FINAL REPORT

Mary River Project

2021 Marine Mammal Aerial Survey

Submitted to:

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Executive Summary

From 18 July to 3 August (Leg 1), 8 to 26 August (Leg 2), and 29 to 31 October (Leg 3) 2021, Golder, 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 2021 MMASP was staged in three separate legs. Leg 1 targeted a 21-day window in mid-July and was designed to collect data on the presence/absence and distribution of marine mammals in the RSA relative to available ice conditions at that time of year and prior to the start of shipping activities. Leg 2 targeted a 21-day window in August, started immediately after the end of the Leg 1 surveys and was designed with the objective of obtaining an annual abundance estimate for the Eclipse Sound and Admiralty Inlet narwhal summer stocks during the open-water season. Leg 3 targeted a three-day period at the end of the shipping season in late October to conduct a visual clearance survey to document if narwhal entrapment events occurred in the RSA following completion of Baffinland's 2021 shipping operations along the Northern Shipping Route. 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 in 2019 (Golder 2020a) and 2020 (Golder 2021a) 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 Mysticetus© database.

During the visual-based surveys, a total of 3,349 sightings of 11,361 individual marine mammals were recorded by the observers during July and August 2021. A total of nine different marine mammals species were observed during the surveys: narwhal (*Monodon monoceros*; 1,482 sightings totalling 4,448 individuals), ringed seal (*Pusa hispida*; 887 sightings totalling 1,061 individuals), harp seal (*Pagophilus groenlandicus*; 287 sightings totalling 4,975 individuals), bowhead whale (*Balaena mysticetus*; 186 sightings totalling 248 individuals), polar bear (*Ursus maritimus*; 51 sightings totalling 84 individuals), bearded seal (*Erignathus barbatus*; 13 sightings totalling 13 individuals), beluga (*Delphinapterus leucas*; seven sightings totalling nine individuals), killer whale (*Orcinus orca*; six sightings totalling 46 individuals), and walrus (*Odobenus rosmarus*; one sighting of an individual walrus). Unidentified seal (422 sightings totalling 468 individuals) and unidentified whale (seven sightings totalling eight individuals) were also recorded during the surveys.

During the photographic surveys, a total of 17,413 sightings of 37,647 individual marine mammals were recorded during the 2021 MMASP photo review. Two different species of marine mammals were recorded during the photographic surveys: narwhal (17,356 sightings totalling 37,559 individuals), and bowhead whale (57 sightings totalling 88 individuals).

At the beginning of Leg 1 surveys open water was present in the north Navy Board Inlet, Milne Inlet and Pond Inlet strata and by the end of Leg 1 open water was present throughout the RSA. Results from the 2021 Leg 1 survey indicated low narwhal numbers prior to the first vessel transit into the RSA. By the time of the first ore carrier transit in the RSA on 26 July 2021, narwhal relative abundance appeared to have increased and their

distribution had moved to be primarily concentrated in Koluktoo Bay and Tremblay Sound and remained concentrated in those areas for the duration of the Leg 1 program.

For the Leg 2 surveys, narwhal summer stock abundance was calculated for the Eclipse Sound stock, Admiralty Inlet stock, and the combined Eclipse Sound and Admiralty Inlet stock. The narwhal abundance estimate for the combined Eclipse Sound and Admiralty Inlet stock during the 2021 open-water season (Leg 2) was 75,177 individuals (Coefficient of Variation (CV) = 0.08, 95% confidence interval (CI) of 63,795–88,590) based on surveys conducted on 19–21 August 2021. This estimate is statistically higher 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), the 2019 estimate of 38,677 (CV = 0.11, 95% CI of 31,155–48,015), and the 2020 estimate of 36,044 (CV = 0.12, 95% CI of 28,267–45,961) (t-test = 1.82, p = 0.042, t-test = 4.64, p < 0.001, t-test = 5.06, p < 0.001, respectively).

For Eclipse Sound stock alone, the narwhal abundance estimate was 2,595 narwhal (CV = 0.33, 95% CI of 1,369–4,919) based on Baffinland's aerial survey conducted on 20–21 August 2021. The 2021 estimate is statistically lower than the 2016 DFO estimate of 12,039 (CV = 0.23, 95% CI of 7,768–18,660; Marcoux et al. 2019) (t-test = 3.25, p = 0.016). The 2021 abundance estimate is also statistically lower 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 = 2.96, p = 0.021), the 2019 abundance estimate of 9,931 (CV = 0.05, 95% CI of 9,009–10,946) (t-test = 7.33, p < 0.001), and the 2020 abundance estimate of 5,018 (CV = 0.03, 95% CI of 4,736–5,317) (t-test = 2.75, p = 0.026).

For the Admiralty Inlet stock alone, the narwhal abundance estimate was 72,582 narwhal (CV = 0.09, 95% CI of 61,333–85,895) based on Baffinland's aerial survey conducted on 19 August 2021. This estimate is statistically higher than the abundance calculated of the 2013 DFO estimate of 35,043 narwhal (CV = 0.42, 95% CI of 14,188–86,553; Doniol-Valcroze et al. 2015a) (t-test = 2.35 p = 0.015), the 2019 Baffinland estimate of 28,746 narwhal (CV = 0.15, 95% CI of 21,545–38,354) (t-test = 5.80, p < 0.001), and 2020 Baffinland estimate of 31,026 narwhal (CV = 0.14, 95% CI of 23,406–41,126) (t-test = 5.40, p < 0.001).

Given that there were very light ice conditions during the Leg 3 surveys, the low numbers and location of confirmed narwhal observations (east of Pond Inlet travelling toward Baffin Bay), and input from the community members who participated in the clearance aerial surveys, there was no concern regarding the risk of entrapment of narwhal caused by the Project at the end of the 2021 shipping season.

Results from the 2021 Leg 2 aerial survey indicated that: i) narwhal abundance in Eclipse Sound was statistically lower in 2021 than observed in previous years when aerial surveys were conducted (i.e., 2013, 2016, 2019 and 2020), and ii) the combined narwhal abundance in Eclipse Sound and Admiralty Inlet was statistically higher in 2021 to what was observed in previous years (2013, 2019 and 2020). These results suggest that a portion of the Eclipse Sound stock occupied the Admiralty Inlet summering ground during the summer of 2021. The results also suggest there is potentially greater mixing between neighbouring summer stocks (i.e., Admiralty Inlet, Somerset Island, and/or East Baffin Island) than is currently recognized.

Despite the adaptive management measure aimed at eliminating underwater noise from icebreaking in 2021, results from the 2021 monitoring programs again indicated lower narwhal numbers in Eclipse Sound during the 2021 shipping season. Underwater noise from open-water shipping was also not considered to be a likely cause of narwhal displacement from the RSA based on the available monitoring results collected to date (Austin et al. 2022; Baffinland 2021; Golder 2020d, 2021b).

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 Inuit Qaujimajatuqangit (IQ) regarding the degree of exchange between narwhal groups on their summering grounds, the observed decrease in narwhal relative abundance in Eclipse Sound likely reflected natural exchange between the two putative stock areas, or alternatively, that animals shifted to Admiralty Inlet due to more favorable ecological conditions related to sea ice conditions, prey availability and/or predation pressure.

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 that ocean warming has resulted in species distribution shifts for both marine mammals in the Arctic (Laidre et al. 2008, 2015; Frederiksen and Haug 2015; Nøttestad et al. 2015; Víkingsson et al. 2015; Albouy et al. 2020; Chambault et al. 2020, 2022; NAAMCO 2021) and their prey (Frainer et al. 2017; Møller and Nielsen 2020). 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).

How this might be manifesting on a micro-geographic scale in the North Baffin region is presently unclear. 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 suggest that the current distribution of Baffin Bay narwhal during summer will undergo a +200 km northward shift to cope with climate change, and that summer narwhal habitats in this region are predicted to decline by between 31 and 66% (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 explanation of 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

Comments on the draft 2021 MMASP Report were received from the Marine Environmental Working Group (MEWG) in June of 2022. Baffinland’s responses to MEWG comments and recommendations on the draft report are included as Appendix F.

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ᔪᓚᐃ 18-ᒥᑦ ᐋᒡᒋᓯ 3-ᒧᑦ (ᖃᖓᑕᓂᖅ 1), 8-26 ᐋᒡᒋᓯ 8-ᒥᑦ 26-ᒧᑦ (ᖃᖓᑕᓂᖅ 2), ᐊᒻᒪᓗ ᐅᑐᐱᕆ 29-ᒥᑦ 31-ᒧᑦ (ᖃᖓᑕᓂᖅ 3), ᒨᑦᑯᑦ, ᐱᓕᕆᔾᔪᔾᔨᓪᓗᑎᒃ ᐹᕝᕕᓛᓐ ᓴᕕᒃᓴᓂᒃ ᐅᔭᕋᖕᓂᐊᖅᑏᑦ ᑯᐊᐳᕇᓴᖏᓐᓂᒃ (ᐹᕝᕕᓛᓐ), ᐱᐊᓂᒃᓯᓚᐅᖅᑐᑦ ᑕᕆᐅᒥ ᐳᐃᔾᓂᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᖃᖓᑕᓲᒃᑯᑦ ᐱᓕᕆᐊᒥᒃ (MMASP) ᐋᖅᑭᒃᑕᐅᓯᒪᔪᖅ ᖃᐅᔨᓴᕐᓂᐊᕐᓗᑎᒃ ᑑᒑᓖᑦ ᓇᓅᒻᒪᖔᑕ ᐊᒻᒪᓗ ᐱᑕᖃᕐᓂᖏᑦ ᑕᐅᕙᓂ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕝᕕᐅᔪᒥ (RSA) ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ. ᑖᓐᓇ 2021 ᑕᕆᐅᒥ ᐳᐃᔾᓂᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᖃᖓᑕᓲᒃᑯᑦ ᐱᓕᕆᐊᖅ (MMASP) ᐋᖅᑭᒃᓱᖅᑕᐅᓯᒪᓚᐅᖅᑐᑦ ᐱᖓᓲᓗᑎᒃ ᐃᓛᒃᑰᕐᓗᑎᒃ ᖃᖓᑕᔭᕋᕐᓂᐅᓗᑎᒃ. ᖃᖓᑕᓂᖅ 1 ᑐᕋᒐᖃᓚᐅᖅᑐᑦ 21-ᓄᑦ ᐅᓪᓗᓄᑦ ᐱᓕᕆᐊᖑᓗᓂ ᔪᓚᐃ–ᕿᑎᐊᓂ ᐊᒻᒪᓗ ᐋᖅᑭᒃᑕᐅᓯᒪᓪᓗᓂ ᑲᑎᖅᓯᐃᓗᑎᒃ ᖃᐅᔨᓴᕈᑎᓂᒃ ᐱᑕᖃᕐᓂᖏᓐᓄᑦ/ᐱᑕᖃᖏᓐᓂᖏᓐᓄᑦ ᐊᒻᒪᓗ ᓇᓃᓐᓂᖏᑦ ᑕᕆᐅᒥ ᐳᐃᔾᑦ ᑕᐅᕙᓂ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕝᕕᐅᔪᓂᒃ (RSA) ᐊᒃᑐᐊᔪᑦ ᐊᑐᐃᓐᓇᐅᔪᓄᑦ ᓯᑯᐃᑦ ᖃᓄᐃᓕᖓᓂᖏᓐᓄᑦ ᑕᐃᑲᓂ ᐊᕿᒍᒥ ᐊᒻᒪᓗ ᐱᒋᐊᖅᑕᐅᖅᑳᖅᑎᓐᓇᒋᑦ ᐅᓯᑲᖅᑕᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᑦ. ᖃᖓᑕᓂᖅ 2 ᑐᕋᒐᖃᓚᐅᖅᑐᑦ 21-ᓄᑦ ᐅᓪᓗᓄ ᐱᓕᕆᐊᖑᓗᓂ ᐋᒡᒋᓯᒥ ᐱᒋᐊᑲᐅᑎᒋᓂᐊᖅᓱᓂ ᐃᓱᓕᑕᐅᒃᐸᑦ ᖃᖓᑕᖃᑦᑕᕐᓂᖅ 1-ᒥ ᖃᐅᔨᓴᕐᓃᑦ ᐊᒻᒪᓗ ᐋᖅᑭᒃᓱᖅᑕᐅᓯᒪᓪᓗᓂ ᑐᕋᒐᖅᓱᓂ ᐱᓂᐊᕐᓗᑎᒃ ᐊᕋᕉᑕᒦᑦ ᐱᑕᖃᕐᓂᖏᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᔪᓂᒃ ᑕᓯᐅᔭᒥ ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᑑᒑᓖᑦ ᐱᑕᖃᕐᕕᒋᕙᒃᑕᖏᑦ ᐅᐊᔭᒃᑯᑦ ᓯᑯᖃᕐᒥᑎᓪᓗᒍ. ᖃᖓᑕᓂᖅ 3 ᑐᕋᒐᖅᑐᑦ ᐱᖓᓱᓄᑦ-ᐅᓪᓗᓄᑦ ᐱᓕᕆᐊᖑᓂᐊᖅᓱᓂ ᐃᓱᓕᓕᖅᑎᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᖃᕐᓇᖅ ᓄᙳᐊᓂ ᐅᑐᐱᕆᒥ ᐱᓕᕆᐊᖑᓂᐊᖅᓱᑎᒃ ᑕᑯᔭᒃᓴᐅᔪᑦ ᐊᓂᒍᐃᑦᑎᐊᕋᓗᐊᕐᒪᖔᑕ ᖃᐅᔨᓴᕐᓂᑦ ᑎᑎᕋᖅᑕᐅᕐᑯᓪᓗᑎᑦ ᑑᒑᓖᑦ ᓯᒃᑯᔭᐅᓂᖏᑦ ᑕᐅᕙᓂ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕝᕕᐅᔪᓂ ᐱᐊᓂᓚᐅᖅᑎᓪᓗᒋᑦ ᐹᕝᕕᓛᓐᑯᑦ 2021-ᒥ ᐅᒥᐊᕐᓇᐊᑦ ᐊᐅᓚᓂᖏᑦ ᑕᐅᕗᓇ ᐅᑭᐅᖅᑕᖅᑑᑉ ᐅᒥᐊᕐᔪᐊᓄᑦ ᐊᖅᑯᑖᒍᑦ. ᖃᐅᔨᓴᕐᓃᑦ ᐋᖅᑭᒃᓯᒪᓚᐅᖅᑐᑦ ᐊᒻᒪᓗ ᑎᑎᖅᑲᖁᑎᓂᒃ ᑲᑎᖅᓯᐃᓂᕐᒧᑦ ᐱᓕᕆᔾᔪᓯᑦ ᑭᖑᓂᖖᑦᑎᓐᓂ ᐱᕙᓪᓕᐊᑎᑕᐅᓚᐅᖅᑐᑦ ᐃᒪᕐᒥᐅᑕᓕᕆᔨᒃᑯᓐᓂᑦ ᑲᓇᑕᒥ (DFO) (ᒫᑎᐅ ᐊᑕᖏᖅᓱᑎᒃ. 2017; ᒪᑲᐅᑰ ᐊᑕᖏᖅᓱᑎᒃ. 2016; ᑑᓇᐃᐆᓪ–ᕕᐅᑯᕉᔅ ᐊᑕᖏᖅᓱᑎᒃ. 2015ᐃ; ᐋᓯᓕᓐ ᐊᒻᒪᓗ ᕆᑦᓱᑦ 2011) ᐊᒻᒪᓗ ᐊᑐᓕᖅᑎᑕᐅᓪᓗᑎᒃ ᒨᑦᑯᓐᓂᑦ 2019-ᒥ (ᒨᑐ 2020ᐃ) ᐊᒻᒪᓗ 2020 (ᒨᑐ 2021ᐃ) ᐊᑐᖅᑕᐅᙱᓕᓚᐅᖅᑐᑦ ᖃᓄᐃᓐᓂᖅᓴᐅᖔᙱᑕ ᖃᐅᔨᓴᖅᑕᐅᖁᓪᓗᑎᑦ ᐱᑕᖃᕐᓂᖏᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ.

ᒪᕈᐃᓕᖅᑲᖓᔪᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓃᑦ ᖃᖓᑕᑎᑕᐅᓚᐅᖅᑐᑦ: ᑕᑯᓂᒃᑯᑦ–ᑐᙵᕕᓛᑦ ᖃᐅᔨᓴᕐᓃᑦ ᑕᒻᒃᑯᐊ ᑕᕆᐅᒥ ᐳᐃᔾᑦ ᑕᑯᔭᐅᔪᑦ ᑲᑎᖅᓯᖅᑕᐅᓪᓗᑎᒃ ᐋᖅᑭᒃᑕᐅᓯᒪᔪᒃᑯᑦ ᑐᑭᓕᕇᑦ ᖃᖓᑕᕝᕕᐅᔪᑦ ᐊᑐᖅᓱᑎᒃ ᒪᕈᐃᓕᖅᑲᖓᔪᒥᒃ ᐊᑐᖅᑕᐅᔪᒥᒃ ᑕᕆᐅᒥ ᐳᐃᔾᓂᒃ ᐅᔾᔨᖅᓱᖅᑎᓂᒃ (MMOs) ᐃᓂᖃᖅᑐᑦ ᐃᓛᒃᑰᖅᓱᑎᒃ ᓇᐅᑦᑎᖅᓱᒃᑯᑦ ᐋᖅᑭᒃᓯᒪᔪᑦ ᓯᕗᓂᐊᓂ ᐊᒻᒪᓗ ᑐᓄᐊᓂ ᖃᖓᑕᓲᑉ, ᐊᒻᒪᓗ ᐊᔾᔨᓕᐅᕆᓂᒃᑰᖅᑐᑦ ᖃᐅᔨᓴᕐᓃᑦ ᖃᕆᓴᐅᔭᒃᑰᖅᑐᓂᒃ ᐊᔾᔨᓕᐅᕈᑎᖃᖅᓱᑎᒃ (DSLR) ᐊᔾᔨᓕᐅᕈᑎᓂᒃ ᐋᖅᑭᒃᑕᐅᓯᒪᔪᑦ ᖃᖓᑕᓲᒧᑦ ᑲᑎᖅᓯᐃᖅᑯᓪᓗᑎᑦ ᐱᐅᓪᓚᕆᒃᑐᓂᒃ ᐊᔾᔪᙳᐊᓂᒃ ᖃᐅᔨᓴᕝᕕᐅᔪᒥ ᐃᓂᒥ ᐊᑖᓂ ᖃᖓᑕᓲᑉ. ᐊᔾᔪᙳᐊᑎᒍᑦ ᖃᐅᔨᓴᕐᓃᑦ ᖃᖓᑕᔭᕋᖅᑕᐅᓚᐅᖅᑐᑦ ᐃᓂᓂ ᐱᑕᖃᕝᕕᐅᓪᓚᕆᒃᑐᓂ ᑑᓕᓐᓂᒃ ᑕᒻᒪᖅᓯᒪᙱᑦᑎᐊᖅᑐᒥᒃ ᓇᐃᓴᖅᑕᐅᓂᖏᑦ ᐊᔪᕐᓇᕋᔭᕐᓂᖓᓄᑦ ᐊᑐᖅᑕᐅᒍᑎᒃ ᑕᑯᑐᐃᓐᓇᕐᓃᑦ. ᑕᕆᐅᒥ ᐳᐃᔾᓂᒃ ᑕᑯᓃᑦ, ᐊᕙᑎᓕᕆᓂᕐᒧᑦ ᖃᓄᐃᓕᖓᓃᑦ ᐊᒻᒪᓗ ᖃᐅᔨᓴᕐᓂᕐᒥᒃ ᑎᑎᖅᑲᖁᑎᖏᑦ ᐃᓕᔭᐅᓚᐅᖅᑐᑦ ᖃᕆᓴᐅᔭᕆᓕᕝᕕᖓᓄᑦ Mysticetus© ᑎᑎᖅᑲᖁᑎᒃᑯᕕᖓᓄᑦ.

ᐱᓕᕆᑎᓪᓗᒋᑦ ᑕᑯᓂᒃᑯᑦ ᖃᐅᔨᓴᕈᑎᓂᒃ, ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 3,349-ᓂᒃ ᑕᑯᓚᐅᖅᑐᑦ ᑖᒃᑯᓇᓂ 11,361 ᐃᓛᒃᑯᑦ ᑕᕆᐅᒥ ᐳᐃᔾᓂᒃ ᑎᑎᕋᖅᑕᐅᓚᐅᖅᑐᑦ ᓇᐅᑦᑎᖅᓱᖅᑎᓄᑦ ᔪᓚᐃᒥ ᐊᒻᒪᓗ ᐋᒡᒋᓯ 2021-ᒥ. ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ ᖁᓕᖅᑲᙳᑎᑐᐃᓐᓇᖅᑐᑦ ᐊᔾᔨᒌᙱᑦᑐᑦ ᑕᕆᐅᒥ ᐳᐃᔾᔨᑦ ᓂᕐᔪᑏᑦ ᐊᔾᔨᒌᙱᑦᑐᑦ ᑕᑯᔭᐅᓚᐅᖅᑐᑦ ᖃᐅᔨᓴᖅᑎᓪᓗᒋᑦ: ᑑᒑᓖᑦ (*Monodon monoceros*, 1,482 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 4,448 ᑑᒑᓖᑦ), ᓇᑦᑏᑦ (*Pusa hispida*, 887 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 1,061 ᓇᑏᑦ), ᖃᐃᕈᓖᑦ (*Pagophilus groenlandicus*, 287 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 4,975 ᖃᐃᕈᓖᑦ), ᐊᕐᕕᖅ (*Balaena mysticetus*, 186 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 248 ᐊᕐᕖᑦ), ᓇᓄᐃᑦ (*Ursus maritimus*, 51 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 84 ᓇᓄᑦ), ᐅᒡᔪᒃ (*Erignathus barbatus*, 13 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 13 ᐅᒡᔪᐃᑦ), ᖃᑯᖅᑕᖅ ᕿᓚᓗᒐᖅ (*Delphinapterus leucas*, 7 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 9 ᖃᑯᖅᑕᑦ ᕿᓚᓗᒐᐃᑦ), ᐋᕐᓗᒃ (*Orcinus orca*, 6 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 46 ᐊᕐᓗᐃᑦ), ᐊᒻᒪᓗ ᐊᐃᕙᖅ (*Odobenus rosmarus*, ᐊᓯᑕᐅᓯᕐᒥᒃ ᑕᑯᔭᐅᔪᖃᖅᓱᓂ ᐃᓄᑐᐊᒥᒃ ᐊᐃᕕᒃᒥᒃ). ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᖅ ᓇᑦᑎᖅ (422 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 468 ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᓇᑏᑦ) ᐊᒻᒪᓗ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᕿᓚᓗᒐᑦ (7 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 8 ᕿᓚᓗᒐᑦ) ᑎᑎᕋᖅᑕᐅᓯᒪᓚᐅᕐᒥᔪᑦ ᖃᐅᔨᓴᖅᑎᓪᓗᒋᑦ.

ᐱᓕᕆᑎᓪᓗᒋᑦ ᐊᔾᔨᓕᐅᕆᖃᑦᑕᕐᓂᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᕐᒥᒃ, ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 17,413 ᑕᑯᔭᐅᔪᑦ ᑖᒃᑯᓇᓂ 37,647 ᐊᑐᓂ ᑕᕆᐅᒥ ᐳᐃᔾᓂᒃ ᑎᑎᕋᖅᑕᐅᓚᐅᖅᑐᑦ ᐱᓕᕆᑎᓪᓗᒋᑦ 2021 ᑕᕆᐅᒥ ᐳᐃᔾᓂᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᖃᖓᑕᓲᒃᑯᑦ ᐱᓕᕆᐊᖅ (MMASP) ᐊᔾᔪᙳᐊᓂᒃ ᕿᒥᕐᕈᓂᕐᒥᒃ. ᒪᕐᕉᒃ ᐊᔾᔨᒌᙱᑦᑐᑦ ᓂᕐᔪᑏᑦ ᐆᒪᔪᑦ ᑕᕆᐅᒥ ᐳᐃᔾᑦ ᑎᑎᕋᖅᑕᐅᓚᐅᖅᑐᑦ ᐱᓕᕆᑎᓪᓗᒋᑦ ᐊᔾᔪᙳᐊᑎᒍᑦ ᖃᐅᔨᓴᕐᓂᕐᓂᒃ: ᑑᒑᓖᑦ (17,356 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 37,559 ᑑᒑᓖᑦ), ᐊᒻᒪᓗ ᐊᕐᕕᖅ (57 ᑕᑯᔭᐅᔪᑦ ᑲᑎᓪᓗᒃᑖᖅᓱᒋᑦ 88 ᐊᕐᕖᑦ).

ᐱᒋᐊᓕᕆᖅᑎᓪᓗᒋᑦ ᖃᖓᑕᓂᖅ 1-ᒥᒃ ᖃᐅᔨᓴᕐᓂᕐᓂᒃ ᓱᑯᖔᙳᕆᑎᓪᓗᒍ ᐅᐊᖕᓇᖓᓂ ᐃᒡᓗᐊᑕ ᓱᓪᓗᐊᓂ ᑲᖏᖅᓱᖏᒥ, ᕿᙵᒍᐊᓂ ᐊᒻᒪᓗ ᒥᑦᑎᒪᑕᓕᕈᔪᖏᒥ ᐊᒻᒪᓗ ᐃᓱᓕᓕᖅᑎᓪᓗᒍ ᖃᖓᑕᓂᖅ 1 ᓱᑯᖔᙳᕆᑦᑐᐃᓐᓇᐅᓚᐅᖅᑐᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ. ᖃᐅᔨᓯᐅᔪᑦ 2021-ᒥ ᖃᖓᑕᓂᐅᓚᐅᖅᑐᖅ 1-ᒥ ᖃᐅᔨᓴᕈᑎᓂ ᓇᓗᓇᐃᖅᓯᔪᖅ ᑑᒃᑐᑦ ᐱᑕᖃᑦᑎᐊᖖᒋᓚᐅᕐᓂᖏᓐᓂᒃ ᓯᕗᓪᓕᖅᐸᖅ ᐅᒥᐊᕐᔪᐊᖅ ᐃᖏᕐᕋᓯᓚᐅᖅᑳᖅᑎᓐᓇᒍ ᑕᐅᕗᓇ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ (RSA). ᓯᕗᓪᓕᖅᐸᖅ ᓴᕕᒃᓴᓂᒃ ᐅᔾᔪᖅᓴᖅ ᐃᖏᕐᕋᓕᖅᑎᓪᓗᒍ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ (RSA) ᔪᓚᐃ 26, 2021-ᒥ, ᑑᒃᑐᑦ ᐱᑕᖃᕐᔭᕐᓂᖏᑦ ᐅᔾᔨᕐᓇᓚᐅᖅᑐᑦ ᐅᓄᖅᓯᒋᐊᕐᓂᖏᓐᓂᒃ ᐊᒻᒪᓗ ᓇᓃᓐᓂᖏᑦ ᓅᑦᑎᒃ ᐱᑕᖃᓪᓗᐊᑕᓲᒧᑦ ᖁᕐᓗᖅᑐ ᑲᖏᖅᓱᖓᓄᑦ ᐊᒻᒪᓗ ᑲᖏᖅᓱᕈᓱᖕᒧᑦ ᐊᒻᒪᓗ ᓱᓕ ᐱᑕᖃᐃᓐᓇᖅᓱᑎᒃ ᑕᐅᕙᓂ ᐃᓂᓂ ᐱᓕᕆᓂᓗᒃᑖᖓᓂ ᖃᖓᑕᖃᑦᑕᕐᓂᖅ 1-ᒥᒃ ᐱᓕᕆᐊᖑᔪᒥ.

ᑕᒪᑐᒨᖓᓕ ᖃᖓᑕᖃᑦᑕᑦᑕᕐᓂᖅ 2 ᖃᐅᔨᓴᕐᓂᕐᒧᑦ, ᑑᒃᑐᑦ ᐊᐅᓯᒃᑯᑦ ᐱᑕᖃᕐᕕᒋᕙᒃᑕᖏᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᖅ ᑕᓯᐅᔾᔨ ᐱᑕᖃᕐᕋᔪᒃᑯᖅ, ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᐱᑕᖃᕐᕕᐅᓲᖅ, ᐊᒻᒪᓗ ᑲᑎᙵᒋᑦ ᑕᓯᐅᔾᔨ ᐃᒃᐱᐊᕐᔫᓪᓗ ᐃᒪᖓᓂ ᐱᑕᖃᕐᕕᐅᓲᑦ. ᑑᒃᑐᑦ ᐱᑕᖃᕐᓂᖏᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᑲᑎᙵᒋᑦ ᑕᓯᐅᔾᔨ ᐊᒻᒪᓗ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᐱᑕᖃᕐᕕᐅᔪᓂ 2021-ᒥ ᓱᑯᖔᙳᕆᑎᓪᓗᒍ (ᖃᖓᑕᓂᖅ 2) ᐃᒪᐃᓐᓇᑎᒋᐅᓚᐅᖅᑐᑦ 75,177 ᑑᒃᑐᑦ (ᓇᐃᓴᐅᑏᑦ ᐅᓄᖅᓯᒋᐊᖅᑕᐅᖃᖅᑎᓐᓇᒋᑦ ᐊᔾᔨᒌᙱᓐᓂᖏᓐᓄᑦ (CV) = 0.08, 95% ᐱᑕᖃᕐᕕᐅᓇᓯᒋᓪᓕᑦᑖᖅᑐᑦ ᐊᑯᓚᐃᓐᓂᖏᑦ (CI) 63,795–88,590) ᑐᙵᕕᒋᔭᐅᓪᓗᑎᒃ ᖃᐅᔨᓴᕈᑕᐅᓚᐅᖅᑐᑦ 19-21 ᐋᒡᒌᓯ 2021-ᒥ. ᑖᒃᑯᐊ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᐅᓄᕐᓂᖅᓴᐅᕗᑦ ᓈᓴᖅᑕᐅᓯᒪᔪᓂᒃ ᓈᓴᖅᑕᐅᓚᐅᖅᑐᓂᒃ ᑭᖑᓂᖓᑦᑎᓐᓂ ᐃᒪᕝᕆᐅᑕᓕᕆᓂᒃᑯᓐᓂ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᑦ ᐋᒡᒌᓯ 2013-ᒥ (45,532 ᑑᒃᑐᑦ, CV = 0.33, 95% CI 22,440-92,384; ᑑᓂᐅᓪ-ᕕᐅᑯᕈᔅ ᐊᑕᖏᖅᓱᑎᒃ. 2015a), 2019–ᒥ ᒥᒃᓴᐅᑎᓯᒪᔪᑦ 38,677–ᖑᓇᓱᒋᔭᐅᓪᓗᑎᒃ (CV = 0.11, 95% CI 31,155–48,015), ᐊᒻᒪ 2020–ᒥ ᒥᒃᓴᐅᑎᓯᒪᔪᑦ 36,044 (CV = 0.12, 95% CI of 28,267–45,961) (ᖃᐅᔨᓴᐅᑦ = 1.82, p = 0.042, t-ᖃᐅᔨᓴᕐᓂᖅ = 4.64, p < 0.001, ᖃᐅᔨᓴᕈᑕᐅᔪᖅ = 5.06, p < 0.001, ᐊᑐᓂ).

ᑕᓯᐅᔾᔨᒥ ᐱᑕᖃᕐᕕᐅᔪᑐᐊᑦ, ᑑᒃᑐᑦ ᐱᑕᖃᕐᓂᖏᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᓚᐅᖅᑐᑦ ᐃᒪᓐᓇᑎᒋᑦ 2,595 ᑑᒃᑐᑦ (CV = 0.33, 95% CI 1,369–4,919) ᐸᕙᓐᓂᓐᓄᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᖅᑕᓂᖏᑦ 20-21 ᐋᒡᒌᓯ 2021–ᒥ. 2021–ᒥ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᑭᓪᓕᓯᓂᐊᖅᑕᐅᓯᒪᔪᑦ ᐅᓄᙱᓐᓂᖅᓴᐅᕗᑦ 2016–ᒥ ᐃᒪᕝᕆᐅᑕᓕᕆᓂᒃᑯᓐᓂ ᐊᑭᓂᐊᕌᓯᒋᔭᐅᔪᓂᒃ 12,039–ᖑᓇᓱᒋᔭᐅᓪᓗᑎᒃ (CV = 0.23, 95% CI 7,768–18,660; ᒫᑯᐊᒃᔅ ᐊᑕᖏᖅᓱᑎᒃ. 2019) (ᖃᐅᔨᓴᐅᑦ = 3.25, p = 0.016). 2021–ᒥ ᐅᓄᕐᓂᖏᑦ ᒥᒃᓴᐅᑎᓯᒪᔪᑦ ᐅᓄᙱᓐᓂᖅᓴᐅᒋᕗᑦ 2013–ᒥ ᐅᓄᕐᓂᖏᑦ ᒥᒃᓴᐅᑎᓯᒪᔪᑦ 10,489–ᖑᓇᓱᒋᔭᐅᓪᓗᑎᒃ (CV = 0.24, 95% CI 6,342–17,347; ᑑᓂᐅᓪ-ᕕᐅᑯᕈᔅ ᐊᑕᖏᖅᓱᑎᒃ. 2015a) (ᖃᐅᔨᓴᐅᑦ = 2.96, p = 0.021), 2019 ᐊᒥᓲᓂᖏᑕ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 9,931 (CV = 0.05, 95% CI of 9,009–10,946) (ᖃᐅᔨᓴᐅᑎ = 7.33, p < 0.001), ᐊᒻᒪ 2020 ᐊᒥᓲᓂᖏᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 5,018 (CV = 0.03, 95% CI of 4,736-5,317) (ᖃᐅᔨᓴᕐᓂᖃᓚᐅᖅᑐᑦ = 2.75, p = 0.026).

ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᐱᑕᖃᕐᕕᐅᔪᑐᐊᑦ, ᑑᒃᑐᑦ ᐱᑕᖃᕐᓂᖏᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 72,582 ᑑᒃᑐᑦ (CV = 0.09, 95% CI 61,333–85,895) ᓄᑖᕐᓕᕆᔾᔪᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᓚᐅᖅᑕᖓᑦ 19 ᐋᒡᒌᓯ 2021–ᒥ. ᑖᒃᑯᐊ ᒥᒃᓴᐅᑎᓯᒪᔪᑦ ᐅᓄᕐᓂᖅᓴᐅᕗᑦ ᐅᓄᕐᓂᕆᔭᖏᓐᓂᒃ ᓈᓴᖅᑕᐅᓚᐅᖅᓯᒪᔪᓂᒃ 2013-ᒥ ᐃᒪᕝᕆᐅᑕᓕᕆᓂᒃᑯᓐᓂ ᒥᒃᓴᐅᑎᓯᒪᔪᓂᒃ 35,043 ᑑᒃᑐᑦ (CV = 0.42, 95% CI 14,188–86,553; ᑑᓂᐅᓪ-ᕕᐅᑯᕈᔅ ᐊᑕᖏᖅᓱᑎᒃ. 2015a) (t-test = 2.35 p = 0.015), 2019 ᓄᑖᕐᓕᕆᔾᔪᑦ ᓇᓚᐅᑦᑖᖅᓯᒪᖕᒋᑦ 28,746 ᕿᑲᓗᒐᐃᑦ (CV = 0.15, 95% CI 21,545–38,354) (ᖃᐅᔨᓴᐅᒃᓴᖅ = 5.80, p < 0.001), ᐊᒻᒪ 2020 ᓄᑖᕐᓕᕆᔾᔪᑦ ᓇᓚᐅᑦᑖᖅᓯᒪᔪᑦ 31,026 ᑑᒃᑐᑦ (CV = 0.14, 95% CI 23,406–41,126) (ᖃᐅᔨᓴᕈᑎ = 5.40, p < 0.01).

ᐱᔾᔪᑎᒋᓪᓗᒋᑦ ᓱᑯᖃᓗᐊᖏᓐᓂᖓᓄᑦ ᐱᓕᕆᐊᖑᑎᓪᓗᒍ ᖃᖓᑕᓂᖅ 3 ᖃᐅᔨᓴᕐᓂᖅ, ᐅᓄᙱᑦᑐᑦ ᐊᒻᒪᓗ ᓇᓃᓐᓂᖏᑦ ᓇᓗᓇᐃᖅᑕᐅᔪᑦ ᑑᒃᑐᑦ ᑕᑯᔭᐅᔪᑦ (ᑲᓇᖕᓇᖓᓂ ᒥᑦᑎᒪᑕᓕᐅᑉ ᐃᖏᕐᕋᔪᑦ ᑕᐅᕗᖓ ᓴᓂᕈᑎᐅᑉ ᐃᒪᖓᓄᑦ), ᐊᒻᒪᓗ ᐅᖃᐅᔾᔭᐅᓯᒪᓪᓗᑎᒃ ᓄᓇᓕᖕᓂ ᐃᓚᒋᔭᐅᔪᓂᒃ ᐃᓚᐅᓚᐅᖅᑐᓂᒃ ᐊᓂᒍᐃᑦᑎᐊᕐᑯᔨᓂᕐᒧᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᒥᒃ, ᐃᓱᒪᓘᑕᐅᓚᐳᙱᑦᑐᑦ ᖁᐊᖅᓵᕐᓇᕈᓐᓇᕐᓂᖓ ᓯᒃᑯᔭᐅᓇᓴᕐᓂᖏᑦ ᑑᒃᑐᑦ ᑕᐃᒪᐃᑎᑕᐅᔪᑦ ᐱᓕᕆᐊᒥᑦ ᐃᓱᐊᓂ 2021 ᐅᒥᐊᕐᔪᐊᖃᕐᓇᐅᑎᓪᓗᒍ.

ᖃᐅᔨᓴᐅᔪᑦ 2021-ᒥ ᖃᖓᑕᓂ 2-ᒥ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᕐᓂᒃ ᓇᓗᓇᐃᖅᓯᔪᖅ ᐃᒪᓐᓇ: i) ᑑᒃᑐᑦ ᐱᑕᖃᕐᓂᖏᑦ ᑕᓯᐅᔾᔨᒥ ᓇᐃᓴᐅᑎᑎᒍᑦ ᐊᒃᐸᓯᖕᓂᖅᓴᐅᓚᐅᖅᑐᑦ 2021-ᒥ ᐅᔾᔨᕆᔭᐅᓯᒪᔪᓂ ᑭᖑᓂᖓᑦᑎᓐᓂ ᐊᕐᕌᒍᓂ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓃᑦ ᐱᓕᕆᐊᖑᑎᓪᓗᒋᑦ (ᓲᕐᓗ 2013, 2016, 2019 ᐊᒻᒪᓗ 2020), ᐊᒻᒪ ii) ᑲᑎᓪᓗᒃᑖᖑᒋᑦ ᑑᒃᑐᑦ ᐱᑕᖃᕐᓂᖏᑦ ᑕᓯᐅᔾᔨᒥᒃ ᐃᒃᐱᐊᕐᔫᓪᓗ ᐃᒪᖓᓂ ᓇᐃᓴᐅᑎᑎᒍᑦ ᖁᕝᕙᓯᖕᓂᖅᓴᐅᓚᐅᖅᑐᑦ 2021-ᒥ ᐅᔾᔨᕆᔭᐅᔪᓂᒃ ᑭᖑᓂᖓᑦᑎᓐᓂ ᐊᕐᕌᒍᓂ (2013, 2019 ᐊᒻᒪᓗ 2020). ᑕᒪᒃᑯᐊ ᖃᐅᔨᓴᐅᔪᑦ ᐃᒪᐃᑎᑦᑎᓇᓱᒋᓐᓈᔪᑦ ᐃᓚᖏᑦ ᑕᓯᐅᔾᔨ ᐱᑕᖃᕐᕕᒧᑦ ᑕᐅᕙᓃᓚᐅᖅᑐᑦ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓂ ᐊᐅᔭᒃᑯᑦ ᐃᓂᐅᕙᒃᑐᓂ ᐊᐅᔭᐅᑎᓪᓗᒍ 2021-ᒥ. ᖃᐅᔨᓴᐅᔪᑦ ᐃᒪᐃᓐᓇᓯᒋᓈᖅᒥᔪᑦ ᑲᑎᑉᓗᑦᔭᕐᓂᖅᓴᐅᖃᑦᑕᕋᓱᒋᔭᐅᔪᑦ ᖃᓂᒌᑦ ᐊᐅᔭᒃᑯᑦ ᐱᑕᖃᕐᕕᐅᔪᑦ (ᓲᕐᓗ, ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓ, ᑯᓚᓇᔪᒃ, ᐊᒻᒪᓗ/ᐅᕝᕙᓘᓐᓃᑦ ᑲᓇᖕᓇᖓᓂ ᕿᑭᖅᑖᓗᒃ) ᒫᓐᓇ ᐃᓕᓴᕆᔭᐅᓯᒪᔪᓂᑦ.

ᐋᖅᑭᒋᐊᕐᕕᖃᐃᓐᓇᖅᑐᑦ ᐊᐅᓚᑦᑎᔾᔪᑏᑦ ᑐᕌᒐᖃᕋᓗᐊᖅᑎᓪᓗᒋᑦ ᐱᑕᖃᕈᓐᓃᖅᑎᑦᑎᓂᕐᓂᒃ ᐃᒫᓂ ᓂᐱᓂᒃ ᓯᑯᓂᒃ ᐊᔭᐅᖅᑐᐃᓂᕐᓂᒃ 2021-ᒥ, ᖃᐅᔨᔭᐅᔪᑦ 2021-ᒥ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᖅᑎᓇᕐᓂᕐᒧᑦ ᐱᓕᕆᓂᕐᓂᒃ ᓇᓗᓇᐃᖅᓯᒃᑲᓂᓚᐅᖅᑐᑦ ᐅᓄᙱᓂᖅᓴᐅᓂᖅᑎᑦ ᑑᒐᓖᑦ ᓇᐃᓴᐅᑎᑎᒍᑦ ᑕᓯᐅᔭᒥ ᐱᓕᕆᐊᕐᒎᑎᓪᓗᒍ 2021 ᐅᒥᐊᕐᔪᐊᖅᑲᕐᓇᖅ. ᐃᒫᓂ ᓂᐱᑦ ᓯᑯᖃᙱᑎᓪᓗᒍ ᐊᐅᓪᓚᖅᑎᑦᑎᖃᑦᑕᕐᓂᕐᒧᑦ ᐃᓱᒪᒋᔭᐅᓚᐅᙱᑦᑐᖅ ᐱᔾᔪᑕᐅᓗᓂ ᑑᒐᓖᑦ ᑕᐅᕝᕗᓐᑐᓐᓂᕐᓂᖅᑎᓐᓄᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ (RSA) ᑐᙵᕕᖃᖅᑯᑎᒃ ᐊᑐᐃᓐᓇᐅᔪᓂᒃ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᖅᑎᓇᕐᓂᕐᒧᑦ ᖃᐅᔨᔭᐅᔪᓂᒃ ᑲᑎᖅᓱᖅᑕᐅᔪᑦ ᐅᓪᓗᒥᒧᑦ (ᐋᒃᑎᓐ ᐊᑕᖏᖅᑯᑎᒃ. 2022; ᐸᕙᓛᓐ 2021; ᒌᑐ 2020ᑭ, 2021ᐱ).

ᐱᔾᔪᑕᐅᓪᓗᑎᒃ ᑲᑎᖑᒋᑦ ᐱᑕᖃᕐᕕᐅᔪᓄᑦ ᒥᒃᓴᐅᓴᒍᑕᐅᔪᑦ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓᓄᑦ ᐊᒻᒪᓗ ᑕᓯᐅᔭᕐᒧᑦ ᓇᓗᓇᐃᖅᓯᔪᑦ ᑲᑎᓪᓗᒋᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᑑᒐᓖᑦ ᐱᑕᖃᕐᓂᖅᑎᑦ ᓱᓚ ᓱᕐᖁᒃᓯᒪᙱᑦᑐᑦ ᐃᓱᒪᒋᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᖅᑲᖅᑳᖅᑎᓐᓇᒍ ᖃᓄᐃᓕᖓᓂᐅᔪᑦ, ᐊᒻᒪᓗ ᐃᓱᒪᒋᖃᓯᐅᑎᓪᓗᒋᑦ ᐊᑐᐃᓐᓇᐅᔪᑦ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏᑦ (IQ) ᐱᔾᔪᑎᒋᓪᓗᒋᑦ ᐊᓯᔾᔨᖅᑕᖃᑦᑕᕐᓂᖅᑎᓐᓄᑦ ᑖᒃᑯᓇᓂ ᑑᒐᓖᑦ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᐊᐅᔭᒃᑯᑦ ᓇᔪᓚᖓᕝᑕᖏᑦ, ᐅᔾᔨᕆᔭᐅᔪᑦ ᐅᓄᕈᓐᓂᖅᐹᓪᓕᕐᓂᖅᑎᑦ ᑑᒐᓖᑦ ᐱᑕᖃᕐᓂᖅᑎᑦ ᑕᓯᐅᔭᒥ ᓴᖅᑮᔭᖅᑎᑦᑎᑐᐃᓐᓇᖓᐊᓕᒃ ᑕᐃᒪᐃᑐᐃᓐᓇᖃᑦᑕᕐᓂᖏᓐᓄᑦ ᒪᕐᐹᒃ ᐱᑕᖃᕐᕕᐅᔫᒃ ᐃᓅᑦ. ᐃᒪᐃᒻᒪᑦ, ᐃᒪᐃᑐᐃᓐᓇᖓᐊᓕᒃ ᐆᒪᔪᑦ ᓇᔪᖏᑕ ᓯᓚᑎᖏᑕ ᖃᓄᐃᓕᖓᓂᖏᑦ ᐃᒃᐱᐊᕐᔫᑉ ᐃᒪᖓ ᒫᓐᓇ ᐱᐅᑦᔭᐅᓂᖅᓴᐅᓚᐅᕙᖕᓂᖓᓄᑦ ᑕᓯᐅᔭᒥ ᑑᒐᓕᖏᓐᓂᓄᑦ ᐱᔾᔪᑎᖃᖅᑯᑎᒃ ᓲᕐᓗ ᐊᓯᔾᔨᖅᐸᓪᓕᐊᔪᖅ ᓯᑰᒃ ᖃᓄᐃᓕᖓᓂᖓ, ᐊᖑᓇᓱᒃᑲᓴᖃᕐᓂᖓᓄᑦ ᐊᒻᒪᓗ/ᐅᕙᓘᓐᓂᑦ ᐊᖑᓇᓱᒃᕕᐅᖃᑦᑕᕐᓂᖓᓄᑦ (ᓵᓪᐸᑦ ᐊᑕᖏᖅᑯᑎᒃ. 2020; ᕗᕈᐃᕋ ᐊᑕᖏᖅᑯᑎᒃ. 2017; Hᐊᐃᑦ-ᔪᐊᒐᒃᓴ ᐊᑕᖏᖅᑯᑎᒃ. 2021; Hᐃᒃᑕᓐ ᐊᑕᖏᖅᑯᑎᒃ 2012; ᓚᐃᑐᕆ ᐊᑕᖏᖅᑯᑎᒃ 2018; ᓕᕗᐊᑦ ᐊᑕᖏᖅᑯᑎᒃ. 2020; ᐨᑕᐃᓄ ᐊᑕᖏᖅᑯᑎᒃ. 2019, 2021), ᐊᑕᖏᖅᑯᒋᑦ ᖃᐅᔨᒪᔭᐅᔪᑦ ᐃᓱᒪᓕᐅᕈᑕᐅᖃᑦᑕᕐᓂᖓ ᐊᓯᔾᔨᖅᐸᓪᓕᐊᔪᖅ ᓱᒃᑲᓕᔪᒥᒃ ᓯᓚᖓ ᐅᑭᐅᖅᑕᖅᑑᑉ (ᐨᑑᕝ ᐊᑕᖏᖅᑯᑎᒃ. 2012; IPCC 2013; ᐆᕗᓛᓐ ᐊᒻᒪᓗ ᕗᐊᖕ 2013). ᑐᑭᓯᑦᑎᐊᒃᑲᓐᓂᕐᑯᓪᓗᑕ ᑭᓯᑦ ᖃᓄᐃᓕᕐᒪᖔᑕ, ᐃᓚᐅᑎᑦᑎᒃᑲᓐᓂᕐᓈᑦ ᐊᒻᒪᓗ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᖅᑎᓇᕐᓈᑦ ᐃᓄᐃᑦ ᓇᖏᓂᖃᖅᑕᐅᔪᑦ ᐊᒻᒪᓗ ᒪᓕᒐᓕᕆᔩᑦ ᑎᒥᖏᑦ ᐱᑕᖃᕆᐊᖅᑐᑦ, ᐃᓚᐅᑎᑦᑎᓗᑎᒃ ᐱᓕᕆᖃᑎᒌᓂᒃ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂᒃ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᓂᕐᓂᒃ ᕿᒥᕐᕈᕙᒃᑐᓂᒃ ᐅᓄᕐᓂᖏᓐᓄᑦ ᖃᓄᐃᓕᖓᓂᐅᔪᑦ ᓴᓇᕈᑎᑯᑖᒥ ᑑᒐᓕᖅᕕᐅᔪᓂ.

