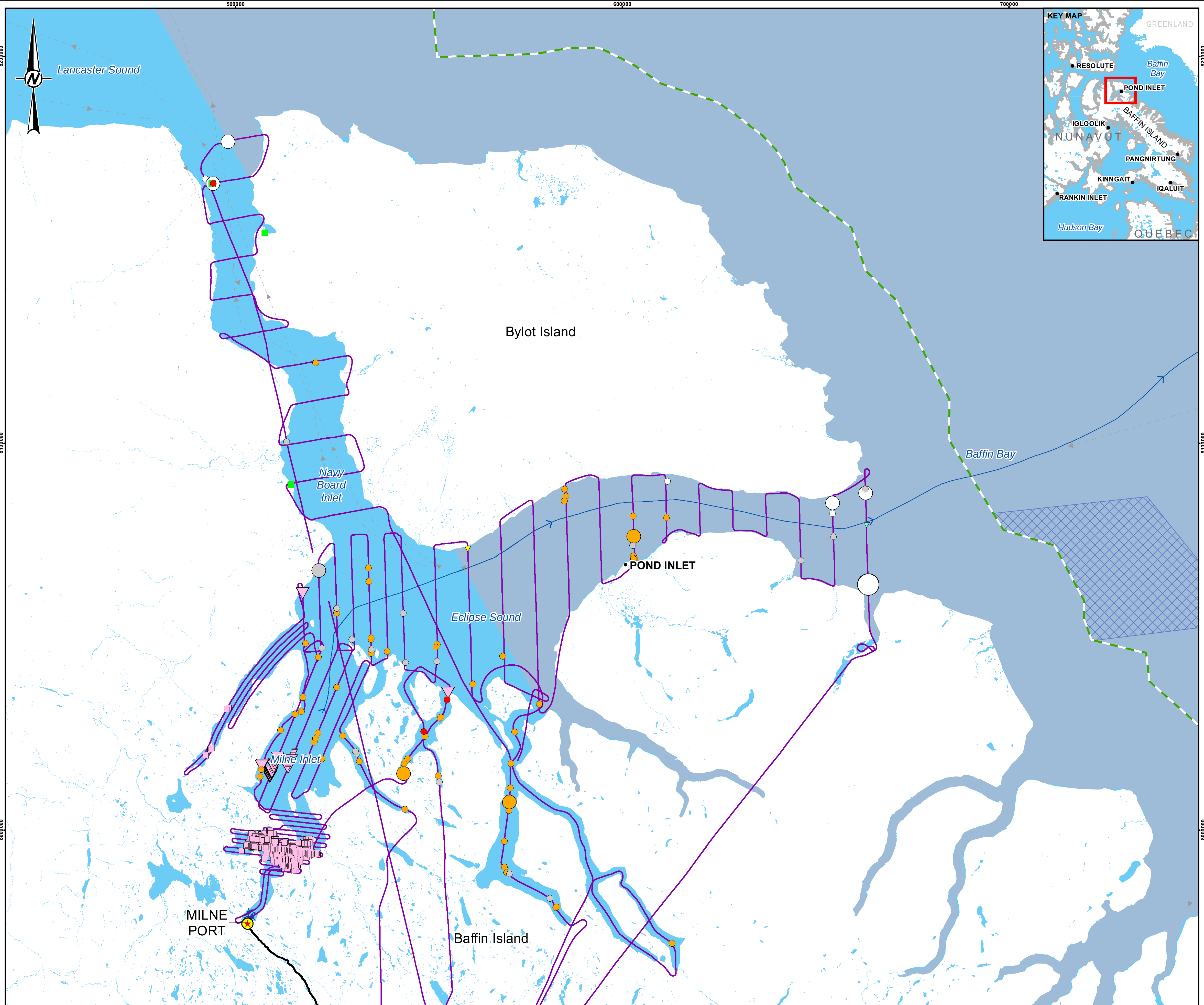

LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BELUGA
- 1

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

UNIDENTIFIED WHALE
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

PROJECT VESSEL SHIP TRACKS
- BULK (ORE) CARRIER
- SERVICE VESSEL

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION
- < 1/10

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED JANUARY 20, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2022 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 2 SURVEY 4 – AUGUST 21, 2022