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Table of Contents

TABLES

FIGURES

APPENDICES

APPENDIX A
MMO Training Manual

APPENDIX B
Mapbook

APPENDIX C
Distance Sampling and Mark-Recapture Models

APPENDIX D
Leg 2 Relative Abundance of Marine Mammals

APPENDIX E
EWI Tech Memo

APPENDIX F
Responses to MEWG Comments

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

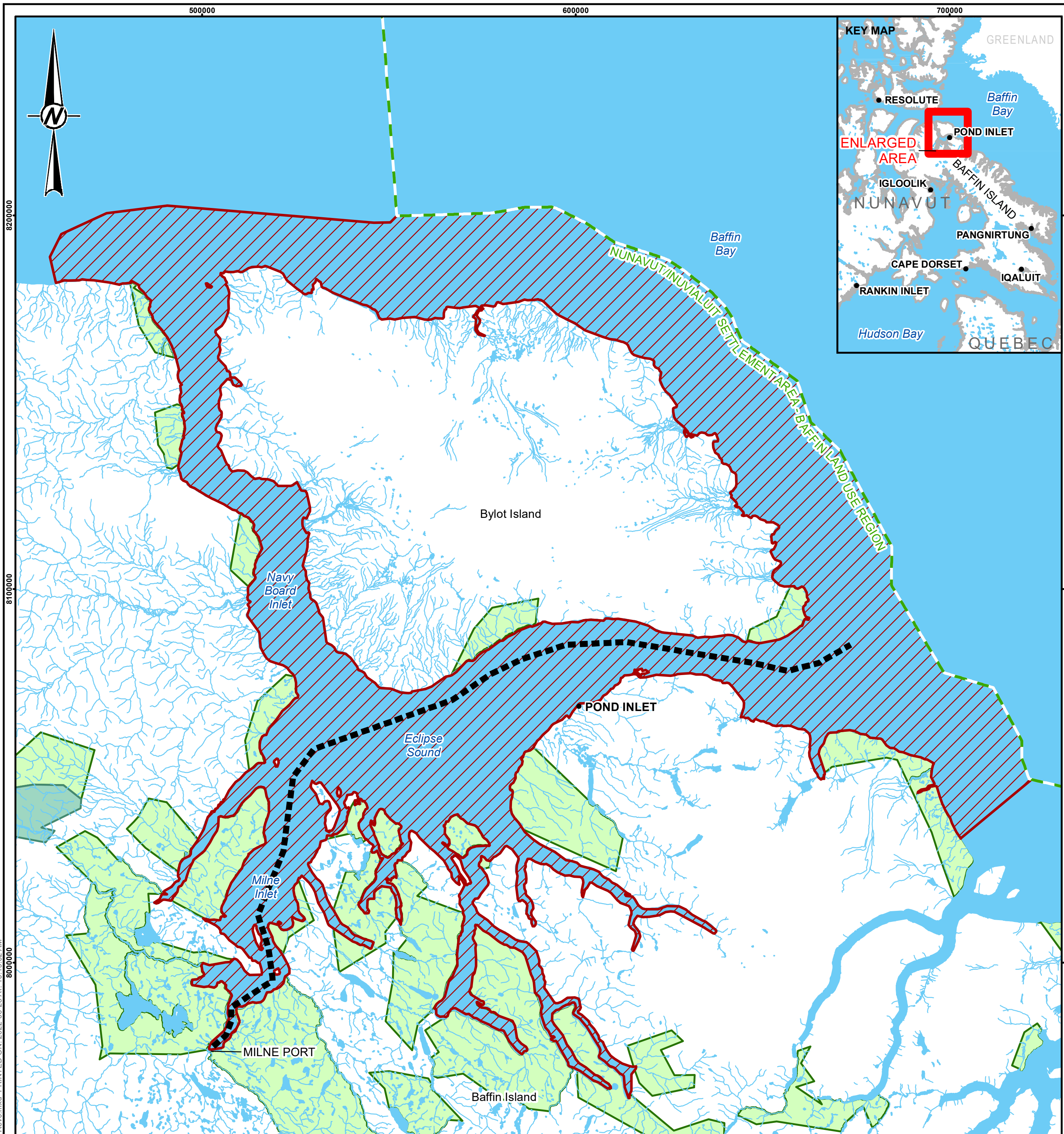
1.0 INTRODUCTION

This report presents the results of the 2021 Marine Mammal Aerial Survey Program (MMASP) conducted at North Baffin Island during July, August, and October 2021. Marine mammal aerial surveys were conducted by Golder 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 (the Project) is an operating open-pit iron ore mine located in the Qikiqtani Region of North Baffin Island, Nunavut (Figure 1). Baffinland Iron Mines Corporation (Baffinland) is the owner and operator of the Project. The operating mine site is connected to a port at Milne Inlet (Milne Port) via the 100 km long Milne Inlet Tote Road. Approved, but undeveloped components of the Project include a South Railway connecting the mine site to a future port at Steensby Inlet (Steensby 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 from 2018 to 2021 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 ~900,000 tonnes of iron ore from Milne Port involving 13 return ore carrier voyages. The amount of ore shipped increased in 2016 with 38 return ore carrier voyages shipping ~2.7 million tonnes. In 2017, the total volume of ore shipped out of Milne Port reached ~4.2 million tonnes involving 56 return ore carrier voyages. Following approval to increase production to 6.0 Mtpa, a total of 5.44 million tonnes of ore were shipped via 71 return voyages in 2018, 5.86 million tonnes of ore were shipped via 81 return voyages in 2019, and 5.5 million tonnes of ore were shipped involving 72 return ore carrier voyages in 2020. The total volume of ore shipped out of Milne Port in 2021 reached 5.6 million tonnes involving 73 return ore carrier voyages. An additional vessel was called to Milne Port in 2021, but not loaded due to timing constraints at the end of the shipping season. The Northern Shipping Route is inhabited by a variety of marine mammals, predominantly narwhal (*Monodon monoceros*), ringed seal (*Pusa hispida*), harp seal (*Pagophilus groenlandicus*), bowhead whale (*Balaena mysticetus*), polar bear (*Ursus maritimus*), bearded seal (*Erignathus barbatus*), beluga (*Delphinapterus leucas*), and walrus (*Odobenus rosmarus*).



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

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REFERENCE(S)

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PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
MARINE MAMMAL REGIONAL STUDY AREA

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
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 conditions:

- 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).*"
- 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".*
- Condition No. 111 — "*The Proponent shall develop clear thresholds for determining if negative impacts as a result of vessel noise are occurring".*
- 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 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 (JPCS 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 2007–2008 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 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). In 2019 and 2020, 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).

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 six 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), respectively (Golder 2020a). Bowhead numbers during Leg 2 of 2019 and 2020 were too low to calculate an abundance with only four bowhead recorded in the RSA in 2019 (Golder 2020a) and one bowhead recorded in 2020 (Golder 2021a). 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 2019a). 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 (*Orcinus orca*) 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.

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 ship-based monitoring programs between 2013 to 2019 (SEM 2014, 2016; Golder 2019a, 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 fast 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 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 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 2019a), 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). 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 year of the 2018 and 2019 SBO program (Golder 2019a, 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 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 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

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 being harvested occasionally and that 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).

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 Objectives

The 2021 MMASP was staged in three separate survey legs. Leg 1 targeted a 21-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 2021 aerial survey took place over one 21-day period (18 July to 3 August 2021) with one 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 two Golder biologists and three contracted marine biologists with previous marine mammal survey experience as Marine Mammal Observers (MMOs) on this program, two pilots, and one mechanic.

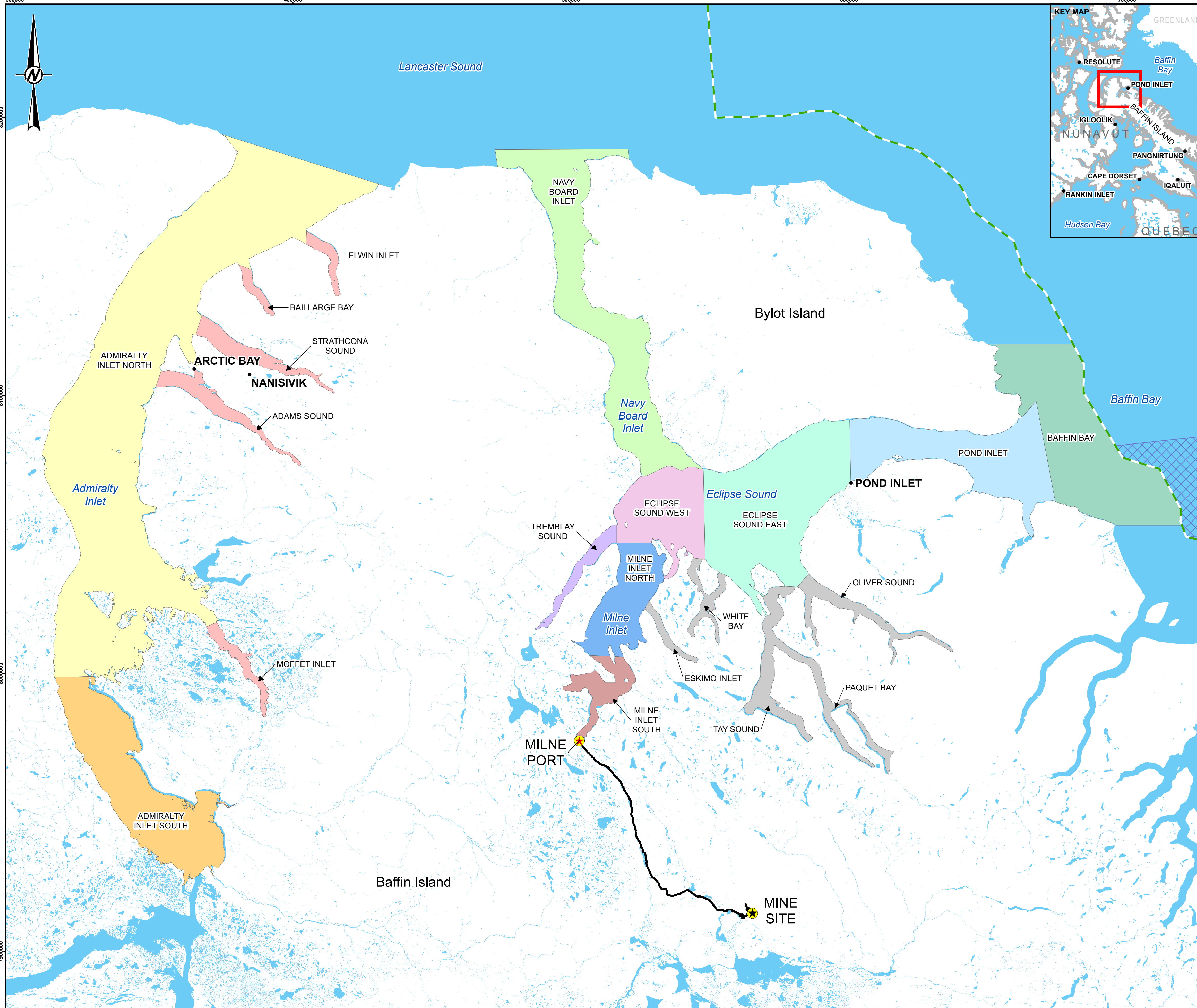
Prior to mobilization, the survey team attended a one-day Baffinland orientation workshop that was held at Mary River on 17 July 2021. The workshop aimed to familiarize team members with Baffinland's policies and procedures, including health and safety, while working at Mary River.

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 2; Golder 2020a, 2021a). 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 3). Reconnaissance flights were also flown in Admiralty Inlet, around Bylot Island, and in two fjords (North Arm and Coutts Inlet) to verify narwhal presence/absence in these areas.

Systematic random visual line-transect surveys were flown for all strata in open water 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 3). 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 3). 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 3). 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

GEOGRPHIC STRATA

ADMIRALTY INLET GRID

- ADMIRALTY INLET NORTH
- ADMIRALTY INLET SOUTH
- ADMIRALTY FJORDS

ECLIPSE SOUND GRID

- BAFFIN BAY
- ECLIPSE SOUND EAST
- ECLIPSE SOUND WEST
- MILNE INLET NORTH
- MILNE INLET SOUTH
- NAVY BOARD INLET
- POND INLET
- TREMBLAY SOUND
- ECLIPSE FJORDS

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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
GEOGRAPHIC STRATA FOR 2021 MARINE MAMMAL AERIAL SURVEYS

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	2

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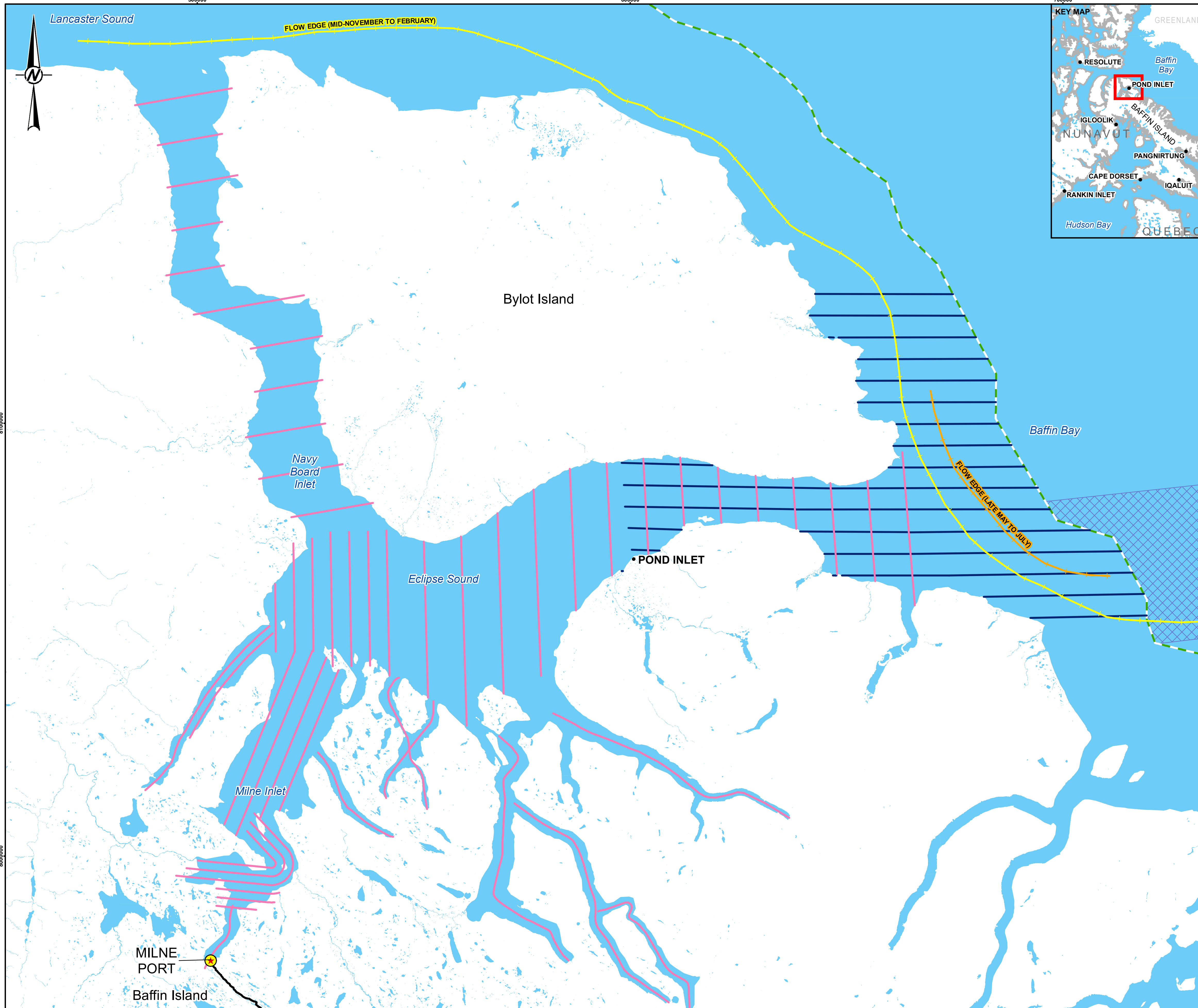

LEGEND

- 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
TRANSECT LINES FOR ECLIPSE SOUND GRID DURING LEG 1

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	3

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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 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. Speaking into a handheld digital recorder, observers counted all sightings of marine mammals. Using a geometer (or clinometer), the perpendicular declination angle to the center of each group was measured once it was abeam of the observer. MMOs noted the species and number of animals in the group. A ‘group’ 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 two MMOs stationed on the same side of the aircraft were separated visually and 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 Primary observers were automatically entered into the Mysticetus program by the Primary observers using geometers during the survey. Geometers were linked to the Mysticetus program, allowing Primary 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 2021. 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 18 July to 3 August. A total of seven surveys on marine mammal presence/abundance and two exploratory reconnaissance surveys were attempted in Leg 1.

2.5.1 Survey Coverage

When surveys began on 18 July 2021, ice conditions were similar to those observed in 2019 with no fast ice present along the shipping corridor (Figure 4; see Appendix B, Figure B-1). Open water was present throughout western Eclipse Sound and Milne Inlet with pack ice in central and eastern Eclipse Sound, Pond Inlet, and Baffin Bay. The ice then shifted into Milne Inlet and western Tremblay Sound with minimal ice in Navy Board Inlet and ice becoming less consolidated in eastern Eclipse Sound (Figure 5; see Appendix B, Figure B-3). On the first day of shipping operations (24 July 2021), when two tugs transited to Milne Port for safety reasons due to poor weather, there was ice present in Milne Inlet and western Eclipse Sound (Figure 6; see Appendix B, Figure B-6). Two days later (26 July 2021), during the first transit of one ore carrier followed by the MSV *Botnica*, almost all the ice has broken up with exception of an ice belt of 1–3/10 ice concentration in southern Milne Inlet from Bruce Head to the opposite shoreline (Figure 7; see Appendix B, Figure B-7).

[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.

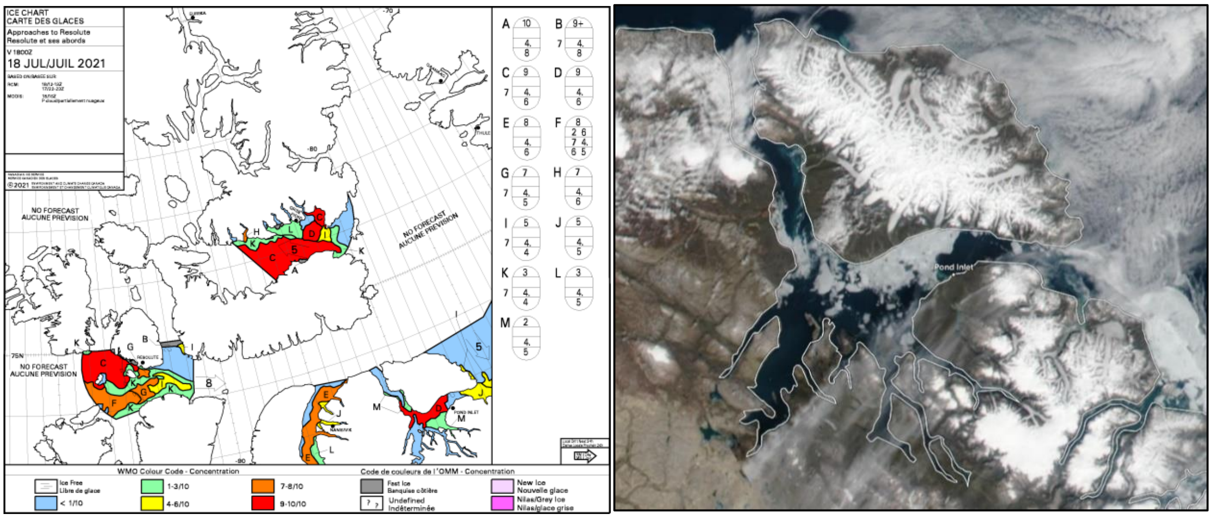


Figure 4: Ice chart for 18 July 2021 (left; Canadian Ice Service) and satellite image (right; Zoom Earth; https://zoom.earth) showing ice conditions in Eclipse Sound area at the start of Leg 1 aerial surveys.

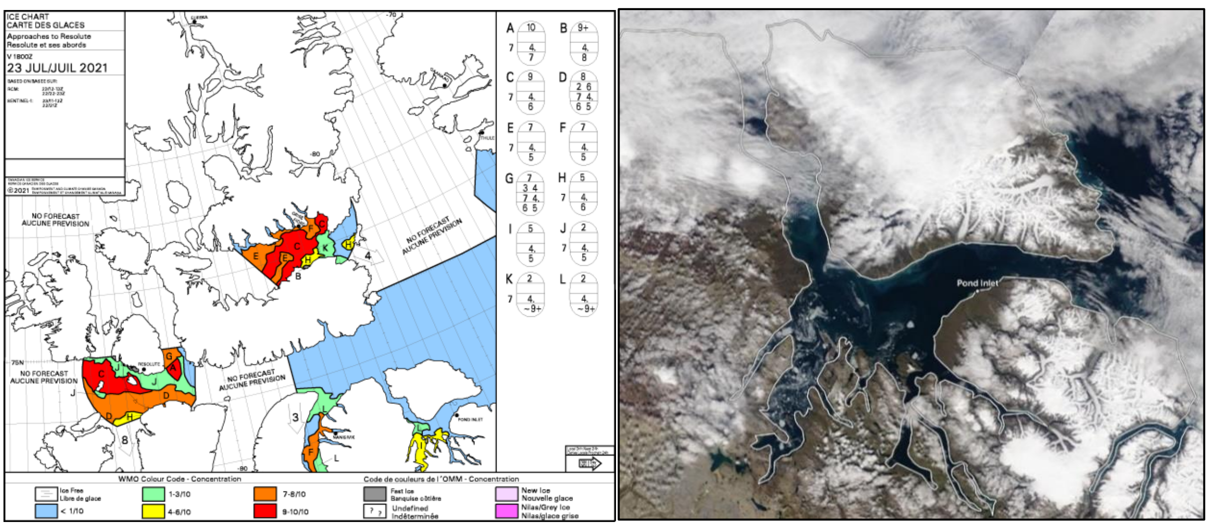


Figure 5: Ice chart for 23 July 2021 (left; Canadian Ice Service) and satellite image (right; Zoom Earth) showing ice concentrations in Eclipse Sound prior to shipping operations with ice concentrations of 1/10 to 6/10 along the Northern Shipping Route.

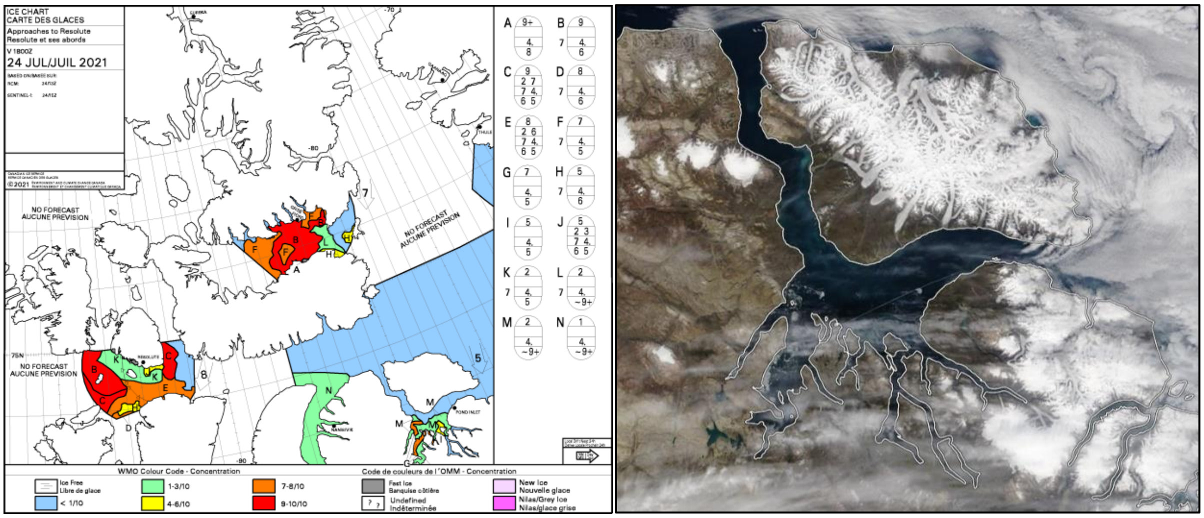


Figure 6: Ice chart for 24 July 2021 (left; Canadian Ice Service) and satellite image (right; Zoom Earth) showing ice concentrations on the first day of shipping operations in Eclipse Sound with ice concentration of <7-8/10 along the Northern Shipping Route. Two tugs entered the RSA for safety reasons due to poor weather conditions.

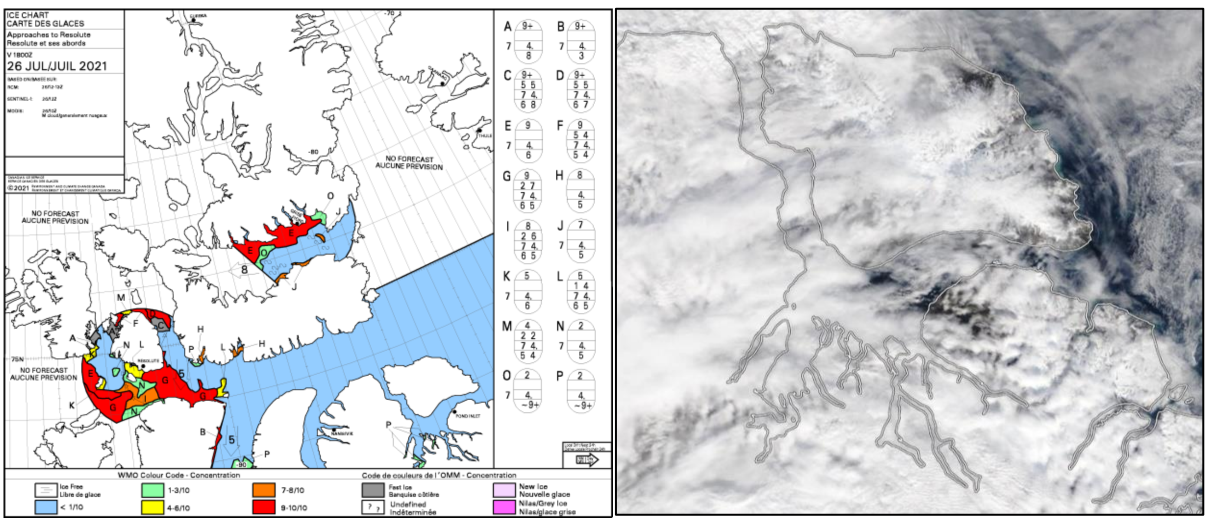


Figure 7: Ice chart for 26 July 2021 (left; Canadian Ice Service) and satellite image (right; Zoom Earth) showing ice concentrations in Eclipse Sound on the first day of shipping operations, when MSV *Botnica* and ore carriers entered the RSA with ice concentration of <1/10 along the Northern Shipping Route.

Nine surveys (including two reconnaissance surveys) were flown over 21 days during Leg 1 (see Appendix B; Figures B-1 to B-10). Over the course of the nine surveys, a total of 8,006.0 km of survey effort was conducted. This effort included systematic transect lines, dedicated transects (i.e., the ship route), and reconnaissance flights (Table 1). Systematic transects (i.e., pre-planned transects; see Figure 3) were flown in areas with <9/10 ice to open water and dedicated transects were flown along the ship route. Systematic transect lines totaled 6,229.9 km, dedicated transect totaled 109.2 km and reconnaissance flights totaled 1,666.9 km of total effort.

Table 1: Summary of 2021 Leg 1 survey flights. Systematic transect lines (S), dedicated transect lines (D), and reconnaissance (R) were flown over nine surveys in nine strata.

Survey Stratum	Recon 1	Survey 1	Survey 2	Recon 2	Survey 3	Survey 4	Survey 5	Survey 6	Survey 7
	18 July	19 July	21 - 22 July	23 July	24 July	26 - 27 July	28 - 30 July	31 July & 2 Aug	3 Aug
Baffin Bay (BB)	R	—	—	R	S	—	—	—	—
Pond Inlet (PI)	R	S	S	—	S	S	S	S	—
Eclipse Sound East (ESE)	R	S	S	—	D	S	S	S	—
Eclipse Sound West (ESW)	R	S	S	R	D	S	S	S	S
Milne Inlet North (MIN)	R	S	S	—	S	S	S	S	S&R
Milne Inlet South (MIS)	R	S	S	—	—	S	S	S	S
Tremblay Sound (TB)	—	—	S	—	—	S	S	S	S
Navy Board Inlet (NB)	—	—	S	R	—	S	S	S	S
Fjords	—	—	S	R	—	S	S	S	S
Admiralty Inlet	—	—	—	R	—	—	—	—	—
Bylot Island	—	—	—	R	—	—	—	—	—
Systematic transects (km)	**0.0**	**817.4**	**1,089.7**	**0.0**	**305.4**	**1,059.6**	**1,248.1**	**1,060.0**	**649.7**
Dedicated transects (km)	**0.0**	**0.0**	**0.0**	**0.0**	**109.2**	**0**	**0**	**0**	**0**
Recon. (km)	**183.5**	**0.0**	**0.0**	**1,451.9**	**0**	**0**	**0**	**0**	**31.5**
Total Effort (km)	**183.5**	**817.4**	**1,089.7**	**1,451.9**	**414.6**	**1,059.6**	**1.248.1**	**1,060.0**	**681.2**

2.5.2 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 <1/10 to 9-10/10 ice cover during Leg 1 of the 2021 MMASP (Figure 8). Ice conditions changed, with ice cover decreasing, from the first survey on 18 July to the second to last survey on the 31 July with <1/10 ice after 31 July (see Figure 4 to Figure 8; see Appendix B, B-1 to B-10). Fast ice was present in the RSA until the 12 July before the start of Leg 1. Survey effort in areas of high ice concentrations (i.e., 9-10/10 ice) did not include any ice leads during Leg 1 of the 2021 MMASP. Areas of <1/10 ice represented 86% of the total survey effort flown, whereas areas of 9-10/10 ice represented 2% of the total survey effort flown.

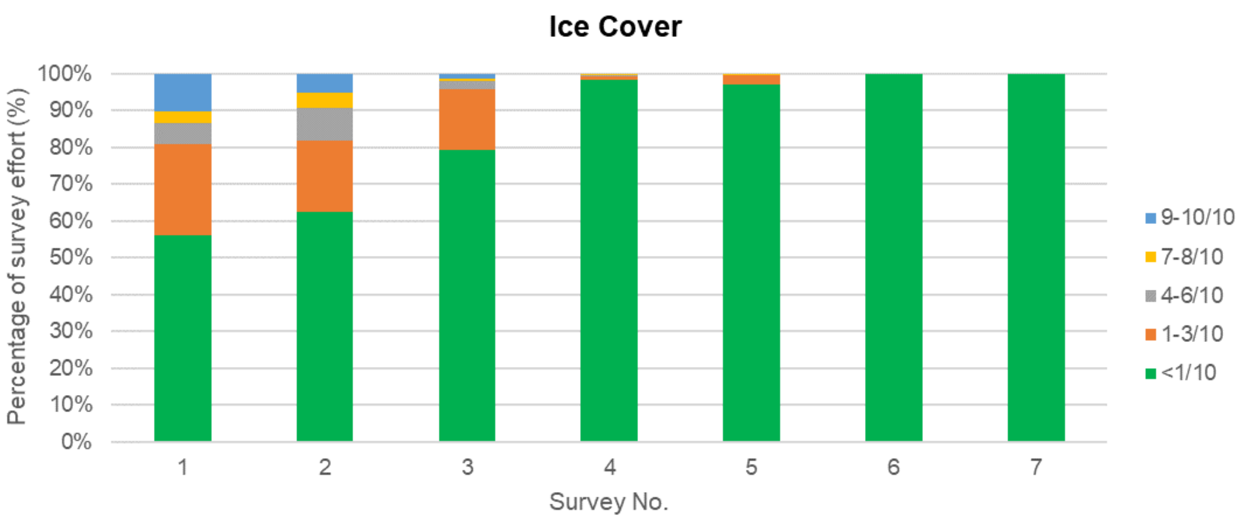


Figure 8: Ice Cover during Leg 1 of the 2021 MMASP.

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. In Figure 9, "Present" represents a condition when 1–100% of the viewing area was obscured with fog. Surveys 2 to 7 had fog present. Fog was present for 2% of the total effort flown in 2021.

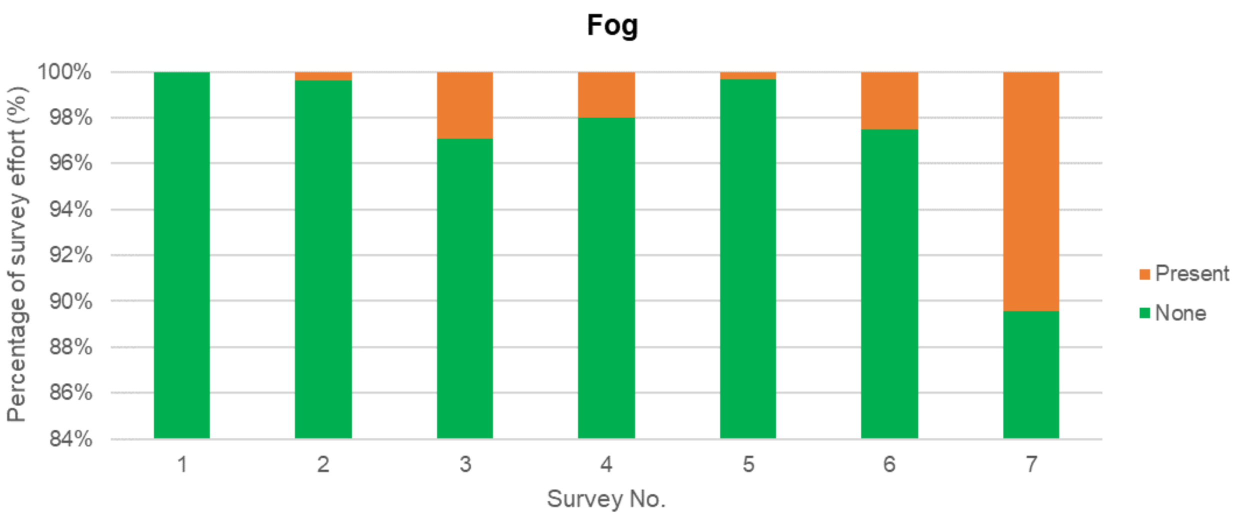


Figure 9: Fog Cover During Leg 1 of the 2021 MMASP

Beaufort Sea State

On a scale of 0 to 12, the Beaufort Sea State (BF) ranged from BF 0 (glassy mirror) to BF 6 (large waves) during Leg 1 of the 2021 MMASP (Figure 10). Sea state conditions were recorded between BF 0 (glassy mirror) and BF 3 (large wavelets, scattered whitecaps) for 92% of the total effort flown. Areas that were forecasted to have high sea states 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.

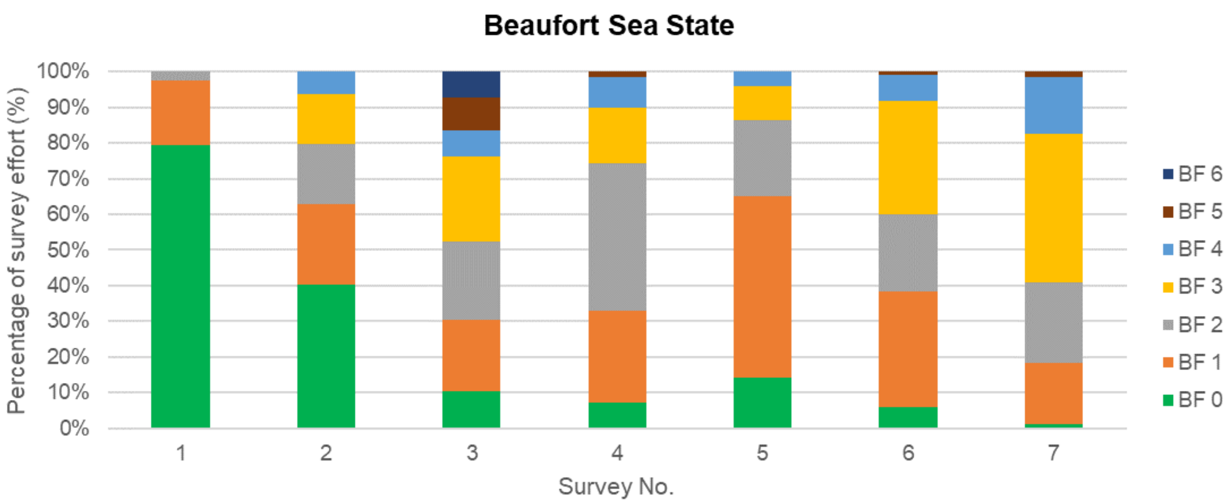


Figure 10: Beaufort Sea State During Leg 1 of the 2021 MMASP.

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 34% of the total effort flown in 2021 (Figure 11). Intense glare was present during 5% of the total effort flown in 2021 (Figure 12).

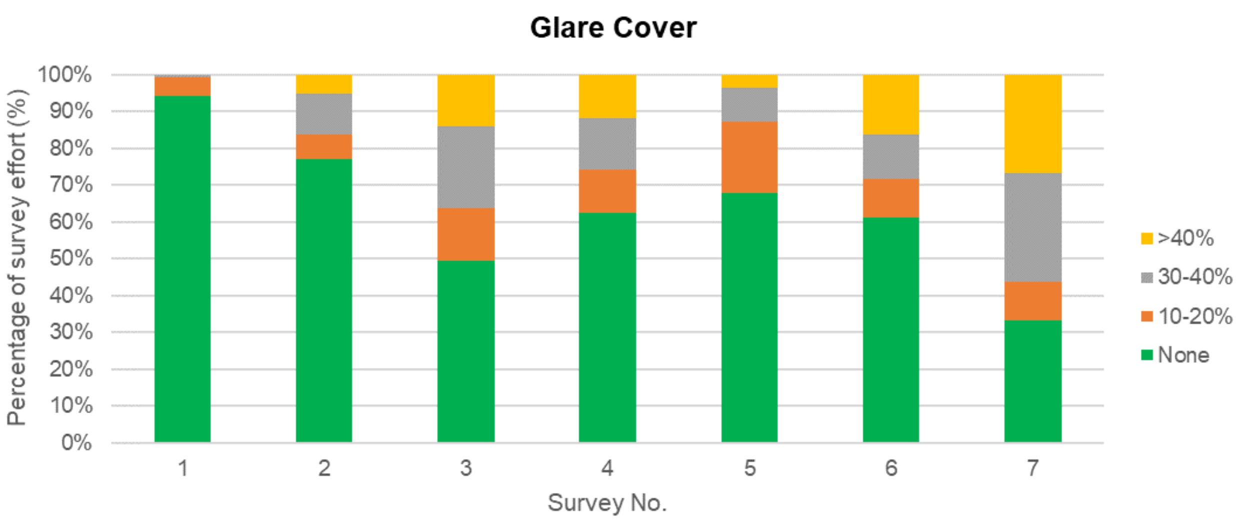


Figure 11: Glare Cover During Leg 1 of the 2021 MMASP.

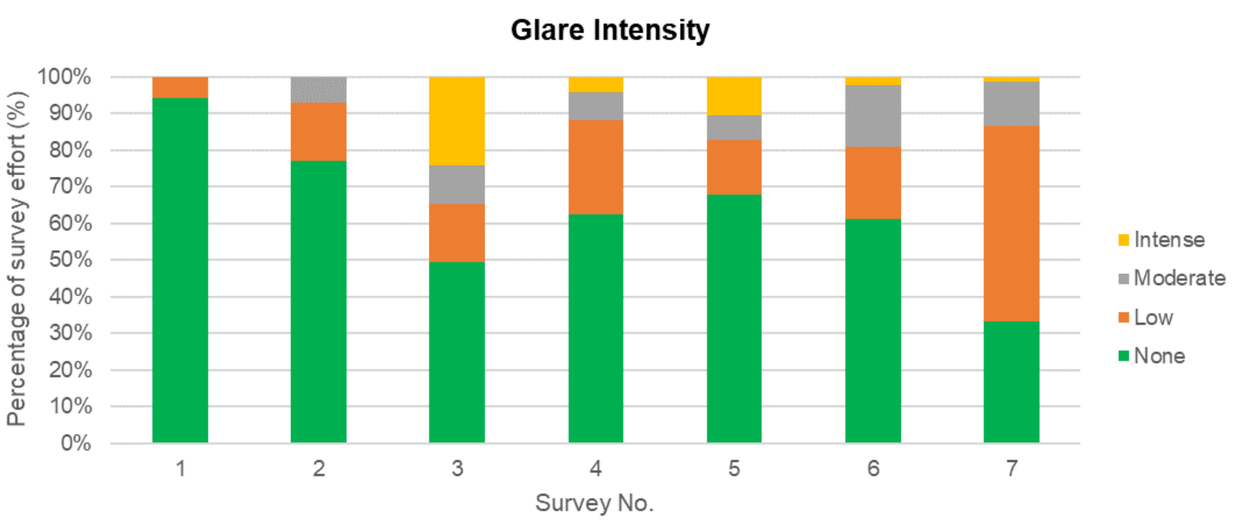


Figure 12: Glare Intensity During Leg 1 of the 2021 MMASP.

2.5.3 Survey Sightings

Nine different marine mammal species were observed during systematic and dedicated surveys (not including reconnaissance surveys) during Leg 1 of the 2021 MMASP: narwhal, bowhead whale, killer whale, beluga whale, ringed seal, harp seal, bearded seal, walrus, 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 1,907 sightings totalling 5,437 marine mammals were recorded during Leg 1 surveys.

Table 2: Number of sightings (including off-effort) in Eclipse Sound grid during Leg 1.

Survey #	Narwhal	Bowhead Whale	Beluga Whale	Killer Whale	Unidentified Whale	Ringed Seal	Harp Seal	Bearded Seal	Walrus	Unidentified Seal	Polar Bear	Total
Survey 1	91	18	0	0	0	42	1	0	1	16	0	**169**
Survey 2	139	30	0	0	0	102	51	0	0	18	4	**344**
Survey 3	12	9	0	0	0	28	5	2	0	2	0	**58**
Survey 4	236	33	0	1	2	56	1	5	0	14	2	**350**
Survey 5	241	38	1	0	1	180	94	3	0	41	2	**601**
Survey 6	73	13	2	0	1	85	17	0	0	12	3	**206**
Survey 7	153	5	2	1	1	10	1	0	0	2	4	**179**
Total	**945**	**146**	**5**	**2**	**5**	**503**	**170**	**10**	**1**	**105**	**15**	**1,907**

Table 3: Number of animals (including off-effort) in Eclipse Sound grid during Leg 1.

Survey #	Narwhal	Bowhead Whale	Beluga Whale	Killer Whale	Unidentified Whale	Ringed Seal	Harp Seal	Bearded Seal	Walrus	Unidentified Seal	Polar Bear	Total
Survey 1	183	21	0	0	0	46	12	0	1	20	0	**283**
Survey 2	243	40	0	0	0	141	533	0	0	19	4	**980**
Survey 3	29	9	0	0	0	35	6	2	0	2	0	**83**
Survey 4	472	46	0	11	2	61	1	5	0	15	2	**615**
Survey 5	545	44	1	0	1	213	953	3	0	41	3	**1,804**
Survey 6	237	20	4	0	1	89	811	0	0	12	3	**1,177**
Survey 7	460	6	2	9	1	10	1	0	0	2	4	**495**
Total	**2,169**	**186**	**7**	**20**	**5**	**595**	**2,317**	**10**	**1**	**111**	**16**	**5,437**

Narwhal

Narwhal were observed throughout the survey area during the Leg 1 surveys with greatest concentrations in the Western Eclipse Sound, Tremblay Sound and Milne Inlet strata (Figure 13). A total of 945 sightings and 2,169 individual narwhal were recorded during the Leg 1 surveys (Table 2 and Table 3). Narwhal group sizes ranged from single animals to a group size of 15, with mean and median group sizes of 2.3 and 2.0, respectively. A total of 83 mother/calf pairs and eight lone calves were recorded during the surveys.

Bowhead whale

Bowhead whale were observed throughout the survey area with greater concentration in the Eclipse Sound West grid. A total of 146 sightings and 186 individual bowhead whales were recorded during the Leg 1 surveys (Figure 13; Table 2 and Table 3). Bowhead group sizes ranged from single animals to a group size of five, with mean and median group sizes of 1.3 and 1.0, respectively. One sighting of a mother/calf pair in northern Navy Board Inlet stratum was recorded on 22 July (Survey 2) and one sighting of a single calf were recorded in Eclipse Sound West stratum on 22 and 24 July respectively (Surveys 2 and 3 respectively).

Beluga whale

During the Leg 1 surveys, there were five beluga sightings totalling seven individuals with group sizes ranging from one to two animals (Figure 13; Table 2 and Table 3). The first sighting of a single beluga was observed during Survey 5 (30 July) (Appendix B, B-8) in White Bay, the second and third sightings were sightings of two beluga each in Tremblay Sound during Survey 6 (31 July) (see Appendix B, Figure B-9). The last two sightings were of individual beluga observed during Survey 7 (3 August) in the Navy Board Inlet stratum (see Appendix B, Figure B-10).

Killer whale

There were two sightings of a total of 20 killer whale during the Leg 1 surveys. There was one sighting of 11 killer whale in Pond Inlet Stratum near the entrance to Baffin Bay on 27 July (Survey 4) and another sighting of nine killer whale in the Navy Board Inlet stratum on 8 August (Survey 7) (Figure 13; Table 2 and Table 3; see Appendix B, Figures B-7 and B-10).

Unidentified whale

There were five sightings of individual unidentified whales during the Leg 1 surveys (Figure 13; Table 2 and Table 3). Two unidentified whales were observed in the Pond Inlet Stratum on 27 July (Survey 4); the first one east of Pond Inlet and the second one in Erik H.R Inlet at the entrance to Baffin Bay. The remaining three sightings were of individual animals; one on 29 July (Survey 5) in the Navy Board Inlet stratum, one on 31 July (Survey 6) in the Eclipse Sound West stratum, and one on 3 August in southern Navy Board Inlet (Survey 7) (see Appendix B, Figures B-, B-9, B-10).

Ringed seal

Ringed seal were observed throughout the survey area during the Leg 1 surveys with the highest numbers in the Milne Inlet and Eclipse Sound West strata, (Figure 14). Five hundred and three sightings totalling 595 ringed seal were recorded during Leg 1 surveys (Table 2 and Table 3). Most of the ringed seal sightings observed in the water were of single animals (388 of 465 sightings), with mean and median group sizes of 1.1 and 1.0, respectively. The remaining ringed seal groups observed in the water consisted of groups of two to twelve animals. Ringed seal on the ice were observed with group sizes ranging from one to ten seals, with mean and median group sizes of 1.5 and 1.0, respectively.

Harp seal

One hundred and seventy sightings totalling 2,317 harp seals were recorded during Leg 1 surveys (Table 2 and Table 3). Most harp seal were observed in the Eclipse Sound, Pond Inlet, or northern Navy Board Inlet strata with the greatest numbers of harp seal observed in northern Navy Board Inlet during Leg 1 surveys (Figure 14). All harp seal were observed in the water with group sizes that ranged from one to 300 animals and with mean and median group sizes of 13.6 and 3.0, respectively.

Bearded seal

Ten sightings of individual bearded seals were recorded during Leg 1 surveys (Figure 14; Table 2 and Table 3). Two were observed during Survey 3; one in the Pond Inlet stratum and one in the Baffin Bay stratum (see Appendix B; Figure B-6). Five individuals were observed during Survey 4; three in the Pond Inlet stratum, one in West Eclipse Sound stratum and one in Navy Board Inlet stratum (see Appendix B; Figure B-7). The last three bearded seals were observed during Survey 5 in the Milne Inlet North, north Navy Board and Eclipse Sound East strata, respectively (see Appendix B; Figure B-8).

Walrus

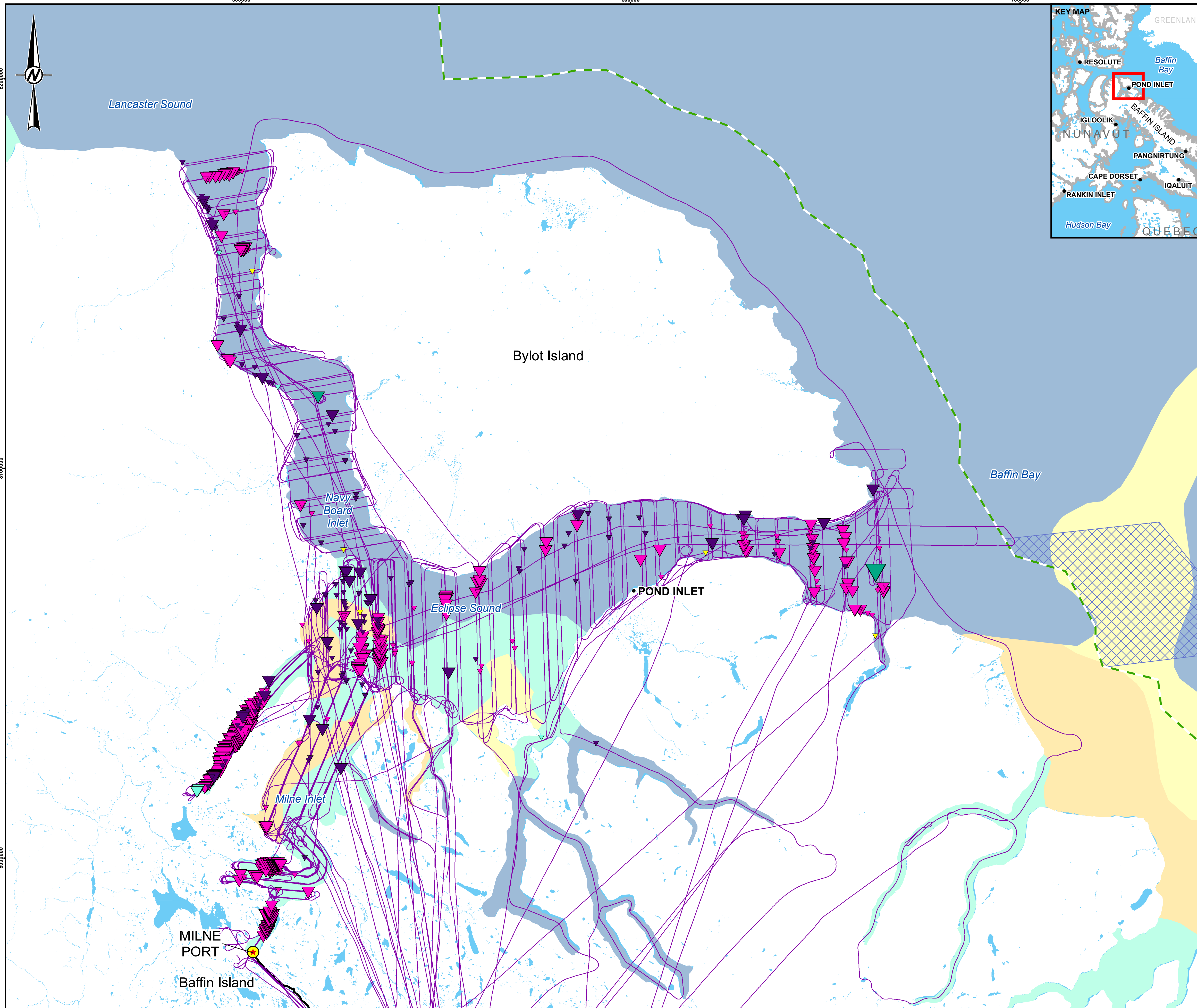
One sighting of an individual walrus was recorded during Leg 1 surveys (Figure 14; Table 2 and Table 3). It was observed during Survey 1 in the Pond Inlet stratum (Appendix B; Figure B-2).

Unidentified seal

Unidentified seal were observed throughout the survey area during Leg 1 surveys (Figure 14). There were 105 sightings totalling 111 seals (Table 2 and Table 3).

Polar bear

Fifteen sightings totalling 16 polar bears were recorded during Leg 1 surveys (Figure 14; Table 2 and Table 3). All sightings were observed in northern Navy Board Inlet during Survey 2 and Surveys 4–7 (see Appendix B; Figures B-3 and B-7 to B-10). All sightings were of single polar bear except for was one sighting of a mother/cub pair in northern Navy Board Inlet stratum on 29 July (Survey 5).



LEGEND

- COMMUNITY
- MILNE PORT

VISUAL SURVEY CETACEAN SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1
- 2-10

BOWHEAD WHALE
- 1
- 2-10

KILLER WHALE
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

UNIDENTIFIED CETACEAN
- 1

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

ICE CONCENTRATION (JULY 24, 2021)
- < 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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE

DISTRIBUTION OF CETACEANS DURING LEG 1 – JULY AND AUGUST 2021 IN ECLIPSE SOUND GRID

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	12

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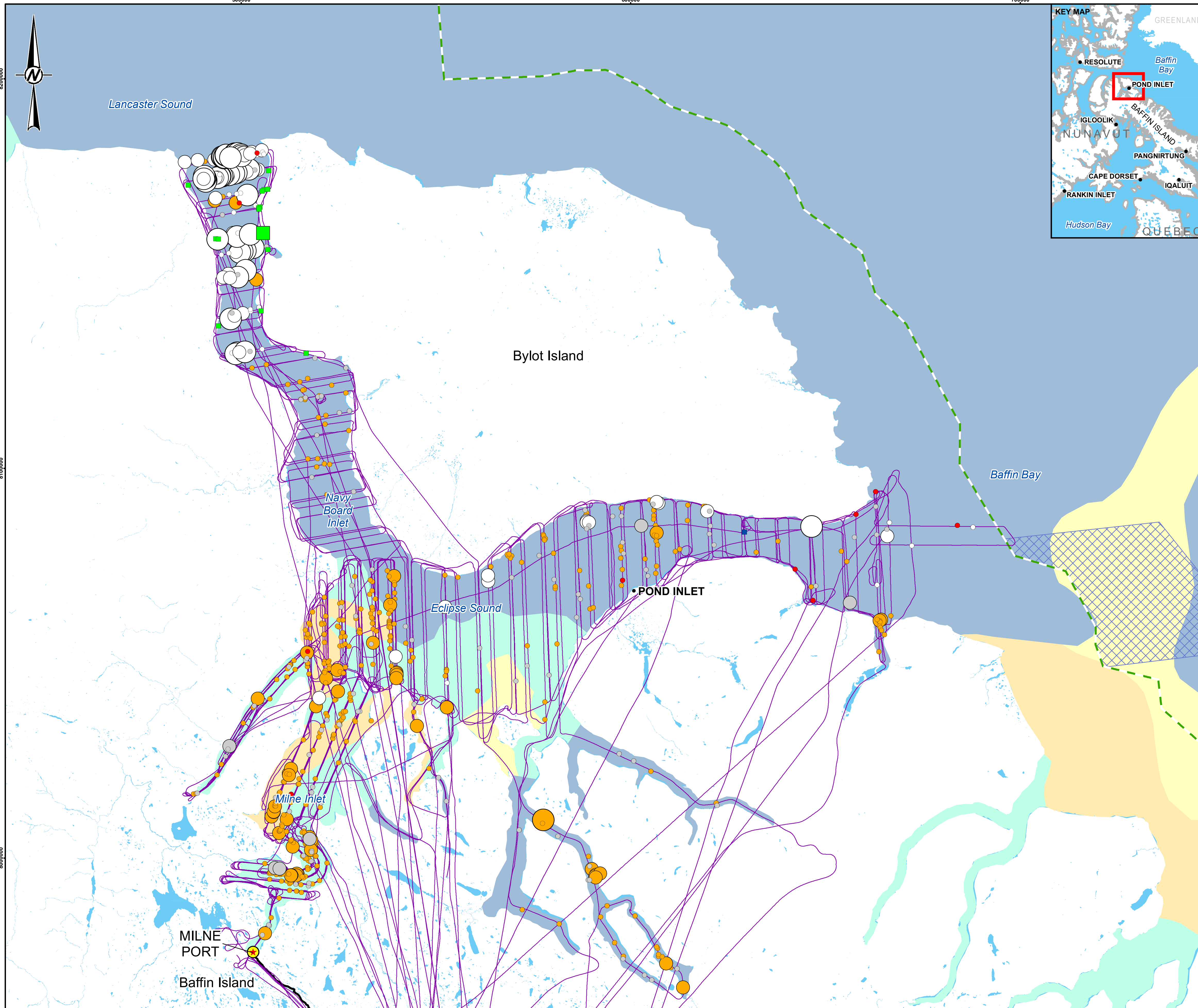


LEGEND

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

VISUAL SURVEY PINNIPED SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

HARP SEAL
- 1
- 2-10
- 10+

POLAR BEAR
- 1
- 2-10

RINGED SEAL
- 1
- 2-10
- 10+

UNIDENTIFIED SEAL
- 1
- 2-10

WALRUS
- 1

ICE CONCENTRATION (JULY 24, 2021)
- < 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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF PINNIPEDS AND POLAR BEAR DURING LEG 1 – JULY AND AUGUST 2021 IN ECLIPSE SOUND GRID

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	14

2.5.4 Relative Abundance of Marine Mammals in RSA

In 2021, a total of 6,339.1 km of effort (6,229.9 km during systematic transects and 109.2 km during dedicated transects) was flown over seven 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 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 (along ship track) (Table 4). All nine species were observed during systematic transect surveys while the only species observed during dedicated surveys were bowhead whale (0.04 animals/km) and ringed seal (0.009 animals/km). Harp seal had the highest relative abundance for systematic transects (0.37 animals/km) and narwhal had the second highest relative abundance (0.34 animals/km). Bowhead relative abundance was greater on dedicated transects than in areas where systematic transects were flown (0.04 animals/km and 0.02 animals/km, respectively). Narwhal relative abundance varied between surveys ranging from 0.00 to 0.68 animals/km along systematic transects (Table 5).

During the first vessel passage, two tugs transited through mostly <3/10 ice except for some large ice pans (7-8/10 ice concentration) present in Milne Inlet North on 24 July (see Appendix B, Figure B-6). During aerial surveys on 24 July (Survey 3), prior to the tugs entering the RSA, there were two sightings of narwhal in the vicinity of the ship track in Milne Inlet North strata near Ragged Island. There is no information regarding narwhal distribution during the second day (25 July) the tugs were transiting the survey area; no aerial surveys were flown due to high winds, fog and rain in the survey area. The following day, 26 July, one ore carrier followed by the MSV *Botnica* entered the RSA and transited through ice free waters along the length of the Northern Shipping Route, except for a small ice belt 1-3/10 ice in MIS (see Section 2.5.1; Appendix B, B-7). Narwhal relative abundance prior to the first day of shipping activity ranged from 0.00 animals/km (Survey 3, dedicated survey on 24 July) to 0.22 animals/km (Survey 1 on 19 July and Survey 2 on 21–22 July). Narwhal relative abundance ranged from 0.22 animals/km (Survey 6 on 31 July to 2 August) to and 0.68 animals/km after shipping started (Survey 7 on 3 August) (Table 5).

Table 4: Sighting and Animal Detection Rates (Relative Abundance) of Marine Mammals in RSA during Leg 1.

Species	No. of Sightings		Sighting Rate (sightings/km)			No. of Animals		Animal Detection Rate (animals/km)		
	Sys.[a] Tran.	Ded.[b] Tran.	Sys. Tran.	Ded. Tran.	Combined	Sys. Tran.	Ded. Tran.	Sys. Tran.	Ded. Tran.	Combined
Narwhal	917	0	0.1472	0.0000	0.1447	2,091	0	0.3356	0.000	0.3299
Bowhead Whale	93	4	0.0149	0.0366	0.0153	118	4	0.0189	0.0366	0.0192
Beluga Whale	2	0	0.0003	0.0000	0.0003	3	0	0.0005	0.0000	0.0005
Killer Whale	2	0	0.0003	0.0000	0.0003	20	0	0.0032	0.0000	0.0032
Unknown Whale	4	0	0.0006	0.0000	0.0006	4	0	0.0006	0.0000	0.0006
Ringed Seal	482	1	0.0774	0.0092	0.0762	568	1	0.0912	0.0092	0.0898
Harp Seal	166	0	0.0266	0.0000	0.0262	2,306	0	0.3701	0.0000	0.3638
Bearded Seal	5	0	0.0008	0.0000	0.0008	5	0	0.0008	0.0000	0.0008
Walrus	1	0	0.0002	0.0000	0.0002	1	0	0.0002	0.0000	0.0002
Unknown Seal	101	0	0.0162	0.0000	0.0159	107	0	0.0172	0.0000	0.0169
Polar Bear	2	0	0.0003	0.0000	0.0003	2	0	0.0003	0.0000	0.0003

[a] abbreviation for Systematic Transects
[b] abbreviation for Dedicated Transects

Table 5: Sighting and Animal Detection Rates (Relative Abundance) of Narwhal in RSA during each survey of Leg 1.

Survey	No. of Animals		Animal Detection Rate (animals/km)	
	Sys.[a] Tran.	Ded.[b] Tran. (Ship Track in Open Water)	Sys. Tran.	Ded. Tran. (Ship Track in Open Water)
1	183	—	0.2239	—
2	243	—	0.2230	—
3	0	0	0.0000	0.0000
4	460	—	0.4341	—
5	528	—	0.4230	—
6	232	—	0.2189	—
7	445	—	0.6849	—
Total	**2,091**	**0**	**0.3356**	**0.0000**

[a] abbreviation for Systematic Transects
[b] abbreviation for Dedicated Transects

2.5.5 Comparison with Previous Surveys

The relative abundance for 2019 considered only data collected during systematic transects because dedicated transect were not flown in 2019 due to the limited amount of ice present during that year. The relative abundance of marine mammals in the RSA during Leg 1 of the surveys was higher in 2021 (0.84 animals/km) than in 2019 (0.37 animals/km) and 2020 (0.56 animals/km; Table 6). Much of this increase can be attributed to a greater relative abundance of seals observed in 2021. Seal species observed in greater relative abundance in 2021 compared to 2019 and 2020 included ringed seal (0.09 vs 0.02 and 0.04 animals/km, respectively), harp seal (0.37 vs 0.03 and 0.16 animals/km, respectively), and bearded seal (0.0008 vs 0.0006 and 0.0005 animals/km, respectively). Relative abundance of unknown seal was lower in 2021 compared to 2020 (0.017 animals/km vs 0.025 animals/km respectively) but higher than in 2019 (0.005 animals/km). 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 state increases.

Narwhal relative abundance in the RSA during the Leg 1 surveys was similar in 2021 to that observed in 2019 and 2020 (0.34, 0.30, and 0.33 animals/km, respectively; Table 6), however, the comparison of relative abundances between years should be considered with caution (see Section 2.6.1 Discussion). Bowhead whale relative abundance in the RSA was similar in 2021 (0.019 animals/km) to that observed in 2019 (0.023 animals/km) and higher than observed in 2020 (0.009 animals/km) (Table 6).

Table 6: Relative Abundance (animal detection rate) of Marine Mammals in RSA during Leg 1 in 2019, 2020 and 2021.

Species	2019		2020		2021	
	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
Bowhead Whale	94	0.0234	39	0.0091	118	0.0189
Beluga Whale	1	0.0002	4	0.0009	3	0.0005
Killer Whale	10	0.0025	0	0.0000	20	0.0032
Unknown Whale	4	0.0010	1	0.0002	4	0.0006
Ringed Seal	71	0.0199	154	0.0359	568	0.0912
Harp Seal	102	0.0286	680	0.1584	2,306	0.3701
Bearded Seal	2	0.0006	2	0.0005	5	0.0008
Walrus	0	0.0000	0	0.0000	1	0.0002
Unknown Seal	19	0.0053	107	0.0249	107	0.0172
Polar Bear	1	0.0002	2	0.0005	2	0.0003
Total	**1,491**	**0.3709**	**2,420**	**0.5637**	**5,225**	**0.8387**

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

2.6 Discussion

2.6.1 Narwhal

High-level Summary: *In 2021, the Leg 1 surveys were extended to capture narwhal presence prior to the start of shipping, and to determine if there were obvious narwhal response to initial shipping traffic in the RSA. Results from the 2021 Leg 1 survey indicated low narwhal numbers prior to the first vessel transit into the RSA. By the time of the first ore carrier transit in the RSA on 26 July 2021, narwhal relative abundance appeared to have increased and their distribution had moved to be primarily concentrated in Koluktoo Bay and Tremblay Sound and remained concentrated in those areas for the duration of the Leg 1 program.*

The main focus of the Leg 1 surveys in 2021 was to obtain data on the presence/absence and distribution of marine mammals in the open water areas and in the ice leads throughout the Eclipse Sound survey grid prior to and immediately following the start of shipping activities. By the time surveys began on 18 July 2021, the floe edge had broken apart and the new ice edge was situated close to Pond Inlet (see Figure 4; Appendix B, Figure B-1). The first Baffinland vessels to enter the RSA in 2021 were two tugs which transited directly to Milne Port on 24 and 25 July. The second transit consisted of one ore carrier followed by the MSV *Botnica* on 26 July.

Narwhal distribution shifted westward from eastern Eclipse Sound and Pond Inlet strata toward Milne Inlet and Tremblay Sound throughout the Leg 1 surveys. During Survey 1 (19 July), narwhal were distributed in ice conditions ranging from 1-6/10, in the Pond Inlet stratum, to 9-10/10 ice in Eclipse Sound West and the Eclipse Sound East strata (see Appendix B, Figure B-2). During this survey, the concentration of narwhal was highest in the Pond Inlet stratum near the entrance to Baffin Bay and in the Eclipse Sound East stratum along the south shore of Bylot Island. By the time Survey 2 was flown (21–22 July), the majority of narwhal had moved to Eclipse Sound West where 4-6/10 ice was still present. A reconnaissance flight on 23 July was flown up Navy Board Inlet, around Bylot Island and then south to North Arm and Coutts Inlet with narwhal observed in Lancaster Sound off the northwest end of Bylot Island and in North Arm and Coutts Inlet (see Appendix B, Figure B-4). Survey 3 (24 July) was flown along the shipping track resulting in two narwhal sightings in Eclipse Sound West north of Ragged Island and a few narwhal sightings in the eastern Pond Inlet stratum. Narwhal were first observed in Tremblay Sound and Milne Inlet North and South stratum during Survey 4 (26-27 July) (see Appendix B, Figure B-6). With the exception of a few sightings in Eclipse Sound West and Pond Inlet strata, the majority of narwhal sightings were observed in Tremblay Sound and Milne Inlet North and South stratum for the remainder of Leg 1 surveys (Surveys 5 to 7, 28 July to 3 August) (see Appendix B, Figure B-7 to B-9).

Narwhal distribution appeared to have differed between 2019, 2020, and 2021 Leg 1 surveys, possibly due to different ice conditions in the study area. In 2019, the remaining sea ice present in the RSA when icebreaking started was fragmented into a loose pack ice formation allowing narwhal to disperse throughout the Eclipse Sound area somewhat evenly. In 2020, sea ice present in the RSA at the start of icebreaking was largely intact (i.e., large, consolidated ice field) with a few ice leads running through it. As a result, narwhal were highly concentrated in the ice leads in Eclipse Sound, forming a more clumped distribution compared to 2019. In 2021, no icebreaking took place in the RSA. During the first vessel transit in 2021 (i.e., two tugs on 24 July), Eclipse Sound was largely ice free, and ice was primarily only present in western Eclipse Sound and Milne Inlet. By the time Project vessels entered the RSA on 24–25 July (two tugs) and 26 July (MSV *Botnica* and one ore carrier), narwhal were already concentrated in the Tremblay Sound and Milne Inlet South strata (Appendix B, Figure B-6). In the days following the entrance of Project vessels, and for the remainder of Leg 1 surveys (26 July to 3 August), most narwhal were observed in the Tremblay Sound and Milne Inlet South strata. Narwhal that were initially dispersed through the Eclipse Sound and Pond Inlet stratum moved westward as ice concentrations declined shifting their distribution into the Tremblay Sound and Milne Inlet South strata.

Seven aerial surveys (Systematic and Dedicated surveys) were conducted during the Leg 1 surveys (see Table 1). Relative abundance estimates were calculated for all marine mammals observed during the early shoulder season for both the systematic transects and the dedicated transects. Narwhal had the second highest relative abundance (0.34 animals/km) during systematic transects. Narwhal relative abundance was greater after shipping started for three of the four surveys (range: 0.42 animals/km during Survey 5 to 0.68 animals/km during Survey 7) (see Table 5). Narwhal relative abundance during systematic transects in 2021 was similar to what was observed in 2019 and 2020 in the open water areas (0.34 animals/km, 0.30 animals/km and 0.33 animals/km, respectively) (see Table 6), however, these results should be considered with caution due to a variety of factors that would influence the relative abundance estimates including uneven coverage effort between surveys, exclusion of dedicated surveys when comparing all years, and the timing of the surveys varied yearly.

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 and icebreaking activities. Complete effort coverage of the entire RSA was not the main goal during Leg 1 surveys, and 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 and it is not possible to determine which narwhal stay and which pass through the area. When narwhal do stay in the RSA, they tend to concentrate in either Koluktoo Bay or Tremblay Sound and the Leg 2 aerial survey effort often focuses on those areas. 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.

During Leg 1 in 2019, higher narwhal relative abundance was observed during Survey 2 (0.38 animals/km) and Survey 4 (0.40 animals/km) compared to the other surveys in Leg 1 (range 0.03 to 0.18 animals/km) (Golder 2020a, Appendix B, B-1 to B-5). These two peaks in narwhal numbers during Leg 1 suggest that some narwhal were migrating through the RSA while others remained. Relative abundance dropped notably from Survey 4 (0.40 animals/km, the second peak), when narwhal were distributed throughout the survey area, compared to Survey 5 (0.03 animals/km) when narwhal were concentrated in Koluktoo Bay in lower numbers. Surveys 4 and 5 had similarly extensive aerial coverage of the RSA (Golder 2020a, Appendix B, B-4 and B-5), however the differences in narwhal relative abundance suggests some of the narwhal observed during the two peaks had migrated out of the area. As well, the combined visual and photographic narwhal abundance estimate during Leg 1 was higher (15,591 narwhal, Survey 4) than Leg 2 (9,931 narwhal, Survey 3 and 4) in 2019 also suggesting some narwhal were migrating through Eclipse Sound. Abundance during Leg 1 would 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, e.g., Admiralty Inlet, for the summer. Abundance would then be lower during Leg 2 when the narwhal passing through the area to other areas left the Eclipse Sound grid.

Calculations from systematic (open water) surveys, and not dedicated (leads, ship track) surveys, were used to compare relative abundance in 2019, 2020, and 2021. It was not possible to compare dedicated surveys between all three years because 2020 was the only year with sea ice in the RSA, where leads were flown as dedicated surveys. The relative abundance estimate from Leg 1 systematic surveys for 2020 suggests that narwhal numbers in 2020 were similar to 2019 and 2021 (0.33, 0.30, and 0.34 animals/km respectively). However, when the relative abundance estimate from dedicated survey results for 2020 is also considered (2.09 animals/km) it indicates the relative abundance of narwhal in the area during Leg 1 should be higher than 0.33 animals/km. Again, these results should be interpreted with caution.

In 2021, Leg 1 surveys started approximately a week later (19 July) than in 2019 (12 July) and 2020 (10 July). Not long after Leg 1 surveys started in 2021, narwhal had migrated and concentrated in Tremblay Sound and Milne Inlet; this differed from 2019 when narwhal were more evenly distributed and passed through the area in two peaks of animals that appear to have consisted of narwhal migrating on to areas outside the RSA. Compared to 2020, there were no ice leads to fly during Leg 1 surveys in 2021 and all surveys were flown as systematic surveys over open water making it difficult to directly compare of relative abundances, e.g., systematic and dedicated surveys cannot be compared.

In summary, the comparison of the relative abundance results from Leg 1 surveys across 2019, 2020 and 2021 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 at the exclusion of observations during dedicated surveys. 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 locations, and timing of Leg 1 surveys.

2.6.2 Other Marine Mammals

2.6.2.1 Cetaceans

Bowhead Whale

Bowhead whales were observed throughout the RSA during Leg 1 with a broader distribution compared to 2019 and 2020. In 2021, bowhead whales were observed in every stratum in the Eclipse Sound grid (see Figure 13). Bowhead whale concentrations were highest in the Eclipse Sound West, Navy Board Inlet, and Tremblay Sound strata in 2021.

Bowhead relative abundance in the RSA was higher in 2021 (0.019 animals/km) compared to 2020 (0.009 animals/km) and similar to that observed in 2019 (0.023 animals/km). The higher number of bowhead observed in 2019 and 2021 may be indicative of a more regular occurrence, as it was noted by many local residents in Pond Inlet that bowhead numbers observed in 2019 were higher than those observed in recent years.

Killer Whale

Killer whale were observed twice during the Leg 1 surveys in 2021; there was one sighting in the Navy Board Inlet stratum and one sighting east of Pond Inlet in the Pond Inlet stratum (see Figure 13). The latter was observed at the eastern end of Eclipse Sound, where it meets Baffin Bay. This is also near the location where one killer whale sighting of three individuals was recorded during Leg 1 of the 2019 MMASP. No killer whale were observed during Leg 1 in 2020.

Relative abundance of killer whale during Leg 1 was higher in 2021 than in 2019 and 2020 (0.0032 animals/km, 0.0025 animals/km and 0.0000 animals/km, respectively). The increase in relative abundance between 2019 and 2021 suggests increased presence of killer whale in the area during Leg 1. Although killer whale were not observed during Leg 1 surveys in 2020, killer whale presence during Leg 2 of 2020 was greater in the Eclipse Sound area than in 2019 suggesting that there could be a general increase in killer whale presence in Eclipse Sound through the 2019 to 2021 survey seasons.

Beluga Whale

Beluga numbers have been consistently low during the present and previous surveys in the RSA. Three beluga were observed in the RSA during Leg 1 of the 2021 MMASP. One and four beluga were observed in the RSA during Leg 1 of the 2019 and 2020 MMASP, respectively (Golder 2020a, 2021a). Beluga were not observed during Baffinland surveys from 2013 to 2015 (Elliott et al. 2015; Thomas et al. 2015, 2016), suggesting their numbers have always been low in the RSA. In 2007 and 2008, beluga were observed in the RSA in small numbers (three animals in 2007 and 59 animals in 2008; Baffinland 2012).

2.6.2.2 Pinnipeds

Pinniped data collected in 2019, 2020 and 2021 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 sighting data may result from changes in survey conditions and ability of MMOs to identify species rather than actual changes in pinniped numbers or distribution.

Ringed Seal

Ringed seals were distributed throughout the survey area during Leg 1 of the 2019, 2020 and 2021 MMASPs, similar to what was observed in previous years (Elliott et al. 2015; Thomas et al. 2015, 2016; Golder 2020a, 2021a). In 2020 and 2021 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 2020 (0.036 animals/km) and then 2019 (0.020 animals/km). The difference in ringed seal distribution and relative abundance between the three years may be attributable to the different environmental conditions observed; there was less ice in the survey area during Leg 1 surveys in 2019 compared to 2020 and 2021. Ringed seal distribution in 2020 and 2021 was greatest where ice remained concentrated in the Eclipse Sound West and Milne Inlet strata.

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. Refer to Golder (2022b) for a summary of the 2021 ringed seal aerial survey program that indicated that ringed seal densities had remained stable with some annual variations since the onset of shipping or ice-breaking activities in the RSA.

Harp Seal

Harp seals were observed throughout northern Navy Board Inlet, Pond Inlet, and Eclipse Sound strata during Leg 1 of the 2021 MMASP, similar to what had been observed in previous years (Elliott et al. 2015; Thomas et al. 2015, 2016; Golder 2020a, 2021a). Harp seal were dispersed throughout these areas in 2019 and 2020, while in 2021 harp seal concentrations were greatest in northern Navy Board Inlet stratum.

During Leg 1, harp seal relative abundance was much higher in 2021 (0.37 animals/km) than in 2020 (0.16 animals/km) and 2019 (0.029 animals/km). This may be attributable to the different environmental conditions observed between the two years, where 2019 had much less ice in the survey area compared to 2020, or to a greater number of harp seals in the RSA in July 2021. Harp seal numbers in the RSA have been variable during aerial surveys from 2013 to 2020. The highest count of harp seals recorded on one 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 2021 MMASP. There were five sightings recorded during Leg 1 in the Eclipse Sound Grid in 2021 compared to two in each of the 2019 and 2020 Leg 1 surveys with similar relative abundance rates of 0.0008 animals/km, 0.0005 animals/km and 0.0006 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

One walrus was recorded during Leg 1 surveys in Eclipse Sound in 2021. 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 one survey on 31 August (Thomas et al. 2016). 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 the 2015 workshops, IQ indicated the Navy Board Inlet floe edge had more walrus present than at the Pond Inlet floe edge (JPCS 2017).

2.6.2.3 Polar Bear

Polar bear sightings have been regularly recorded during the Baffinland aerial survey programs. The distribution of polar bears in 2021 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 Leg 1 surveys in 2021 were in the northern Navy Board Inlet stratum. 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 on transect. Polar bear observations provide relative distribution information but cannot be used to assess effects of Project shipping or reliable abundance estimates.

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

3.1 Objectives

The 2021 MMASP was staged in three separate survey legs. Leg 2 targeted a 21-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 (2021) 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 in 2019 and 2020 (Golder 2020a, 2021a) enabled for a comparison to previously reported abundance estimates.

3.2 Survey Team and Training

Leg 2 of the 2021 aerial surveys took place over one 21-day period (8–26 August with two aircraft). The survey team consisted of three Golder biologists, seven contracted marine biologists and two Inuit Researchers with previous marine mammal survey experience as MMOs, four pilots, and one mechanic. Each survey team (i.e., aircraft) included one survey coordinator, four marine biologist MMOs, one Inuit researcher, and two pilots. Two local Inuit Researchers, one from Pond Inlet and one from Arctic Bay, participated in the Leg 2 surveys. Both Inuit Researchers had previous experience as MMOs on the aerial survey program in previous years.

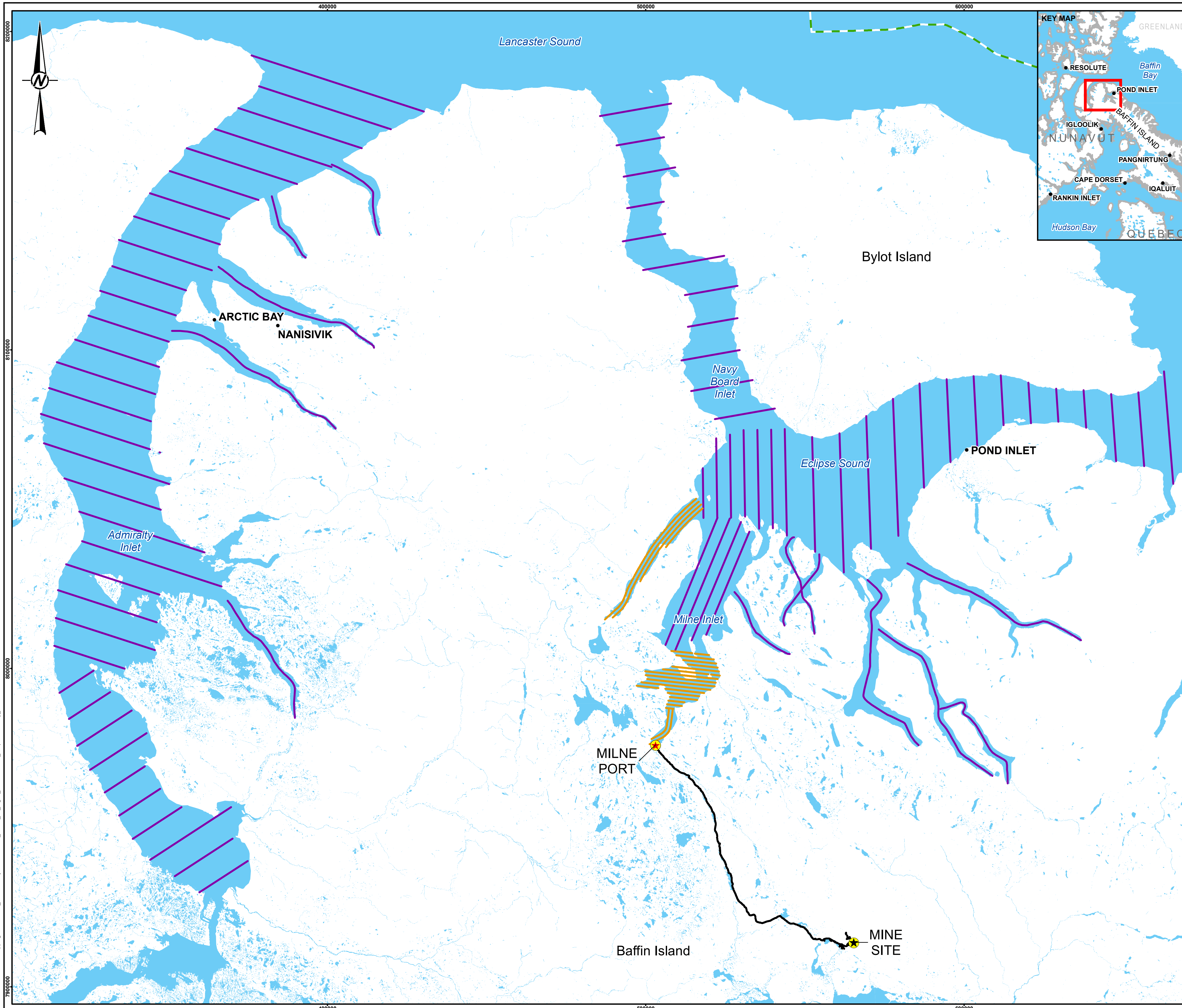
Prior to mobilization, a one-day data collection and safety training workshop was held at Mary River on 7 August 2021. The training and orientation session was led by a Golder senior marine mammal biologist. The safety component of the workshop aimed to familiarize team members with the Health and Safety Plan that was developed for the program, to review Golder'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 (Appendix A) and obtained practical experience using the surveying equipment including recorders, clinometers, and geometer.

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 2). 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 15). Transect spacing was the same as those flown during Leg 1 in the Eclipse Sound grid. 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 2.4 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 2). 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 15).

The survey design consisted of systematically placed and evenly distributed (when possible) line transects across the survey area (Figure 15). 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
- 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE

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

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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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 app) which was sync'd with the other iPad each time modifications to the planned survey flights were made.

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. Speaking into a handheld digital recorder, observers counted all sightings of marine mammals. Using a geometer (or clinometer), the perpendicular declination angle to the center of each group was measured once it was abeam of the observer. MMOs noted the species and number of animals in the group. A 'group' 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 visually and 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 while a sixth member of the team was responsible for overseeing navigation along the survey grid.

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 Primary observers were automatically entered into the Mysticetus program by the Primary observers using geometers during the survey. Geometers were linked to the Mysticetus program, allowing Primary 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 the 2021 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. To identify aggregations observed during visual surveys, all personnel on board the aircraft were instructed to look out for herds of narwhal and alert everyone when one was sighted. When such an aggregation was located, lines would be flown in a cross pattern over the group, to determine its spatial extent. Using pre-planned survey grids, the aggregation would be photographed using a systematic grid with complete coverage as seen in Figure 15 (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 ($\alpha = 27°$) equal to half its field of view (shown as β in Figure 16), calculated using (Covington 1985):

$$\alpha = \beta = arctan\left(\frac{SensorWidth}{FocalLength \times 2}\right)$$

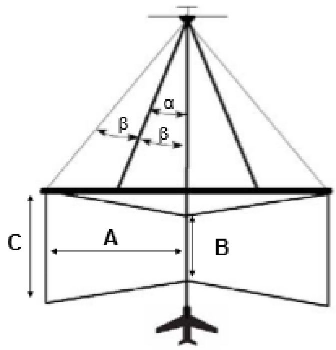


Figure 16: Geometry of oblique aerial photos (modified from Grendzdörffer et al. 2008).

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) if conditions did not allow surveying at higher altitude (610 m). Using the methods described in Grendzdörffer et al. (2008), the photograph dimensions of the two-camera system (see Figure 16) 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 and 1,200 m, the lateral overlap between photos from adjacent transects was approximately 30%.

Table 7: Dimensions of images at two possible altitudes.

	Altitude (m)	
	305	610
A (m)	423	846
B (m)	186	372
C (m)	318	636
Interval (sec)	3	6

Two sets of grid lines (one for 305 m and a second 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 17). 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.

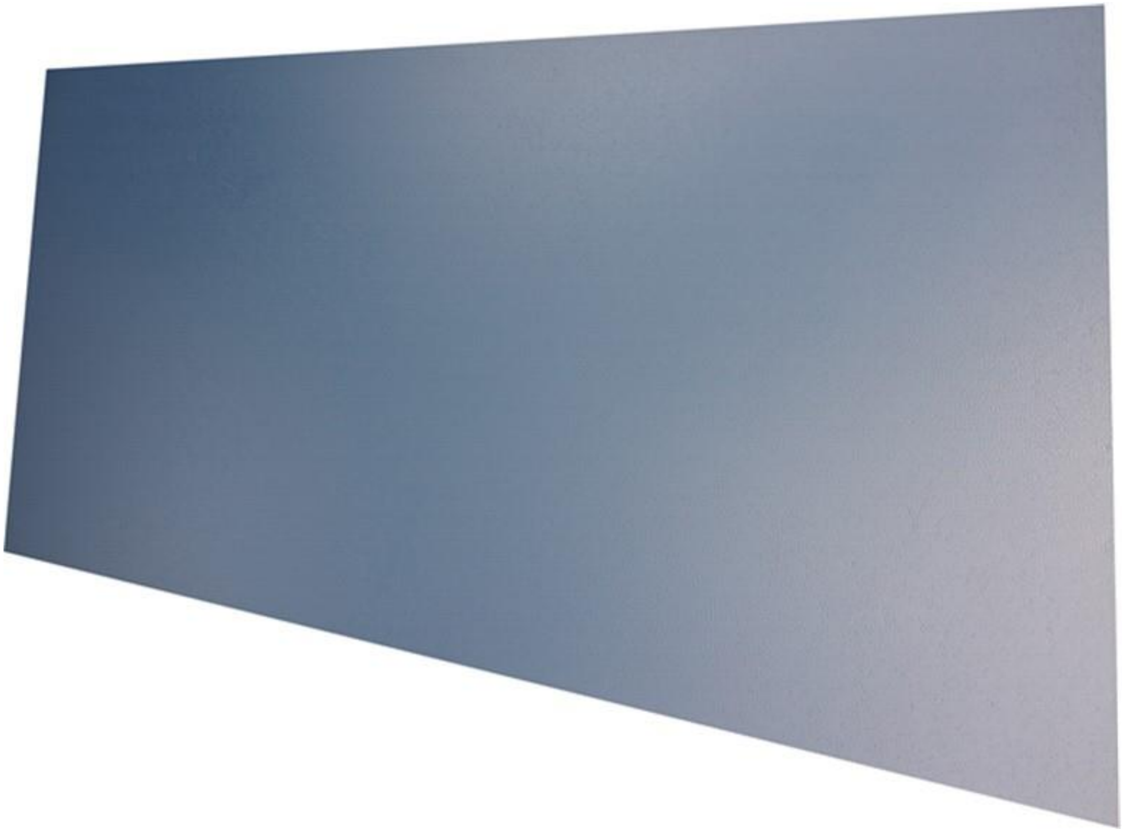


Figure 17: Orthophotograph of an image taken at 610 m (2,000 ft) in Eclipse Sound on 20 August 2020.

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 (C_α) 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 [Ê(*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

For the post season photographic analysis, an analyst experienced in analysing aerial photos from previous DFO narwhal surveys and the 2019 and 2020 photographic surveys analyzed all the 2021 photographs.

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 trackline 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.

Aerial photos were viewed in ArcMap (Esri Inc.) and all narwhal within the top 2 m of the water column were counted. Photographs were examined for narwhal on a high resolution 50” 4K television. Photographs were orthorectified prior to being examined in ArcMap 10.1 (Esri). 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).

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:

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

Where $\bar{x}$ 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):

$$var(N_i) = var(N_{iV}) + var(N_{iP})$$

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 ($\widehat{N}_{avg}$) 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):

$$\widehat{N}_{avg} = \frac{E_1 \widehat{N}_1 + E_2 \widehat{N}_2}{E_1 + E_2}$$

Where E_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):

$$var(\widehat{N}_{avg}) = \frac{E_1^2\ \widehat{var}(\widehat{N}_1) + E_2^2\ \widehat{var}(\widehat{N}_2)}{(E_1 + E_2)^2}$$

3.4.3 Quality Management

To confirm data integrity, validity, and reliability, the following QA/QC measures were undertaken:

- Data was collected and entered into the MMASP database by qualified experienced MMOs following standard field data collection methods (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 Golder Biologist to ensure accuracy.
- A final QA/QC of the data results was conducted by the senior Golder Biologist.

3.5 Leg 2 Survey Results

Leg 2 aerial surveys for narwhal were conducted in the North Baffin area during August 2021. The objectives of the surveys were to obtain abundance estimates of narwhal during the open-water season 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 8–26 August. A total of five surveys were attempted in the Eclipse Sound survey grid and four surveys were attempted in the Admiralty Inlet survey grid during Leg 2. Complete coverage was obtained on three of the five surveys in Eclipse Sound and two of the four surveys in Admiralty Inlet. One survey of the combined Eclipse Sound and Admiralty Inlet grids occurred within a three-day period.

3.5.1 Survey Coverage

Five surveys were attempted over 19 days during the open-water season in the Eclipse Sound and Admiralty Inlet grids (see Appendix B; Figures B-11 to B-19). Over the course of the five surveys, a total of 11,669.7 km of survey effort was conducted which included both visual and photographic surveys (Table 9).

Eclipse Sound Grid: Visual surveys totaled 5,415.7 km and photographic surveys totaled 2,512.5 km of survey effort (Table 9). Three of the five surveys (Surveys 1 and 2 combined, 4, and 5) achieved complete coverage of the survey grid (see Appendix B; Figures B-11, B-12, B-17 and B-19). Survey 1 missed two fjords (Paquet Bay and Oliver Sound) due to high turbulence. Due to technical issues with photos on one of the aircrafts during Surveys 1 and 2, the photographic survey in Milne Inlet South (MIS) from Survey 1 was combined with the Survey 2 data to make a complete survey. Survey 3 was not retained for the abundance analysis due to poor sightings conditions. Survey 4 was completed in two days due to poor photographic survey conditions encountered on the first day. Survey 5 was retained for the abundance analysis and was completed in one day.

Admiralty Inlet Grid: Visual surveys totaled 3,212.1 km and photographic surveys totaled 529.5 km of survey effort (Table 9). Four surveys (Surveys 2, 3, 4 and 5) were flown in Admiralty Inlet in 2021 and two, Surveys 3 and 4, were retained for analysis (see Appendix B; Figures B-13, B-15, B-16, and B-18). Poor survey conditions during the time allotted for Survey 1 did not allow for all planned surveys to be conducted. Surveys 2 and 5 were not completed due to poor survey conditions in the northern portion of the survey area. Survey 3 was completed in two days due to deteriorating weather conditions at Mary River site. Survey 4 achieved complete coverage of the survey grid in a single day under good sighting conditions.

Table 9: Visual (V) and photographic (P) surveys undertaken during Leg 2.

Survey Stratum	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5
	8 Aug	10–11 Aug	14–18 Aug	19–21 Aug	22–26 Aug
Pond Inlet (PI)	V	V	V	V	V
Eclipse Sound East (ESE)	V	V	V	V	V
Eclipse Sound West (ESW)	V	V	V	V	V
Milne Inlet North (MIN)	V	V	V	V	V
Milne Inlet South (MIS)	P	P	P	P	P
Tremblay Sound (TS)	P	P	P	P	P
Navy Board Inlet (NBI)	V	V	V	V	V
Eclipse Fjords	V	V	V	V	V
Eclipse Visual Effort (km)	**1,028.6**	**1,064.5**	**916.6**	**1,210.3**	**1,195.7**
Eclipse Photographic Effort (km)	**376.1**	**361.4**	**642.2**	**495.5**	**637.2**
Eclipse Total Effort (km)	**1,404.7**	**1,425.9**	**1,558.8**	**1,705.8**	**1,832.9**
Admiralty Inlet North (AIN)	—	V	V	V&P	V
Admiralty Inlet South (AIS)	—	V	V&P	V&P	V&P
Admiralty Fjords	—	—	V	V	—
Admiralty Visual Effort (km)	—	**508.2**	**1,051.2**	**1,141.8**	**510.8**
Admiralty Photographic Effort (km)	—	—	**88.6**	**270.7**	**170.1**
Admiralty Total Effort (km)	—	**508.2**	**1,139.8**	**1,412.5**	**680.9**
Combined Total Effort (km)	**1,404.7**	**1,934.2**	**2,698.7**	**3,118.3**	**2,513.8**

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. Sighting conditions are pooled for both Eclipse and Admiralty survey grids during Surveys 2 to 5. Survey 1 represent sightings conditions for the Eclipse survey grid as Admiralty Inlet was not flown. For calculating abundance estimates, distance analyses used the sighting conditions as covariates in the model.

Ice Cover

No ice was present in Eclipse Sound or Admiralty Inlet during Leg 2 surveys (Figure 18).

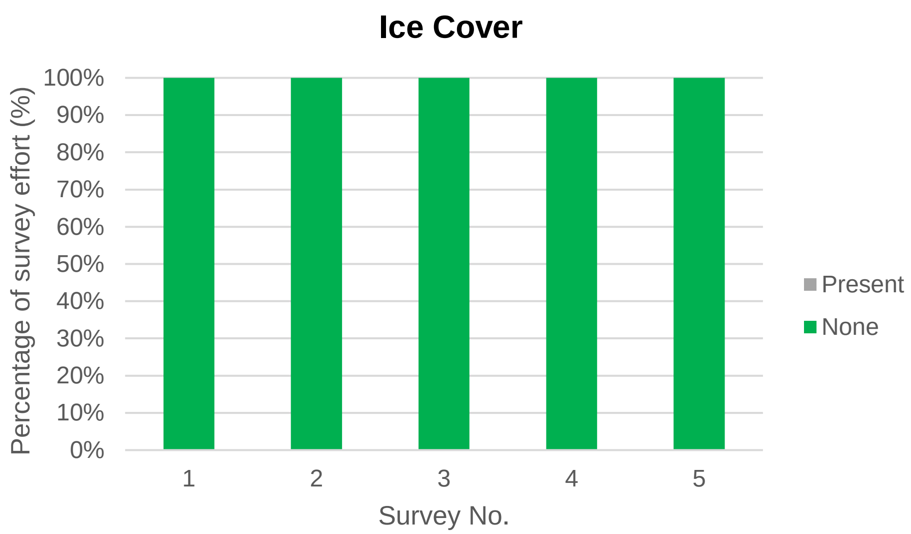


Figure 18: Ice Cover during Leg 2 of the 2021 MMASP.

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 cover ranged from None to 100% cover during Leg 2 of the 2021 MMASP. Fog was present during Surveys 2 to 5 and accounted for 0.2% to 4% of the effort of each survey, respectively (Figure 19). Most of the fog that was present on the survey was primarily of light and moderate thickness (Figure 20).

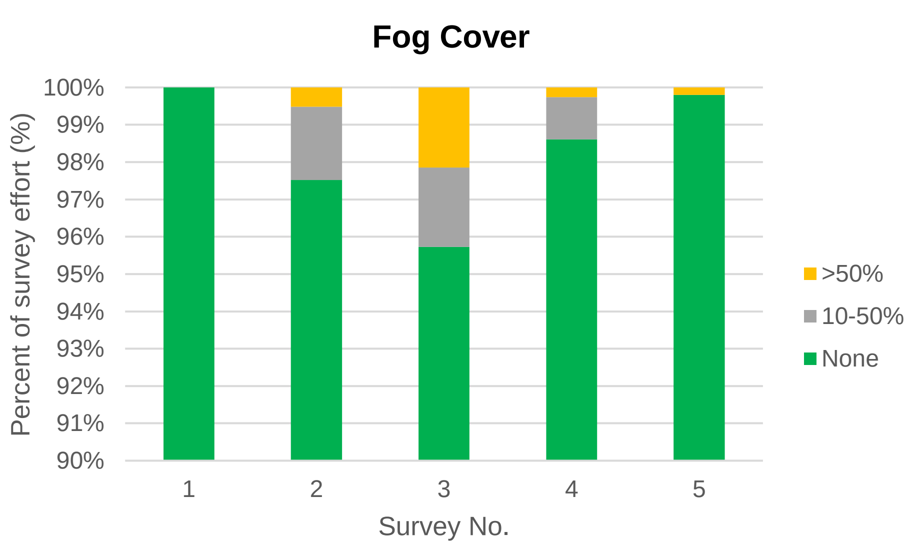


Figure 19: Fog Cover During Leg 2 of the 2021 MMASP.

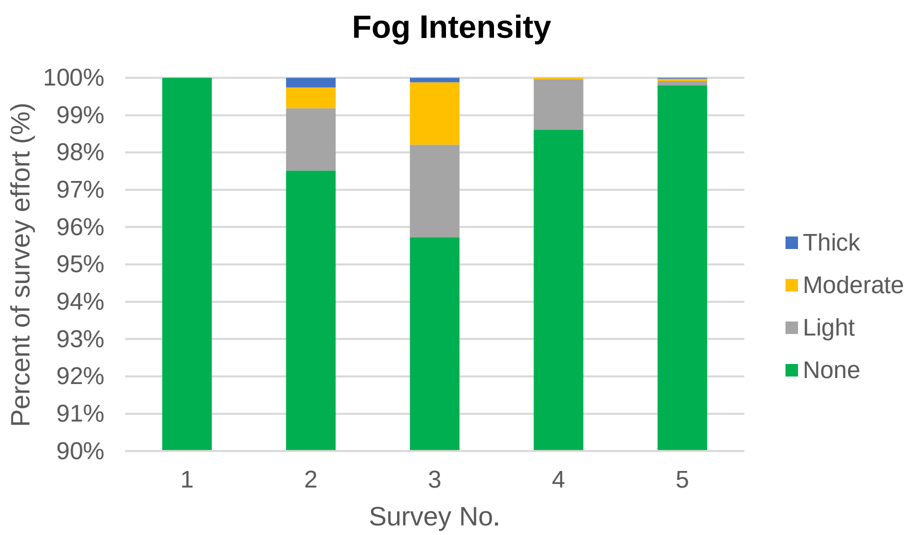


Figure 20: Fog Intensity During Leg 2 of the 2021 MMASP

Beaufort Sea State

On a scale of 0 to 12, the Beaufort Sea State (BF) ranged from BF 0 (glassy mirror) to BF 6 (large waves) during Leg 2 of the 2021 MMASP (Figure 21). 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 (i.e., BF 5) 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.

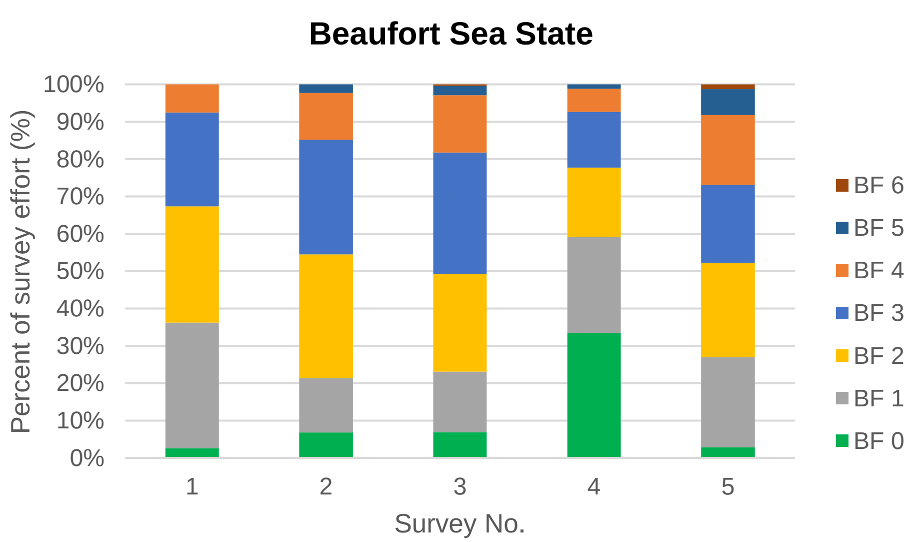


Figure 21: Beaufort Sea State During Leg 2 of the 2021 MMASP

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). All surveys were flown during partial cloudy conditions with glare recorded as “none” for 36% to 60% of the survey effort in each survey (Figure 22 and Figure 23).

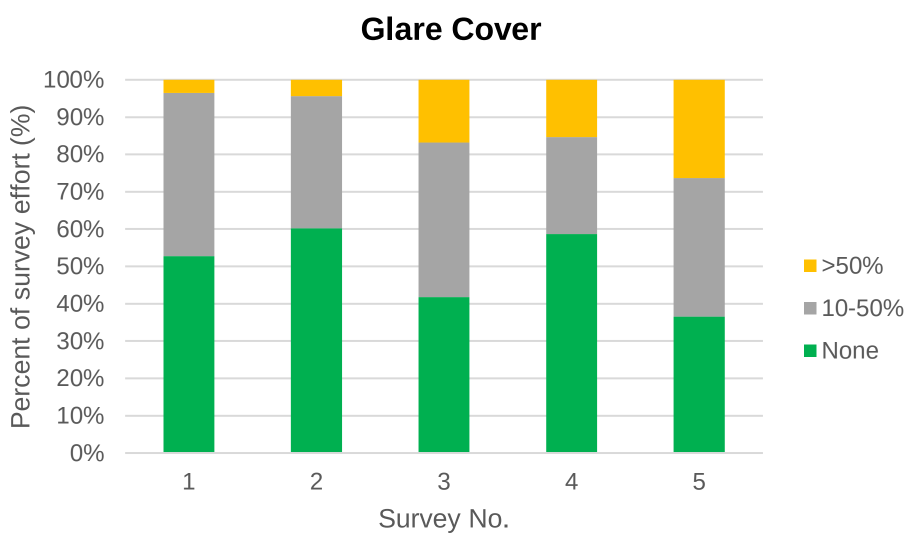


Figure 22: Glare Cover During Leg 2 of the 2021 MMASP

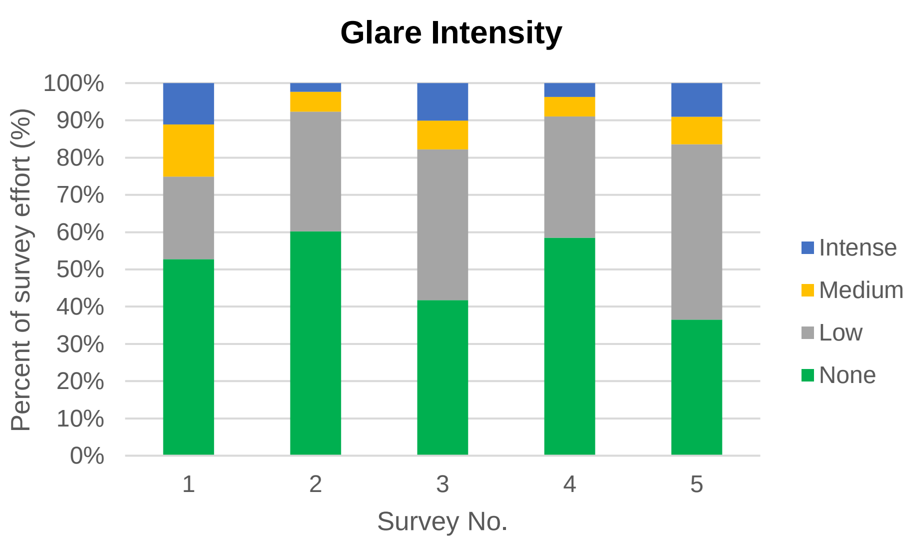


Figure 23: Glare Intensity During Leg 2 of the 2021 MMASP

3.5.3 Visual Survey Sightings

Eclipse Sound Grid: Six different species of marine mammals were observed during Leg 2 visual surveys of the 2021 MMASP in the Eclipse Sound grid: narwhal, bowhead whale, ringed seal, harp seal, bearded seal, and polar bear. Unidentified whales and seals were also recorded during the visual surveys.

Table 10 summarizes the number of marine mammal sightings and animals recorded for each species in each of the five Leg 2 surveys. A total of 338 sightings and 1,135 animals were recorded during Leg 2 visual surveys in the Eclipse Sound grid. The most commonly sighted species was ringed seal (180 sightings totalling 220 animals), followed by narwhal (25 sightings totalling 60 animals), harp seal (25 sightings totalling 729 animals), polar bear (13 sightings totalling 22 animals), bowhead whale (two sighting of single whales), and bearded seal (one sighting of a single animal). There were also 91 unidentified seal sightings totalling 100 animals and one sighting of a single unidentified whale.

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

Species	Survey 1		Survey 2		Survey 3		Survey 4		Survey 5	
	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals
Narwhal	3	4	3	3	5	5	13	47	1	1
Bowhead Whale	0	0	0	0	0	0	2	2	0	0
Unidentified Whale	1	1	0	0	0	0	0	0	0	0
Ringed Seal	39	42	23	47	11	12	78	86	29	33
Harp Seal	8	23	7	61	1	3	3	48	6	594
Bearded Seal	0	0	0	0	0	0	1	1	0	0
Unidentified Seal	24	25	11	11	8	10	34	40	14	14
Polar Bear	2	2	3	7	0	0	5	8	3	5
Total	**77**	**97**	**47**	**129**	**25**	**30**	**136**	**232**	**53**	**647**

Admiralty Inlet Grid: Eight different species of marine mammals were observed during Leg 2 visual surveys of the 2021 MMASP in the Admiralty Inlet grid: narwhal, bowhead whale, beluga whale, killer whale, ringed seal, harp seal, bearded seal, and polar bear. Unidentified whales and seals were also recorded during the surveys. 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 1,104 sightings and 4,789 animals were recorded during Leg 2 visual surveys in the Admiralty Inlet grid.