CONSULTANT

YYYY-MM-DD	2023-03-22
DESIGNED	TT
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372401	59000-06	0	B-14

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

APPENDIX C

Distance Sampling and Mark-Recapture Models

Table 1: Narwhal Distance Sampling and Mark-Recapture Models

Distance Sampling			Mark-Recapture	
AIC + key function + series adjustment	Model[1]		AIC	Model[1]
12724.323 gamma cos(2)	~GlareAng:GlareInt + ObsPair		1479.416	~observer + ObsPair:observer + ObsPair:distance + ObsPair
12728.864 gamma cos(2)	~ObsPair + GlareAng:GlrIntRank + GlareAng + RC45		1488.310	~observer + ObsPair:observer + observer:distance + ObsPair
12729.258 gamma cos(2)	~ObsPair + GlareAng:GlrIntRank + GlareAng + RC45 + size		1503.855	~observer + ObsPair:observer + size
12729.761 gamma cos(2)	~ObsPair + GlareAng:GlrIntRank + GlareAng + RC60 + Bft		1504.537	~observer + ObsPair:observer + size:Bft + size
12730.029 half-norm cos(2)	~GlareAng:GlareInt + ObsPair		1504.773	~observer + ObsPair:observer + size:Bft + Bft + size
12730.563 gamma cos(2,3)	~ObsPair + GlareAng:GlrIntRank + GlareAng + RC30		1505.846	~observer + ObsPair:observer + Bft + size
12730.822 gamma cos(2,3)	~ObsPair + GlareAng:GlrIntRank + GlareAng + RC45		1511.333	~observer + ObsPair:observer + size:Bft
12731.824 half-norm cos(2,3)	~GlareAng:GlareInt + ObsPair		1512.386	~observer + ObsPair:observer + size:Bft + Bft
12732.505 half-norm cos(2)	~ObsPair + GlareAng:GlrIntRank + GlareAng + GlrIntRank + size		1515.764	~observer + ObsPair:observer + ObsPair:distance
12733.817 haz-rate poly(4)	~ObsPair + GlareAng:GlrIntRank + GlareAng		1516.743	~observer + ObsPair:observer:distance + Bft + distance + ObsPair
12733.923 half-norm cos(2)	~ObsPair + GlareAng:GlrIntRank + GlareAng + RC15 + Bft + size		1518.152	~observer + ObsPair:observer:distance + distance + ObsPair

Distance Sampling			Mark-Recapture	
AIC + key function + series adjustment	**Model[1]**		**AIC**	**Model[1]**
12734.101 half-norm cos(2)	~ObsPair + GlareAng:GlrIntRank + GlareAng + RC15 + Bft		1518.367	~observer + ObsPair:observer + observer:distance + distance
12734.210 haz-rate poly(4)	~ObsPair + GlareAng:GlrIntRank + GlareAng + RC15		1523.046	~observer + ObsPair:observer:distance + Bft + ObsPair
12734.385 haz-rate poly(4)	~GlareAng:GlareInt + ObsPair		1524.683	~observer + ObsPair:observer:distance + ObsPair
12734.763 half-norm cos(3)	~GlareAng:GlareInt + ObsPair		1524.890	~observer + ObsPair:observer + GlareAng:GlrInt + GlareAng
12734.822 Haz-rate cos(2)	~ObsPair + GlareAng:GlrIntRank + GlareAng		1525.199	~observer + ObsPair:observer
12734.923 half-norm cos(3)	~ObsPair + GlareAng:GlrIntRank + GlareAng + RC15 + size		1525.738	~observer + ObsPair:observer + Bft:distance
12734.947 Haz-rate poly(6)	~ObsPair + GlareAng:GlrIntRank + GlareAng		1526.000	~observer + ObsPair:observer + Bft + distance
12734.988 Haz-rate cos(2)	~ObsPair + GlareAng:GlrIntRank + GlareAng + GlrIntRank		1526.050	~observer + ObsPair:observer + Bft:distance + distance
12735.011 half-norm cos(2)	~ObsPair + GlareAng:GlrIntRank + GlareAng + Bft + size		1526.349	~observer + ObsPair:observer + Bft + Bft:distance