The most commonly identified species was narwhal (512 sightings totalling 2,219 animals), followed by ringed seal (204 sightings totalling 246 animals), harp seal (92 sightings totalling 1,929 animals), polar bear (23 sightings totalling 46 animals), bowhead whale (38 sightings totalling 60 animals), killer whale (4 sightings totalling 26 animals), beluga whale (two sightings of a single whale), and bearded seal (two sightings of a single seal). There were also 226 sightings of unidentified seal totalling 257 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		Survey 4		Survey 5	
	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals
Narwhal	77	221	103	252	195	976	137	770
Bowhead Whale	9	9	1	1	17	35	11	15
Beluga Whale	2	2	0	0	0	0	0	0
Killer Whale	0	0	1	7	3	19	0	0
Unidentified Whale	0	0	0	0	1	2	0	0
Ringed Seal	0	0	68	81	96	111	40	54
Harp Seal	10	212	22	294	51	1,393	9	30
Bearded Seal	0	0	2	2	0	0	0	0
Unidentified Seal	8	8	36	38	168	196	14	15
Polar Bear	2	4	12	24	3	9	6	9
Total	**108**	**456**	**245**	**699**	**534**	**2,741**	**217**	**893**

Narwhal

Eclipse Sound Grid: During the open-water season (Leg 2) narwhal were primarily sighted in Milne Inlet South and Tremblay Sound strata as evident in the photographic coverage of the areas (see Appendix B, Figures B-11, B-12, B-14, B-17 and B-19). Relatively few narwhal were recorded in Eclipse Sound, Navy Board Inlet or the Fjords during the five Leg 2 surveys conducted in August.

A total of 25 sightings and 60 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 15, with mean and median group sizes of 2.4 and 1.0, respectively. Two mother/calf pairs were recorded during the surveys. One mother/calf pair was observed during Survey 1 (8 August) in White Bay fjord stratum. During Survey 4 (20 August), one mother/calf pair was observed in Milne Inlet North stratum.

Admiralty Inlet Grid: Narwhal were observed clumped close to shore on the western side of the Admiralty Inlet (as evident in the photographic coverage for Leg 2 Surveys 3 and 4; see Appendix B; Figures B-15, B-16, and B-18) and dispersed in the southern portion of Admiralty Inlet South stratum (see Appendix B, Figures B-15 and B-16).

A total of 512 sightings and 2,219 individual narwhal were recorded during the Leg 2 visual surveys of the Admiralty Inlet grid (Table 11). Narwhal group sizes ranged from single animals to a group size of 16, with mean and median group sizes of 2.5 and 2.0, respectively (observer sightings that lumped multiple sightings together were excluded from the mean and median group size estimates). Fifty-nine mother/calf pairs and nine lone calves were recorded during the surveys. Eight mother/calf pairs and one lone calf were observed in the Admiralty Inlet North stratum. Fifty-one mother/calf pairs and eight lone calves were observed in the Admiralty Inlet South stratum.

Bowhead Whale

Eclipse Sound Grid: Two bowhead whale were observed in the RSA during the open-water surveys (Table 10). Both were sighted on August 20 (Survey 4), one in Pond Inlet stratum on the south shore of Bylot Island and one in the Eclipse Sound East stratum north of Emerson Island (see Appendix B; Figure B-17).

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, clumped close to shore on the western side of Admiralty Inlet and dispersed in the southern portion of the Admiralty Inlet South stratum (see Appendix B, Figures B-13, B-15, B-16 and B-18). A total of 38 sightings and 60 individual 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 a group size of seven, with mean and median group sizes of 1.6 and 1.0, respectively. No mother/calf pairs were observed.

Beluga Whale

Eclipse Sound Grid: No beluga were observed in Eclipse Sound during Leg 2 visual surveys.

Admiralty Inlet Grid: There was two sightings of a single beluga observed on 11 August (Survey 2) in the Admiralty North stratum during the Leg 2 visual surveys (Table 11; see Appendix B, Figure B-13). One sighting was at the mouth of Moffet Inlet and the other was on the western shore in Admiralty Inlet North.

Killer Whale

Eclipse Sound Grid: No killer whale were observed in Eclipse Sound during Leg 2 visual surveys.

Admiralty Inlet Grid: Killer whale were observed on two days during Leg 2 visual surveys (Table 11). The first sighting of approximately seven killer whales was observed on 16 August (Survey 3) in the Admiralty Inlet South stratum in close proximity to the concentration of narwhal clumped close to shore on the western side of the Admiralty Inlet (Appendix B, Figure B-15). On the 19 August (Survey 4), three sightings of killer whales (group sizes of 2, 5 and 12) were observed in close proximity to each other in the Admiralty North stratum and near the concentration of narwhal clumped close to shore on the western side of the Admiralty Inlet (see Appendix B, Figure B-16).

Unidentified Whale

Eclipse Sound Grid: A single unidentified whale was observed in Eclipse Sound West stratum during Leg 2 Survey 1 (Table 10; see Appendix B, Figure B-11).

Admiralty Inlet Grid: There was one sighting of a pair of unidentified whale observed in Admiralty Inlet South stratum during Leg 2 Survey 4 (Table 11; see Appendix B, Figure B-16).

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-11, B-12, B-14, B-17 and B-19). There was a total of 180 sightings totalling 220 individual ringed seals recorded during Leg 2 visual surveys (Table 10). Ringed seal sightings were primarily of single animals (162 of 180 sightings). The remaining ringed seal sightings observed consisted of groups of two, three, one sighting of six animals, one sighting of nine animals, and one sighting of ten animals.

Admiralty Inlet Grid: Ringed seals were observed during three of the four surveys flown during Leg 2 visual surveys of the Admiralty Inlet grid (see Appendix B, Figures B-15, B-16 and B-18). There was a total of 204 sightings totalling 246 individual ringed seals recorded during Leg 2 visual surveys (Table 11). Ringed seal sightings were primarily of single animals (177 of 204 sightings). The remaining ringed seal sightings observed consisted of groups of two, three, and seven 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-11, B-12, B-14, B-17 and B-19). A total of 25 sightings and 729 individual harp seals were recorded during Leg 2 visual surveys (Table 10). Harp seal were observed with group sizes that ranged from one to 400 animals with mean and median group sizes of 29.2 and 5.0, respectively.

Admiralty Inlet Grid: Harp seal were observed on all Leg 2 visual surveys in Admiralty Inlet grid (see Appendix B, Figures B-13, B-15, B-16 and B-18). A total of 92 sightings and 1,929 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 300 animals with mean and median group sizes of 21.0 and 2.0, respectively.

Bearded Seal

Eclipse Sound Grid: One sighting of an individual bearded seal was recorded in Eclipse Sound East stratum during Survey 4 of Leg 2 (Table 10; see Appendix B, Figure B-17).

Admiralty Inlet Grid: There were two sightings of an individual bearded seal observed in Admiralty Inlet grid in Strathcona Sound and Moffet Inlet during Survey 3 of Leg 2 visual surveys (Table 11; see Appendix B, Figure B-17).

Unidentified Seal

Eclipse Sound Grid: Unidentified seals were observed throughout the survey area during Leg 2 visual surveys (see Appendix B, Figures B-11, B-12, B-14, B-17 and B-19). A total of 91 sightings and 100 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-13, B-15, B-16 and B-18). A total of 226 sightings and 257 seals were recorded with mean and median group sizes of 1.1 and 1.0, respectively (Table 11).

Polar Bear

Eclipse Sound Grid: thirteen polar bear sightings totalling 22 individuals were made during Leg 2 visual surveys in the Eclipse Sound grid (Table 10). Ten of the sightings occurred in Navy Board Inlet stratum, two in Pond Inlet stratum, and one in the Paquet Bay (see Appendix B, Figures B-11, B-12, B-17 and B-19). Ten of the sightings were of single animals and the other four sightings were of a mother with two cubs.

Admiralty Inlet Grid: Twenty-three polar bear sightings totalling 46 individuals were made during Leg 2 visual surveys in the Admiralty Inlet grid (Table 11). Eleven of the sightings were of single animals, ten sightings were of a mother with one or two cubs, and two sightings were of a group of three bears of unknown age class.

3.5.4 Photographic Survey Sightings

Photographic analyses were only completed for surveys with complete survey (transect) coverage and adequate sighting conditions. For the Eclipse Sound survey grid, this included Surveys 1, 2, 4 and 5. Survey 1 in MIS and Survey 2 in TS were combined due to technical issues with the photographs on one of the aircrafts. Survey 3 was not retained due to poor sightings conditions including low ceilings and high sea states. Survey 4 was completed in two days due to poor photographic survey conditions encountered on the first day. For the Admiralty Inlet survey grid, analysis of the aerial photographic data for Admiralty (Leg 2) was limited to Surveys 3 and 4. Survey 3 was completed over two days due to deteriorating weather conditions at Mary River. Surveys 1, 2 and 5 were not used for the analysis; Survey 1 was not flown due to poor weather and Surveys 2 and 5 were not completed due to poor observation conditions. All photographic surveys were flown at 610 m (2,000 ft).

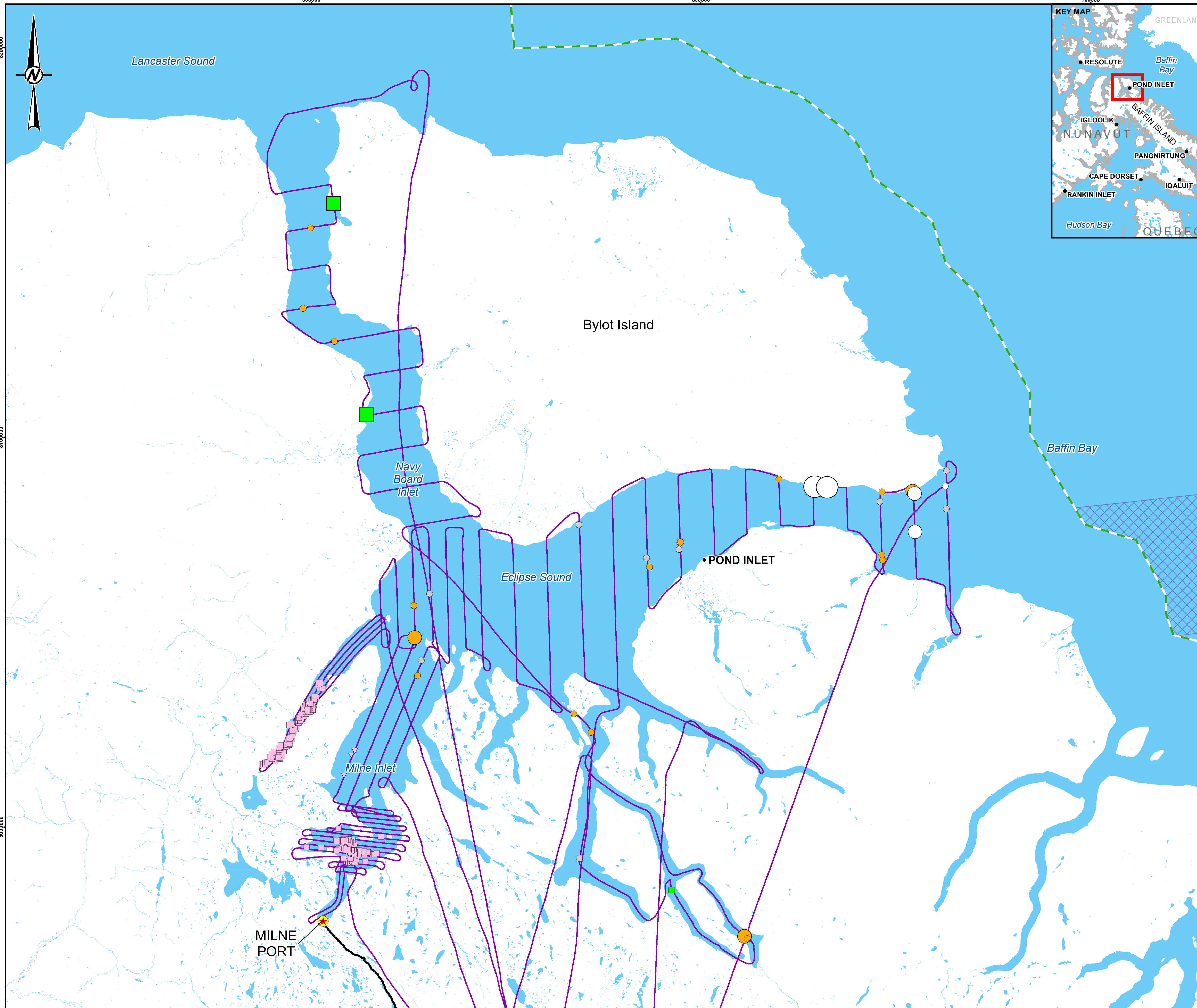
Eclipse Sound Grid: During the open-water season (Leg 2), narwhal were primarily sighted in Milne Inlet South and Tremblay Sound strata as evident in the photographic coverage of the areas (Figure 24 A–B, Figure 26 A–B, and Figure 27 A–B). A total of 1,753 sightings and 2,833 narwhal were recorded during 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 1.6 and 1.0, respectively.

Admiralty Inlet Grid: In Admiralty Inlet, two of the three photographic surveys were conducted in the south stratum and one was conducted in the north stratum (Figure 25 A–B and Figure 26 A–B). A total of 15,603 sightings and 34,726 narwhal were recorded during the photographic surveys in the Admiralty Inlet grid (Table 12). Narwhal group sizes ranged from single animals to a group size of 178, with mean and median group sizes of 2.2 and 1.0, respectively. Large group sizes of 30+ animals were observed on the 19 August in the Admiralty Inlet North (AIN) stratum during a herding event. Fifty-seven bowhead whale sightings totalling 88 bowhead whales were recorded on three of the Leg 2 photographic surveys in the Admiralty Inlet grid (see Table 12). Bowhead group sizes ranged from single animals to a group size of four, with mean and median group sizes of 1.5 and 1.0, respectively. No mother/calf pairs were observed.

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

Grid	Survey	Stratum[a]	Narwhal		Bowhead[b]	
			No. Sightings	No. Animals	No. Sightings	No. Animals
Eclipse	1	MIS	386	760	0	0
Eclipse	2	TS	257	366	0	0
Eclipse	4	MIS	230	335	0	0
Eclipse	4	TS	330	631	0	0
Eclipse	5	MIS	230	269	0	0
Eclipse	5	TS	320	472	0	0
Admiralty	3	AIS	3,390	7,643	18	23
Admiralty	4	AIS	11,378	21,845	23	30
Admiralty	4	AIN	835	5,238	16	35

[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

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL

- 1
- 2-10
- 10+

NARWHAL

- 1

POLAR BEAR

- 1
- 2-10

RINGED SEAL

- 1
- 2-10

UNIDENTIFIED SEAL

- 1

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

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. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE

DISTRIBUTION OF MARINE MAMMALS RECORDED DURING LEG 2 - SURVEYS 1 AND 2 ON 8 AND 10 AUGUST 2021 IN ECLIPSE SOUND GRID

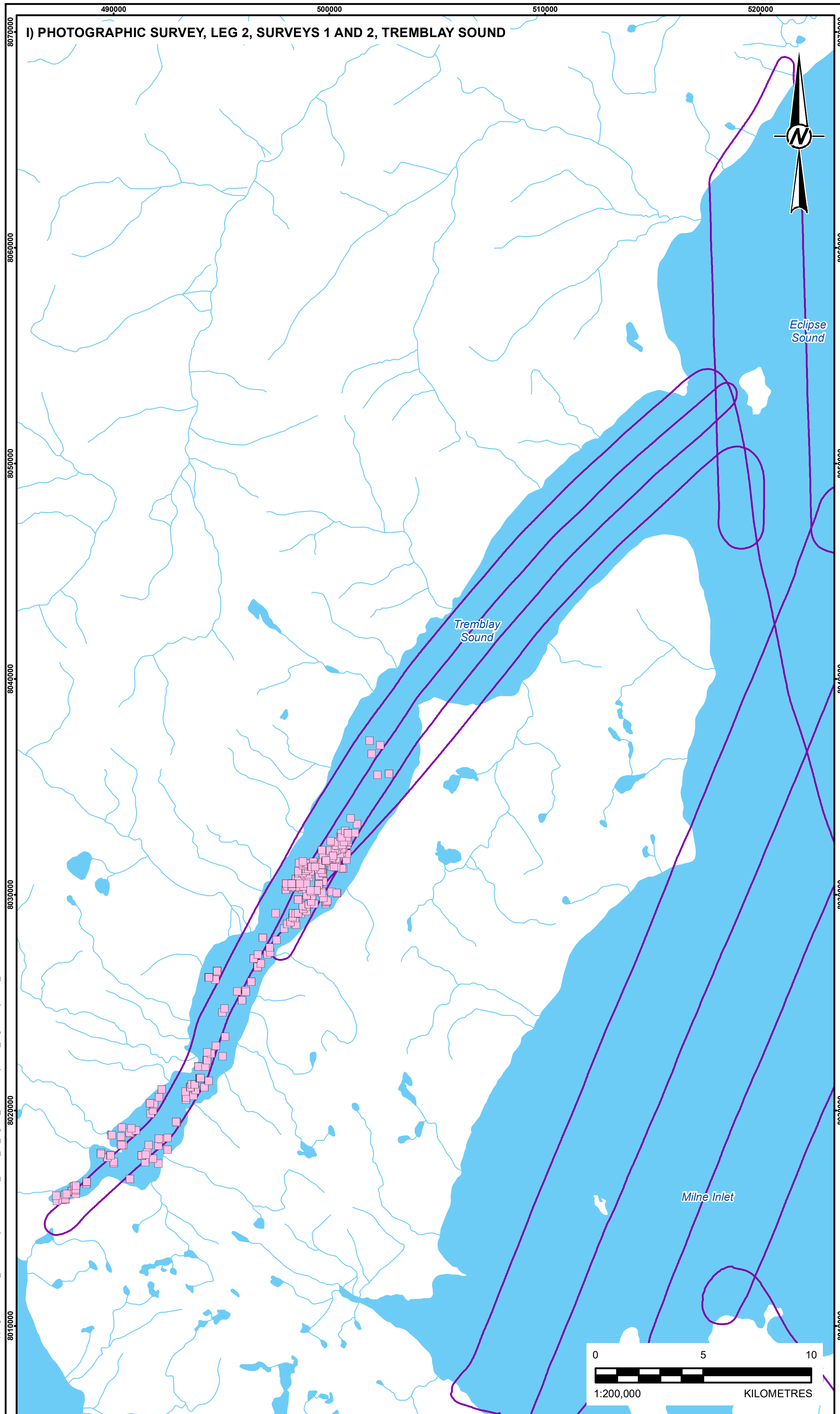
CONSULTANT

GOLDER
MEMBER OF WSP

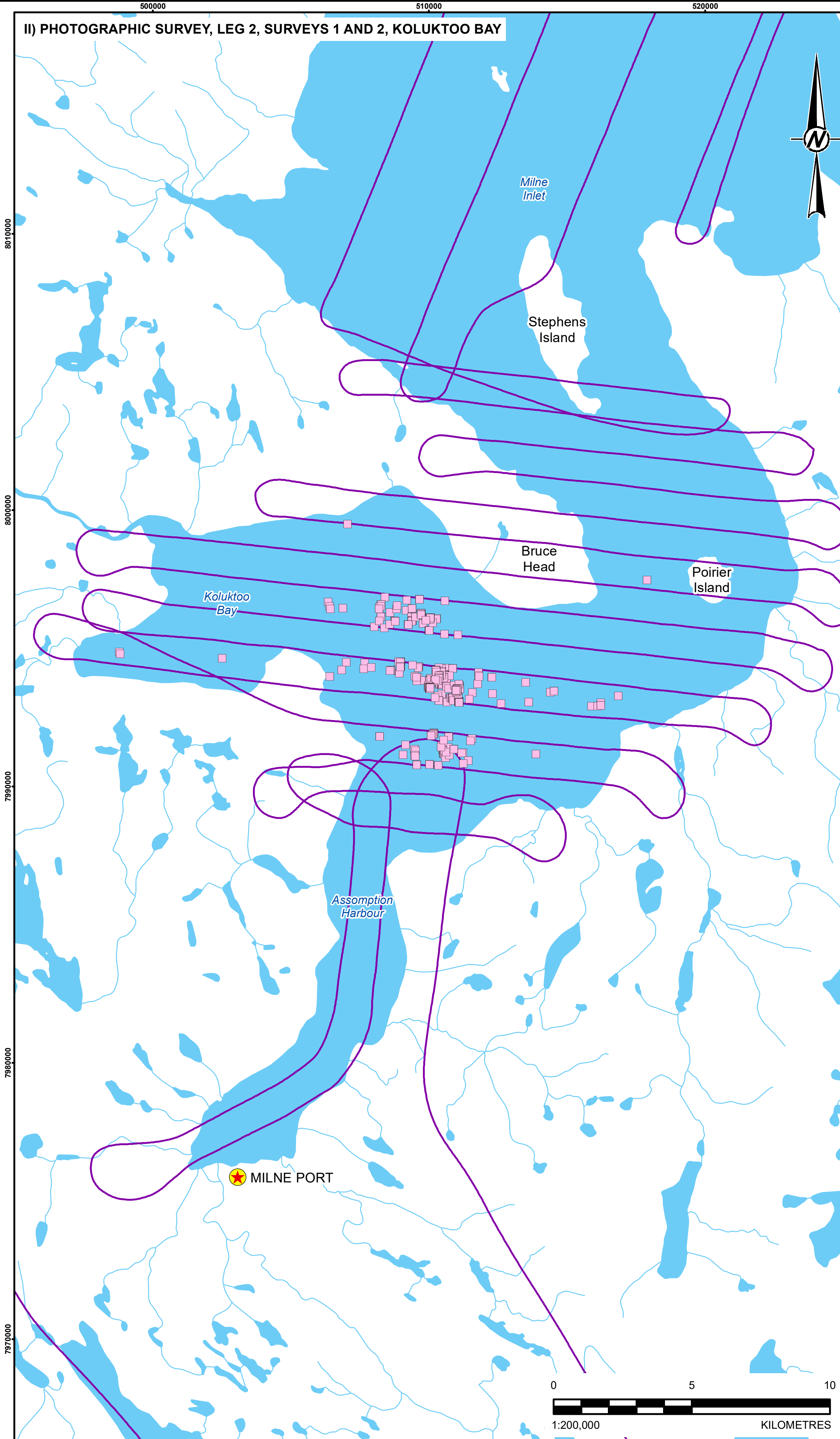
YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	24A

I) PHOTOGRAPHIC SURVEY, LEG 2, SURVEYS 1 AND 2, TREMBLAY SOUND



II) PHOTOGRAPHIC SURVEY, LEG 2, SURVEYS 1 AND 2, KOLUKTOO BAY



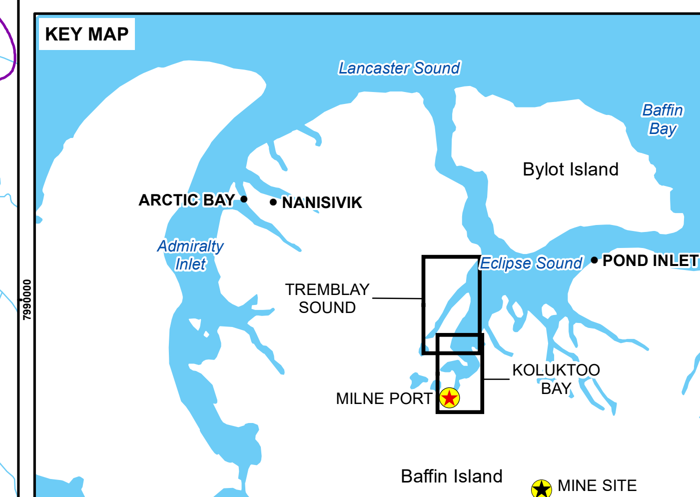
LEGEND

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

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

KEY MAP



REFERENCE(S)

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PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

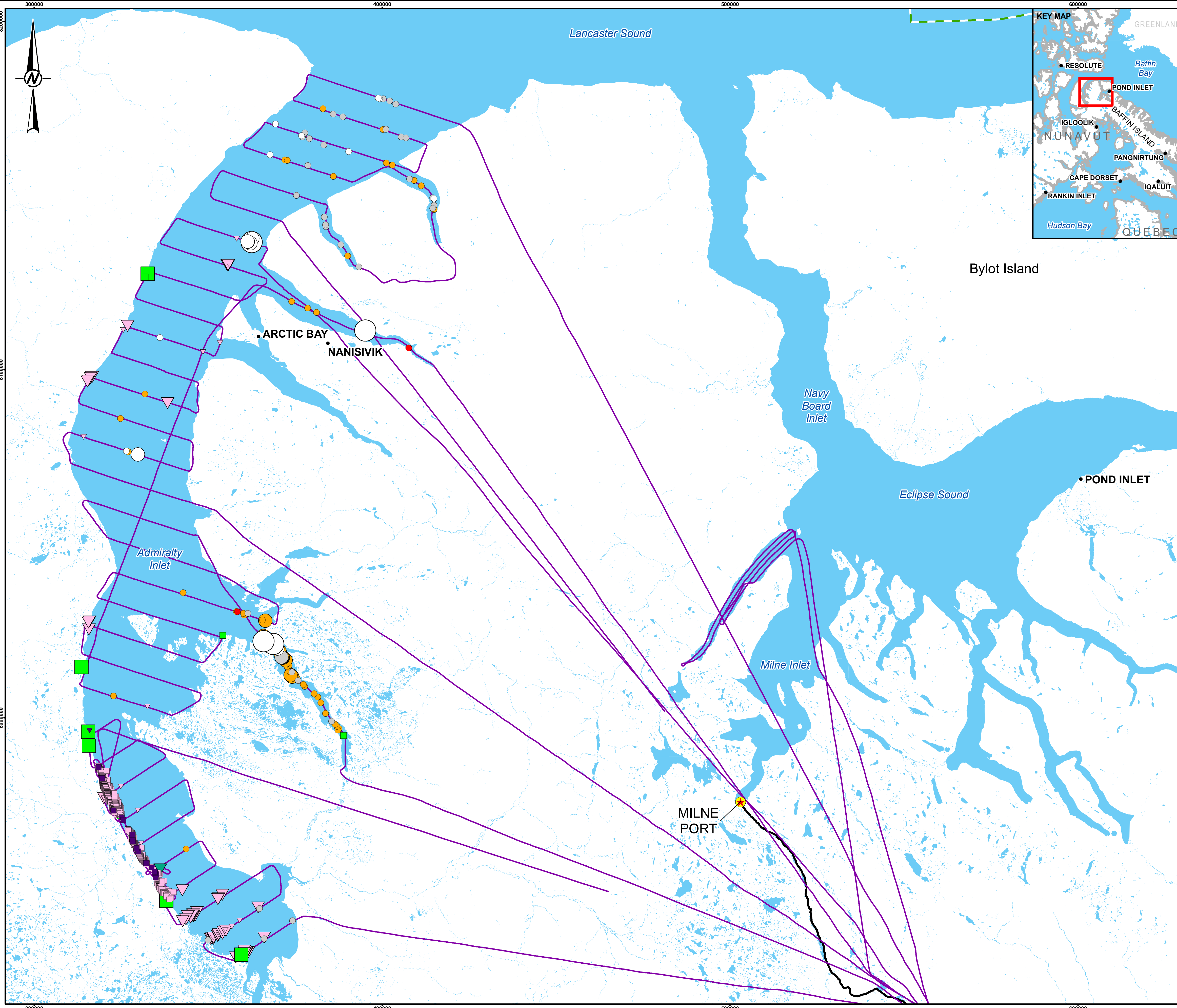
PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
PHOTOGRAPHIC SURVEYS DURING LEG 2 SURVEYS 1 AND 2 ON 8 AND 10 AUGUST IN ECLIPSE SOUND GRID

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	24B



LEGEND

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

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD WHALE
- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2-10
- 10+

KILLER WHALE
- 2-10

NARWHAL
- 1
- 2-10

POLAR BEAR
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

0 25 50
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. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF MARINE MAMMALS RECORDED DURING LEG 2 - SURVEY 3 ON 15-16 AUGUST 2021 IN ADMIRALTY INLET GRID

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	25A

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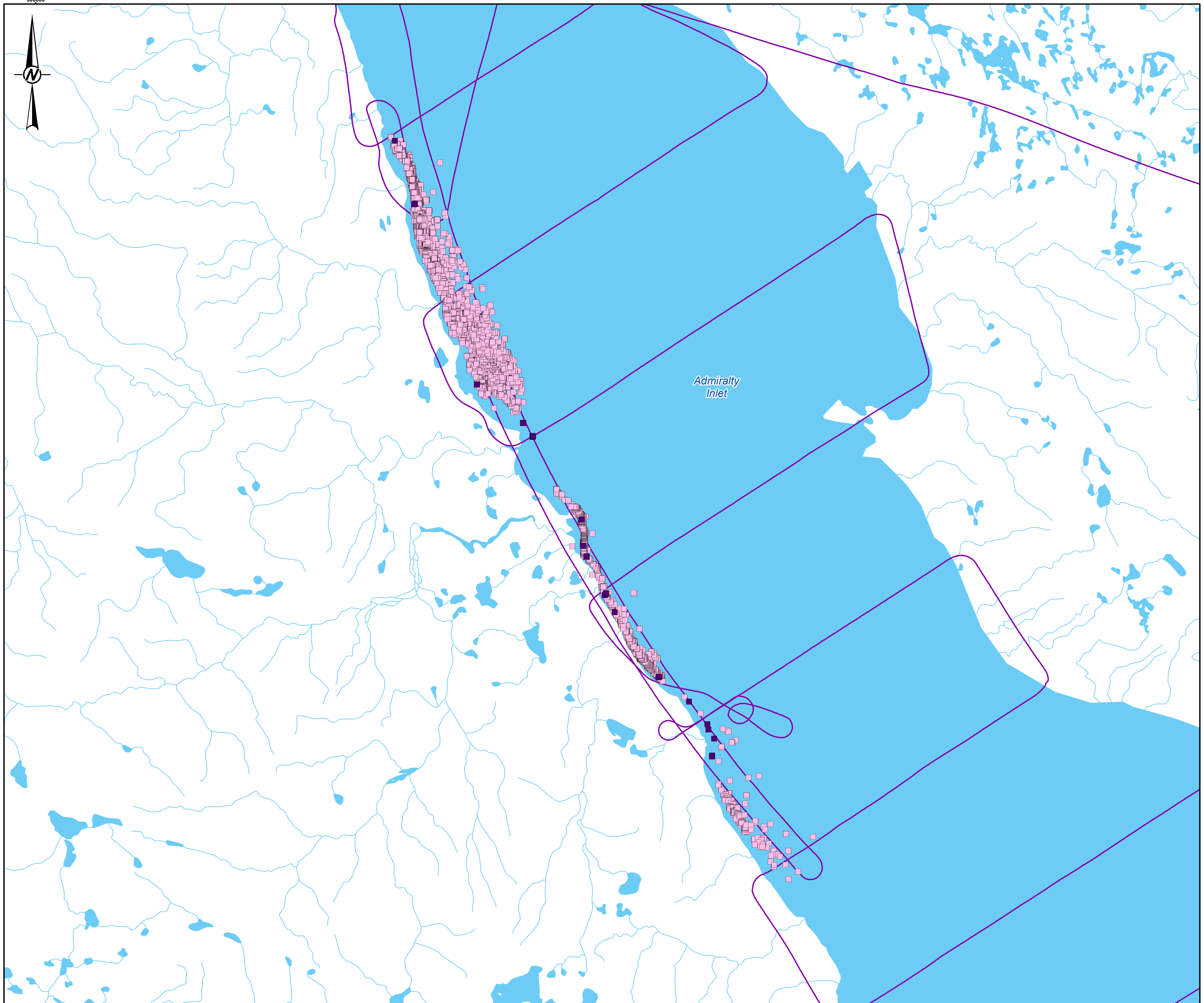


LEGEND

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

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD WHALE
- NARWHAL

KEY MAP

0 5 10

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
2021 MARINE MAMMAL AERIAL SURVEYS

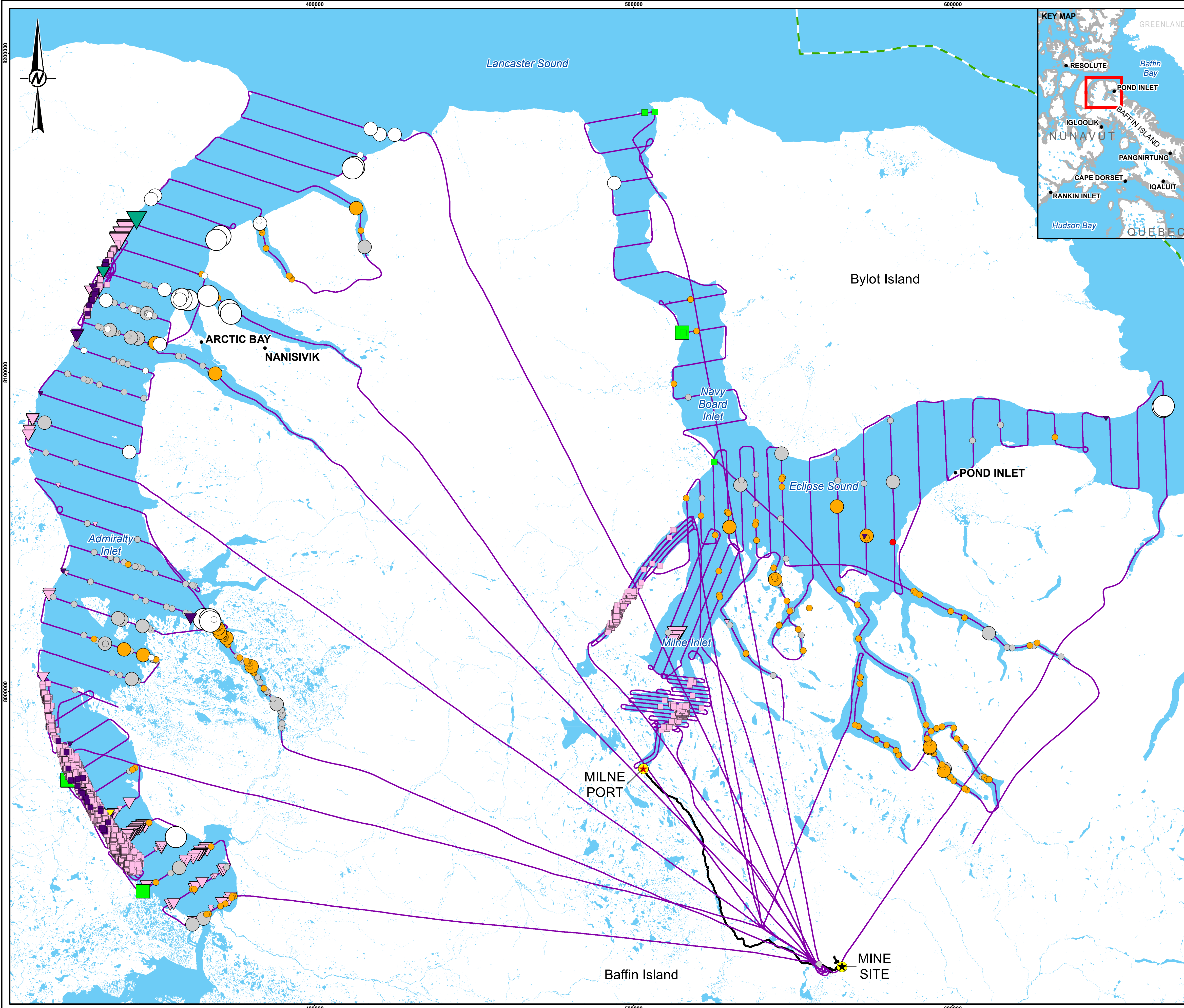
TITLE
DISTRIBUTION OF MARINE MAMMALS RECORDED DURING LEG 2 - SURVEY 3 ON 15-16 AUGUST 2021 IN ADMIRALTY INLET GRID

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	25B



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CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE

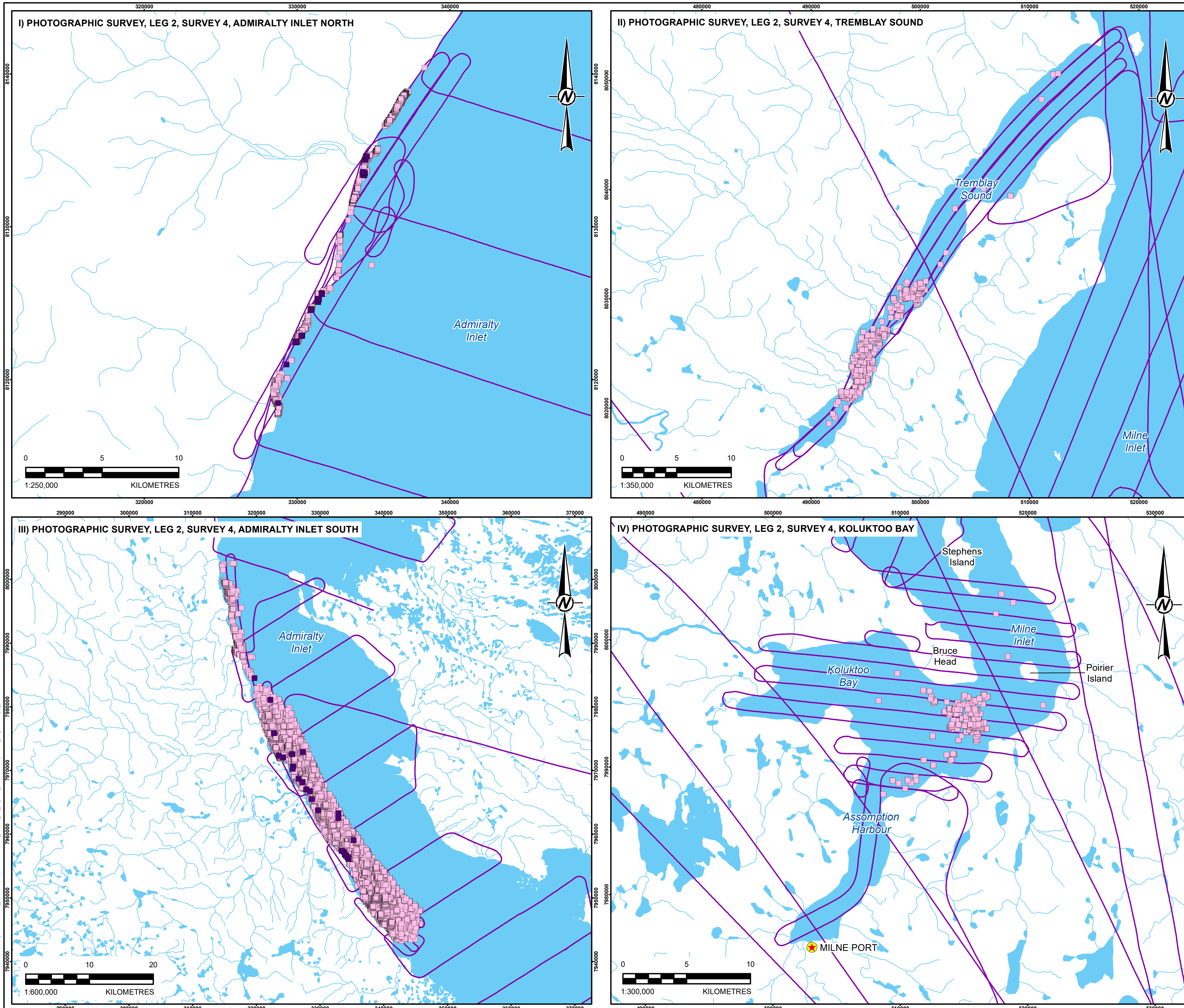
DISTRIBUTION OF MARINE MAMMALS RECORDED DURING LEG 2 - SURVEY 4 ON 19-21 AUGUST 2021 IN ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	26A



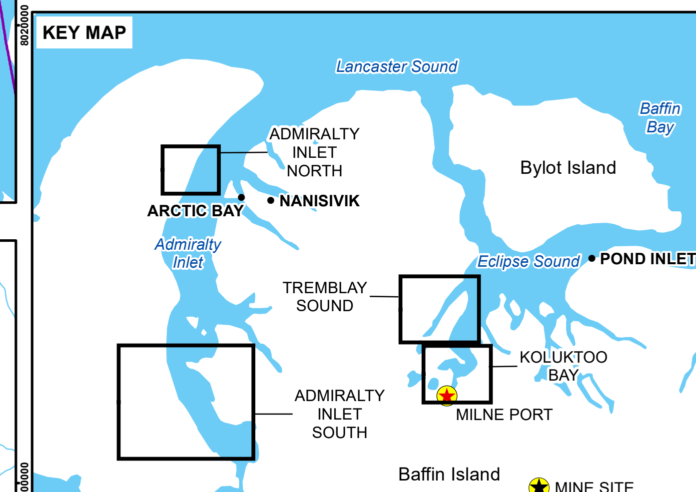
LEGEND

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

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD WHALE
- NARWHAL

KEY MAP



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CLIENT
BAFFINLAND IRON MINES CORPORATION

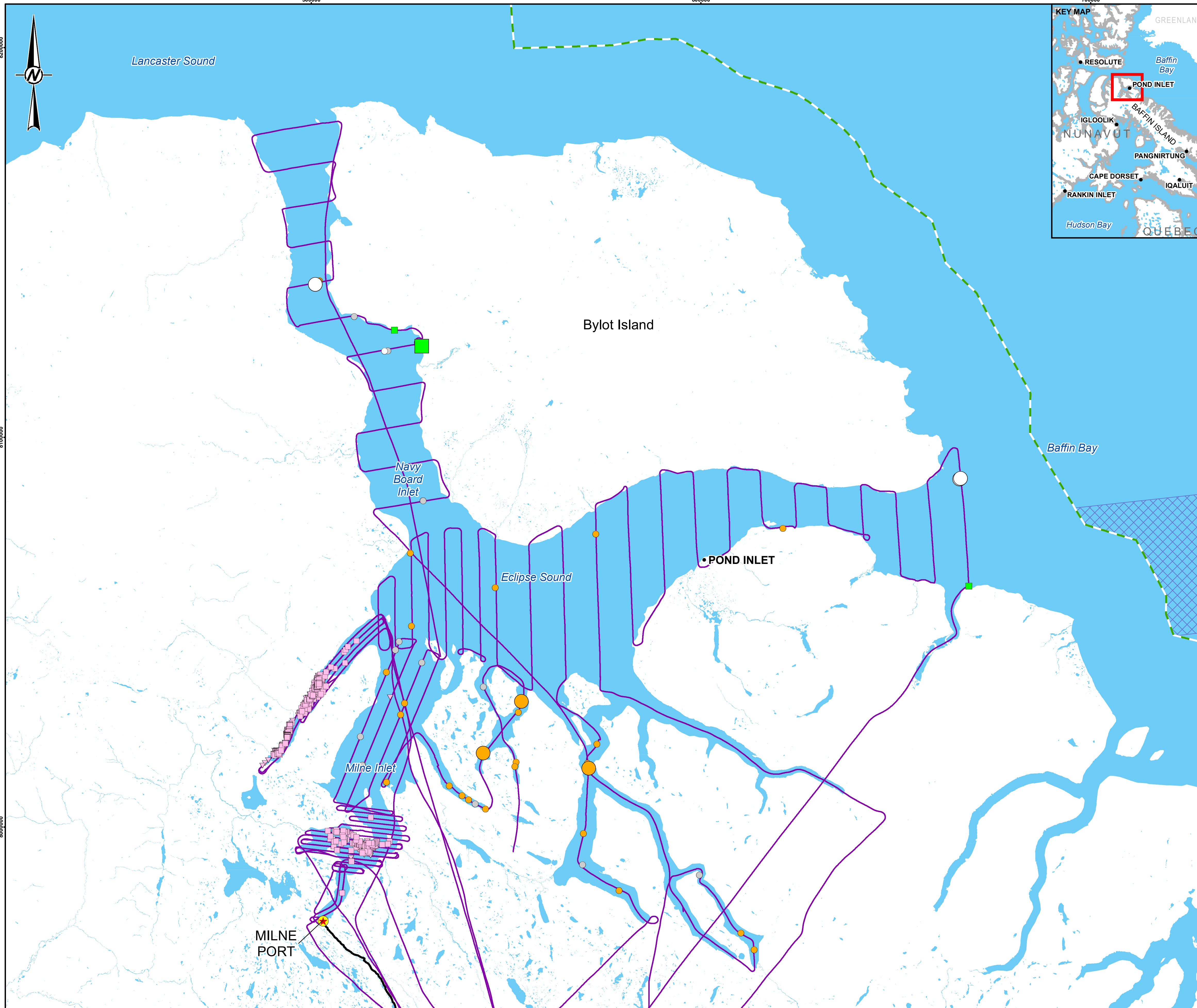
PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
PHOTOGRAPHIC SURVEYS DURING LEG 2 - SURVEY 4 ON 19-21 AUGUST 2021 IN ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	26B



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)

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2-10

NARWHAL
- 1

POLAR BEAR
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1

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. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF MARINE MAMMALS RECORDED DURING LEG 2 - SURVEY 5 ON 26 AUGUST 2021 IN ECLIPSE SOUND GRID

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	27A

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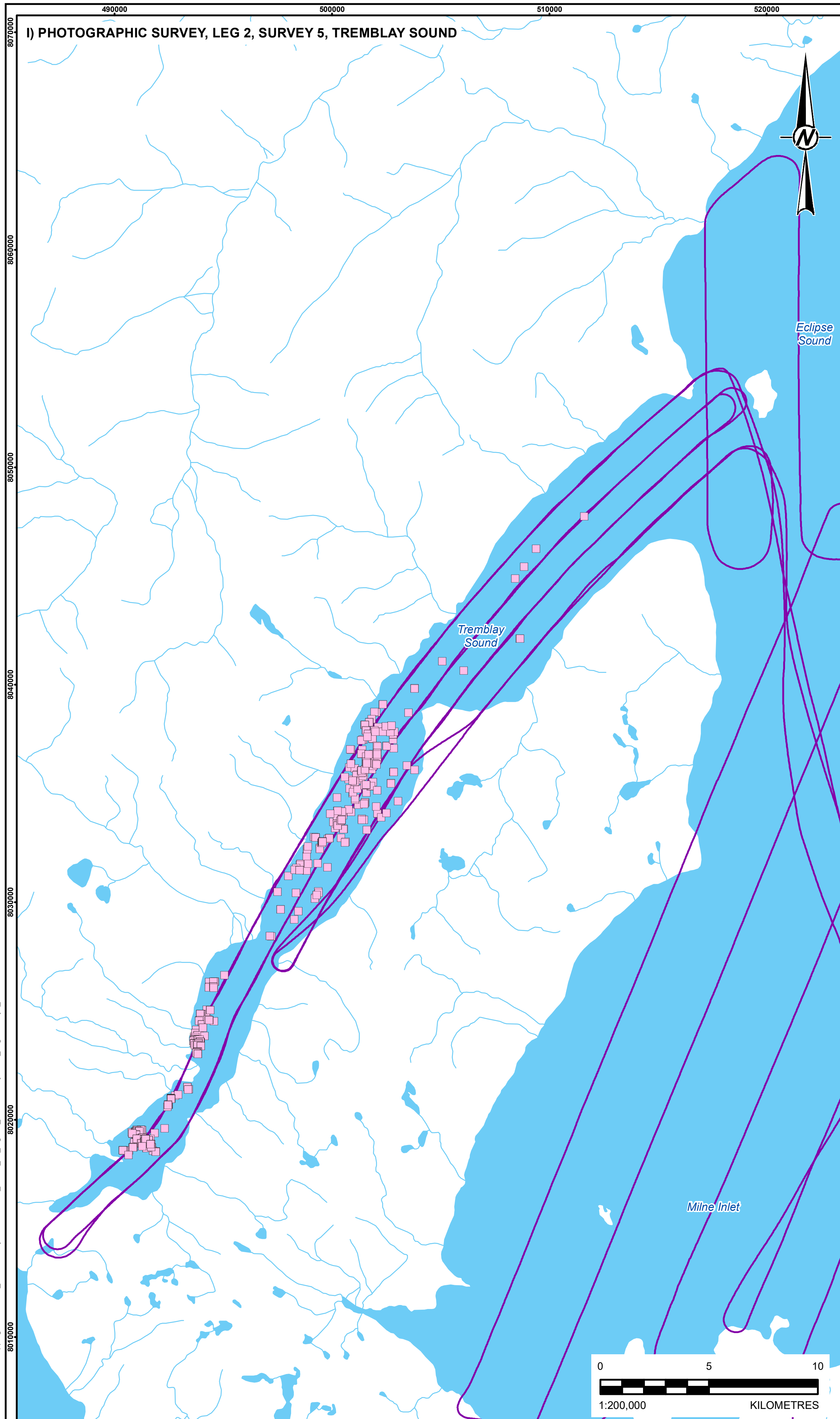
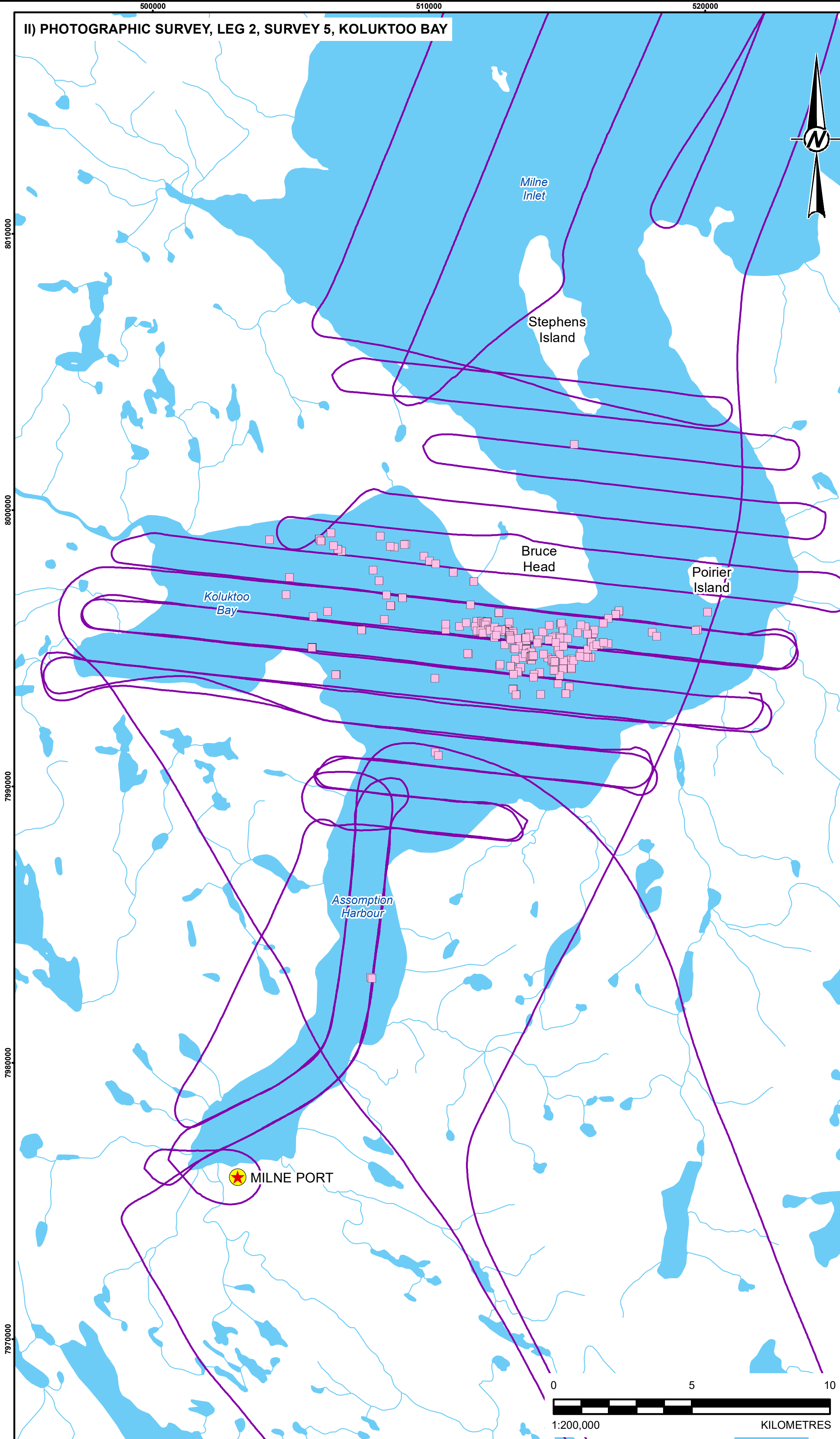




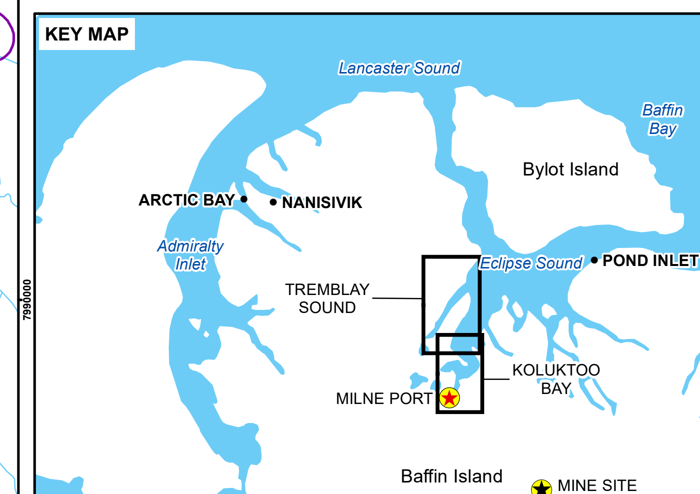
LEGEND

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

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

KEY MAP



REFERENCE(S)

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PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
PHOTOGRAPHIC SURVEYS DURING LEG 2 - SURVEY 5 ON 26 AUGUST 2021 IN ECLIPSE SOUND GRID

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	A	27B

3.5.5 Narwhal Abundance Estimate

Narwhal abundance estimates were only calculated for survey replicates with complete transect coverage and adequate sighting conditions. For the Eclipse Sound survey grid, this included Surveys 1 and 2, 4, and 5. Surveys 1 and 2 were combined due to technical issues. Survey 3 was not retained due to poor sighting conditions including low ceilings and high sea states resulting in incomplete coverage. Survey 4 was completed in two days due to poor photographic survey conditions encountered on the first day. Survey 5 was completed in one day with good sighting conditions.

For the Admiralty Inlet survey grid, analysis of the aerial photographic data for Admiralty (Leg 2) was limited to Surveys 3 and 4. Survey 3 was completed in two days due to deteriorating weather conditions at Mary River and Survey 4 was completed in one day with good sighting conditions. Surveys 1, 2 and 5 were not used for the analysis. Survey 1 was not flown due to poor weather and Surveys 2 and 5 were not completed due to poor sighting conditions.

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 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. Environmental conditions were good for all the surveys chosen to calculate abundances. 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=2) 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 Mark-Recapture Distance Sampling (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 trackline 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. Since the decrease in detections near the trackline was minimal for the data collected in 2021, the gamma key function was not a good fit for the 2021 data. Environmental and observer covariates were included for fitting the detection function and mark-recapture models. Models were selected using the minimum AIC.

The combined narwhal sightings (n=414) 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 28). 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 1,000 m (i.e., discarding sightings beyond 1,000 m).

Model selection was performed on the three key functions and all the combinations of environmental covariates. A half normal key function and covariates for observer pair, glare angle, glare angle and the interaction of glare intensity, 30 second rolling count of observations, and group size had the lowest AIC for detection function models: (g(x)=0.36 and CV=0.04%; 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, distance, observer pair and the interaction of distance, 15 second rolling count of observations, and group size (see Appendix C). It resulted in a p(0) of 0.69 for observers 1 (Figure 29) and 0.57 for observers 2 (Figure 30), and a combined p(0) of 0.86 and (CV=0.03). The combined models resulted in a detection probability of 0.31 (CV=0.05).

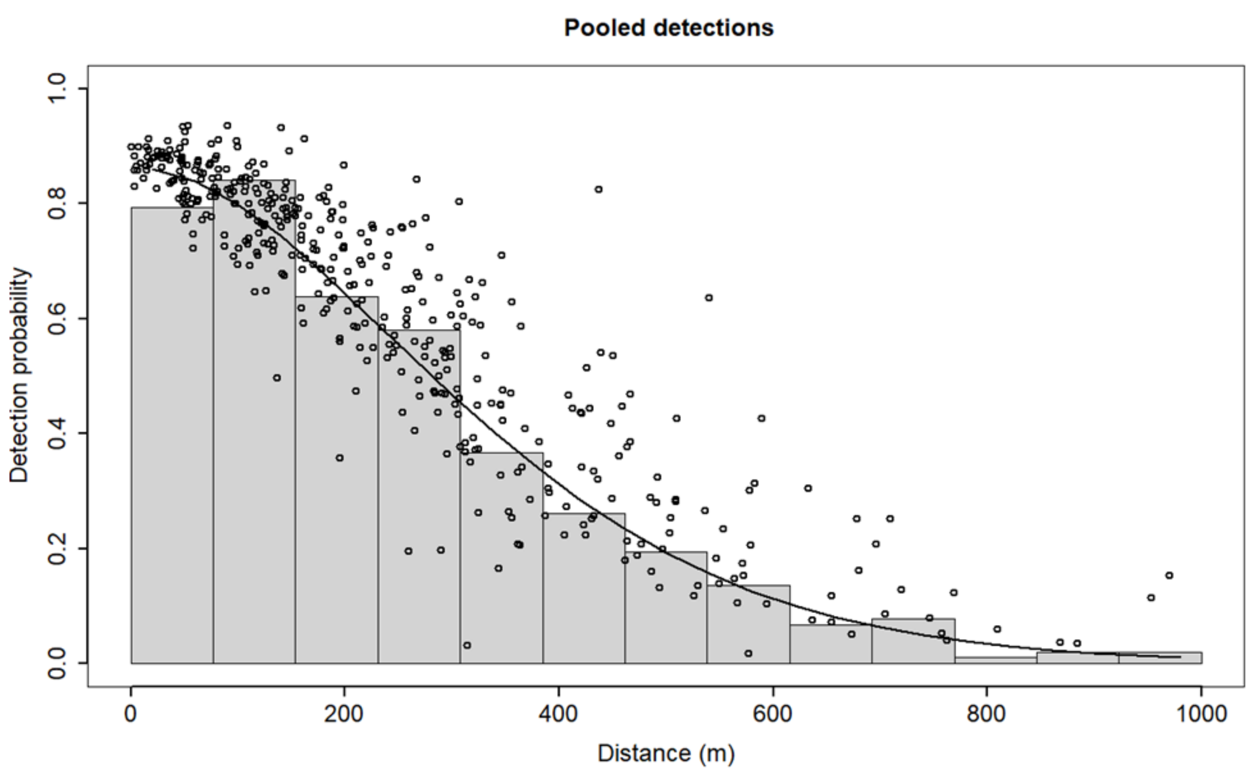


Figure 28: Histogram showing perpendicular distances of narwhal sightings in Eclipse Sound and Admiralty Inlet survey grids. Note: Fitted half normal key function is shown with right truncation at 1,000 m (no left truncation). O = probability of detection for each sighting based on perpendicular distance and other covariates.

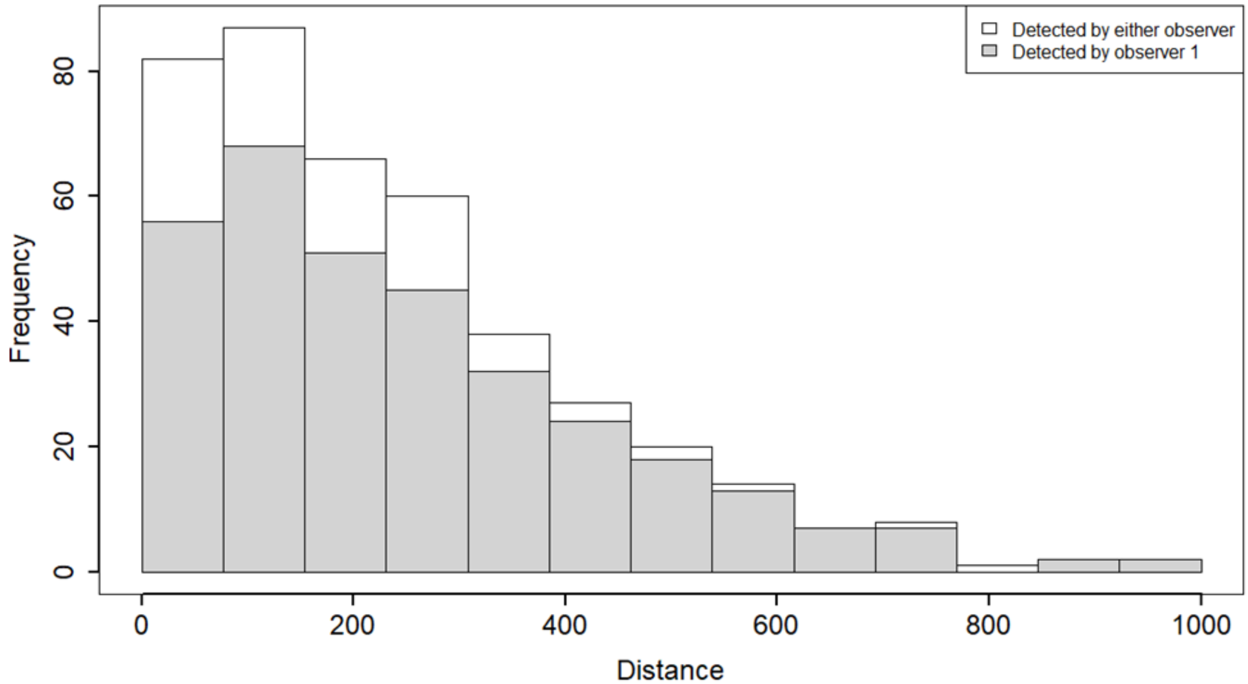


Figure 29: Distribution of narwhal sighting distances for Observer 1 and Combined (Observers 1 and 2) in Eclipse Sound and Admiralty Inlet survey grids.

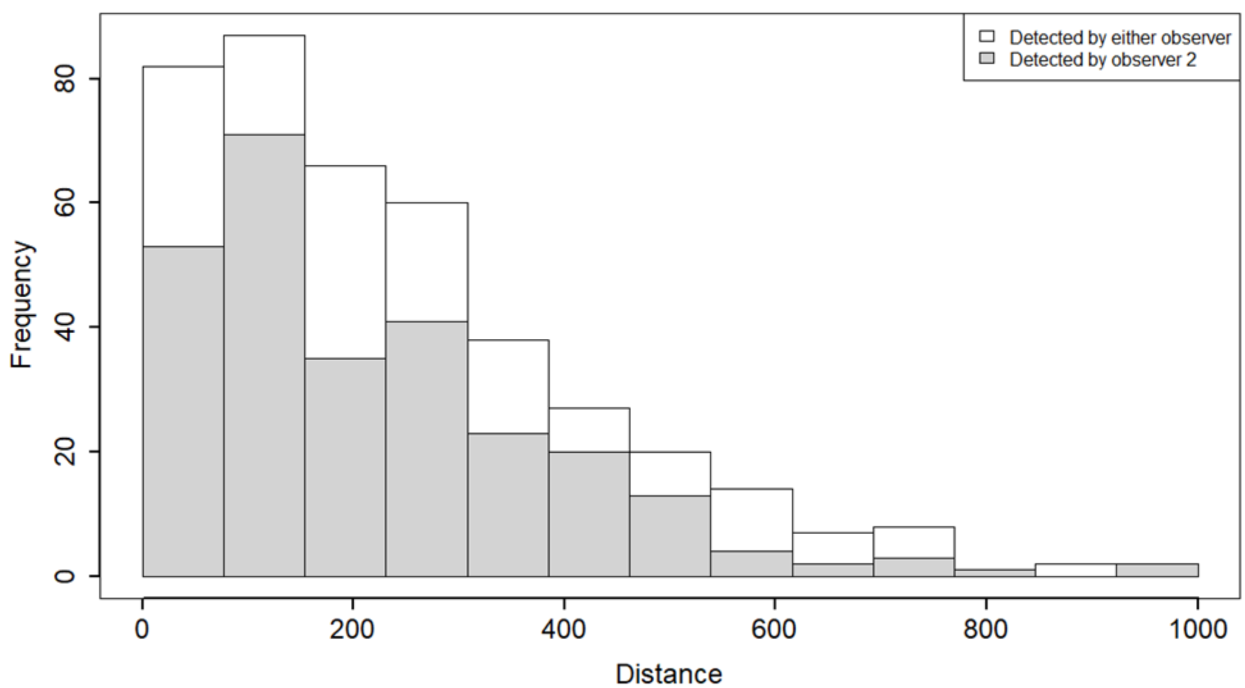


Figure 30: Distribution of narwhal sighting distances for Observer 2 and Combined (Observers 1 and 2) in Eclipse Sound and Admiralty Inlet survey grids.

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 and 2.92, CV=0.03 for late 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 408 photos were highly correlated (simple linear regression; $R^2 = 0.990$, $F_{1,406} = 42.298 \times 10^3$, $p < 0.0001$). Counts for the first and repeat reads were the same for 126 of the 408 photos, differed by one for 123 photos, and by two for 56 photos, by three for 54 photos, by four for 28 photos, by five and six for seven photos, by seven for three photos and by eight for five photos. The original counts were kept for the abundance analysis.

On average, 2.3% of the photos had murky water (see Tables 14 and 17 in Section 3.5.5.3), and 13.5% of the photos had glare (see Tables 14 and 17 in Section 3.5.5.3). Photographs overlapped by an average of 45%.

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 31). Possible factors affecting the detectability bias include camera angle, aircraft crab angle (cross wind), imprecise aircraft altitudes, obscurity of subsurface animals, 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. Environmental conditions were appropriate for all the surveys chosen to calculate abundances.

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 0.9116 ($C_d =$ detectability bias correction factor of 1.10, n=2,260), CV=0.02 (Figure 31). A hazard rate key function with no adjustments had the lowest AIC of 30417.1 for the detection function model.

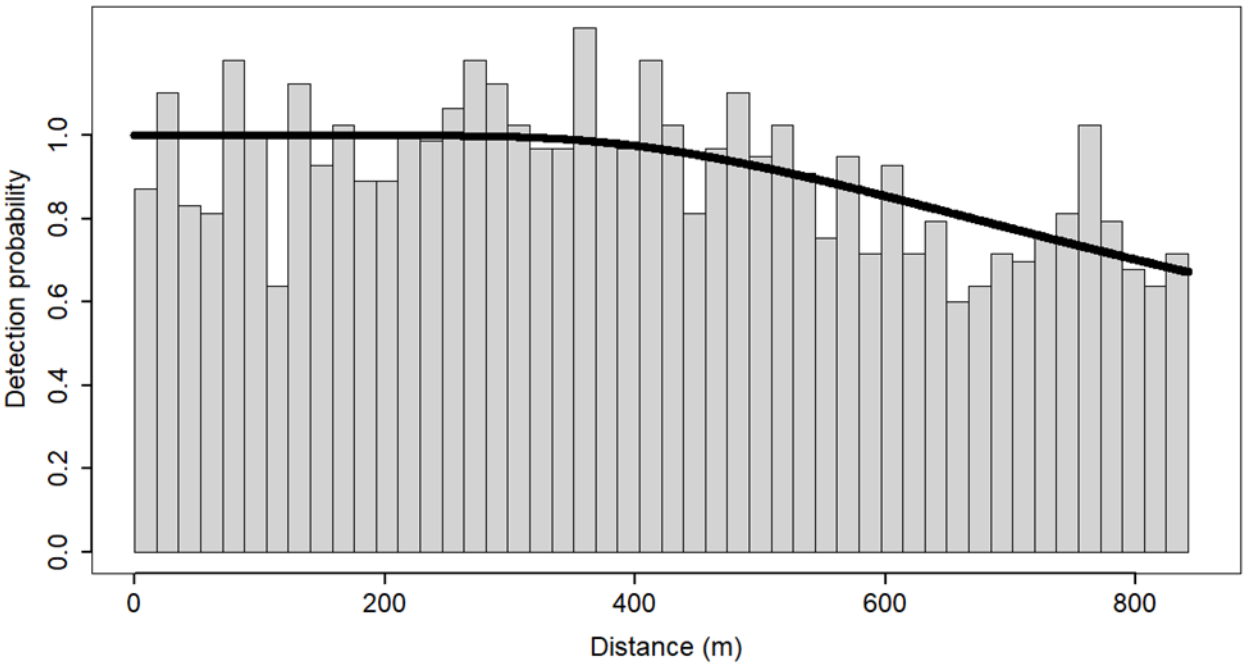


Figure 31: Detection Function for Photographic Survey Data at 610 m (2,000 ft).

3.5.5.3 2021 Narwhal Abundance

3.5.5.3.1 Eclipse Sound Stock

Overall, there were 17 narwhal visual sightings for Surveys 2, 4 and 5 (Table 13). All sightings had perpendicular distances recorded during flight.

During Surveys 2 (10 August), a total of 1,064.5 km of transects were visually surveyed (Table 13). The total count of narwhal sightings observed on-effort in the visual survey area was three sightings before and after truncation (Table 13). 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 13). The total narwhal abundance for Survey 2 combined visual surveys was estimated at 61 narwhal (CV=1.00) (Table 13).

The total length of transect lines visually surveyed during Survey 4 (20 and 21 August) was 1,210.3 km (Table 13). The total count of narwhal sightings observed on-effort in the visual survey area was 13 sightings before and 12 after truncation (Table 13). For this survey, the overall variation in abundance estimates came primarily from the encounter rate and the cluster size component. The total narwhal abundance for Survey 4 visual surveys was estimated at 873 narwhal (CV=0.99) (Table 13).

During Survey 5 (26 August), a total of 1,195.7 km of transects were visually surveyed (Table 13). The total count of narwhal sightings observed on-effort in the visual survey area was one sighting before and after truncation (Table 13). For this survey, the overall variation in abundance estimates came primarily from the encounter rate component (Table 13). The total narwhal abundance for Survey 5 visual surveys was estimated at 20 narwhal (CV=0.96) (Table 13).

Table 13: 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	150.3	0	0	-	-	-	-
2	ESE	2,066.5	228.5	0	0	-	-	-	-
2	ESW	841.0	180.0	0	0	-	-	-	-
2	MIN	681.3	160.7	3	3	61	1.00	99.7	0
2	NBI	2,007.8	145.3	0	0	-	-	-	-
2	Fjords	957.5	199.7	0	0	-	-	-	-
2	***Total***	**7,935.5**	1,064.5	**3**	**3**	**61**	1.00	-	-
4	PI	1,381.3	138.6	0	0	-	-	-	-
4	ESE	2,066.5	226.9	0	0	-	-	-	-
4	ESW	841.0	205.6	0	0	-	-	-	-
4	MIN	681.3	159.4	12	11	857	1.01	88.3	11.4
4	NBI	2,007.8	166.7	0	0	-	-	-	-
4	Fjords	957.5	313.0	1	1	16	1.14	99.8	0
4	***Total***	**7,935.5**	1,210.3	**13**	**12**	**873**	**0.99**	-	-
5	PI	1,381.3	141.7	0	0	-	-	-	-
5	ESE	2,066.5	211.8	0	0	-	-	-	-
5	ESW	841.0	206.4	0	0	-	-	-	-
5	MIN	681.3	158.5	1	1	20	0.96	99.7	0
5	NBI	2,007.8	165.0	0	0	-	-	-	-
5	Fjords	957.5	312.2	0	0	-	-	-	-
5	***Total***	**7,935.5**	1,195.7	**1**	**1**	**20**	**0.96**	-	-

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

During Survey 2 (10 August), two photographic surveys were undertaken, one in Milne Inlet South (MIS) stratum and one in the Tremblay Sound (TS) stratum. Due to technical issues with the photographs taken on 10 August in MIS stratum, the photographic survey that was flown on 8 August in MIS (Survey 1) was used in its place (see Figure 24-B). A total of 2,293 photographs were taken to capture the narwhal aggregations in the two areas. The total area photographed was 425.9 km^2 (272.1 km^2 in MIS and 153.8 km^2 in TS; Table 14). The total count of narwhal in the photographed areas was 1,126 narwhal (760 in MIS and 366 in TS; see Table 12). The sum of the area of the individual photographs totaled 540.1 km^2 in MIS and 253.4 km^2 in TS, resulting in an average density of 1.4 narwhal/km^2 in MIS and TS. Multiplying the average density by the total area photographed resulted in a surface estimate of 383 narwhal in MIS and 222 narwhal in TS. The surface estimate was then corrected for availability bias using C_α=3.18 (correction from Watt et al. 2015), and detectability bias of 1.10, resulting in a total narwhal estimate for the photographed areas of 1,336 narwhal (CV=0.04) in MIS and 775 narwhal (CV=0.04) in TS (Table 14).

During Survey 4 (20 and 21 August), two photographic surveys were undertaken in the Eclipse Sound study area, one in MIS stratum and one in the TS stratum (see Figure 26-B). A total of 2,415 photographs were taken to capture the narwhal aggregations in the two areas. The total area photographed was 425.9 km^2 (272.1 km^2 in MIS and 153.8 km^2 in TS; Table 14). The total count of narwhal in the photographed areas was 966 narwhal (335 narwhal in MIS and 631 narwhal in TS; see Table 12). The sum of the area of the individual photographs totaled 572.6 km^2 in the MIS and 315.2 km^2 in TS, resulting in an average density of 0.6 narwhal/km^2 in MIS and 2.0 narwhal/km^2 in TS. Multiplying the average density by the total area photographed resulted in a surface estimate of 159 narwhal in MIS and 308 narwhal in TS. The surface estimate was then corrected for availability bias using C_α = 3.18 (correction from Watt et al. 2015), and detectability bias of 1.10, resulting in a total narwhal estimate for the photographed areas for Survey 4 of 586 narwhal (CV=0.05) in MIS and 1,136 narwhal (CV=0.05) in TS (Table 14).

During Survey 5 (26 August), two photographic surveys were undertaken, one in MIS stratum and one in the TS stratum (see Figure 27-B). A total of 2,385 photographs were taken to capture the narwhal aggregations in the two areas. The total area photographed was 425.9 km^2 (272.1 km^2 in MIS and 153.8 km^2 in TS; Table 14). The total count of narwhal in the photographed areas was 741 narwhal (269 in MIS and 472 in TS; see Table 12). The sum of the area of the individual photographs totaled 514.6 km^2 in MIS and 280.6 km^2 in TS, resulting in an average density of 0.5 narwhal/km^2 in MIS and 1.7 narwhal/km^2 in TS. Multiplying the average density by the total area photographed resulted in a surface estimate of 142 narwhal in MIS and 259 narwhal in TS. The surface estimate was then corrected for availability bias using C_α=3.16 (correction from Watt et al. 2015), and detectability bias of 1.10, resulting in a total narwhal estimate for the photographed areas for Survey 5 of 493 narwhal (CV=0.04) in MIS and 897 narwhal (CV=0.04) in TS (Table 14).

Table 14: Narwhal abundance estimates from photographic survey in Eclipse Sound grid during Leg 2.

Survey	Stratum[a]	# Photos	# Photos with Murky Water	# Photos wit h Glare	Photo Are a (km^2)	Surface Count	Corrected Abundance	CV
1	MIS	1,472	68	120	272.10	383	1,336	0.04
2	TS	821	3	223	153.84	222	775	0.04
4	MIS	1,535	60	0	272.10	159	586	0.05
4	TS	880	0	2	153.84	308	1,136	0.05
5	MIS	1,521	84	40	272.10	142	493	0.04
5	TS	864	0	248	153.84	259	897	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, 4 and 5) ranged from 1,410 to 2,595 narwhal (Table 15). During Leg 2, Survey 4 was the only survey that flew the combined Eclipse Sound and Admiralty Inlet grids within a three-day period. The other surveys flown in 2021 were missing either the Eclipse Sound grid or the Admiralty Inlet grid. Thus, Survey 4 was selected as the best abundance estimate for the stocks, with the Eclipse Sound stock of 2,595 narwhal (CV = 0.33, 95% CI of 1,369–4,919).

The abundance estimate for Survey 4 (2,595 narwhal, CV = 0.33, 95% CI of 1,369–4,919) was similar to the abundance estimate for Survey 2 (2,172 narwhal, CV = 0.04, 95% CI of 2,005–2,353) and Survey 5 (1,410 narwhal, CV = 0.03, 95% CI of 1,329–1,496) (t-test = 0.48, p = 0.66 and t-test = 1.36, p = 0.27, respectively). The majority of the sightings were based on photographic data for all surveys. Survey 4 had more visual sightings which resulted in a higher coefficient of variation.

Table 15: 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	61	1.00	12 – 312
1/2	Photographic	2,111	0.03	1,989 – 2,241
1/2	**Combined**	**2,172**	**0.04**	**2,005 – 2,353**
4	Visual	873	0.99	172 – 4,429
4	Photographic	1,722	0.04	1,594 – 1,860
4	**Combined**	**2,595**	**0.33**	**1,369 – 4,919**
5	Visual	20	0.96	4 – 98
5	Photographic	1,390	0.03	1,318 – 1,466
5	**Combined**	**1,410**	**0.03**	**1,329 – 1,496**

3.5.5.3.2 Admiralty Inlet Stock

Overall, there were 245 narwhal sightings while on-effort for Surveys 3 and 4 (Table 16). Initially, 50 of the sightings were missing perpendicular distances. After photo-verification of sightings with missing measurements, 35 perpendicular distances were recovered from the photographs, with the remaining 15 left as missing values.

During Survey 3 (15 and 16 August), a total of 1,051.2 km of transects were visually surveyed (Table 16). The total count of narwhal sightings observed on-effort in the visual survey area was 93 sightings before truncation and 91 after truncation (Table 16). Variation of the abundance estimate was a combination of the variation of detection function, encounter rate, cluster size, and availability bias. For Survey 3 the variation in abundance estimates came primarily from the encounter rate and the cluster size component. The total narwhal abundance for Survey 3 visual surveys was estimated at 10,010 narwhal (CV=0.28) (Table 16).

The total length of transect lines visually surveyed during Survey 4 (19 August) was 1,141.8 km (Table 16). The total count of narwhal sightings observed on-effort in the visual survey area was 152 sightings before truncation and 151 after truncation (Table 16). The overall variation in abundance estimates came primarily from the encounter rate and cluster size component. The total narwhal abundance for Survey 4 visual surveys was estimated at 13,038 narwhal (CV=0.43) (Table 16).

Table 16: 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
3	AIN	6,835.4	736.7	18	16	2,576	0.48	84.9	13.8
3	AIS	1,554.4	169.7	75	75	7,434	0.35	94.8	2.8
3	Fjords	756.2	144.8	0	0	-	-	-	-
3	***Total***	***9,146.1***	***1,051.2***	***93***	***91***	***10,010***	***0.28***	-	-
4	AIN	6,770.9	765.8	8	8	1,508	0.56	80.2	18.9
4	AIS	1,389.8	162.3	144	143	11,530	0.49	97.5	1.2
4	Fjords	756.2	213.6	0	0	-	-	-	-
4	***Total***	***8,916.9***	***1,141.8***	***152***	***151***	***13,038***	***0.43***	-	-

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

During Survey 3 (15 and 16 August), one photographic survey was undertaken in the Admiralty Inlet South (AIS) stratum (see Figure 25). A total of 516 photographs were taken to capture the narwhal aggregations in the area. The total area photographed was 97.3 km^2 (Table 17). The total count of narwhal in the photographed areas was 7,643 narwhal (see Table 12). The sum of the area of the individual photographs totaled 185.0 km^2, resulting in an average density of 41.3 narwhal/km^2. Multiplying the average density by the total area photographed resulted in a surface estimate of 4,024 narwhal. The surface estimate was then corrected for availability bias using C_α=3.18 (correction from Watt et al. 2015), and detectability bias of 1.10, resulting in a total narwhal estimate for the photographed area for Survey 3 of 14,037 narwhal (CV=0.04) in AIS (Table 17).

During Survey 4 (19 August), two photographic surveys were undertaken in the Admiralty Inlet study area, one in AIS stratum and one in Admiralty Inlet North (AIN) stratum (Figure 26). A total of 1,762 photographs were taken to capture the narwhal aggregations in the two areas, with a total area photographed of 326.5 km^2 (64.5 km^2 in AIS and 262.0 km^2 in AIN; Table 17). The total count of narwhal in the photographed areas was 27,083 narwhal (5,238 in AIN and 21,845 in AIS; see Table 12). The sum of the area of the individual photographs totaled 115.6 km^2 in AIN and 432.7 km^2 in AIS, resulting in an average density of 45.3 narwhal/km^2 in AIN and 50.5 narwhal/km^2 in AIS. Multiplying the average density by the total area resulted in a surface estimate of 2,923 narwhal in AIN and 13,225 narwhal in AIS. The surface estimate was then corrected for availability bias using C_α=3.18 (correction from Watt et al. 2015), and detectability bias of 1.10, resulting in a total narwhal estimate for the photographed areas for Survey 4 of 10,778 narwhal (CV=0.05) in AIN and 48,766 narwhal (CV=0.05) in AIS (Table 17).

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

Survey	Stratum[a]	# Photos	# Photos Murky Water	# Photos with Glare	Area (km2)	Surface Count	Corrected Abundance	CV
3	AIS	516	0	24	97.3	4,024	14,037	0.04
4	AIN	363	0	48	64.5	2,923	10,778	0.05
4	AIS	1,399	0	564	262.0	13,225	48,766	0.05

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

For the Admiralty Inlet stock, the narwhal abundance estimates calculated for the two survey replicates (Surveys 3 and 4) ranged from 24,047 to 72,582 (Table 18). During Leg 2, Survey 4 was the only survey that flew the combined Eclipse Sound and Admiralty Inlet grids within a three-day period. The other surveys flown in 2021 were missing either the Eclipse Sound grid or the Admiralty Inlet grid. Thus, Survey 4 was selected as the best abundance estimate for the stocks, with the Admiralty Inlet stock of 72,582 narwhal (CV = 0.09, 95% CI of 61,333–85,895).

The abundance estimate for Survey 4 (72,582 narwhal, CV = 0.09, 95% CI of 61,333–85,895) was statistically higher than the abundance estimate for Survey 3 (24,047 narwhal, CV = 0.12, 95% CI of 18,989–30,452) (t-test = 7.04, $p < 0.001$). The majority of the sightings were based on photographic data for both surveys. The difference in abundance estimates between Survey 3 and 4 may be attributed to fewer narwhal being present in the photographic survey areas during Survey 3 compared to Survey 4. This may have been due to natural movement patterns of narwhal in and out of the photographic survey areas. Another potential reason for the difference in abundance estimates between Survey 3 and 4 may be that more narwhal could have migrated into Admiralty Inlet after Survey 3 was flown. If this is the case, then there may be more movement in narwhal stocks during the summer then previously thought.

Table 18: Narwhal abundance estimates from combined visual and photographic surveys in Admiralty Inlet grid during Leg 2.

Survey	Survey Type	Estimate	CV	95% CI
3	Visual	10,010	0.28	5,793 – 17,296
3	Photographic	14,037	0.04	12,935 – 15,233
3	*Combined*	*24,047*	*0.12*	*18,989 – 30,452*
4	Visual	13,038	0.43	5,765 – 29,485
4	Photographic	59,544	0.04	54,626 – 64,904
4	*Combined*	*72,582*	*0.09*	*61,333 – 85,895*

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 one survey (Survey 4) was 75,177 (CV = 0.08, 95% CI of 63,795–88,590) (Table 19). The majority of the sightings were based on photographic data.

Table 19: Narwhal abundance estimates for the combined Eclipse Sound and Admiralty Inlet stocks during Leg 2.

Survey #	Stock	Estimate	CV	95% CI
4	Eclipse Sound	2,595	0.33	1,369 – 4,919
4	Admiralty Inlet	72,582	0.09	61,333 – 85,895
4	*Combined*	75,177	0.08	63,795 – 88,590

3.5.6 Abundance Comparison with Previous Years

During Leg 2, Survey 4 was the only survey that flew the combined Eclipse Sound and Admiralty Inlet grids within a three-day period. The other surveys flown in 2021 were missing either the Eclipse Sound grid or the Admiralty Inlet grid. Thus, Survey 4 was selected as the best abundance estimate for the stocks, with the Eclipse Sound stock of 2,595 narwhal (CV = 0.33, 95% CI of 1,369–4,919), the Admiralty Inlet stock of 72,582 narwhal (CV = 0.09, 95% CI of 61,333–85,895), and the combined Eclipse Sound and Admiralty Inlet stocks of 75,177 (CV = 0.08, 95% CI of 63,795–88,590) (Table 20).

The abundance estimate for the combined Eclipse Sound and Admiralty Inlet stocks was 75,177 narwhal (CV = 0.08, 95% CI of 63,795–88,590; Table 20) based on aerial surveys conducted on 19–21 August 2021. This estimate is statistically higher 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 = 1.82, p = 0.042), the 2019 Baffinland estimate of 38,677 (CV = 0.11, 95% CI of 31,155–48,015) (t-test = 4.64, p < 0.001), and the 2020 Baffinland estimate of 36,044 (CV = 0.12, 95% CI of 28,267–45,961) (t-test = 5.06, p < 0.001). This suggests that narwhal from Eclipse Sound, Admiralty Inlet, and potentially from proximal summer stock areas (i.e., Somerset Island, East Baffin Island) may have used Admiralty Inlet in 2021.

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 (2021 vs 2013: Z-test = 1.82, p = 0.034, 2021 vs 2019: Z-test = 4.64, p < 0.001, 2021 vs 2020: Z-test = 5.06, p < 0.001).

For Eclipse Sound stock alone, the narwhal abundance estimate was 2,595 narwhal (CV = 0.33, 95% CI of 1,369–4,919; Table 20) based on Baffinland's aerial survey conducted on 20–21 August 2021. The 2021 estimate is 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 = 3.25, p = 0.016). The 2021 abundance estimate is also statistically lower 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 = 2.96, p = 0.021), the 2019 abundance estimate of 9,931 (CV = 0.05, 95% CI of 9,009–10,946; Golder 2020a) (t-test = 7.33, p < 0.001), and the 2020 abundance estimate of 5,018 (CV = 0.03, 95% CI of 4,736–5,317; Golder 2021a) (t-test = 2.75, p = 0.026). Calculations of a Z-statistic for the Eclipse Sound stock resulted in similar significance values as the t-statistic (2021 vs 2013: Z-test = 2.96, p = 0.001, 2021 vs 2016: Z-test = 3.25, p < 0.001, 2021 vs 2019: Z-test = 7.33, p < 0.001, 2021 vs 2020: Z-test = 2.75, p = 0.003). This result along with the previously mentioned combined stock estimate suggests a shift of a portion of the Eclipse Sound stock to the Admiralty Inlet summering ground during the summer of 2021.

Table 20: 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**
Eclipse Sound	2021	26 Aug (#5)	1,410	0.03	1,329 – 1,496	Golder 2022b

Stock	Year	Survey Dates (Survey #)	Abundance	CV	95% CI	Source
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**
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**

[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 Admiralty Inlet stock alone, the narwhal abundance estimate was 72,582 narwhal (CV = 0.09, 95% CI of 61,333–85,895; Table 20) based on Baffinland's aerial survey conducted on 19 August 2021. This estimate is statistically higher than the abundance calculated of the 2013 DFO estimate of 35,043 narwhal (CV = 0.42, 95% CI of 14,188–86,553; Doniol-Valcroze et al. 2015a) (t-test = 2.35 p = 0.015), the 2019 Baffinland estimate of 28,746 narwhal (CV = 0.15, 95% CI of 21,545–38,354) (t-test = 5.80, p < 0.001), and 2020 Baffinland estimate of 31,026 narwhal (CV = 0.14, 95% CI of 23,406–41,126) (t-test = 5.40, p < 0.001). Calculations of a Z-statistic for the Admiralty Inlet stock resulted in similar significance values as the t-statistic (2021 vs 2013: Z-test = 2.35, p = 0.009, 2021 vs 2019: Z-test = 5.80, p < 0.001, 2021 vs 2020: Z-test = 5.40, p < 0.001). As mentioned above, this result suggests that narwhal from Eclipse Sound, Admiralty Inlet, and potentially from proximal summer stock areas (i.e., Somerset Island, East Baffin Island) may have used Admiralty Inlet in 2021.

3.6 Discussion

3.6.1 Narwhal Abundance and Distribution

High-level Summary: *Results from the Leg 2 survey indicated that: i) narwhal abundance in Eclipse Sound was statistically lower in 2021 than observed in previous years when aerial surveys were conducted (i.e., 2013, 2016, 2019 and 2020), and ii) the combined narwhal abundance in Eclipse Sound and Admiralty Inlet was statistically higher in 2021 to what was observed in previous years (2013, 2019 and 2020). These results suggest a portion of the Eclipse Sound stock occupied the Admiralty Inlet summering ground during the summer of 2021. The results also suggest there is potentially greater mixing between neighbouring summer stocks (i.e., Admiralty Inlet, Somerset Island, and/or East Baffin Island) than is currently recognized.*

Narwhal stock abundance in the Eclipse Sound grid was significantly lower in 2020 and 2021 than in previous survey years (2013, 2016 and 2019), including years prior to the start of Baffinland's iron ore shipping operations in the RSA (i.e., 2015). The observed decrease in narwhal abundance in the Eclipse Sound grid in 2020 and 2021 was consistent with findings from the 2020 and 2021 Bruce Head study, which indicated that local narwhal relative abundance (total number of narwhal corrected for survey effort) in the Bruce Head study area was substantially lower in 2020 and 2021 than in previous survey years (2014–2019) (Golder 2022a). However, the combined narwhal abundance in Eclipse Sound and Admiralty Inlet was shown to be similar in 2020 to that observed in previous survey years (2013 and 2019); and was statistically higher in 2021 than in previous survey years (2013, 2019 and 2020). Collectively, these results suggest one or more of the following:

- A portion of the Eclipse Sound stock occupied the Admiralty Inlet summering ground during the 2020 and 2021 open-water seasons. Potential primary drivers of displacement considered in 2020 included i) acoustic disturbance effects from icebreaking, ii) acoustic disturbance effects from construction activities (e.g., Year 1 of impact pile driving) associated with the Pond Inlet Small Craft Harbour (SCH) Project, and/or iii) increased killer whale presence in the RSA (Golder 2021c). Note that open-water shipping was not identified as a likely contributing factor to the observed decline in 2020 for reasons identified in Baffinland (2021), and that rationale remains valid for 2021.
- Favorable environmental conditions (e.g., prey availability, ice coverage, lower predation pressure) during the spring and/or summer seasons in Admiralty Inlet may have attracted a larger influx of narwhal from the Eclipse Sound summer stock, and potentially from proximal summer stock areas (i.e., Somerset Island, East Baffin Island) during the 2020/2021 open-water seasons.
- There is a 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 also strongly supported by available IQ (NWNB 2016a, 2016b; QWB 2022).

As noted in Golder (2021c), the above factors may have independently or cumulatively contributed to the observed decrease in narwhal numbers in Eclipse Sound. Prior to the start of the 2021 shipping season, it was not possible to determine whether one of these factors alone was the source of the narwhal decline in Eclipse Sound, whether the combined influence of one or more of these factors was responsible, or whether the observed change was natural in occurrence.

If it was determined that the change in narwhal in the RSA was a result of Project activities, this would be consistent with a high severity response (Southhall et al. 2021) as discussed in Golder 2022a (Section 3.0) and would be considered a significant alteration of natural behavioural patterns of narwhal in the RSA and/or disruption to their daily routine. This finding would be contrary to impact predictions made in the FEIS for the ERP, in that vessel noise effects on narwhal are anticipated to be limited to temporary, localized avoidance behaviour.

Baffinland's commitment to the community of Pond Inlet to not undertake icebreaking during the early shoulder season of 2021 provided an opportunity to determine whether Project activities were the cause of the observed changes in narwhal abundance in Eclipse Sound in 2020 (Baffinland 2021; Golder 2021c). The precautionary and temporary adaptive management measure applied in 2021 eliminated the possibility of acoustic disturbance to narwhal from icebreaking during the timing of narwhal migration into Eclipse Sound in 2021, and also served to avoid the potential for cumulative noise effects associated with the Pond Inlet SCH Project. As a result of this, underwater noise from icebreaking operations was not considered to be an influencing factor on narwhal abundance in Eclipse Sound during the 2021 season. It also provides additional confidence that observed changes in 2020 were likely not a result of Project activities (i.e., early shoulder season icebreaking).

With respect to underwater noise generated by the SCH construction in Pond Inlet, DFO confirmed that impact pile driving undertaken in 2021 was limited to seven days between 24 June and 01 July (DFO 2021), prior to breakup of the landfast ice and what DFO stated to be the possible arrival of narwhal into Eclipse Sound. DFO therefore concluded that underwater noise from pile driving could not be considered an influencing factor on narwhal abundance in Eclipse Sound or nearby waters during the 2021 season (DFO 2021). No further analysis on this can be completed given the lack of publically available data. Any additional analysis would remain the sole responsibility of the Proponent for that SCH construction Project and associated regulatory authorities (i.e., DFO).

<u>Other Considerations:</u>

For the past three consecutive years (2019–2021), 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.

The following is a summary of publicly available IQ regarding the degree of exchange between narwhal occurring in the Eclipse Sound, Admiralty Inlet and East Baffin Island summer stock areas and Inuit insight on what drives the summer distribution and abundance of narwhal in these areas of North Baffin Island:

- Narwhal *move freely throughout the NEBI area. Their distributions and abundances change across NEBI waters between years, showing that individual narwhal do not always return to the same specific areas within NEBI waters every year (QWB 2022).*

- *In spring, narwhal arrive at various areas in waters of NEBI at varying times each year, depending on the development of open water within variable patterns at the floe edges, leads in the ice in various areas, and ice break-up into summer. These patterns and their timing vary from year to year, and can affect the abundance and distributions of narwhal across NEBI waters into August and September (QWB 2022).*
- *Throughout the open-water period, narwhal move as needed for their biological needs like birthing and mating, as well as in response to environmental factors like changing food concentrations, killer whales, and ships. Narwhal also probably move in response to factors largely unknown to humans (QWB 2022).*
- *'I'm sure that you're going to keep saying that Pond Inlet and Arctic Bay narwhal are different stock, different population, but as our Elders have observed and we keep saying at HTO, that is not the case; they're one population. But you don't want to admit that, and we cannot change your mind, because it's been conceived that way. That's that one.' E. Ootoova; 2016 NIRB Public Hearing - 28 November 2016 (NWMB 2016a)*
- *I'm not a hunter anymore. I'm just an Inuk. Long before Qallunaat arrived, Inuit survived solely on wildlife by daily hunting and harvesting, and as observers of these wildlife and these whales, we know that there's peaks and lows of the number of whales, both migratory and summer stocks. And if in a particular year they happen to migrate somewhere else, the department or scientists would say that they decreased, but Inuit would know that they're migrating through somewhere else or for food. And Inuit know that. We Inuit have that knowledge. Inuit are very in tune with the wildlife around them. And I think that it's better if you connect with Inuit at that level. You would understand what we're talking about because it was our daily life, and when we feel that there hasn't really been any change, and when there's a proposal to decrease the number of the TAH, it doesn't really make sense to us. That's what I wanted to say.' Mr. Kilukshak; 2016 NIRB Public Hearing – 28 November 2016 (NWMB 2016a)*
- *'According to the Inuit knowledge, I don't think that is included in this estimate. And they say that there's only one stock, one stock of narwhal from Eclipse Sound and Admiralty Inlet narwhal, one stock. But DFO is considering they're two different stocks, and what was mentioned that the -- are you going to be looking at this when you have that workshop? I know that the communities don't agree with that because you have separated the two stocks. Are you going to be looking at that during the workshop, whether it's one stock or two?' Mr. Irrgaut; 2016 NIRB Public Hearing – 28 November 2016 (NWMB 2016a)*
- *'Go back to the table and really look at the narwhal population. They're not separate. They're not a separate stock like Eclipse Sound or Admiralty Inlet. If there was no more polar bear or narwhal, we wouldn't be having this discussion or debate; but fortunately, there are, so that's why we're talking about summer and migratory stocks. So I give it back to you to recommend to you to put it into one stock because they're not separate.' Mr. Tango; 2016 NIRB Public Hearing - 28 November 2016 (NWMB 2016a)*
- *'Just to supplement that. When there's early ice breakup, the Lancaster Sound to Kitikmeot area, when we didn't have narwhal in our area we heard from Kitikmeot that they have lots of narwhal now. And it's not only the shipping traffic that is contributing to the movement of narwhal. It's early ice breakup that it's obvious they're going further into the western area. Especially this summer, we observed it. It depends year to year, as we keep saying, ever since I can remember as a child, every year is different. And I know that what we're presenting might be of some use.' E. Ootoova; 2016 NIRB Public Hearing - 28 November 2016 (NWMB 2016a)*

- *'Yes, yes. Thank you, Mr. Chairman. As we have been saying, there are a lot of killer whales around when they did the survey. During the month of August, killer whales were around, so the narwhal had to move elsewhere to get away from the killer whales. And perhaps, if there were less killer whales you would have seen more narwhal. Yes, that is the reason why the narwhal were not around because the killer whales were around too much.' Mr. Killiktee; 2016 NIRB Public Hearing - 28 November 2016 (NWMB 2016a)*
- *'Just to add. Yeah, I agree with my fellow board member. I just want to add: August 2013 when they did a survey, there were no other records that they did back in -- there was nothing from 2012, 2014. And we keep saying that they do come back, and they move away. And they do the survey for only a few days in a month, and then they give us a result saying that our narwhal are decreasing so we have to change the total allowable harvest. That's what they told us.' E. Ootoova; 2016 NIRB Public Hearing - 28 November 2016 (NWMB 2016a)*
- *'But I want to reiterate that the narwhal, they don't go back and forth. And I know it will be different in years, because sometimes there are more in Eclipse Sound, and some years there are more in Admiralty Inlet. I know that there's going to be a narwhal in Eclipse Sound all the time, and I know that because there's just one stock that go back and forth between Admiralty Inlet and Eclipse Sound, and when they were -- we're not trying to distinguish the two different ones, and I know they are the same population. When they come through Eclipse Sound, some stay around, and some go over to Admiralty Inlet, and then they come back to Eclipse Sound after Admiralty Inlet. But nowadays there are more migratory narwhal perhaps because the sea ice is decreasing. So they are migrating west, more west. And if there were no more narwhal in Pond Inlet -- and I know that our narwhal would also decrease, but now we're not concerned about that right now because they keep going back and forth, depends what kind of a year it is. There was lots of narwhal in Admiralty Inlet, so they're increasing, and maybe they had moved over to Admiralty Inlet from Eclipse Sound.' Mr. Naqitarvik; 2016 Public NIRB Hearing – 29 November 2016 (NWMB 2016b)*
- *'Yes, we believe that it is one stock going to Admiralty Inlet and Eclipse Sound.' Mr. Attitaq; 2016 Public NIRB Hearing – 29 November 2016 (NWMB 2016b)*
- *'When Arctic Bay and Pond Inlet have stated that it's one stock, they usually migrate through Pond Inlet waters, and then they dive and go to Arctic Bay, Admiralty Inlet, and there's no more whales in Pond because they're in Arctic Bay area; and then when they migrate back -- when there's none left in Arctic Bay, there's lots of whales in Pond Inlet. That's how they're always continuously moving forward, moving forward.' Mr.Qaunaq; 2016 Public NIRB Hearing – 29 November 2016 (NWMB 2016b)*

In summary, despite the adaptive management measure of eliminating underwater noise from icebreaking in 2021, results from the 2021 monitoring programs again indicated lower narwhal numbers in Eclipse Sound during the 2021 shipping season. Underwater noise from open-water shipping was also not considered to be a likely cause of narwhal displacement from the RSA based on the available monitoring results collected to date (Austin et al. 2022; Baffinland 2021; Golder 2020d, 2021b).

Given that the combined stock estimate for Admiralty Inlet and Eclipse Sound indicates that the regional narwhal population remains 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 decrease in narwhal relative abundance in Eclipse Sound likely reflects natural exchange between the two putative stock areas, or alternatively, that animals shifted to Admiralty Inlet due to more favorable ecological conditions related to sea ice conditions, prey availability and/or predation pressure.

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 that ocean warming has resulted in species distribution shifts for both marine mammals in the Arctic (Laidre et al. 2008, 2015; Frederiksen and Haug 2015; Nøttestad et al. 2015; Víkingsson et al. 2015; Albouy et al. 2020; Chambault et al. 2020, 2022; NAAMCO 2021) and their prey (Frainer et al. 2017; Møller and Nielsen 2020). How this might be manifesting on a micro-geographic scale in the North Baffin region is presently unclear.

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 suggest that the current distribution of Baffin Bay narwhal during summer will undergo a +200 km northward shift 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 by between 31 and 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 explanation of 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

3.6.2 Program Integration

To better understand potential short-term, long-term, and cumulative effects of vessel noise on narwhal and other marine mammals in the RSA, Baffinland has implemented follow-up monitoring programs since 2013 aimed at evaluating the potential effects of Project vessel noise on marine mammals. Several indicators and tiered thresholds have been proposed to evaluate and respond to potential Project effects on narwhal and are identified in the Marine Mammal Trigger Action Response Plan (TARP), which is part of Baffinland's draft Adaptive Management Plan (AMP) in support of Baffinland's Phase 2 Proposal for the Project (see Section 1.4 of Golder 2022a) (Baffinland 2019). While the TARP has not been formally agreed to or accepted by Parties, its contents do represent the most advanced thinking on the subject of tiered adaptive management with respect to marine mammals. The TARP uses a broad range of effect indicators that are measured against a series of tiered thresholds (i.e., low, moderate and high-risk thresholds), which are designed to guide short-term and long-term adaptive management strategies. In addition to considerations for the aerial survey program, thresholds have been developed and can be applied to monitoring programs including the Bruce Head Shore-based Monitoring Program, the narwhal tagging program, and the Passive Acoustic Monitoring (PAM) program.

3.6.2.1 Bruce Head Shore-based Monitoring Program

Shore-based monitoring of narwhal along the Northern Shipping Route has been undertaken over an eight-year period at Baffinland's Bruce Head field station (2013–2017; 2019–2021) (Thomas et al. 2014; Smith et al. 2015, 2016, 2017; Golder 2018c; Golder 2020b, 2021b, 2022a). The objective of the Bruce Head Shore-based Monitoring Program is to investigate narwhal response to shipping activities in Milne Inlet. The Bruce Head Shore-based Monitoring Program data were analysed to assess whether there were significant alterations in narwhal group behaviour in relation to vessel proximity, including group size, group spread, group formation, group direction, travel speed, and distance from shore (Golder 2022a). Results of the 2021 Bruce Head behavioural study demonstrated that narwhal responses to shipping ranged from no significant alteration in behaviour (for travel speed and group formation), to low (for group direction and direction from shore) or moderate severity level responses (for group size and group spread) which would not be considered a significant behavioural response and would not be expected to result in a significant alteration of natural behavioural patterns by narwhal in the RSA or disruption to their daily routine (Golder 2022a). Narwhal behavioural responses to open-water shipping were consistent with impact predictions (limited to temporary, localized disturbance) and no additional adaptive management measures were recommended at this stage to mitigate for open-water shipping impacts on narwhal in the RSA (Golder 2022a).