1) distance = horizontal distance, GlareAng = glare coverage angle, GlareInt = glare intensity, GlrIntRank = glare intensity rank, observer = primary/secondary observer, ObsPair = pairing of individual observers on same side of aircraft, size = group size, Bft = Beaufort seastate, RCxx = rolling count for the number of observation recorded within the xx seconds prior to an observation and summed for both observers in a pairing.

APPENDIX D

Leg 2 Relative Abundance of Marine Mammals

Relative Abundance of Marine Mammals in Eclipse Sound and Admiralty Inlet Grids

Marine mammal relative abundance was calculated and expressed as number of animals/km, as outlined in Section 2.4.2 of the report. In 2022 a total of 5,709.49 km of effort (4,641.60 km during visual surveys and 1,067.88 km during photographic surveys) was flown over two completed surveys in Eclipse Sound (Survey 3 and 4) and Admiralty Inlet (Survey 2 and 3) grids. The relative abundance of marine mammals in the Eclipse Sound and Admiralty Inlet grids for the surveys, expressed as the animal detection rate (no. of animals relative to survey effort in km), are shown in Tables 1 and 2.

Eclipse Sound Grid: Narwhal had the highest relative abundance (0.6512 animals/km) of all the marine mammal species identified to the species level, followed by ringed seal, harp seal, bearded seal, beluga whale, bowhead whale, and then polar bear (Table 1). Unidentified seals had the fourth highest relative abundance of 0.0302 animals/km in the Eclipse Sound grid.

Admiralty Inlet Grid: Narwhal had the highest relative abundance (2.8330 animals/km) of all the marine mammal species identified to the species level, followed by harp seal, ringed seal, beluga whale, bowhead whale, and then walrus and polar bear (Table 2). Unidentified seals had the fourth highest relative abundance of 0.0318 animals/km in the Admiralty Inlet grid.

Table 1: Sighting and Animal Detection Rate (Relative Abundance) of Marine Mammals in Eclipse Sound Grid during Leg 2, Surveys 3 and 4

Species	Visual Survey		Photographic Survey	Combined Visual and Photographic Survey
	No. of Sightings	No. of Animals	Surface Count	Animal Detection Rate (animals/km)
Narwhal	76	122	1,883	0.6512
Bowhead Whale	0	0	2	0.0006
Beluga Whale	2	2	3	0.0016
Unidentified Whale	1	1	0	0.0003
Ringed Seal	154	168	–	0.0726
Harp Seal	13	108	–	0.0466
Bearded Seal	5	5	–	0.0022
Walrus	0	0	–	0.0000
Unidentified Seal	63	70	–	0.0302
Polar Bear	2	2	0	0.0006

Table 2: Sighting and Animal Detection Rate (Relative Abundance) of Marine Mammals in Admiralty Inlet Grid during Leg 2, Surveys 2 and 3

Species	Visual Survey		Photographic Survey	Combined Visual and Photographic Survey
	No. of Sightings	No. of Animals	Surface Count	Animal Detection Rate (animals/km)
Narwhal	930	1744	5,708	2.8330
Bowhead Whale	5	8	1	0.0034
Beluga Whale	10	53	22	0.0285
Unidentified Whale	1	1	0	0.0004
Ringed Seal	123	143	–	0.0615
Harp Seal	106	446	–	0.1917
Bearded Seal	0	0	–	0.0000
Walrus	1	1	–	0.0004
Unidentified Seal	62	74	–	0.0318
Polar Bear	1	1	0	0.0004

Comparison with 2021, 2020 and 2019 MMASP

The relative abundance for this section was calculated based on data collected for Survey 2, 3 and 4 in 2022, Survey 4 in the 2021 MMASP, Surveys 1 and 3 in the 2020 MMASP and Surveys 3 and 4 in the 2019 MMASP because these surveys had complete grid coverage of the combined survey grids in good sighting conditions.

Eclipse Sound Grid: The relative abundance of marine mammals in the RSA was higher in 2022 (0.77 animals/km) compared to that observed in 2021 (0.43 animals/km), but lower compared to that observed in 2020 (1.05 animals/km) and 2019 (1.74 animals/km; Table 3). Narwhal relative abundance in 2022 (0.6512 animals/km) increased by 99% compared to 2021 (0.3270 animals/km) and decreased by 60% and 15% compared to 2019 (1.6396 animals/km) and 2020 (0.7682 animals/km), respectively. Ringed seal relative abundance in 2022 (0.0726 animals/km) was similar to that seen in 2021 (0.0702 animals/km) and 2020 (0.0736 animals/km) (Table 3). Harp seals relative abundance in 2022 was higher than in 2021, similar to 2020, and lower then that observed in 2019 (Table 3). It should be noted that the seal data should be interpreted with caution due to the difficulty of observing and identifying seals at survey altitudes of 305 m (1,000 ft) above sea level (ASL), especially as sea states increase.

Admiralty Inlet Grid: The relative abundance of marine mammals in the Admiralty Inlet grid was lower in 2022 (3.1181 animals/km) to that observed in 2021 (12.6872 animals/km), 2020 (3.3705 animals/km) and in 2019 (4.8911 animals/km; Table 3). Narwhal relative abundance in 2022 (2.8330 animals/km) increased by 37% compared to 2020 (2.0704 animals/km) and decreased by 17% and 75% compared to 2019 (3.4363 animals/km) and 2021 (11.6507 animals/km), respectively. Ringed seals and harp seals were observed in lower relative abundance in 2022 compared to 2021 and 2020, but higher relative abundance in 2022 compared to 2019 (Table 3). Unidentified seals were observed in lower relative abundance in 2022 compared to the three previous years (2021, 2020 and 2019).

Table 3: Relative Abundance of Marine Mammals in Eclipse Sound and Admiralty Inlet survey grids during Leg 2 in 2019, 2020 and 2021.

Species	Eclipse Sound Grid				Admiralty Inlet Grid			
	2019 (animals/km)	2020 (animals/km)	2021 (animals/km)	2022 (animals/km)	2019 (animals/km)	2020 (animals/km)	2021 (animals/km)	2022 (animals/km)
Narwhal	1.6396	0.7682	0.3270	0.6512	3.4363	2.0704	11.6507	2.8330
Bowhead Whale	0.0003	0.0003	0.0006	0.0006	0.0313	0.0087	0.0510	0.0034
Beluga Whale	–	–	–	0.0016	–	–	–	0.0285
Killer Whale	0.0010	0.0045	0.0000	–	0.0000	0.0000	0.0085	–
Sperm Whale	0.0000	0.0016	0.0000	–	0.0000	0.0000	0.0000	–
Unidentified Whale	0.0000	0.0006	0.0000	0.0003	0.0000	0.0012	0.0014	0.0004
Ringed Seal	0.0047	0.0736	0.0702	0.0726	0.0122	0.0830	0.0920	0.0615
Harp Seal	0.0527	0.0448	0.0331	0.0466	0.1495	0.3685	0.9441	0.1917
Bearded Seal	0.0000	0.0000	0.0000	0.0022	0.0000	0.0004	0.0000	–
Hooded Seal	0.0000	0.0000	0.0000	–	0.0000	0.0004	0.0000	–
Walrus	–	–	–	–	–	–	–	0.0004
Unidentified Seal	0.0574	0.1829	0.0289	0.0302	1.2938	0.9286	0.1708	0.0318
Polar Bear	0.0000	0.0000	0.0006	0.0006	0.0000	0.0032	0.0000	0.0004
Total	**1.7396**	**1.0490**	**0.4301**	**0.7684**	**4.8911**	**3.3705**	**12.6872**	**3.1181**

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