The Bruce Head Program involves the use of several indicators that are aimed at the rapid identification of adverse impacts on narwhal along the Northern Shipping Route, consistent with requirements outlined in Project Certificate (PC) Condition No. 110 and 112. One of these indicators has been formally identified as the early warning indicator (EWI) for Project effects on narwhal, based on consolidated input from members of the Marine Environmental Working Group (MEWG) since 2019. This EWI is defined as a 'decrease in the proportion of immature narwhal (defined as calves and yearlings) relative to the observed population' (Golder 2020e). This EWI, was originally proposed by DFO and was also confirmed as being of high importance by the MHTO (Golder 2020b). In 2021, results from the multi-year Bruce Head dataset indicated that the proportion of immature narwhal in the observed population in 2021 was 0.102. This was lower than all previous sampling years, representing a 24% decrease from the 2014-2015 baseline condition. However, the observed change was not statistically significant from the baseline condition (p=0.13; Golder 2022e). The analytical model had sufficient statistical power (≥0.8) to detect effect sizes of -55% or +55% in the comparison of 2021 data relative to baseline (Golder 2022a). The effect size observed in 2021 (24%) may have been attributable to the low sample size observed in 2021 (i.e., few narwhal were present in the study area in 2021 compared to previous survey years). Although the 2021 EWI value did not exceed the defined threshold for this indicator, the results did suggest a decreasing trend in the annual proportion of immatures relative to the observed population that warranted further investigation. As a result, Golder recommended that Baffinland undertake an equivalent EWI analysis using available photographic aerial survey data (1000 ft. altitude surveys) to investigate whether the observed change at Bruce Head in 2021 was likely a reflection of the low sample size observed in that year, or was evidence of a decreasing proportion of immature narwhal within the regional population (i.e., Eclipse Sound summer stock).

This additional EWI analysis was completed in September 2022 with detailed results presented in Appendix E. A summary is provided below:

- For the Admiralty Inlet summer stock area (where no Project shipping occurs), EWI aerial survey results demonstrated that the proportion of immature narwhal decreased from 0.158 in 2020 to 0.142 in 2021.
- For the Eclipse Sound summer stock area (where Project shipping occurs), EWI aerial survey results demonstrated that the proportion of immature narwhal increased from 0.117 in 2020 to 0.128 in 2021.
- For comparative purposes, the proportion of immature narwhal in the Eclipse Sound stock was 0.15 in 2014 (pre-Project shipping) and 0.11 in 2015 (first year of iron ore shipping) (Moulton et al. 2019). The 2020 and 2021 EWI values therefore fall within range of the EWI estimates for 2014 and 2015.When looking at the Milne Inlet strata independently, the aerial survey EWI results were in agreement with the Bruce Head EWI results in that they demonstrated a decrease in the proportion of immature narwhal in Milne Inlet from 0.134 in 2020 to 0.075 in 2021. A reverse pattern was observed in Tremblay Sound, where the proportion of narwhal increased from 0.092 in 2020 to 0.156 in 2021. The variability observed between strata does not appear to be shipping-related as shipping levels in the RSA were similar in 2020 (72 ore carriers) compared to 2021 (73 ore carriers).
- There does appear to be variability between years, but there is no indication that the proportion of immature narwhal in the RSA in 2021 has declined compared to 2020 or 2014–2015 levels.
- The 2020 and 2021 EWI aerial survey data were associated with high variability and low sample sizes, resulting in high uncertainty of the EWI estimates, and hence low power to detect small- and medium-sized effect sizes.

3.6.2.2 Narwhal Tagging Program

The behavioral response of narwhal to vessels transiting the Northern Shipping Route, was also studied using data obtained from narwhal tagging programs in 2017 and 2018 in Tremblay Sound (Golder 2020d). A total of 24 narwhal were live-captured in Tremblay Sound during the summer of 2017 and 2018 (20 narwhal in 2017 and four narwhal in 2018) and instrumented with a combination of biologging tags. Biologging tags monitored the fine-scale lateral movements of narwhal, their dive behavior, and habitat use throughout their summering grounds in the coastal fjord system of northern Baffin Island. Behavioral response of narwhal to Project ore carriers and other non-Project related vessel traffic present within the RSA was investigated by comparing animal-borne tag data with Automated Identification System (AIS) vessel-tracking data collected during the 2017 and 2018 shipping seasons. The results from the 2017 and 2018 narwhal tagging study demonstrated that vessel-generated noise effects on narwhal will be limited to temporary, short-term avoidance behavior, consistent with low to moderate severity responses identified in Section 2.6.3 of the Integrated Narwhal Tagging Study (Golder 2020d). No evidence was observed of large-scale avoidance behavior, displacement effects, or abandonment of the summering grounds (i.e., high severity responses), which might in turn result in a population or stock-level consequence (consistent with the definition of a non-significant effect used in the FEIS for the ERP).

3.6.2.3 Underwater Acoustic Monitoring Program

Results presented in JASCO's 2021 Acoustic Monitoring Report (Austin et al. 2022) demonstrate that narwhal would be exposed to sound levels exceeding the established acoustic disturbance for toothed whales (broadband sound pressure level {SPL} of 120 dB re 1 uPa) for less than one hour per day. The report further states that these results are consistent with impact predictions in that acoustic effects would be localized and temporary, and there would be substantial periods in each day when marine mammals are not disturbed by Project vessels.

Another acoustic study (Sweeney et al. 2022) in the North Baffin region was recently undertaken, in which weighted SPL (a metric that accounts for a narwhal's hearing abilities at different acoustic frequencies) were used to assess shipping noise impacts on narwhal in Milne Inlet. Results of this study demonstrated that shipping noise impacts on narwhal and other toothed whales would be negligible at distances beyond several kilometers from the shipping lane, as shipping noise beyond these distances would be largely inaudible to narwhal. The exposure duration associated with a disturbance zone of this size would be equivalent to approximately 20 min per ship transit (equivalent to daily cumulative disturbance period of ~40 min based on an average of two ship transits per day in the RSA). These results are consistent with impact predictions in that acoustic effects would be localized and temporary, and there would be substantial periods in each day when marine mammals are not disturbed by Project vessels.

These acoustic results, combined with results from Baffinland's behavioural response studies referenced above, collectively suggest that open-water shipping is not the likely cause of narwhal displacement from the RSA based on the available monitoring results collected to date.

Further to the above, underwater sounds from active Project-related icebreaking were successfully obtained in Eclipse Sound during the 2019–2020 Passive Acoustic Monitoring (PAM) program (Austin and Dofher 2021). To facilitate collection of this information, the captain of the icebreaker was requested to travel a pre-determined route directly over the underwater recording stations, which would allow for the collection of icebreaking related underwater sound in close proximity to underwater noise recorders. Results from this program indicated that underwater sounds from active Project-related icebreaking were lower than modelling estimates calculated as part of the Environmental Assessment of Icebreaking Operations for Baffinland's Phase 2 Development Proposal (Golder 2019b), demonstrating that the acoustic modelling undertaken in the effects assessment was conservative, and there would be substantial periods in each day when marine mammals are not disturbed by icebreaking noise.

Elimination of icebreaking during the 2021 early shoulder season eliminated the possibility of acoustic disturbance to narwhal from icebreaking during the timing of narwhal migration into Eclipse Sound in 2021. However, despite this mitigation measure, narwhal numbers in the RSA did not increase in 2021. Narwhal disturbance from icebreaking was therefore not considered to be an influencing factor on the observed decline in narwhal abundance in Eclipse Sound during the 2021 season. It also provided additional confidence that the observed decline in 2020 was likely not a result of early shoulder season icebreaking in 2020.

Integrated Program Overview

Collectively, the results from these programs, further inform and substantiate the analysis of the 2021 aerial survey results that indicated that the combined regional narwhal population (Eclipse Sound and Admiralty Inlet stocks) 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 decrease in narwhal relative abundance in Eclipse Sound likely reflects natural exchange between the two putative stock areas, or alternatively, that animals shifted to Admiralty Inlet due to more favorable ecological conditions related to sea ice conditions, prey availability and/or predation pressure.

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 that ocean warming has resulted in species distribution shifts for both marine mammals in the Arctic (Laidre et al. 2008, 2015; Frederiksen and Haug 2015; Nøttestad et al. 2015; Víkingsson et al. 2015; Albouy et al. 2020; Chambault et al. 2020, 2022; NAAMCO 2021) and their prey (Frainer et al. 2017; Møller and Nielsen 2020). 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).

How this might be manifesting on a micro-geographic scale in the North Baffin region is presently unclear. 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 suggest that the current distribution of Baffin Bay narwhal during summer will undergo a +200 km northward shift in order to cope with climate change, and that summer narwhal habitats in this region are predicted to decline by between 31 and 66% (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 explanation of 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

3.6.3 Other Marine Mammals

3.6.3.1 Bowhead Whale

Bowhead whale observations declined substantially prior to the start of the open-water season (Leg 2), suggesting that most bowhead seen during Leg 1 had migrated out of the area prior to 8 August (start of Leg 2). Two bowhead whales were observed in the RSA during the open-water surveys on 20 August, one in Pond Inlet stratum on the south shore of Bylot Island and one in the Eclipse Sound East stratum north of Emerson Island (see Appendix B, Figure B-17). The Bruce Head team reported a single bowhead whale was observed travelling through the study area on 12 August 2021 (Golder 2022a). During previous aerial surveys flown in August in the RSA, 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 dramatically during the open water season. Bowhead relative abundance in the Eclipse Sound grid was low in 2021 (0.0006 animals/km), as in 2020 (0.0003 animals/km) and 2019 (0.0003 animals/km) (see Appendix D). This was consistent with IQ

(JPCS 2017) which included observations of bowhead migrating through the RSA in Aujaq (end of July to September).

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 higher in 2021 (0.0510 animals/km) than in 2020 (0.0087 animals/km) and 2019 (0.0313 animals/km) (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).

3.6.3.2 Killer Whale

In 2021, killer whale were not observed in the Eclipse Sound grid during Leg 2 surveys. However, killer whale were observed by the Bruce Head shore-based monitoring program, where on 10 August 2021 at approximately 06:30, a small pod of four killer whales was observed travelling south through the study area in relatively close proximity to shore (Golder 2022a). The killer whales were observed heading directly toward a group of idle narwhal, at which point several narwhal fled toward Koluktooo Bay, followed shortly after by gulls and fulmars observed gathering in the area near the killer whales. The pod was again observed on 10 August 2021 at approximately 14:30 travelling northbound out of the study area. Leading up to the arrival by killer whales to the area, there were sporadic sightings of narwhal within the study area. No narwhal were observed by the Bruce Head shore-based monitoring program in the study area following the sighting of killer whales. On this day, the aerial survey sighted narwhal deep into Koluktoo Bay and Assomption Harbour.

In Admiralty Inlet, killer whale were observed for the first time in 2021 during aerial surveys for the Baffinland project. Killer whale were observed on two days during Leg 2 visual surveys (Table 11). The first sighting of approximately seven killer whales was observed on 16 August (Survey 3) in the Admiralty Inlet South stratum in close proximity to the concentration of narwhal clumped close to shore on the western side of the Admiralty Inlet (Appendix B; Figure B-15). On the 19 August (Survey 4), three sightings of killer whales (group sizes of 2, 5 and 12) were observed in close proximity to each other in the Admiralty North stratum and near the concentration of narwhal clumped close to shore on the western side of the Admiralty Inlet (see Appendix B; Figure B-16). Killer whales were not observed in the Admiralty Inlet grid during the 2019 or 2020 MMASP (Golder 2020a, 2021a).

3.6.3.3 Beluga Whale

In 2021, beluga were not observed in the Eclipse Sound grid during Leg 2. However, the Bruce Head shore-based monitoring program reported a single beluga was observed in the study area on the afternoon of 8 August 2021 (Golder 2022a). Beluga numbers have been consistently low during the previous surveys in the RSA. One beluga was observed in the RSA during Leg 2 of the 2019 and 2020 MMASP (Golder 2020a, 2021b). Beluga were not observed during Baffinland surveys from 2013 to 2015 (Elliott et al. 2015; Thomas et al. 2015, 2016), suggesting their numbers have always been low in the RSA. In 2007 and 2008, beluga were observed in the RSA in small numbers (three animals in 2007 and 59 animals in 2008; Baffinland 2012).

In Admiralty Inlet, beluga were observed for the first time in 2021 during an aerial survey for the Baffinland project. There were two sightings of a single beluga observed on 11 August (Survey 2) in the Admiralty North stratum during the Leg 2 visual surveys (see Table 11; Appendix B, Figure B-13). One sighting was at the mouth of Moffet Inlet and the other was on the western shore in Admiralty Inlet North. Beluga were not observed in the Admiralty Inlet grid during the 2019 or 2020 MMASP (Golder 2020a; Golder 2021a).

3.6.3.4 Pinnipeds

Pinniped data collected in 2019, 2020 and 2021 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 result from changes in survey conditions and 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 2021 MMASP, similar to what was observed in previous years (Elliott et al. 2015; Thomas et al. 2015, 2016; Golder 2020a). Ringed seal had the highest sighting count of all pinniped species sighted in the 2021 MMASP, accounting for 76% of all known pinniped sightings (384 out of a total of 504). Ringed seal sightings were primarily observed as single animals. The largest group size observed in 2021 was ten animals. During Leg 2, ringed seal relative abundance in the Eclipse Sound grid was also similar in 2021 (0.0702 animals/km) to that observed in the previous year 2020 (0.0736 animals/km) (see Appendix D). A similar pattern was observed in the Admiralty Inlet grid where ringed seal relative abundance was similar in 2021 (0.0920 animals/km) to that observed in 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. Refer to Golder (2022b) for a summary of the 2021 ringed seal aerial survey program which indicates that ringed seal densities have remained stable with some annual variations since the onset of shipping or ice-breaking activities in the RSA.

Harp Seal: Harp seal were observed on all Leg 2 visual surveys. 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). In the Admiralty Inlet grid, harp seals were observed throughout the survey area, although higher numbers were always observed at the mouth of Moffet Inlet in 2021. Harp seal had the highest animal count of all pinniped species sighted in the 2021 MMASP, accounting for 85% of all known pinniped animals (2,658 out of a total of 3,127). Harp seal sightings were primarily observed as groups of animals. The largest group size observed in 2021 was 400 animals. During Leg 2, harp seal relative abundance in the Eclipse Sound grid was slightly lower in 2021 (0.0331 animals/km) than that observed the previous years in 2020 (0.0448 animals/km) and 2019 (0.0527 animals/km) (see Appendix D). In the Admiralty Inlet grid, harp seal relative abundance was higher in 2021 (0.9441 animals/km) than that observed the previous years in 2020 (0.3685 animals/km) and 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 2021 MMASP. Three sightings were recorded during Leg 2 surveys. One sighting of an individual bearded seal was recorded in the Eclipse Sound grid during Survey 4. There were two sightings of an individual bearded seal observed in

Admiralty Inlet grid in Strathcona Sound and Moffet Inlet during Survey 3. 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.

3.6.3.5 Polar Bear

Polar bear sightings have been regularly recorded during the Baffinland aerial survey programs. The distribution of polar bears in 2021 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. Ten of the sightings in Eclipse Sound were of single animals and the other four sightings were of a mother with two cubs. In the Admiralty Inlet grid, polar bears were recorded throughout the study area, although in 2021 most sightings were recorded on the western shore of Admiralty Inlet. Eleven of the sightings in Admiralty Inlet were of single animals, ten sightings were of a mother with one or two cubs, and two sightings were of a group of three bears of unknown age classes.

4.0 LEG 3: CLEARANCE SURVEY

4.1 Objectives

Leg 3 targeted a three-day period at the end of the shipping season in late October. The objective of the Leg 3 surveys was to conduct a visual clearance survey to document whether narwhal entrapment events occurred in the RSA following completion of Baffinland's 2021 shipping operations along the Northern Shipping Route.

4.2 Study Area

Aerial surveys (i.e., narwhal clearance surveys) were flown in the RSA at the end of the shipping season from 29–31 October 2021 (see Figure 2, Section 2.3). Surveys were flown along the shipping corridor and adjacent areas throughout the RSA, including adjoining fjords.

4.3 Materials and Methods

Surveys departed from Pond Inlet and were flown in a de Havilland Twin Otter (DH-6). Leg 3 survey flights consisted of reconnaissance and dedicated, i.e., along the ship route, flights through Eclipse Sound, Milne Inlet, Navy Board Inlet, Tremblay Sound, and adjacent fjords. A single transect was flown down the center of each of the fjords.

Surveys were conducted at an altitude of 457 m (1,500 ft) and a ground speed of 204 km/h (110 kn) so the MMOs could observe further out from the aircraft. When necessary, i.e., to investigate potential sightings or other observations, the aircraft dropped to an altitude of 305 m (1,000 ft) and a ground speed of 185 km/h (100 kn). Four experienced Inuit MMOs and one member of the Mittimatalik Hunters and Trappers Organization (MHTO), all from Pond Inlet, conducted observations during leg 3. Two Inuit MMOs were stationed at the front windows, two at the rear windows and one in a center seat on the left side of the plane. A sixth member of the survey team was seated in the centre seat on the right side of the plane and was responsible for entering sighting data, obtained from the observers, into the database and taking photos of observation conditions and sightings. When possible, a Canon 5DS R DSLR camera with a Zeiss 35 mm f1.4 Milvus ZE lens was used to photograph any sightings observed during surveys.

MMOs broadly scanned the survey area to identify sightings and provide information on weather and ice conditions. During a sighting the MMOs provided details on the species and number of animals in the group. A 'group' was defined as animals within one or a few body lengths of each other and oriented or moving in a similar direction. When possible, observers were instructed to give additional details on the sightings, such as the presence of calves, tusked narwhal, behaviour, and direction of travel.

4.4 Leg 3 Survey Results

The first clearance survey was flown on 29 October, corresponding with loading of the last ore carrier at Milne Port. At the time of the aerial survey, the icebreaker and two tugs were also observed in Milne Port. Total aerial survey effort on 29 October consisted of 4 h and 25 min, covering 900.5 km (Figure 32; see Appendix B, B-20). Most of the survey was flown at a survey speed of 204 km/h (110 knots) and at an approximate altitude of 457 m (1,500 feet) except when the aircraft had to reduce altitude due to low ceilings at the north end of Navy Board Inlet. The aircraft flew west across Eclipse Sound to enter the south end of Navy Board inlet then turned north to fly along the east shore of Navy Board until ceilings were too low to continue, at the north end of Navy Board Inlet. The aircraft returned south tracking along the west shore of Navy Board Inlet, continued along the west shore of Eclipse Sound West, and into Tremblay Sound. After flying through Tremblay Sound tracking closer to the north shore, the aircraft flew out of Tremblay Sound tracking along the south shore. The aircraft continued south following the west coast of Milne Inlet, past Bruce Head, following the shore south through Koluktoo Bay and down to Milne Port. From Milne Port, the aircraft continued tracking along the east shore of Milne Inlet to Ragged Island where it turned along the north shore of Ragged Island. The aircraft then continued flying south along the east side of Ragged Island and east shore of Milne Inlet and into Eskimo Inlet. After flying through Eskimo Inlet, the aircraft crossed overland to survey through White Bay and return to Pond Inlet flying through the middle of Eclipse Sound (Figure 32; see Appendix B, B-20).

There was one narwhal sighting of two individuals, near the northwestern shore of Navy Board Inlet, recorded during the 29 October survey. No other narwhal or marine mammals were observed during the rest of the survey. Almost no ice was observed during the survey; there was some ‘slush’ (grease) ice near the west shore of Navy Board Inlet and a very small amount of ice (grease ice and nilas ice) at the far end (inside) of Eskimo Bay (Figure 32; see Appendix B, B-20).

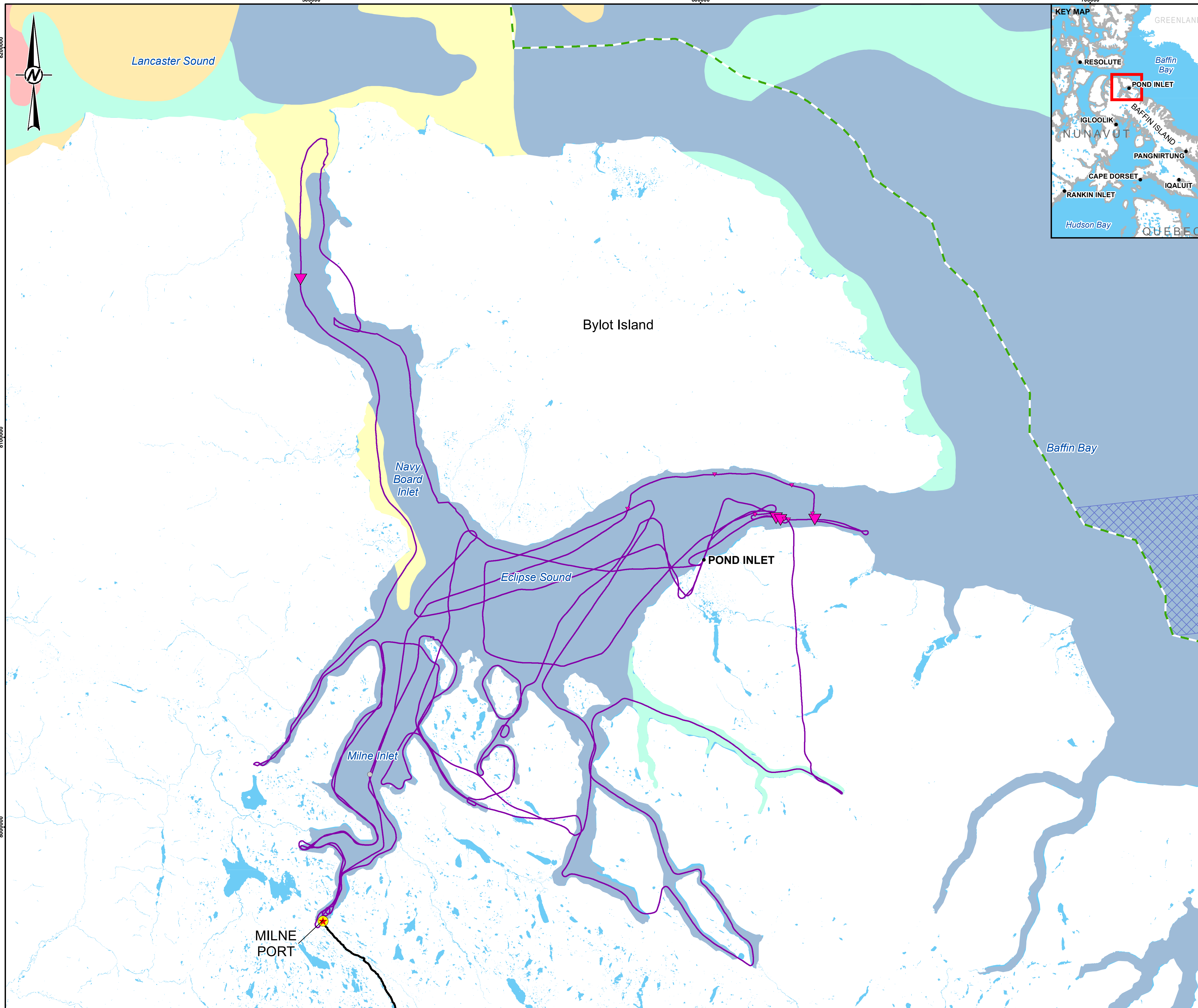
The second clearance survey was flown on 30 October. Total aerial survey effort on 30 October consisted of 2 h and 34 min, covering 661.7 km (Figure 32; see Appendix B, B-21). The aircraft flew the clearance survey at a speed of 204 km/h (110 knots) and at an approximate altitude of 457 m (1,500 ft), transiting initially east towards Baffin Bay until sea states and winds were too high to continue (BF 5-6). The aircraft turned around and continued flying west along the south shore of Eclipse Sound to White Bay where it then flew north crossing Eclipse Sound to fly eastward off the south shore of Bylot Island. Sea state conditions improved to the west and along the south shore of Eclipse Sound (BF 2-4), however, conditions deteriorated again as the aircraft flew east off the coast of Bylot Island. From Bylot Island, the aircraft turned southwest to survey the sounds, including Tay Sound, Paquet Sound and Oliver Sound. After attempting to survey Tay Sound, the aircraft aborted surveying the sounds due to high winds (BF 6+) and departed Tay Sound flying over land to North Milne Inlet and continuing north in Milne Inlet towards Dufour Point, Bylot Island. From Dufour Point, the aircraft flew southwest where conditions appeared to improve in western Eclipse Sound, however sea states deteriorated as the aircraft approached north Milne Inlet (BF 4-5). The aircraft returned to Pond Inlet by flying through Eclipse Sound with sea state conditions picking up again (maximum BF 5) as the aircraft neared Pond Inlet where the survey was ended.

No narwhal, other marine mammals, or vessels were observed during the survey. Historical entrapment areas in the RSA, including south of Bylot Island and north of Ragged Island, were flown during the survey. With exception to some ‘slush’ (grease) ice in western Eclipse Sound, no ice was observed during the survey on 30 October. This ice was possibly the same slush ice observed along the west shore of Navy Board Inlet on 29 October and blown south out of Navy Board Inlet as a result of northerly winds. Winds were too high to finish flying the fjords and sea states too rough to observe ice that may have been in the fjords.

The third clearance survey was flown on 31 October when all Project vessels were confirmed to have left the RSA. The MSV *Botnica* departed the RSA at 08:15 EST, the *Sagar Samrat* at 08:38 EST, and the two tugs at 11:44 and 12:59 EST. Total aerial survey effort on 31 October consisted of 4 h and 38 min, covering 1,306 km (Figure 32; see Appendix B, B-21). The aircraft flew the clearance survey at a speed of 204 km/h (110 knots) and at an approximate altitude of 457 m (1,500 ft), transiting initially eastward towards Baffin Bay towards Mount Herodier along the south shore of Eclipse Sound. This route was recommended by the MHTO representative who indicated narwhal will travel along the south and north shores of Eclipse Sound as they travel to Baffin Bay for the winter.

Not long after flying along the south shore, narwhal were observed off shore near Mount Herodier. The aircraft circled (Figure 32) to assess group sizes and travel direction; there were four sightings of single narwhal and three sightings of two narwhal each (seven sightings of ten individuals total), were spread out along the shore. Most of the narwhal were travelling east towards the entrance to Baffin Bay, except for one individual swimming southwest to the shoreline. After collecting data on the narwhal, the aircraft crossed to the north side of Eclipse Sound to fly west along the south shore of Bylot Island. There were three more sightings of narwhal along this shoreline; two single narwhal travelling east toward Baffin Bay and one single narwhal travelling west. The aircraft continued the survey by flying along the ship track to Milne Inlet and into Assomption Harbour where it turned north to fly through Koluktoo Bay following the shoreline, north into north Milne Inlet along the west shore, and then tracking south along the east shore of Milne Inlet towards Milky Bay. A single unidentified seal was observed swimming north in north Milne Inlet. After flying Milne Inlet, the aircraft flew through Eskimo Inlet to survey Tay, Paquet and Oliver Sounds and then returned overland to Pond Inlet. No other marine mammals were observed for the remainder of the survey flight.

Historical entrapment areas in the RSA, including south of Bylot Island and north of Ragged Island, were flown during the survey. Conditions were mostly good to moderate with sea states ranging BF 1–4 and no clouds except for Oliver Sound where there was light snow and ceilings >610 m (2,000 ft). The aircraft flew at a target altitude of 457 m (1,500 ft) for the entire survey today except in Oliver Sound where it flew at 610 m (2,000 ft). The survey area was ice free through much of the survey area except for some areas where ice was starting to form (grease and nilas ice), including near the shore of south Bylot Island, western Eclipse Sound near the south end of Navy Board Inlet, inside Koluktoo Bay and at the far ends (inside) of Eskimo Inlet, Tay Sound and Paquet Sound.



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

NARWHAL

- 1
- 2-10

UNIDENTIFIED SEAL

- 1

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

ICE CONCENTRATION (OCTOBER 31, 2021)

- < 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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF MARINE MAMMALS RECORDED DURING LEG 3 SURVEYS ON 29-31 OCTOBER 2021 IN ECLIPSE SOUND GRID

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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4.5 Discussion

Very little ice was observed in the RSA over the three days of the Leg 3 surveys. The ice that was observed consisted of 'slush' (grease) ice near the west shore of Navy Board Inlet and a very small concentration of grease ice and nilas ice at the eastern end of Eskimo Bay on 29 October, 'slush' (grease) ice in western Eclipse Sound on 30 October, and a small concentration of grease and nilas ice near the shore of south Bylot Island, western Eclipse Sound near Navy Board Inlet, inside Koluktoo Bay and at the far end (inside) of Eskimo Inlet, Tay Sound and Paquet Sound on 31 October. Very few narwhal were observed during the Leg 3 surveys including one sighting of two narwhal, travelling north through Navy Board Inlet toward Lancaster Sound on 29 October, and ten sightings of a total of 13 narwhal in Pond Inlet stratum (all but two of these narwhal were observed travelling toward Baffin Bay). Given the ice conditions during the Leg 3 surveys (almost none), the numbers and location of confirmed narwhal observations (east of Pond Inlet travelling toward Baffin Bay), and input from the community members who participated in the clearance aerial surveys, there was no concern regarding the risk of entrapment of narwhal caused by the Project at the end of the 2021 shipping season.

5.0 SUMMARY

The 2021 MMASP addressed Project Certificate No. 005 Terms and Conditions 101, 107, 108, 109, 111, and 126. Table 21 demonstrates how Project Certificate Terms and Conditions were met through the 2021 MMASP.

Table 21: NIRB Project Certificate No. 005 Terms and Conditions relevant to the 2021 MMASP.

Project Certificate Terms and Conditions	Condition / Evidence of Conditions Met
101	Efforts to involve Inuit in monitoring studies at all levels: ▪ Inuit involvement was not possible for Leg 1 of the 2021 season due to the COVID-19 global pandemic and ongoing operational restrictions. ▪ Some COVID restrictions were lifting prior to Leg 2 allowing for the involvement Inuit researchers in the field data collection during Legs 2 and 3. 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 were conducted in 2019, 2020 and 2021.
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.
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 observers participated in the Leg 2 and 3 portions of the 2021 MMASP. Inuit involvement was not possible for the Leg 1 portion due to the COVID-19 global pandemic and operational restrictions.

Results from the 2021 aerial survey indicated that: i) narwhal abundance in Eclipse Sound was statistically lower in 2021 than observed in previous years when aerial surveys were conducted (i.e., 2013, 2016, 2019 and 2020), and ii) the combined narwhal abundance in Eclipse Sound and Admiralty Inlet was statistically higher in 2021 to what was observed in previous years (2013, 2019 and 2020). These results suggest that a portion of the Eclipse Sound stock occupied the Admiralty Inlet summering ground during the summer of 2021. The results also suggest there is potentially greater mixing between neighboring summer stocks (i.e., Admiralty Inlet, Somerset Island, and East Baffin Island) than currently recognized.

Despite the adaptive management measure of eliminating underwater noise from icebreaking in 2021, results from the 2021 monitoring programs again indicated lower narwhal numbers in Eclipse Sound during the 2021 shipping season. Underwater noise from open-water shipping was also not considered to be a likely cause of narwhal displacement from the RSA based on the available monitoring results collected to date (Austin et al. 2022; Baffinland 2021; Golder 2020d, 2021b).

Given that the combined stock estimate for Admiralty Inlet and Eclipse Sound indicates that the regional narwhal population remains 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 decrease in narwhal relative abundance in Eclipse Sound likely reflects natural exchange between the two putative stock areas, or alternatively, that animals shifted to Admiralty Inlet due to more favorable ecological conditions related to sea ice conditions, prey availability and/or predation pressure.

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 that ocean warming has resulted in species distribution shifts for both marine mammals in the Arctic (Laidre et al. 2008, 2015; Frederiksen and Haug 2015; Nøttestad et al. 2015; Víkingsson et al. 2015; Albouy et al. 2020; Chambault et al. 2020, 2022; NAAMCO 2021) and their prey (Frainer et al. 2017; Møller and Nielsen 2020). 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).

How this might be manifesting on a micro-geographic scale in the North Baffin region is presently unclear. 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 suggest that the current distribution of Baffin Bay narwhal during summer will undergo a +200 km northward shift in order to cope with climate change, and that summer narwhal habitats in this region are predicted to decline by between 31 and 66% (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 explanation of 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

Comments on the draft 2021 MMASP Report were received from the MEWG in June of 2022. Baffinland's responses to MEWG comments and recommendations on the draft report are included as Appendix F.

6.0 RECOMMENDATIONS

With respect to future monitoring initiatives for the Marine Mammal Aerial Survey Program, Golder provided the following recommendations for implementation in 2022:

- Continuation of the early shoulder season survey if icebreaking resumes in 2022. This survey identifies narwhal movements and distribution in the RSA prior to icebreaking and can help inform vessel transits. UPDATE: As part of precautionary-based adaptive management, Baffinland did not conduct icebreaking operations during the 2022 early shoulder season. Baffinland did however proceed with conducting aerial surveys during the 2022 early shoulder season to assess narwhal movements and distribution during this pre-shipping period.
- With the low narwhal abundances observed in 2020 and in 2021, conduct another August survey to monitor the summer stock abundance of narwhal in Eclipse Sound and Admiralty Inlet. UPDATE: This work was completed in August 2022.
- That Leg 1 and 2 surveys return to two-week surveys given that 2021 Leg 1 and 2 surveys were flown as two consecutive three-week surveys as an adaptive monitoring tool in response to the low narwhal numbers observed in 2020 to ensure continuous monitoring of narwhal distribution and abundance in the RSA. UPDATE: This recommendation was successfully implemented in 2022.
- Conduct photo-analysis of 2020 and 2021 aerial survey data for EWI metrics to help substantiate the values obtained in the Bruce Head Program. UPDATE: This additional analysis was completed with results presented in Appendix E of the present report.

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/technical/49000 2021 marine mammal aerial survey program/05 deliverables/2021 mmasp report/rev0 for wp/1663724-353-r-rev0-49000_2021 mmasp report_14oct-22_pr.docx

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APPENDIX A

MMO Training Manual

REPORT

2021 Marine Mammal Aerial Survey Program

Training Manual

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Table of Contents

TABLES

FIGURES

APPENDICES

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 2021 MMASP is proposed to occur during three separate survey legs: Leg 1 (early shoulder season), Leg 2 (open-water season) and Leg 3 (late shoulder season). The Leg 1 surveys are proposed to occur over a 21-day window in July and early August, 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 determine the relative abundance and distribution of narwhal near the Pond Inlet floe edge prior to and during initial shipping and icebreaking operations. These surveys aim to address identified data gaps for marine mammals along the floe edge during the early shoulder season. Leg 2 surveys are proposed to occur over a 21-day window in August corresponding with the peak open-water period. The objective of Leg 2 surveys is to obtain an updated (2021) 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. Leg 3 surveys are proposed to occur over a 2-day period in late October corresponding with the end of the shipping season. The objective of the Leg 3 surveys is to conduct a visual clearance survey to confirm that no narwhal entrapment events have occurred in the RSA following completion of Baffinland's 2021 shipping operations along the Northern Shipping Route.

3.0 HEALTH AND SAFETY

3.1 Aircraft

Leg 1–3 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 2021 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).

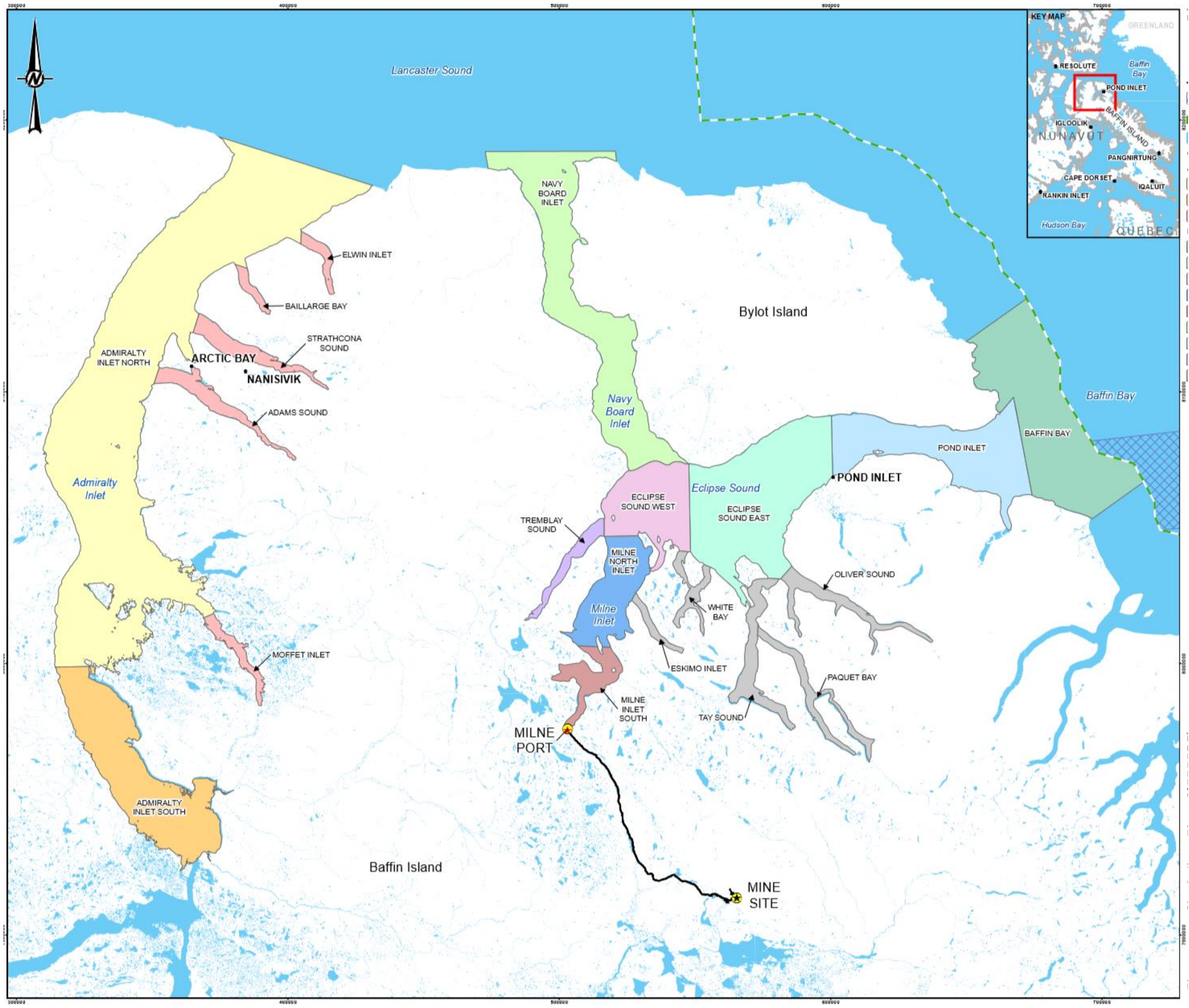


Figure 2: Geographic strata for Eclipse Sound Grid (on the right) and Admiralty Inlet Grid (on the left).

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).

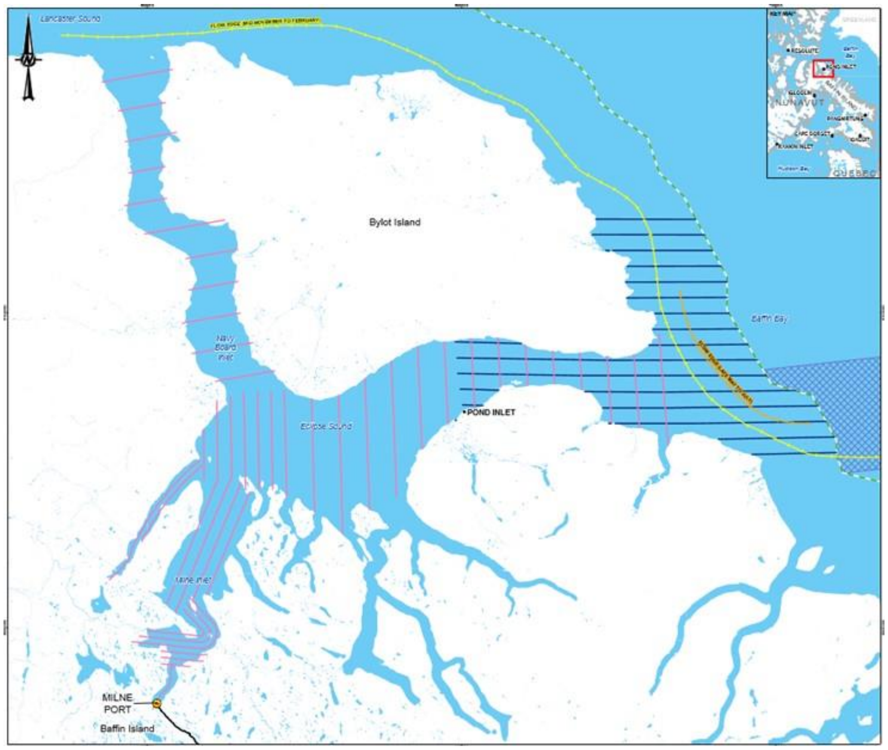


Figure 3: Leg 1 transect lines for the Eclipse Sound study area.

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.

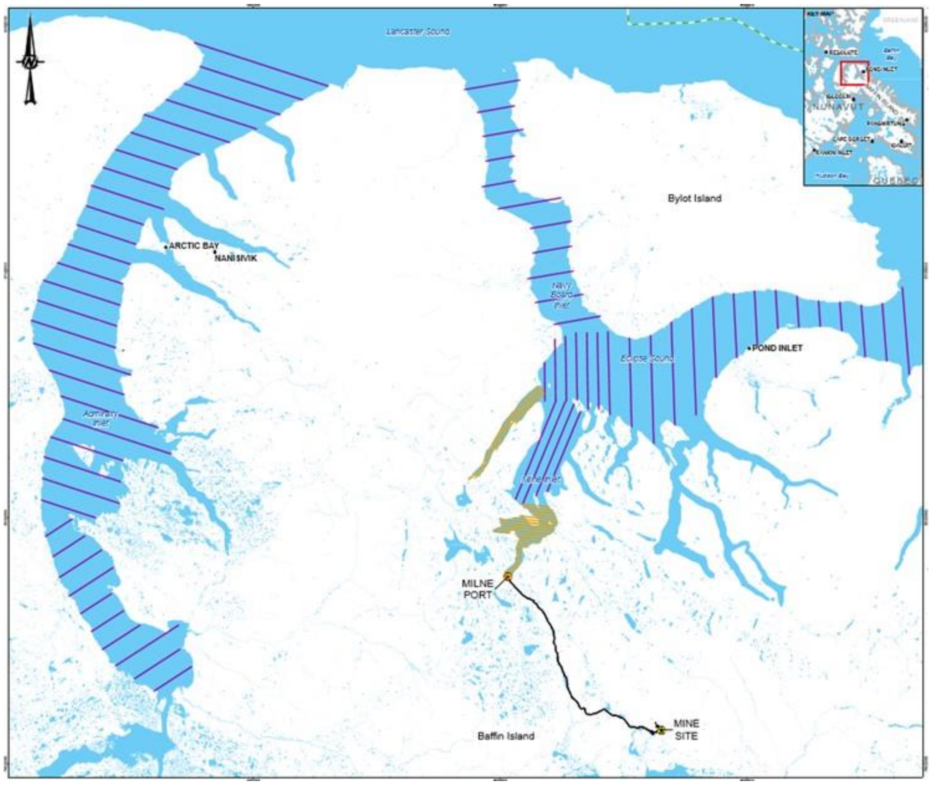


Figure 4: Leg 2 transect lines for the Eclipse Sound and Admiralty Inlet study areas.

Leg 3 study area will focus on the Eclipse Sound Grid with the exclusion of the Baffin Bay stratum. Leg 3 will be flown as a visual clearance survey to confirm that no narwhal entrapment events have occurred in the RSA following completion of Baffinland's 2021 shipping operations along the Northern Shipping Route. Areas flown in this survey will include areas of high ice concentrations along the shipping corridor and areas of known past entrapments.

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.

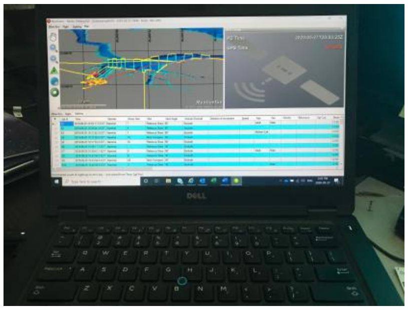
Geometer

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-down 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.

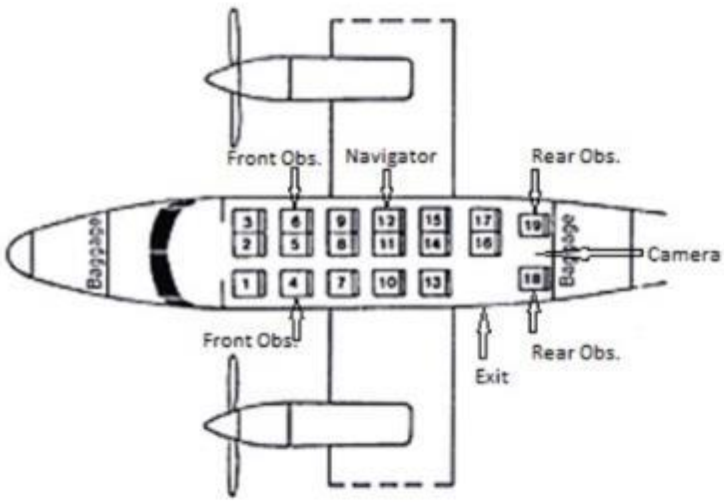


Figure 5: Twin Otter aircraft configuration with aerial crew locations

7.1 Navigator/Data Manager

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.

Sighting Type	Code	Description
	Resting	Animal lying motionless at the surface of the water or on the ice/land.
	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).
	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.

9.0 REFERENCES

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Golder Associates Ltd. 2020. 2019 Marine Mammal Aerial Survey. Golder Report No.1663724-191-R-Rev0. Prepared by Golder Associates Ltd., Victoria, BC for Baffinland Iron Mines Corporation, Oakville, Ontario. 98 p.

Golder Associates Ltd. 2021. Draft 2020 Marine Mammal Aerial Survey. Golder Report No.1663724-270-R-RevB. Prepared by Golder Associates Ltd., Victoria, BC for Baffinland Iron Mines Corporation, Oakville, Ontario. 99 p.

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.

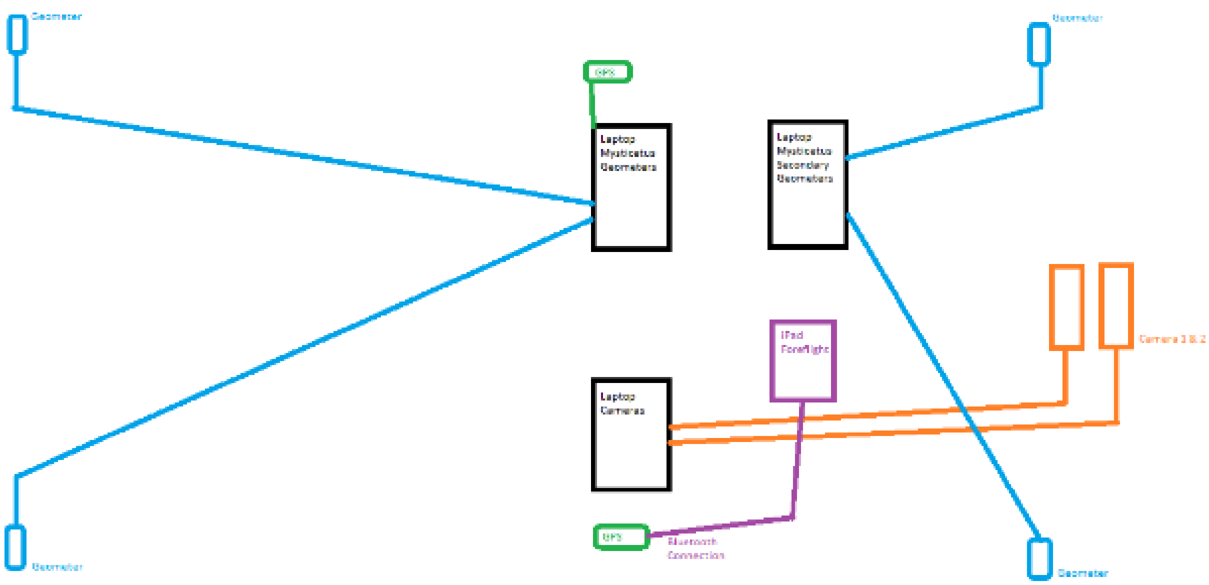
Inverter

- 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 (eg 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:

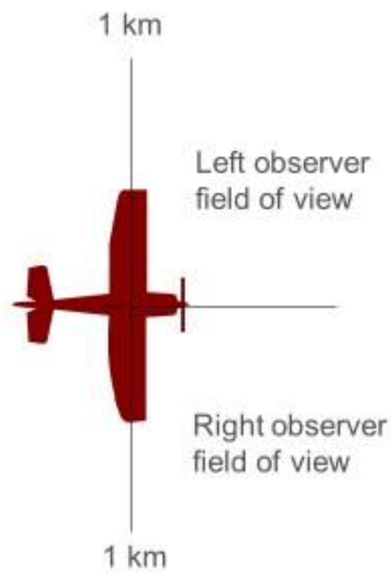
- Ice cover
- Wind force
- Glare
- Fog

Sighitng 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

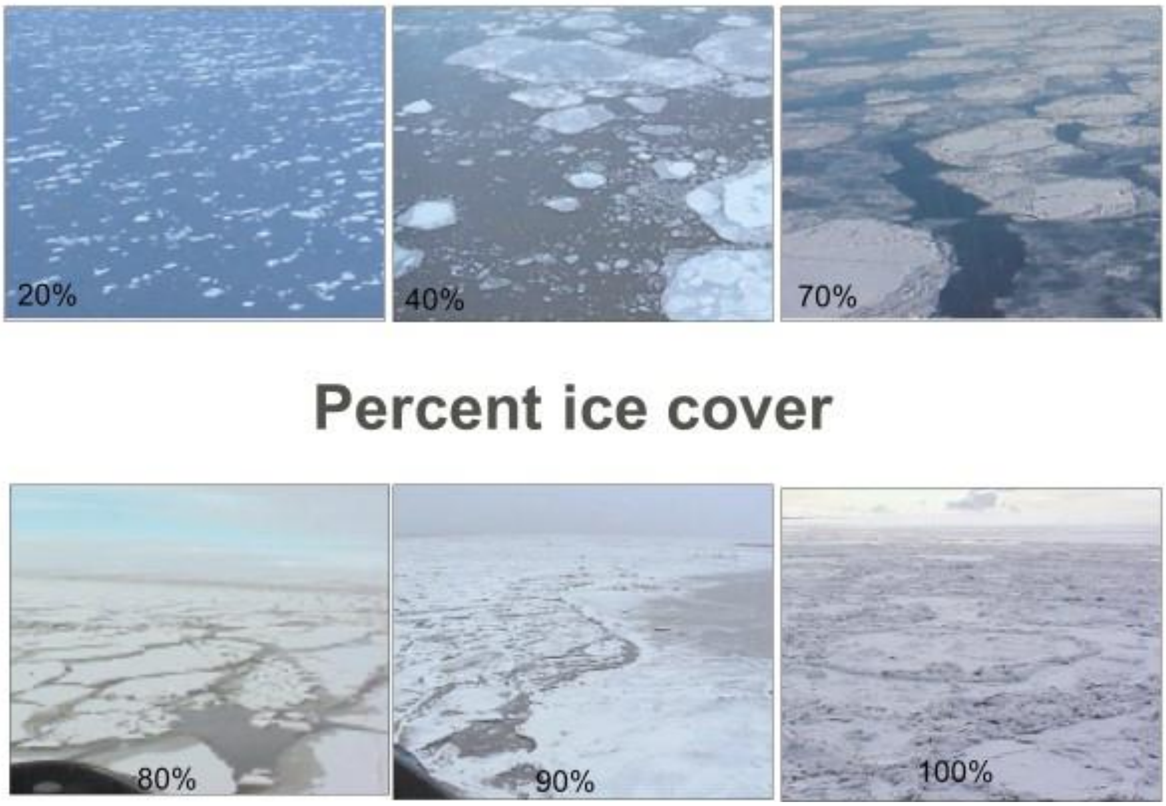


Environmental Data

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

Subjective

Based on average of conditions

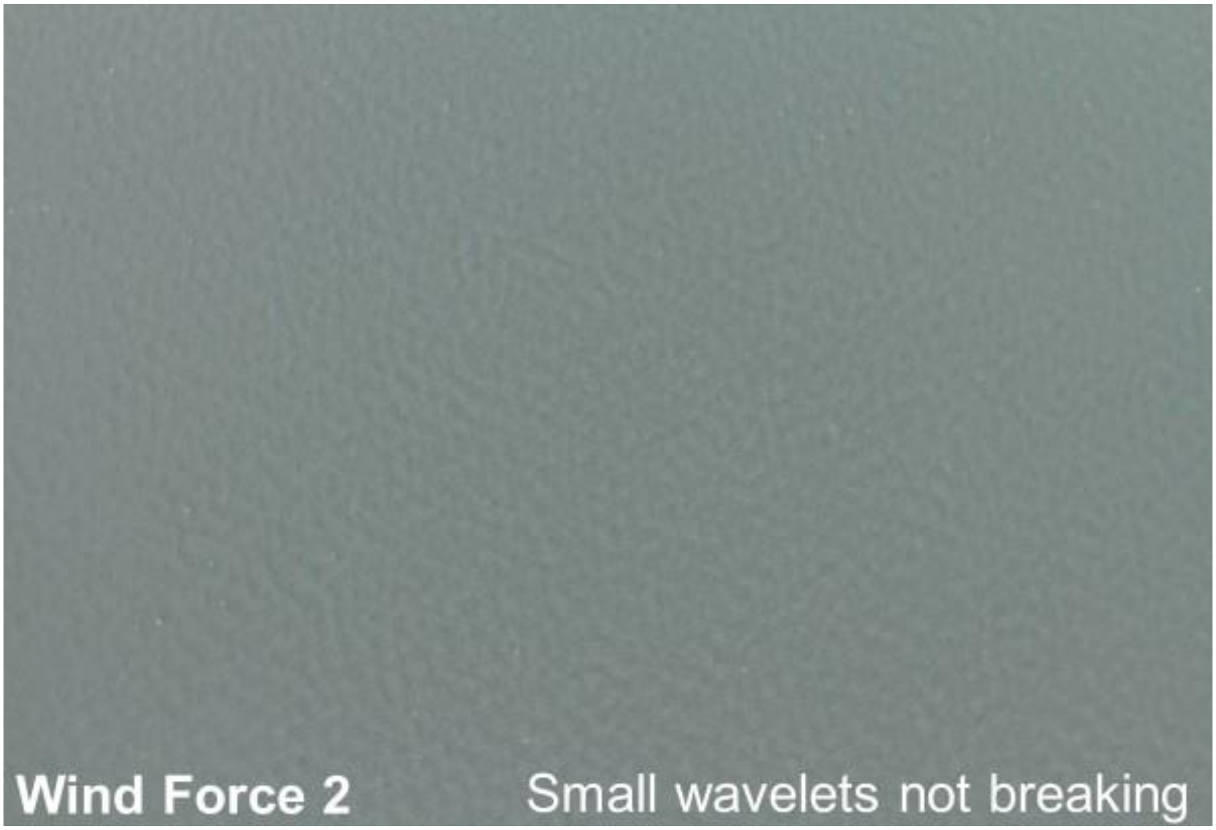


Beaufort Wind Force Chart

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%

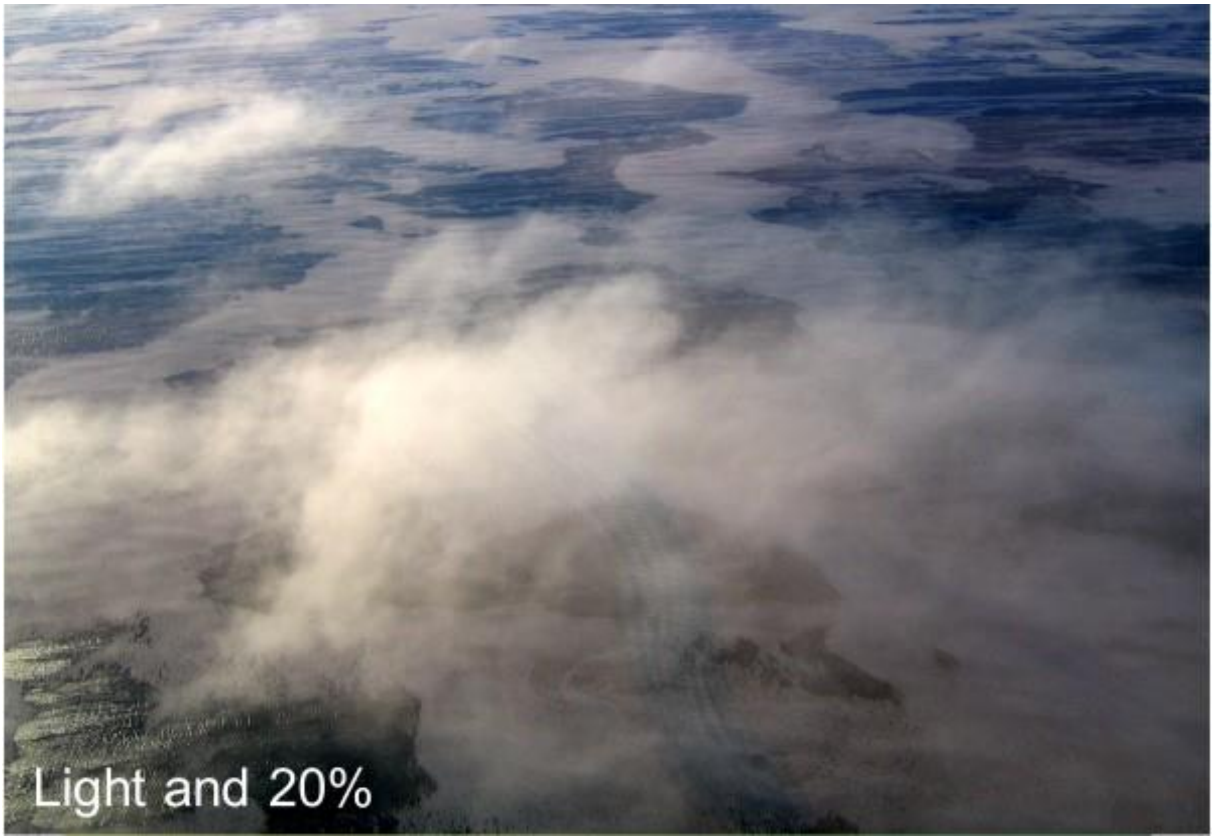
Fog

Two measurements:

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

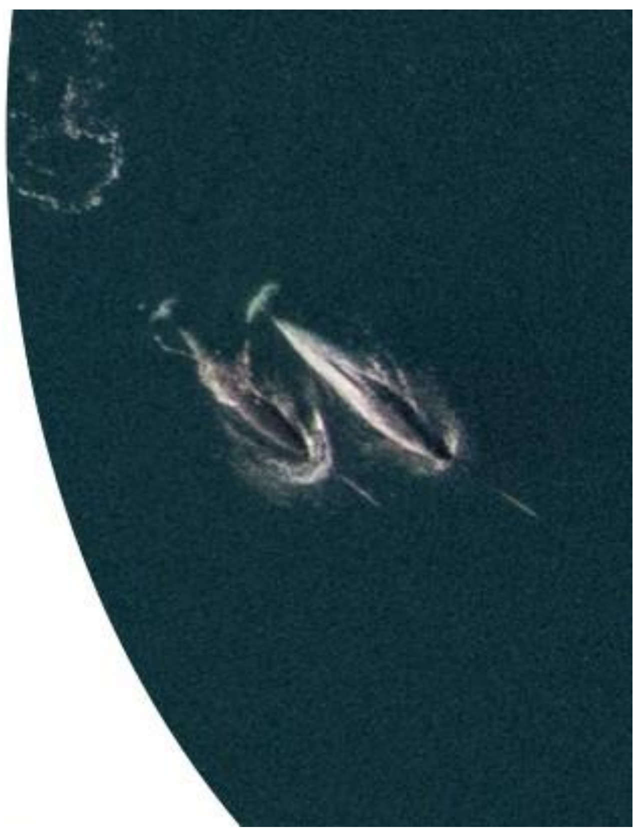

Thick and 100%


Moderate and 100%



Sighting Data

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

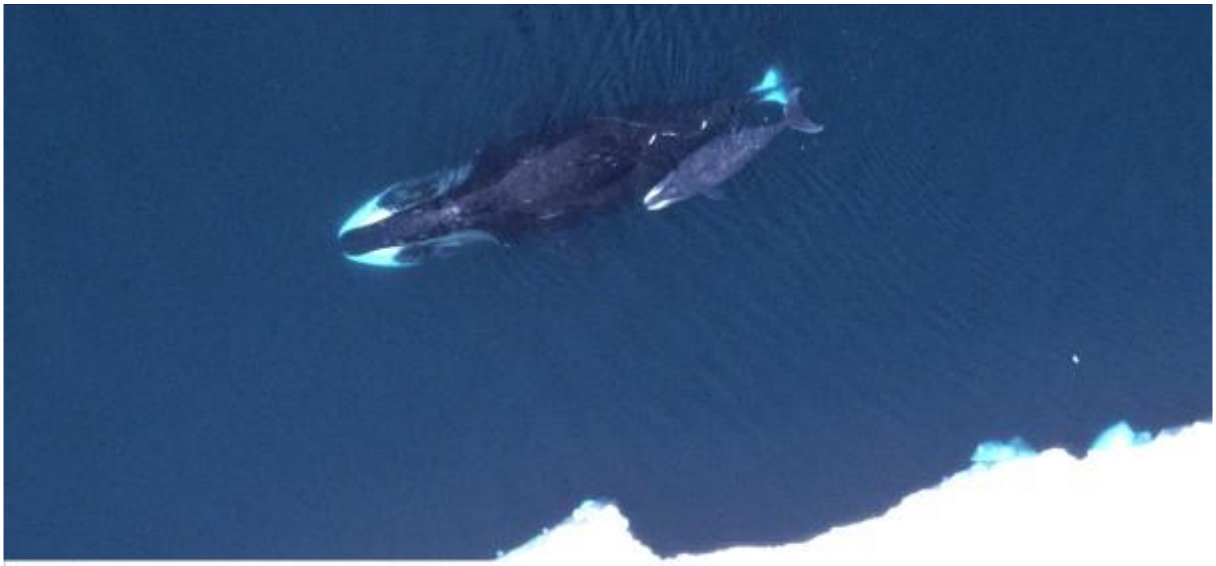


Narwhal

- 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

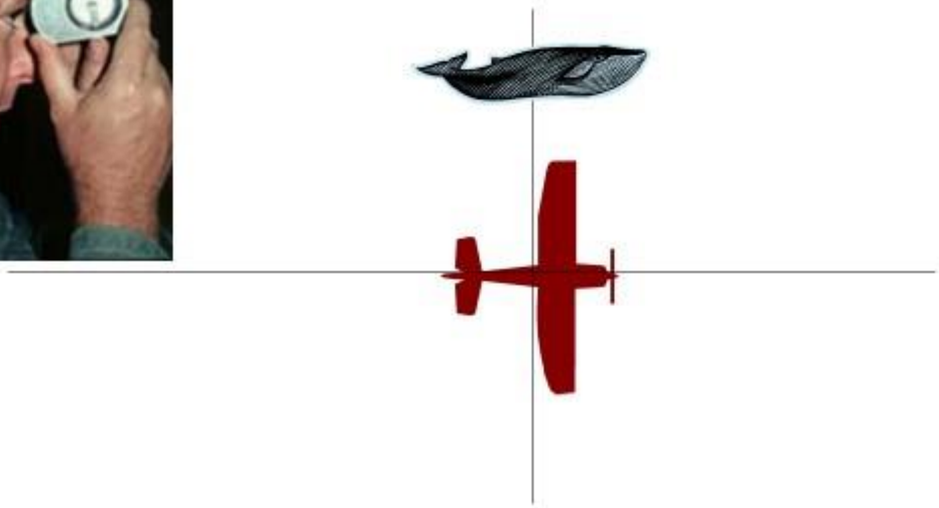
Polar Bear

Group Size

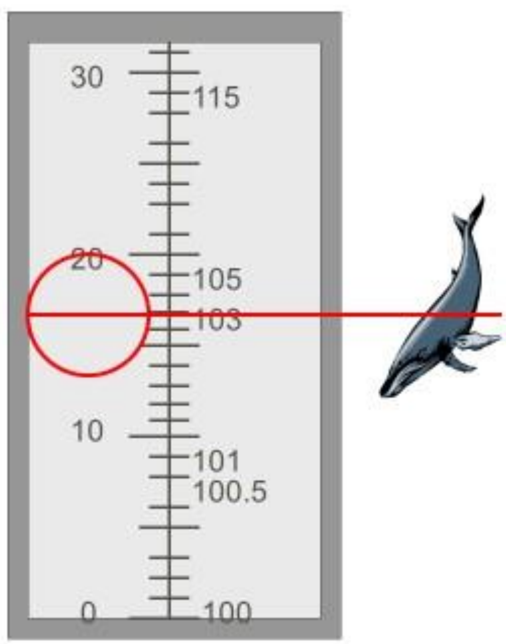
- Number of individuals in group (group is defined as animals that are within one or a few body lengths of each other and oriented or moving in a similar direction)

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 **left** 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

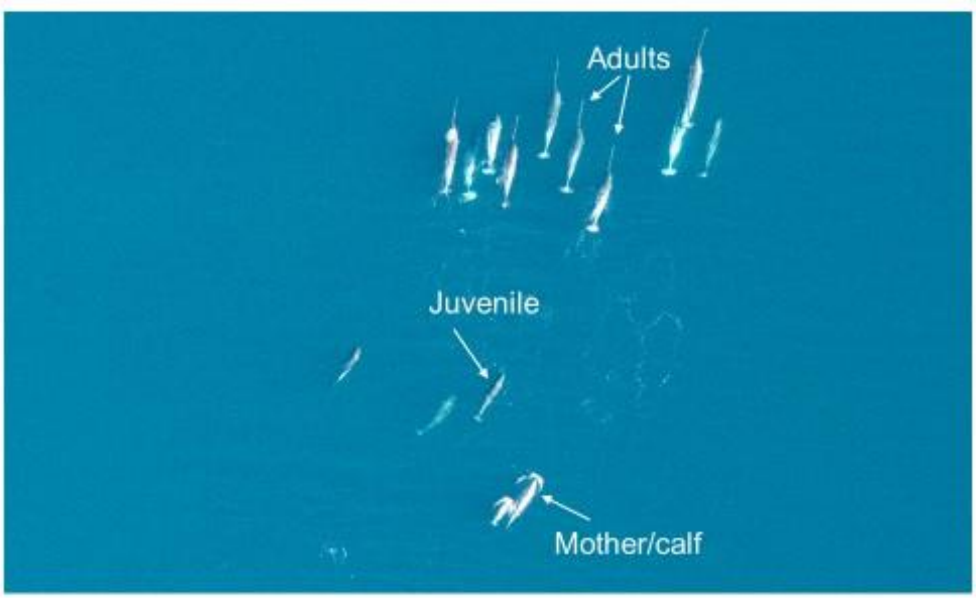
Slow

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

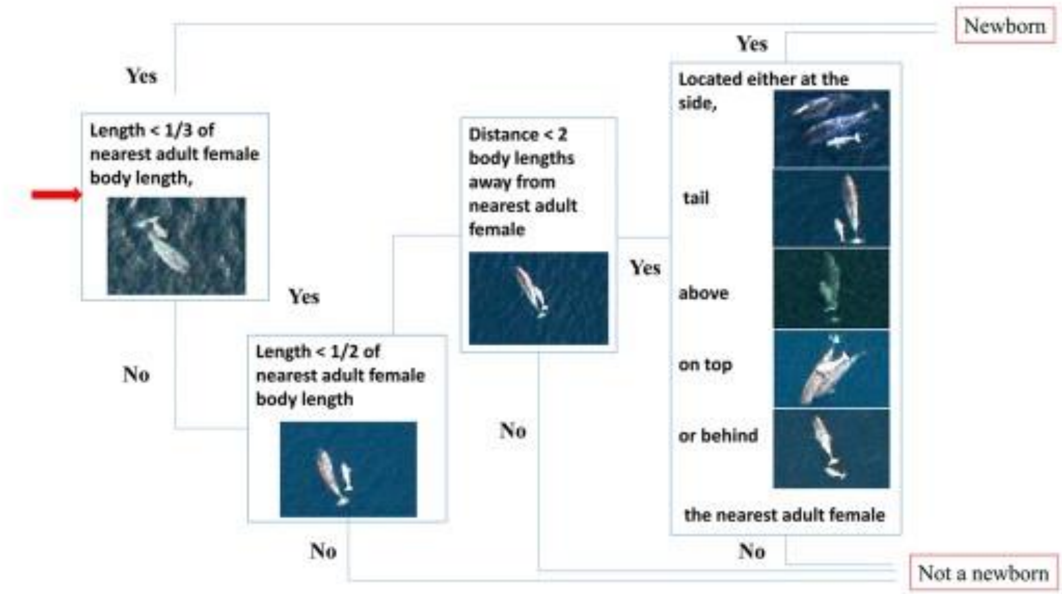
Not Moving

- 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

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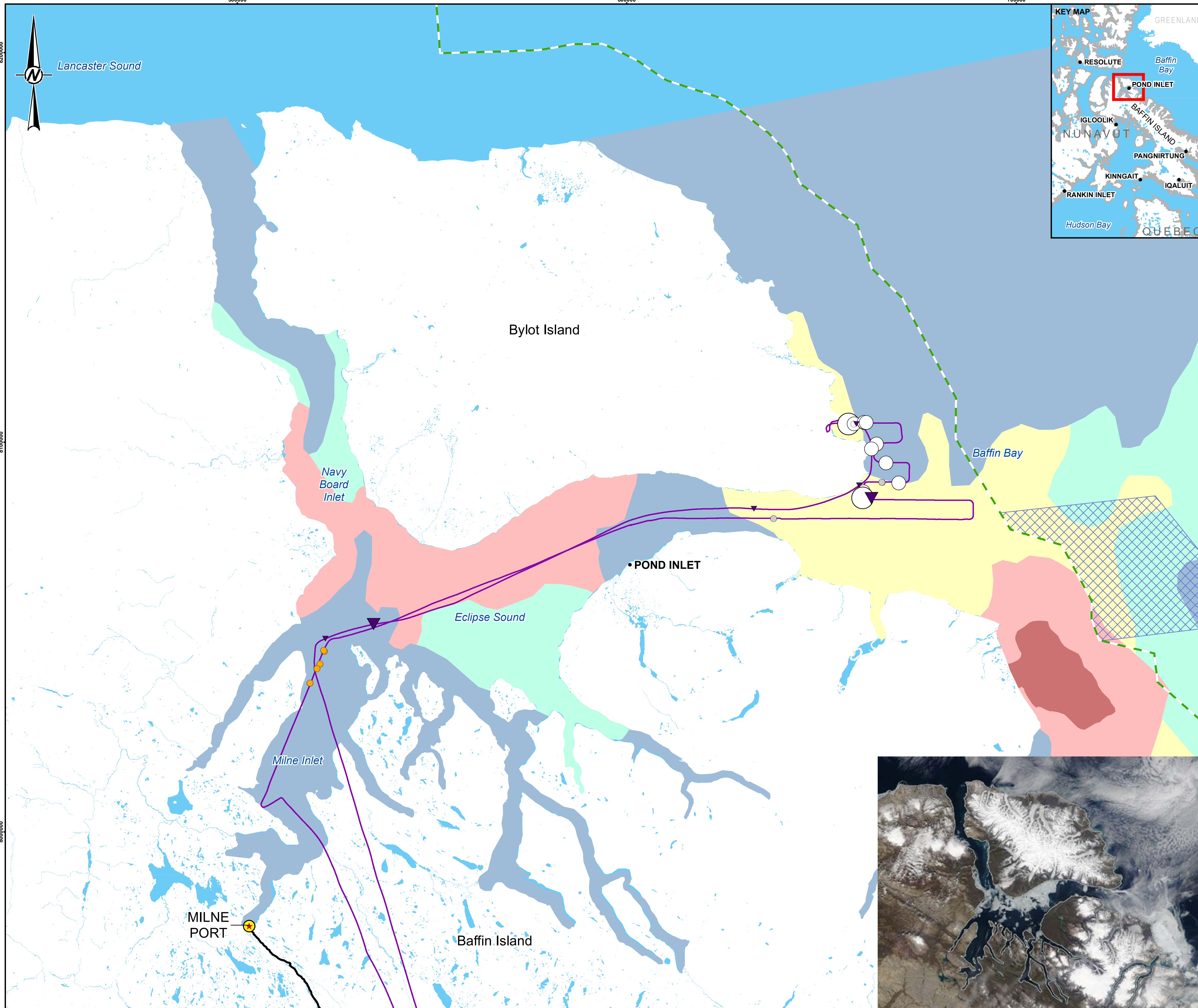
APPENDIX B

Mapbook



LEGEND

- COMMUNITY
- MILNE PORT
- MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)
- BOWHEAD WHALE: 1; 2-10
- HARP SEAL: 1; 2-10; 10+
- RINGED SEAL: 1
- UNIDENTIFIED SEAL: 1
- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY
- ICE CONCENTRATION: < 1/10; 1-3/10; 4-6/10; 7-8/10; 9-10/10; LANDFAST ICE

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

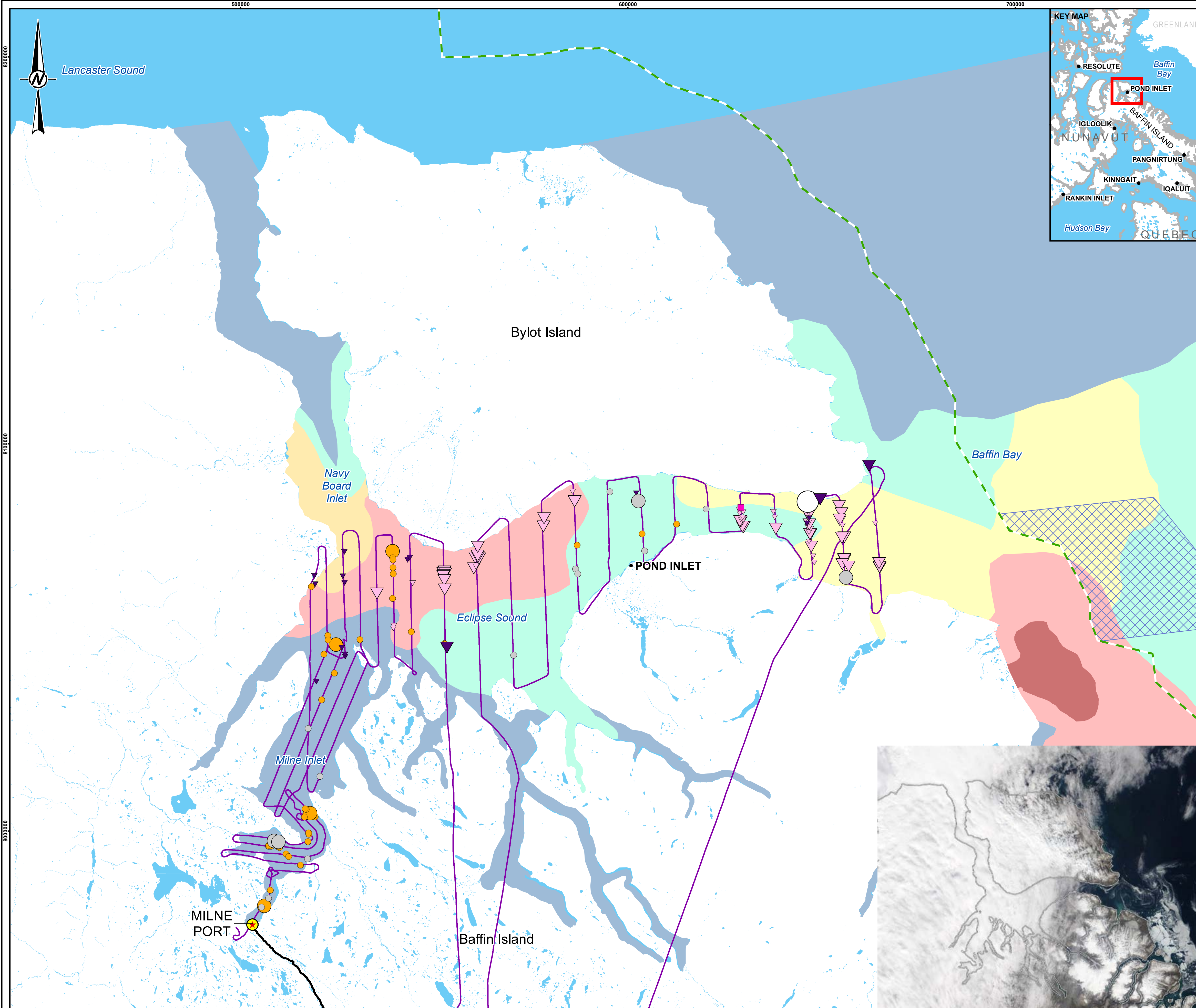
TITLE
ECLIPSE SOUND LEG 1 SURVEY R1 - JULY 18, 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-1

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



LEGEND

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

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE: 1; 2-10

HARP SEAL: 10+

NARWHAL: 1; 2-10

RINGED SEAL: 1; 2-10

UNIDENTIFIED SEAL: 1; 2-10

WALRUS: 1

ICE CONCENTRATION

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

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 1 - JULY 19, 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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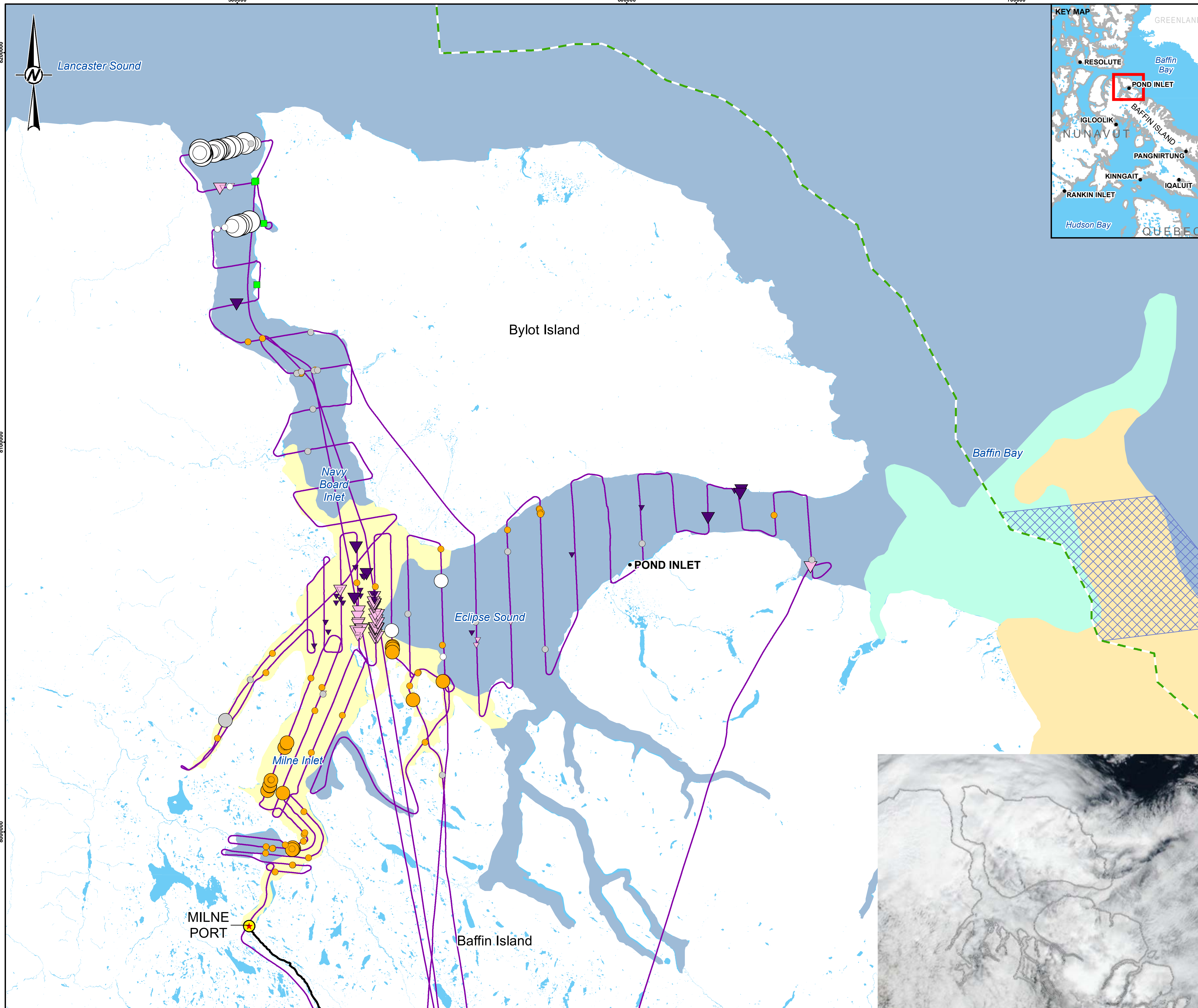

LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

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

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 2 - JULY 21-22, 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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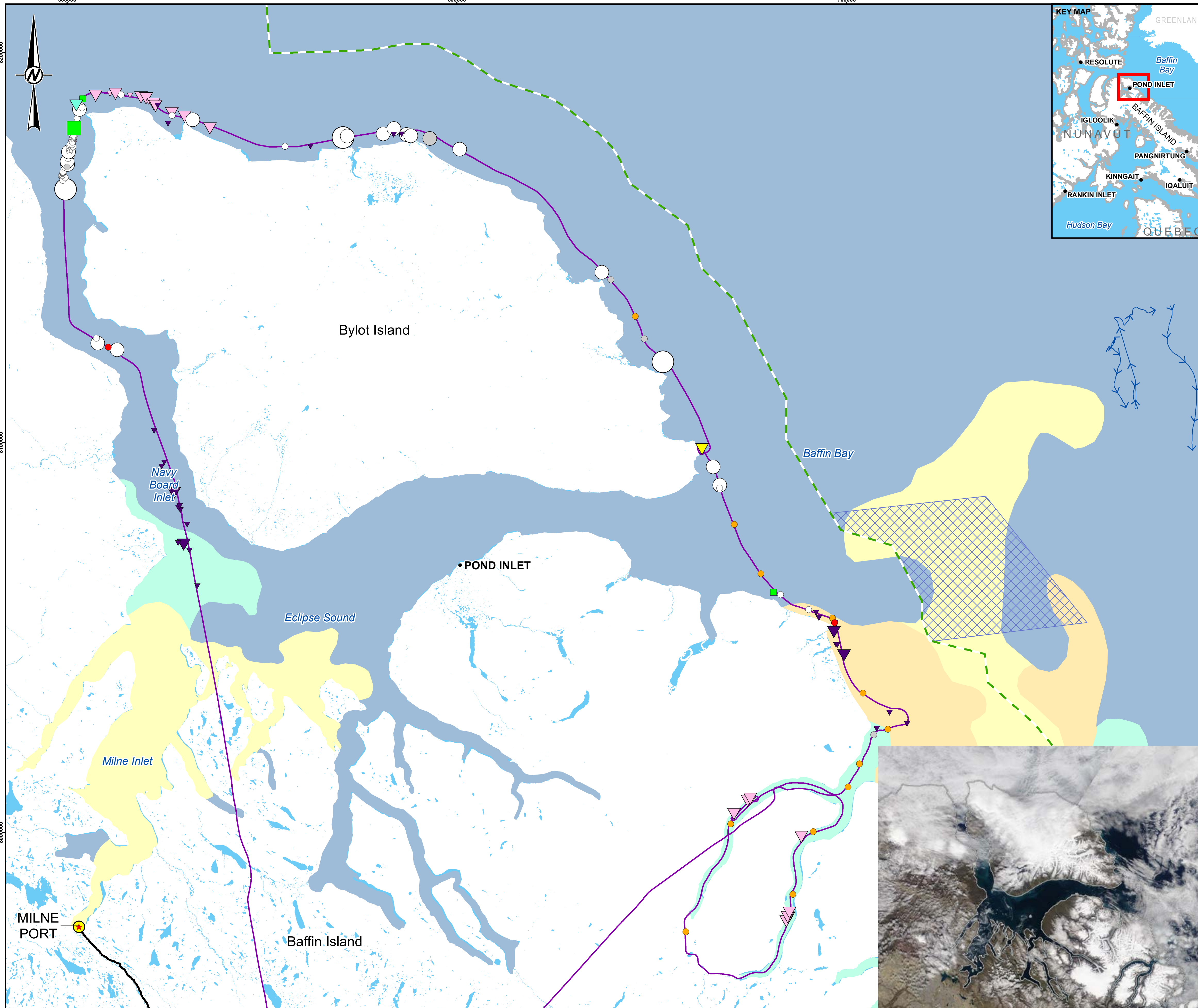


LEGEND

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

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BELUGA
- 2-10

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10

POLAR BEAR
- 1
- 2-10

RINGED SEAL
- 1

UNIDENTIFIED SEAL
- 1
- 2-10

UNIDENTIFIED WHALE
- 2-10

PROJECT VESSEL SHIP TRACKS
- BULK (ORE) CARRIER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE

ECLIPSE SOUND LEG 1 SURVEY R2 - JULY 23, 2021

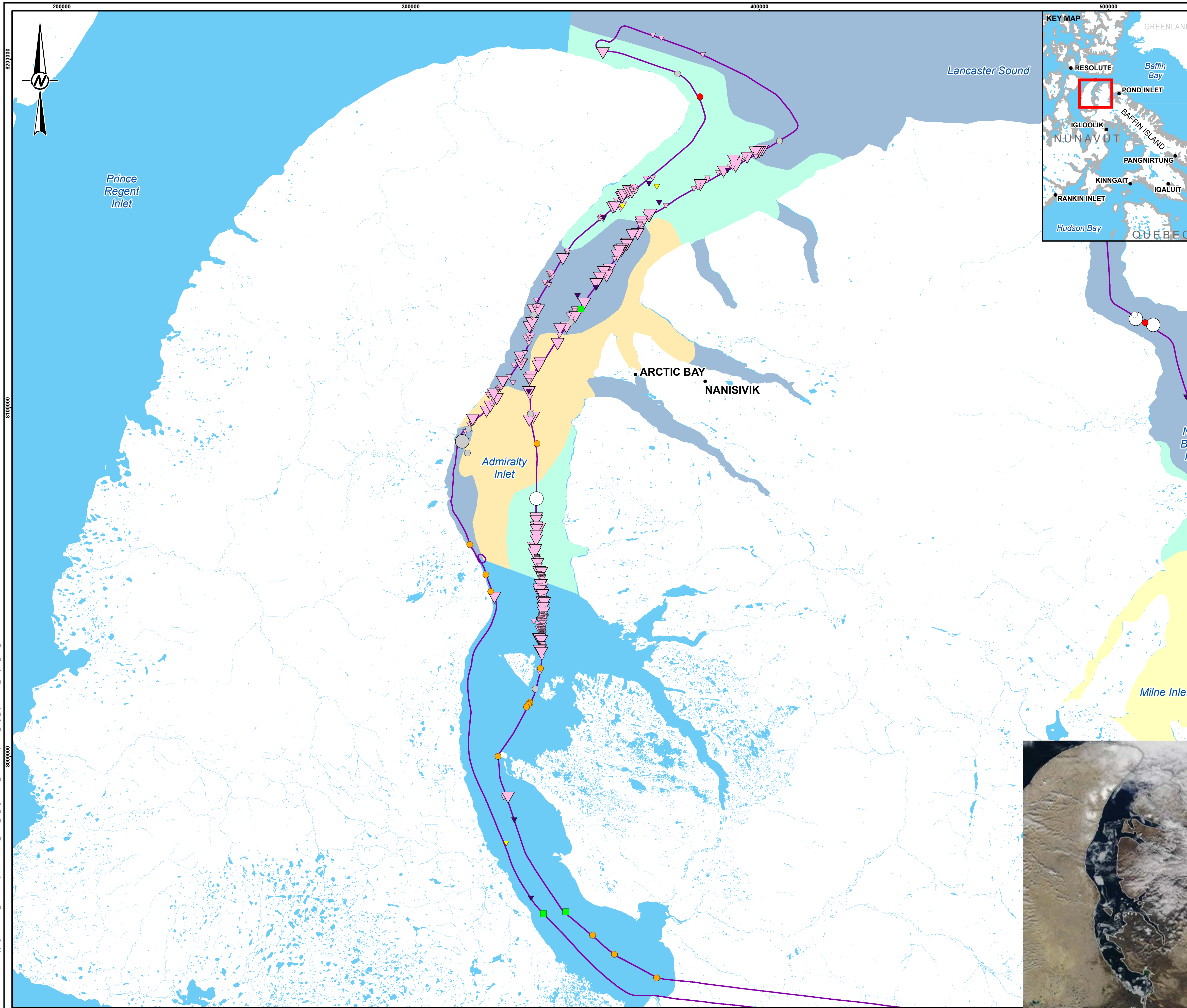
CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-4

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



LEGEND

- COMMUNITY
- MILNE PORT
- MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)
- BEARDED SEAL: 1
- BELUGA: 2-10
- BOWHEAD WHALE: 1
- HARP SEAL: 1; 2-10; 10+
- NARWHAL: 1; 2-10
- POLAR BEAR: 1; 2-10
- RINGED SEAL: 1
- UNIDENTIFIED SEAL: 1; 2-10
- UNIDENTIFIED WHALE: 1
- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

ICE CONCENTRATION

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

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 NOVEMBER 12, 2021. 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

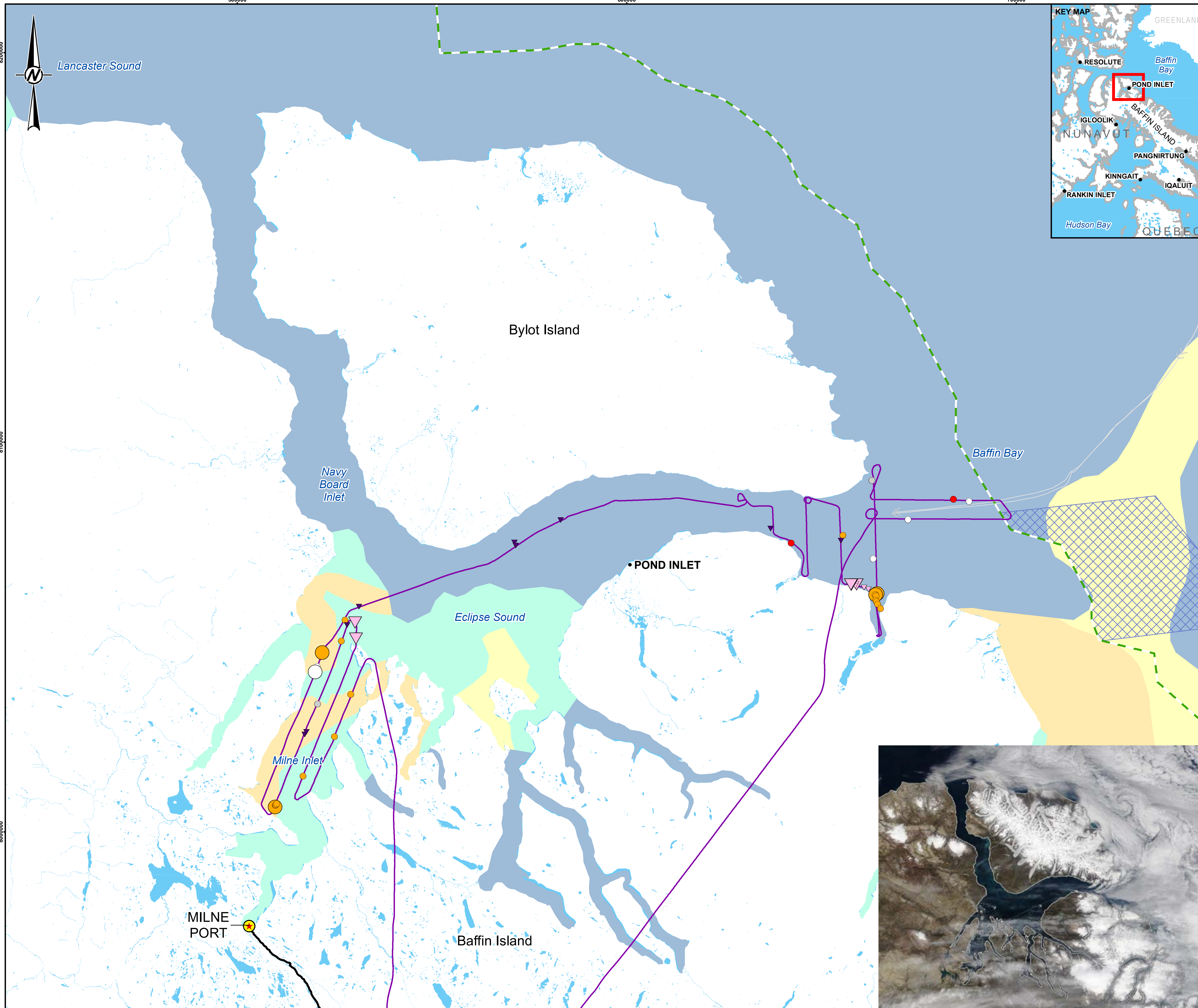
PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ADMIRALTY INLET LEG 1 SURVEY R2 – JULY 23, 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-5



LEGEND

- • COMMUNITY
- MILNE PORT
- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2-10

NARWHAL
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1

PROJECT VESSEL SHIP TRACKS
- SERVICE VESSEL
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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

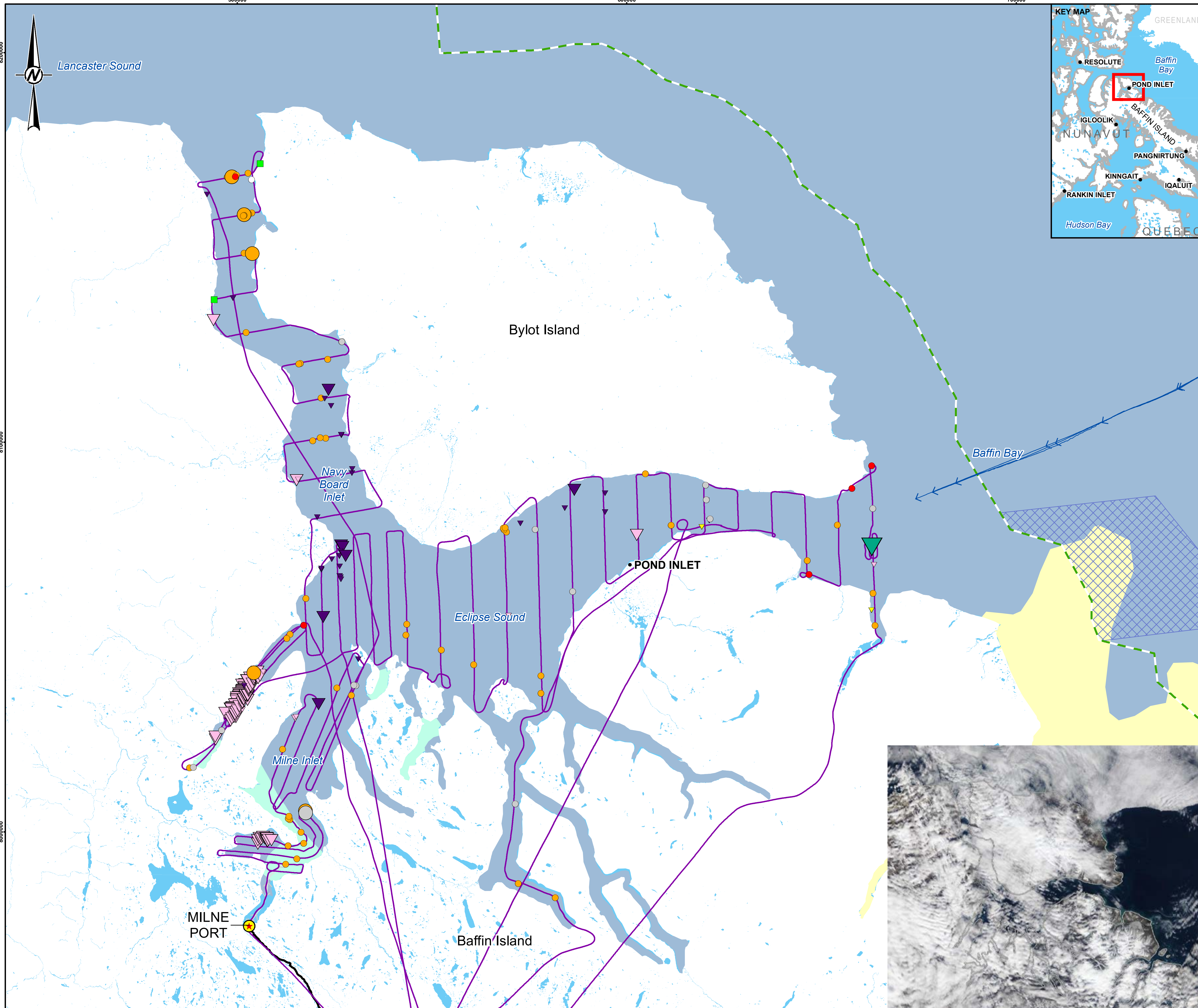
PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 3 - JULY 24, 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-6



LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1

KILLER WHALE
- 10+

NARWHAL
- 1
- 2-10
- 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
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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

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 NOVEMBER 12, 2021. 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

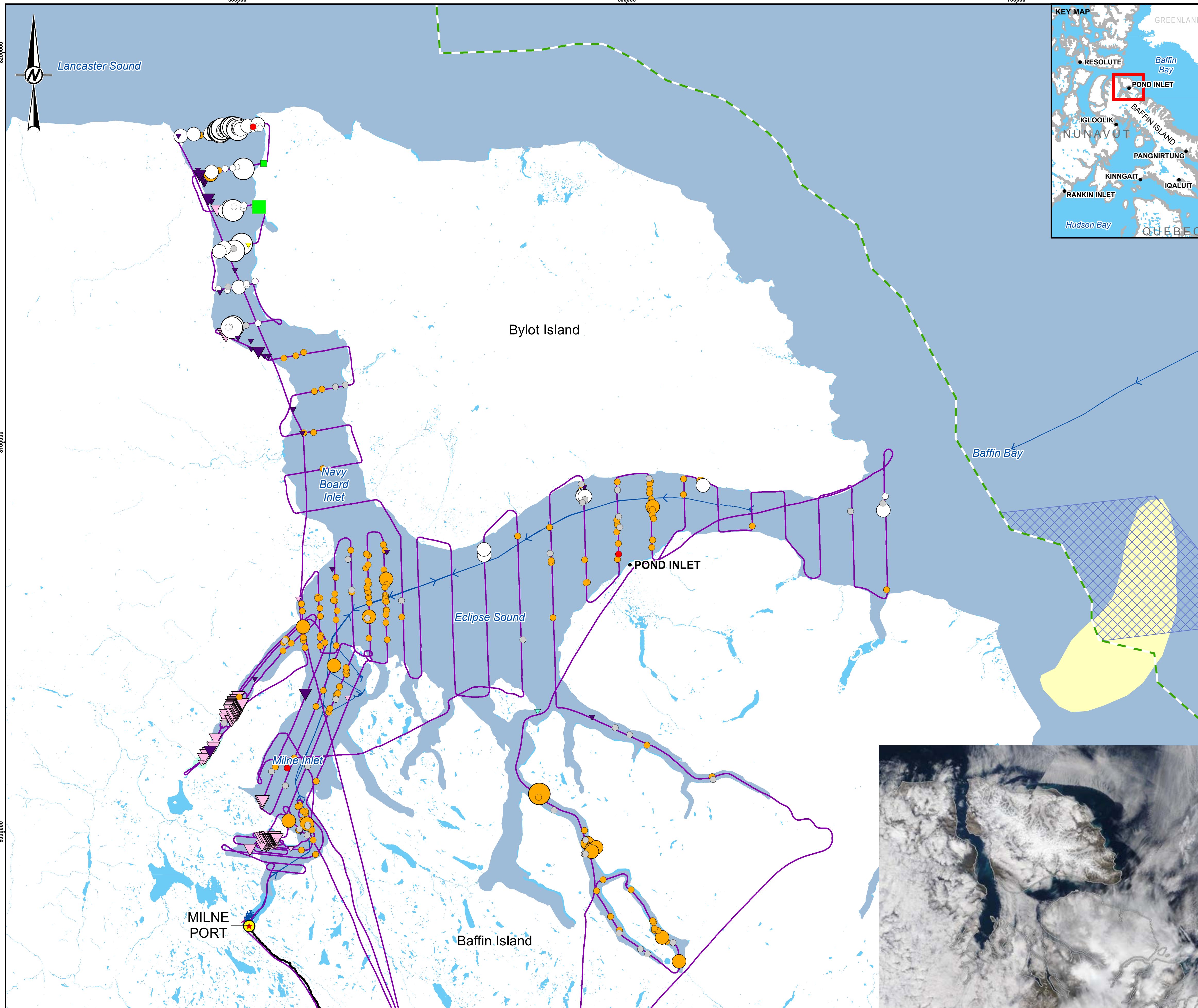
PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 4 - JULY 26-27, 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-7



LEGEND

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

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BELUGA
- 1

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10

POLAR BEAR
- 1
- 2-10

RINGED SEAL
- 1
- 2-10
- 10+

UNIDENTIFIED SEAL
- 1

UNIDENTIFIED WHALE
- 1

PROJECT VESSEL SHIP TRACKS
- BULK (ORE) CARRIER
- ICEBREAKER (BOTNICA)
- SERVICE VESSEL
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 5 - JULY 28-30, 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-8

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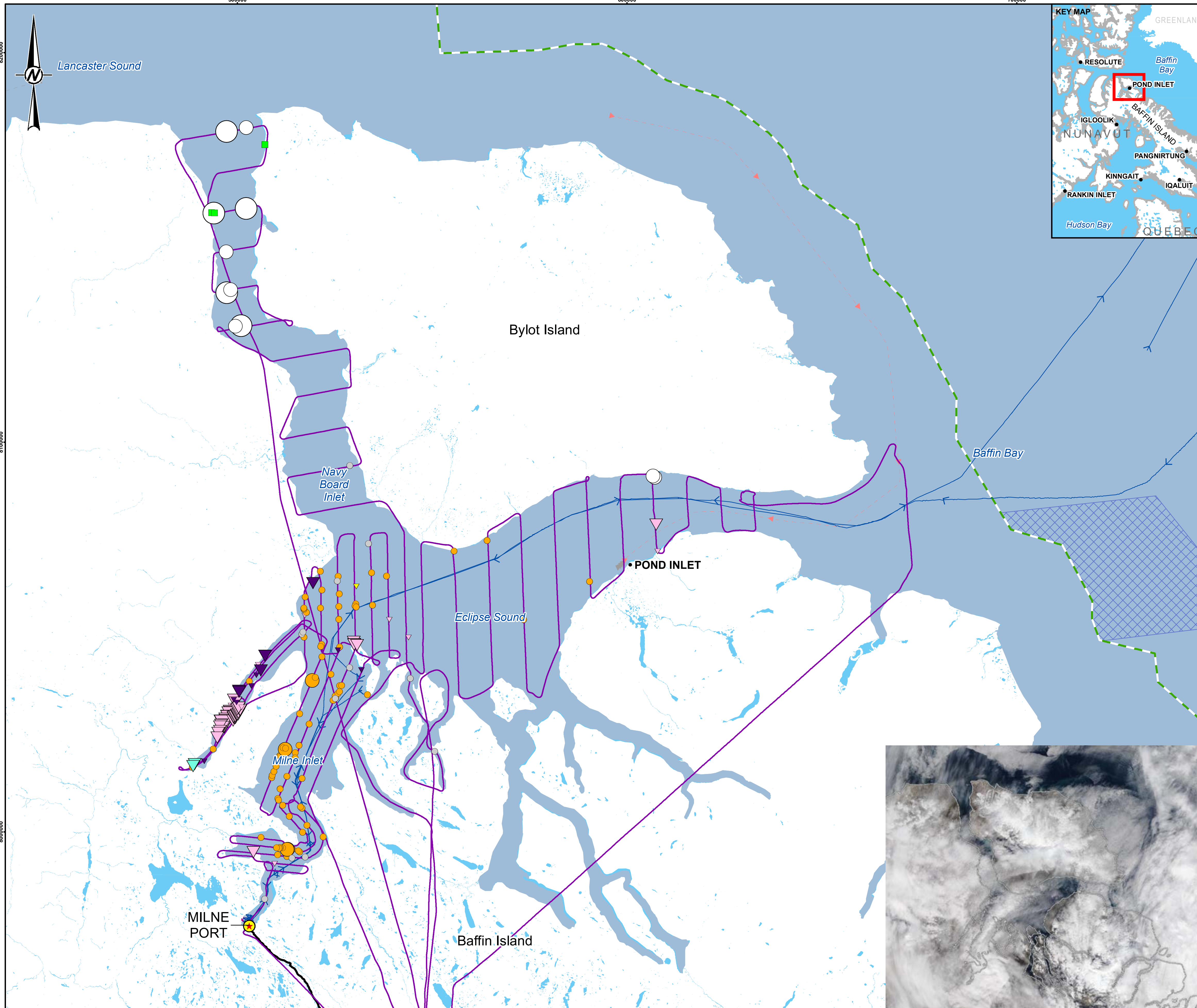


LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 2-10

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1

UNIDENTIFIED WHALE
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

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

NON-PROJECT VESSEL SHIP TRACKS
- ICEBREAKER (TERRY FOX)
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

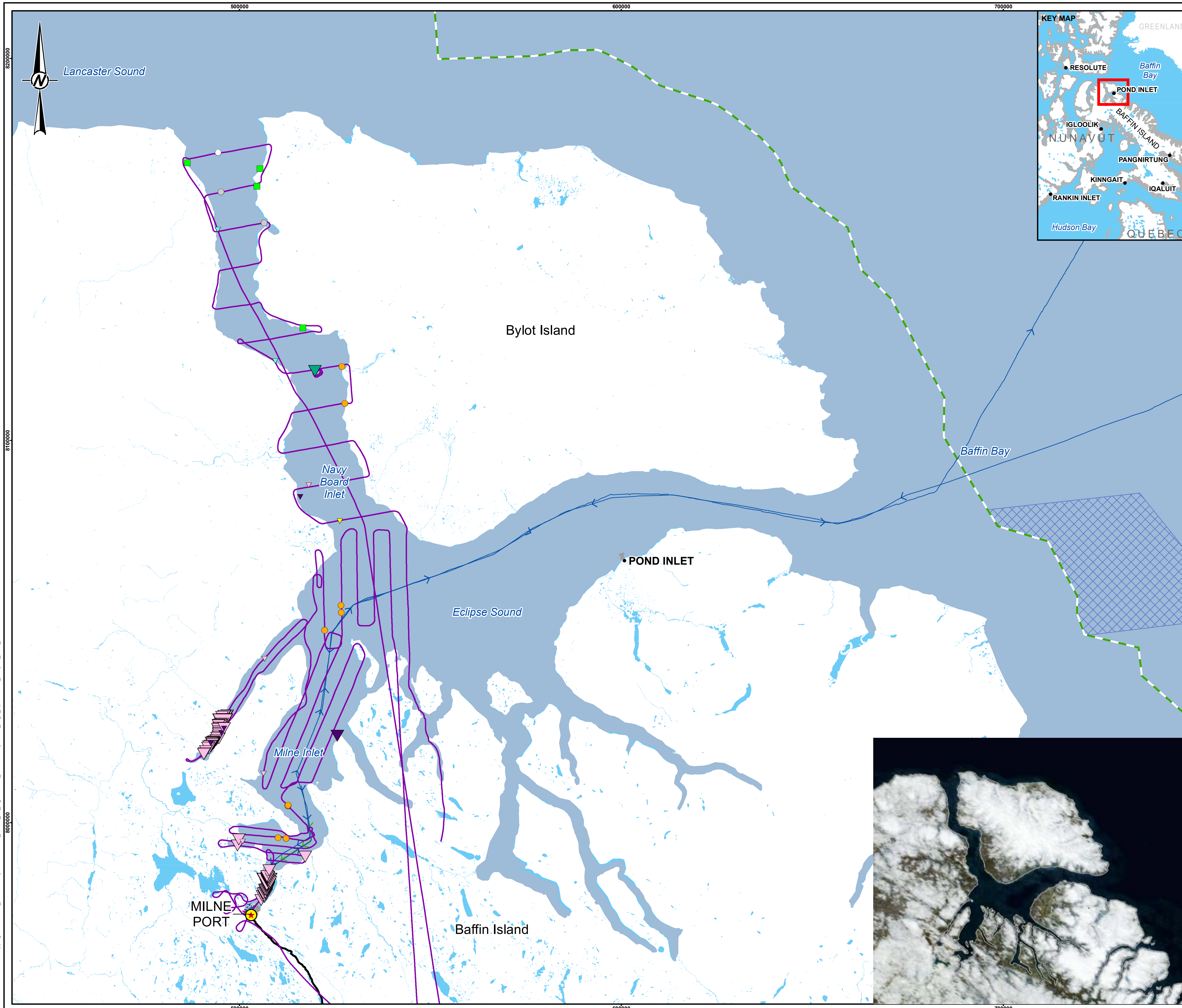
TITLE
ECLIPSE SOUND LEG 1 SURVEY 6 - JULY 31- AUGUST 2, 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-9

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



LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1

KILLER WHALE
- 2-10

NARWHAL
- 1
- 2-10
- 10+

POLAR BEAR
- 1

RINGED SEAL
- 1

UNIDENTIFIED SEAL
- 1

UNIDENTIFIED WHALE
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

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

NON-PROJECT VESSEL SHIP TRACKS
- ICEBREAKER (TERRY FOX)
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 1 SURVEY 7 - AUGUST 3, 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-10

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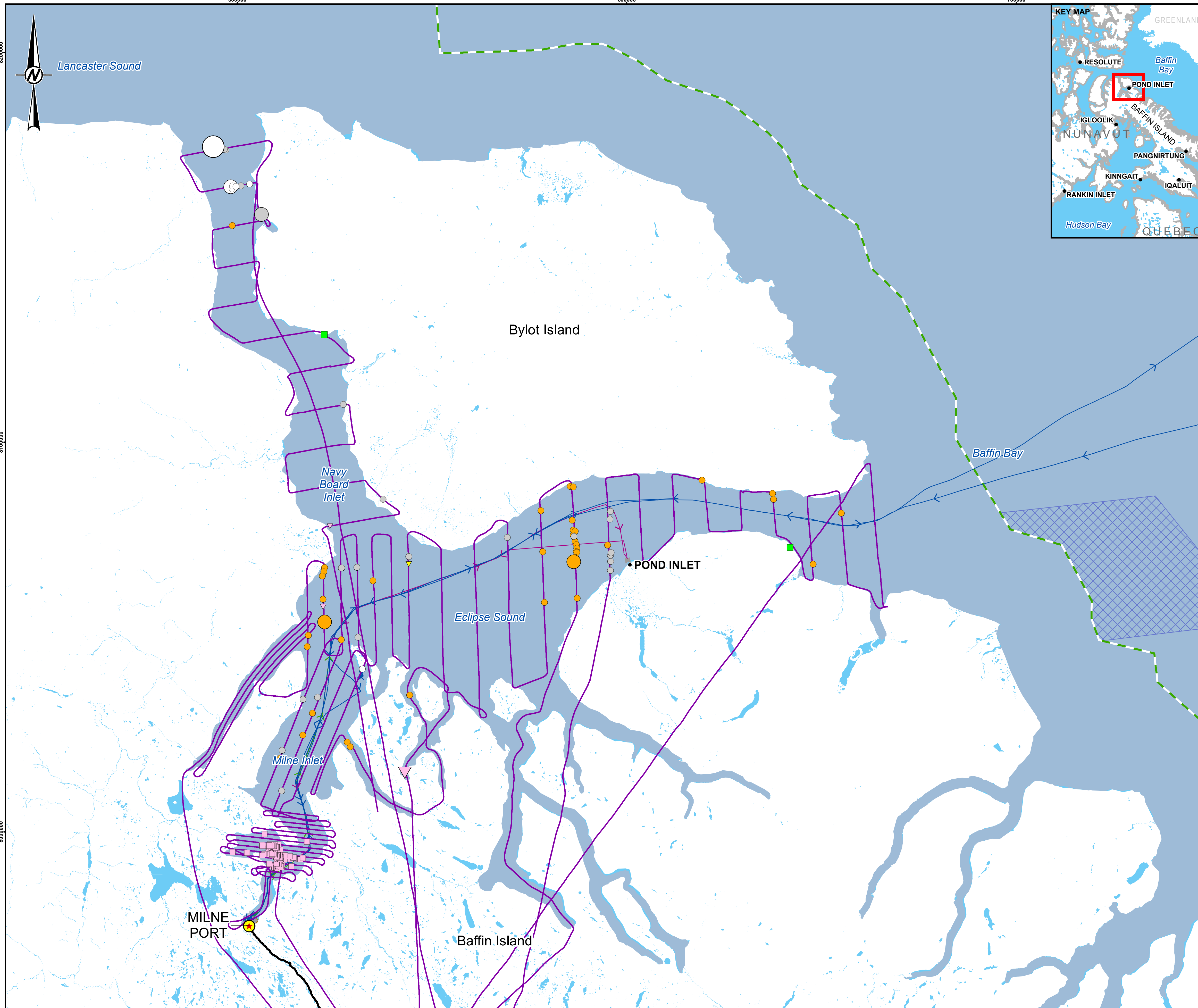
25mm



LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

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
- GENERAL CARGO VESSEL
- ICEBREAKER (BOTNICA)
- OIL TANKER
- SERVICE VESSEL

NON-PROJECT VESSEL SHIP TRACKS

- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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

2021 MARINE MAMMAL AERIAL SURVEYS

TITLE

ECLIPSE SOUND LEG 2 SURVEY 1 – 8 AUGUST 2021

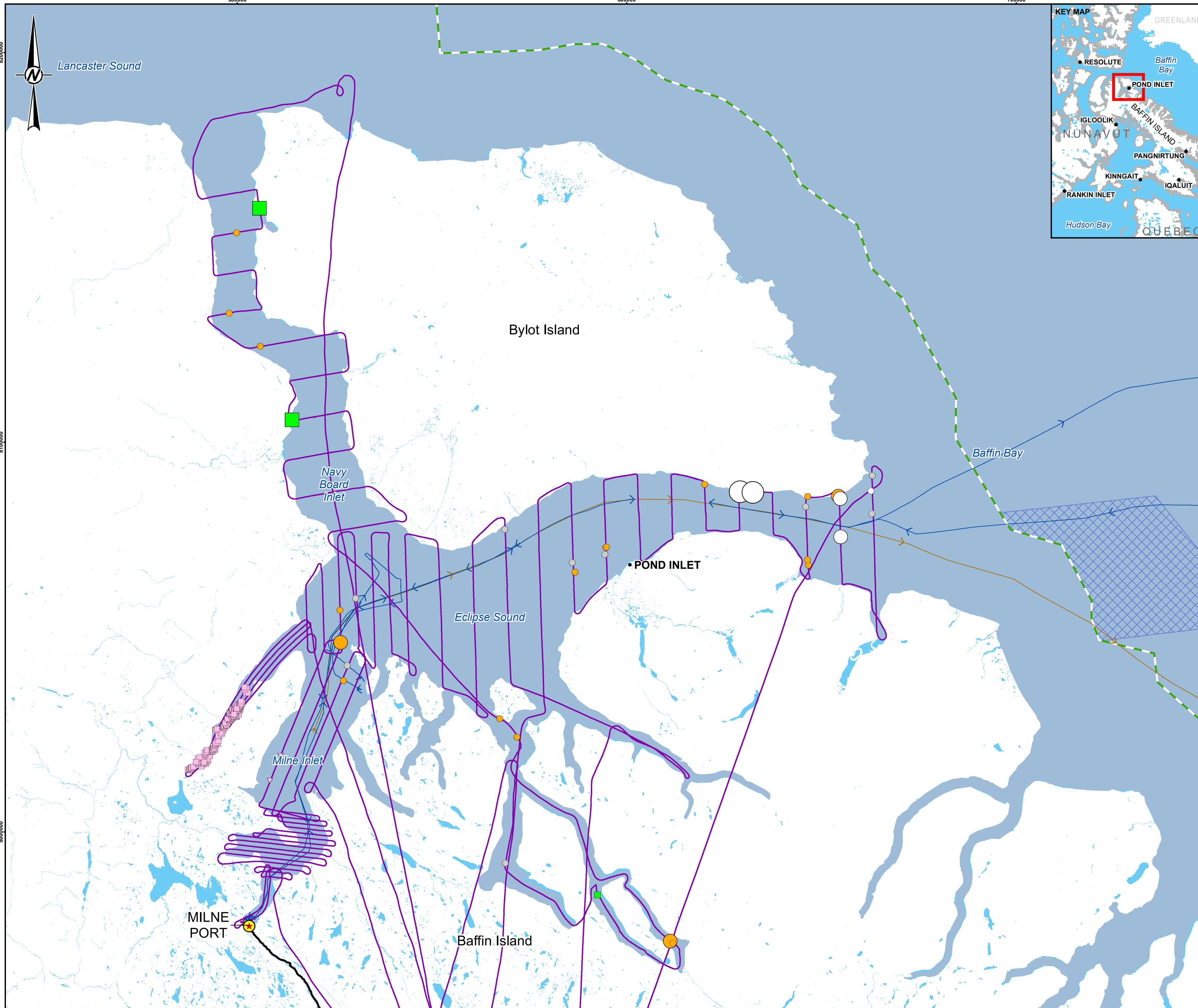
CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-11

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



LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL

- 1
- 2-10
- 10+

NARWHAL

- 1

POLAR BEAR

- 1
- 2-10

RINGED SEAL

- 1
- 2-10

UNIDENTIFIED SEAL

- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

PROJECT VESSEL SHIP TRACKS

- BULK (ORE) CARRIER
- GENERAL CARGO VESSEL
- ICEBREAKER (BOTNICA)
- SERVICE VESSEL
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE

ECLIPSE SOUND LEG 2 SURVEY 2 – 10 AUGUST 2021

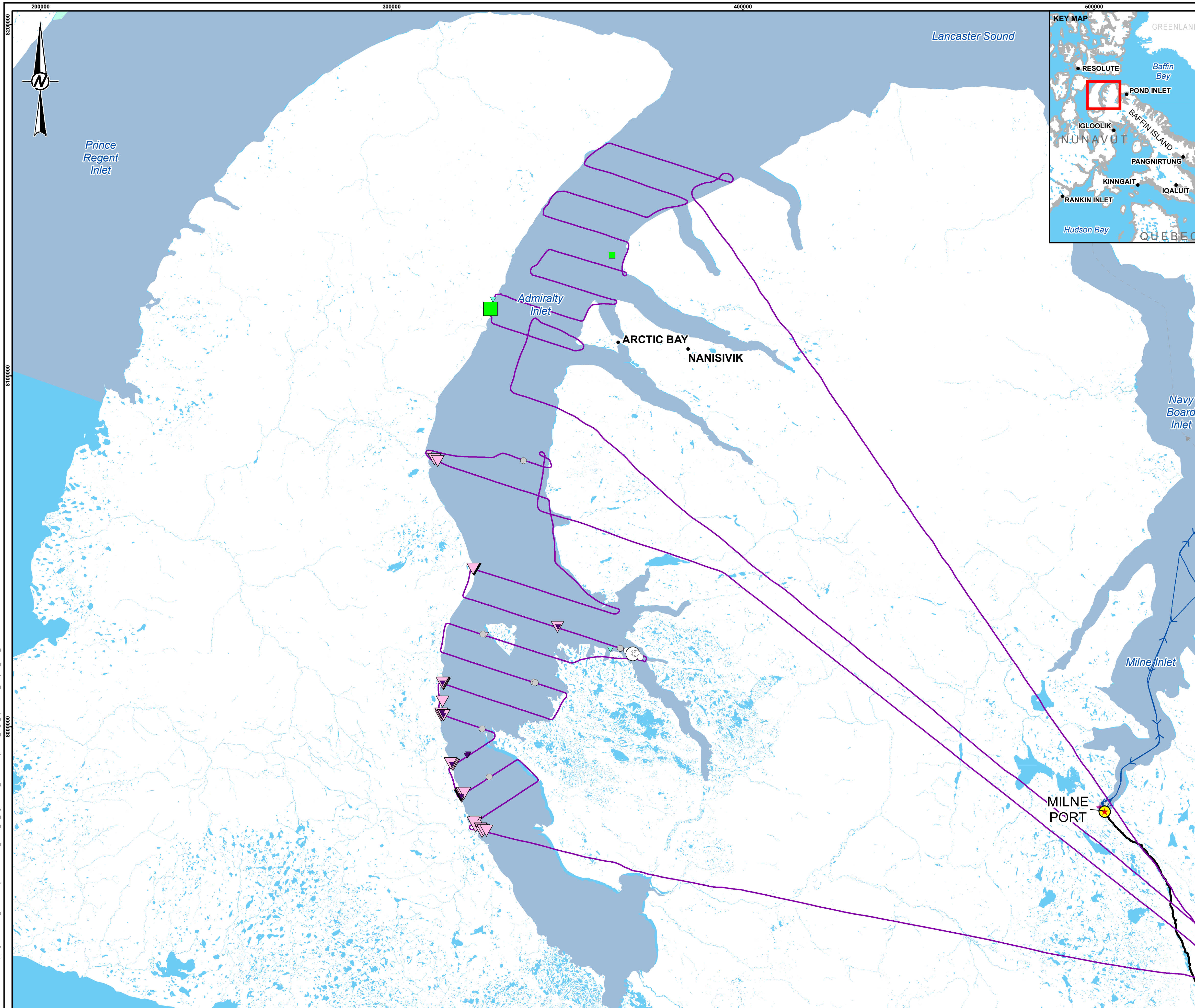
CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-12

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



LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2-10

NARWHAL
- 1
- 2-10

POLAR BEAR
- 1
- 2-10

UNIDENTIFIED SEAL
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

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

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

ICE CONCENTRATION
- < 1/10
- 1-3/10

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

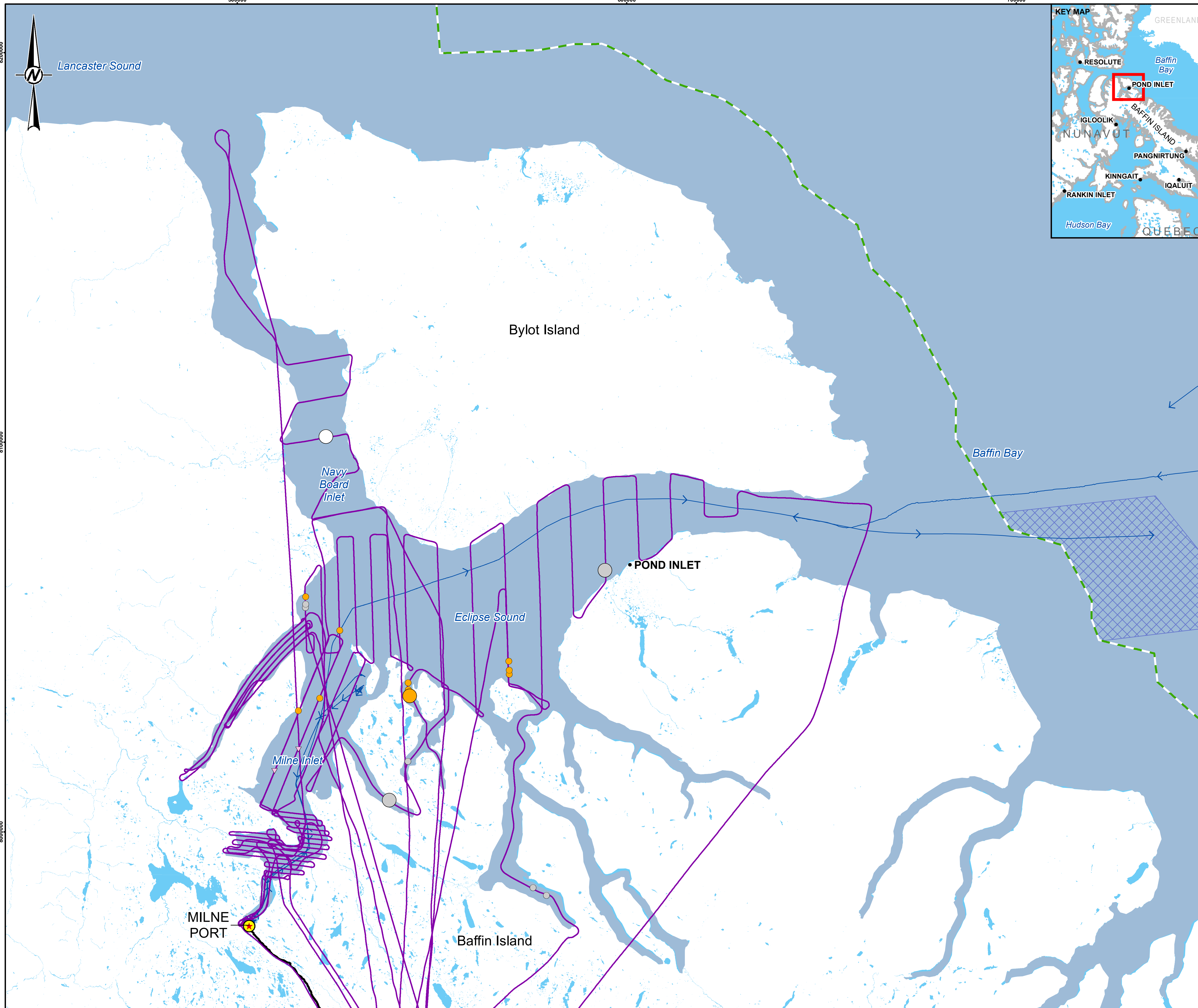
TITLE
ADMIRALTY INLET LEG 2 SURVEY 2 – 11 AUGUST 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm



LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL
- 2-10

NARWHAL
- 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
- ICEBREAKER (BOTNICA)
- SERVICE VESSEL
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 2 SURVEY 3 – 14, 17 AND 18 AUGUST 2021

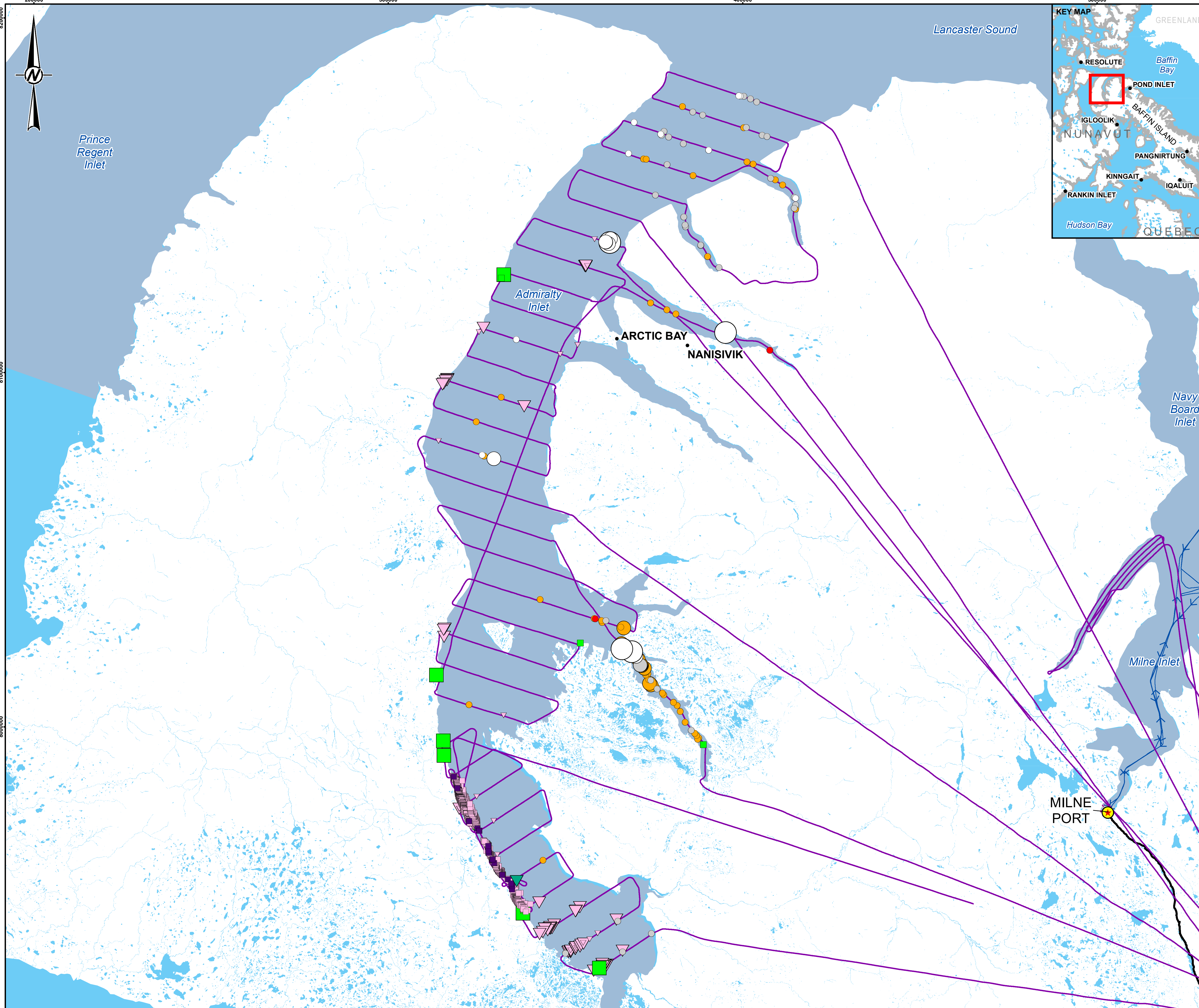
CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-14

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



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 NOVEMBER 12, 2021. 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

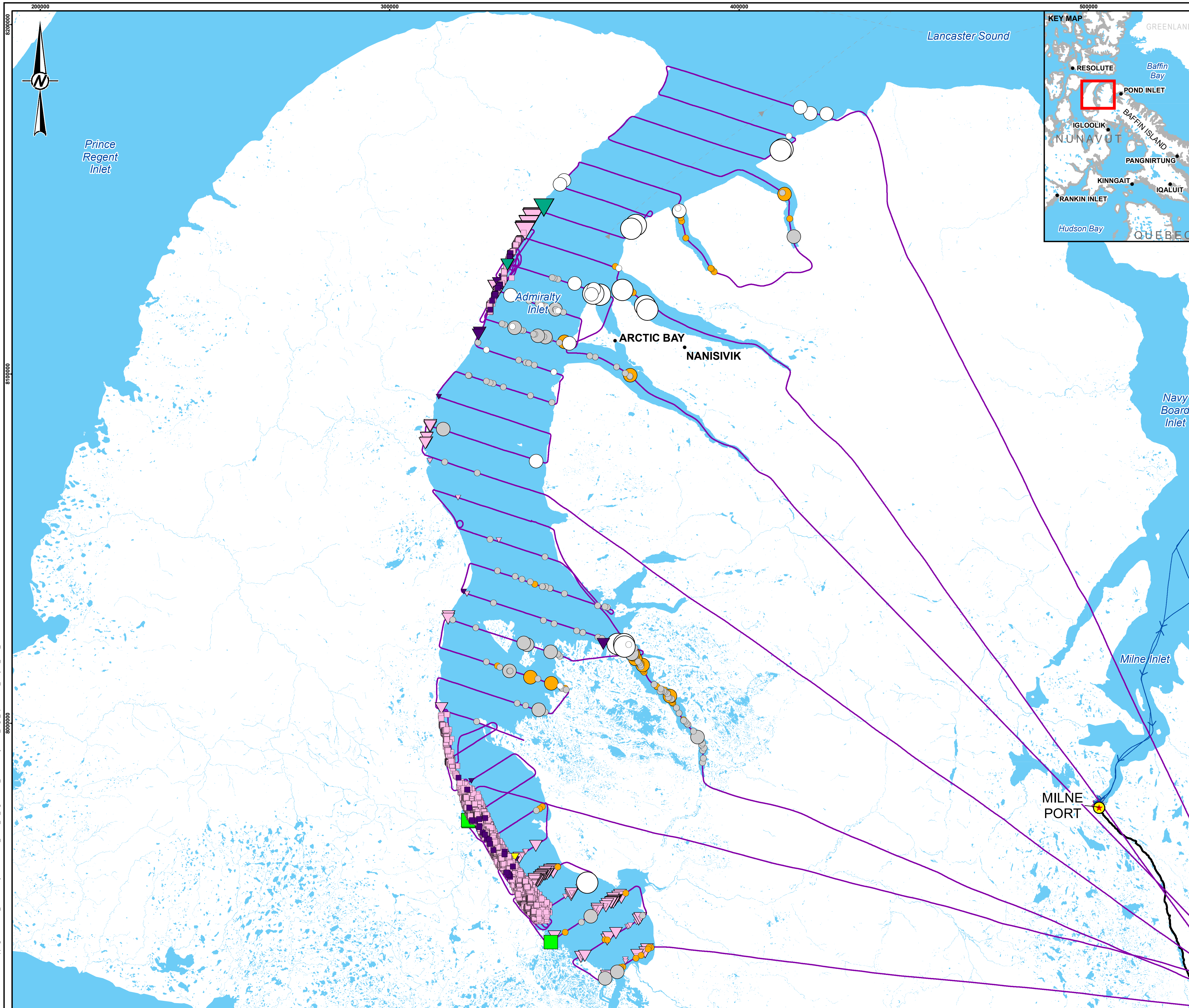
PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ADMIRALTY INLET LEG 2 SURVEY 3 – 15-16 AUGUST 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-15



LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD WHALE
- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1
- 2-10

HARP SEAL
- 1
- 2-10
- 10+

KILLER WHALE
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

POLAR BEAR
- 2-10

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

UNIDENTIFIED WHALE
- 2-10

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

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

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

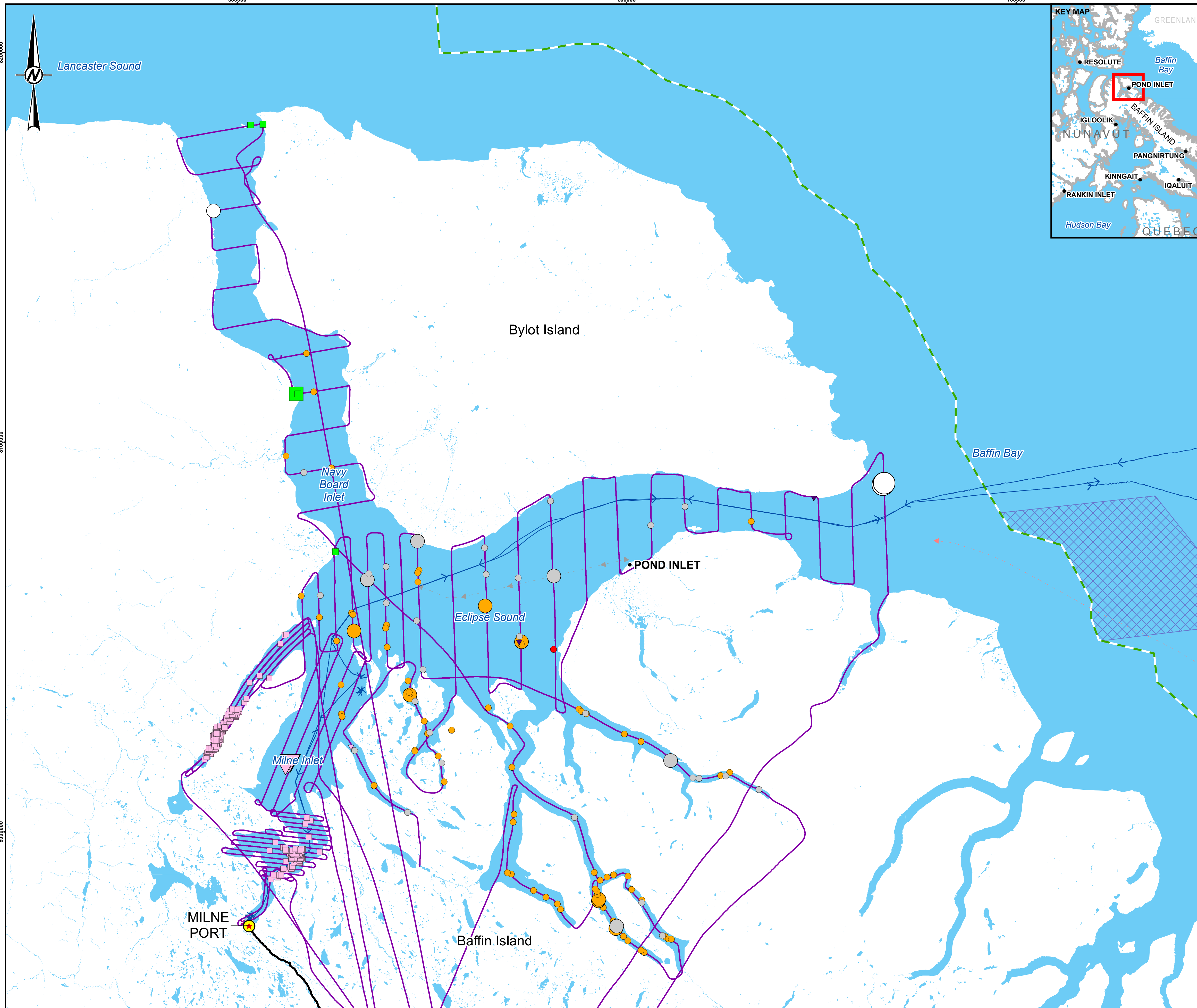
TITLE
ADMIRALTY INLET LEG 2 SURVEY 4 – 19 AUGUST 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-16

25mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS
- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BOWHEAD WHALE
- 1

HARP SEAL
- 2-10
- 10+

NARWHAL
- 1
- 2-10
- 10+

POLAR BEAR
- 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
- ICEBREAKER (BOTNICA)
- SERVICE VESSEL

NON-PROJECT VESSEL SHIP TRACKS
- ICEBREAKER (TERRY FOX)
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
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CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ECLIPSE SOUND LEG 2 SURVEY 4 – 20-21 AUGUST 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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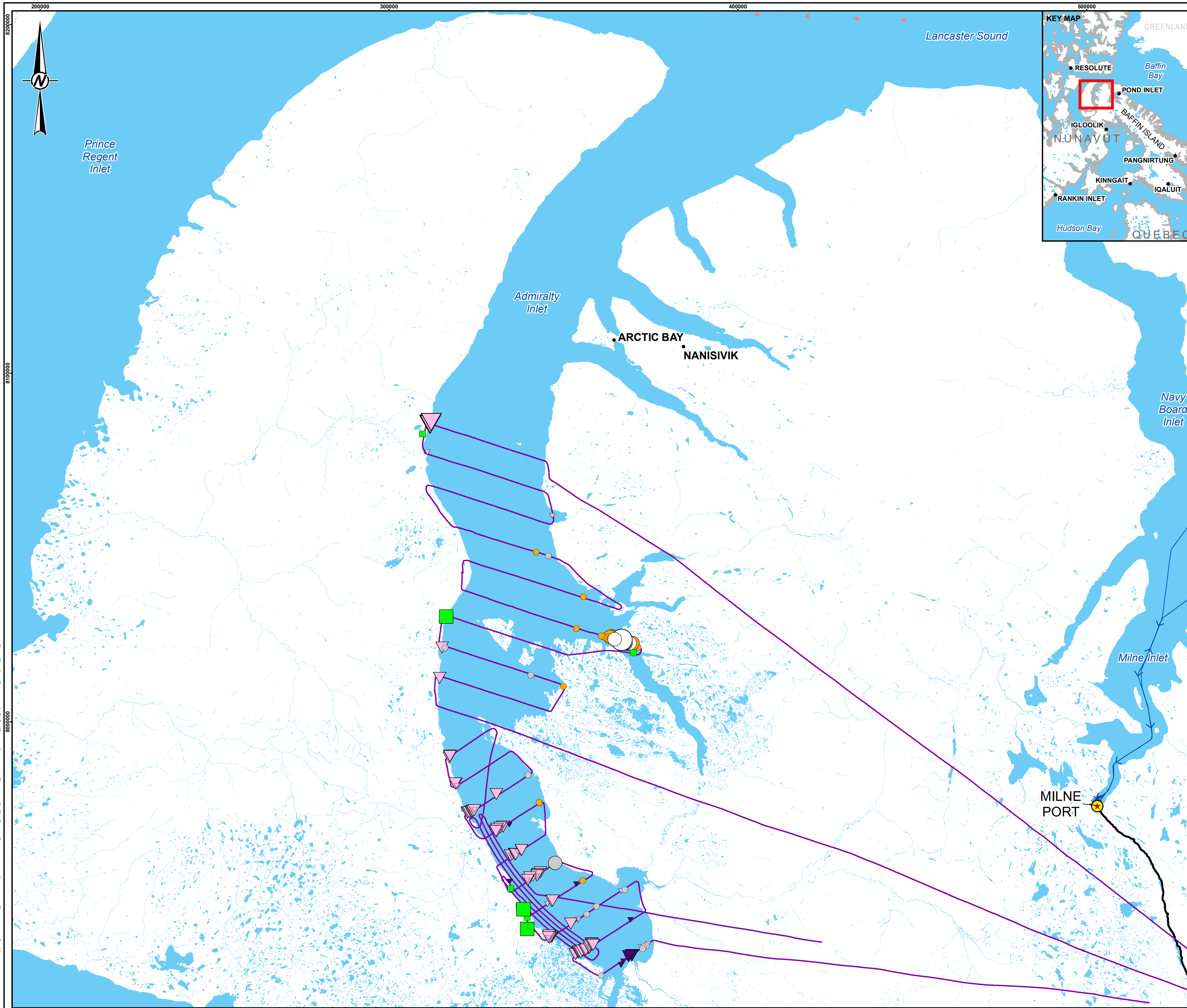

LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

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

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

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

NON-PROJECT VESSEL SHIP TRACKS
- ICEBREAKER (TERRY FOX)
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
ADMIRALTY INLET LEG 2 SURVEY 5 – 22 AUGUST 2021

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
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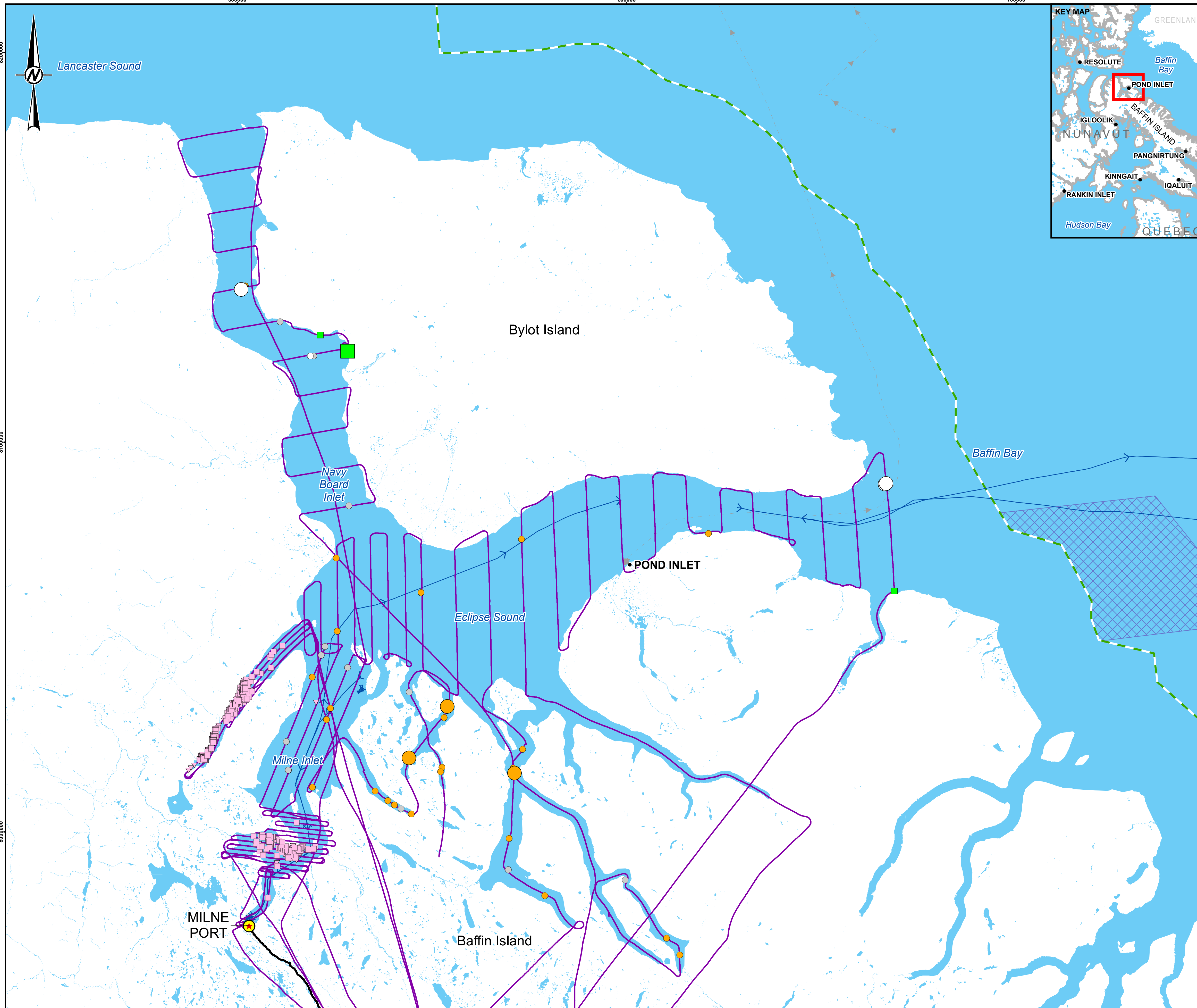


LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2-10

NARWHAL
- 1

POLAR BEAR
- 1
- 2-10

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

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

NON-PROJECT VESSEL SHIP TRACKS
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

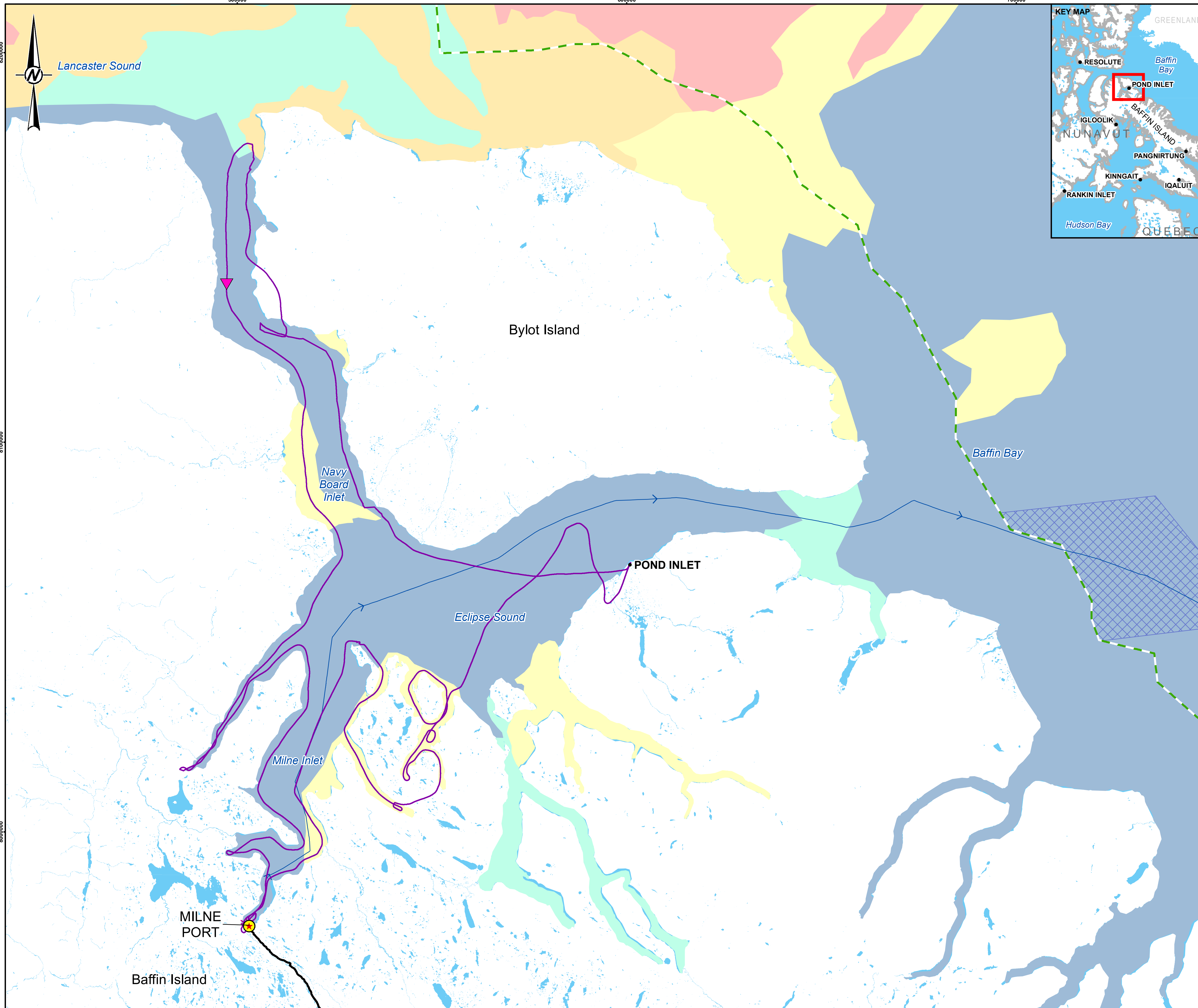
TITLE
ECLIPSE SOUND LEG 2 SURVEY 5 – 25-26 AUGUST 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-19

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



LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

NARWHAL

- 2-10

- AERIAL SURVEY TRACK
- MILNE INLET TOTE ROAD

PROJECT VESSEL SHIP TRACKS

- BULK (ORE) CARRIER
- ICEBREAKER (BOTNICA)
- SERVICE VESSEL
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF SIGHTINGS DURING LEG 3 SURVEY ON 29 OCTOBER 2021

CONSULTANT

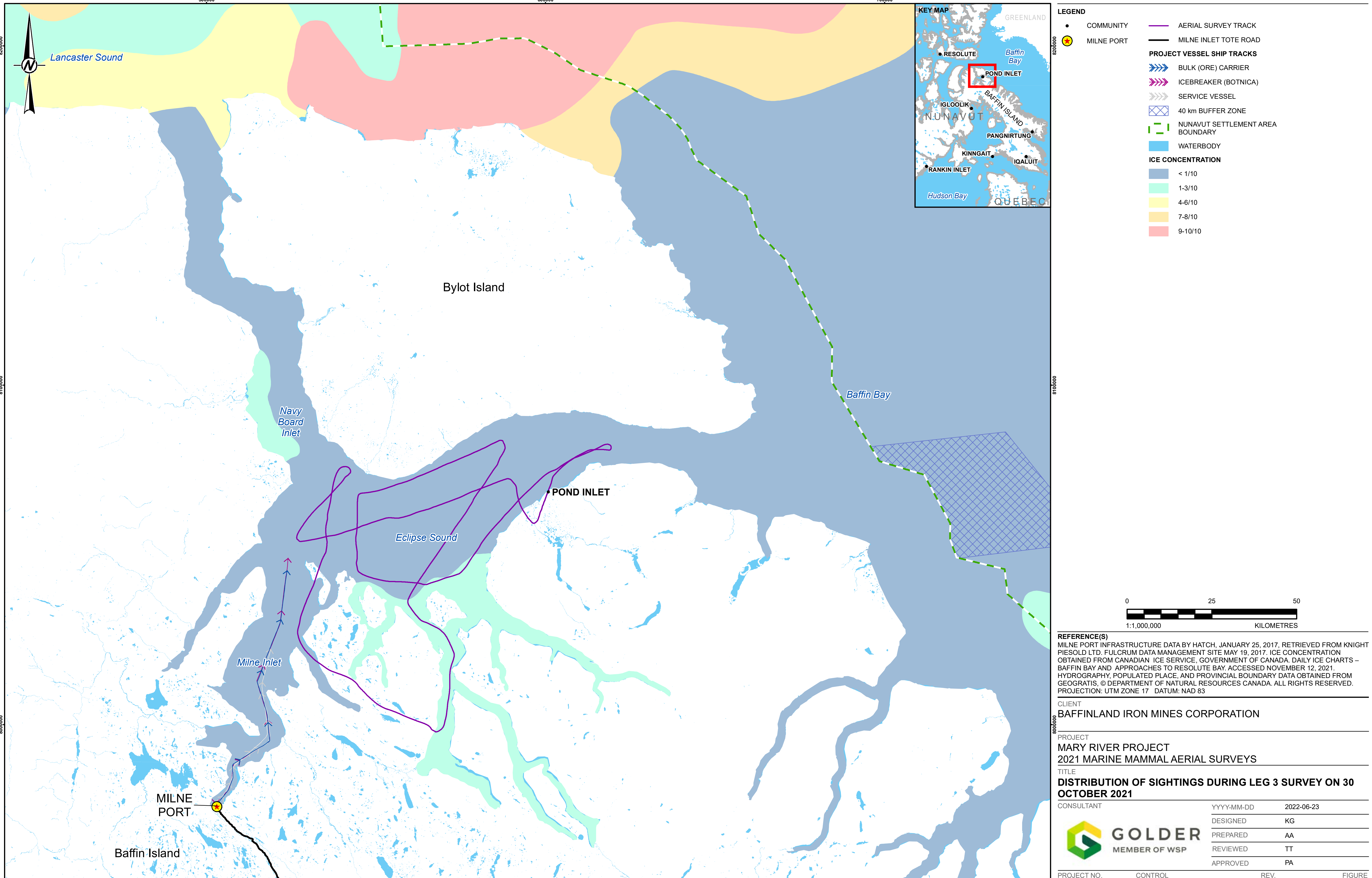
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-20

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 NOVEMBER 12, 2021. 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

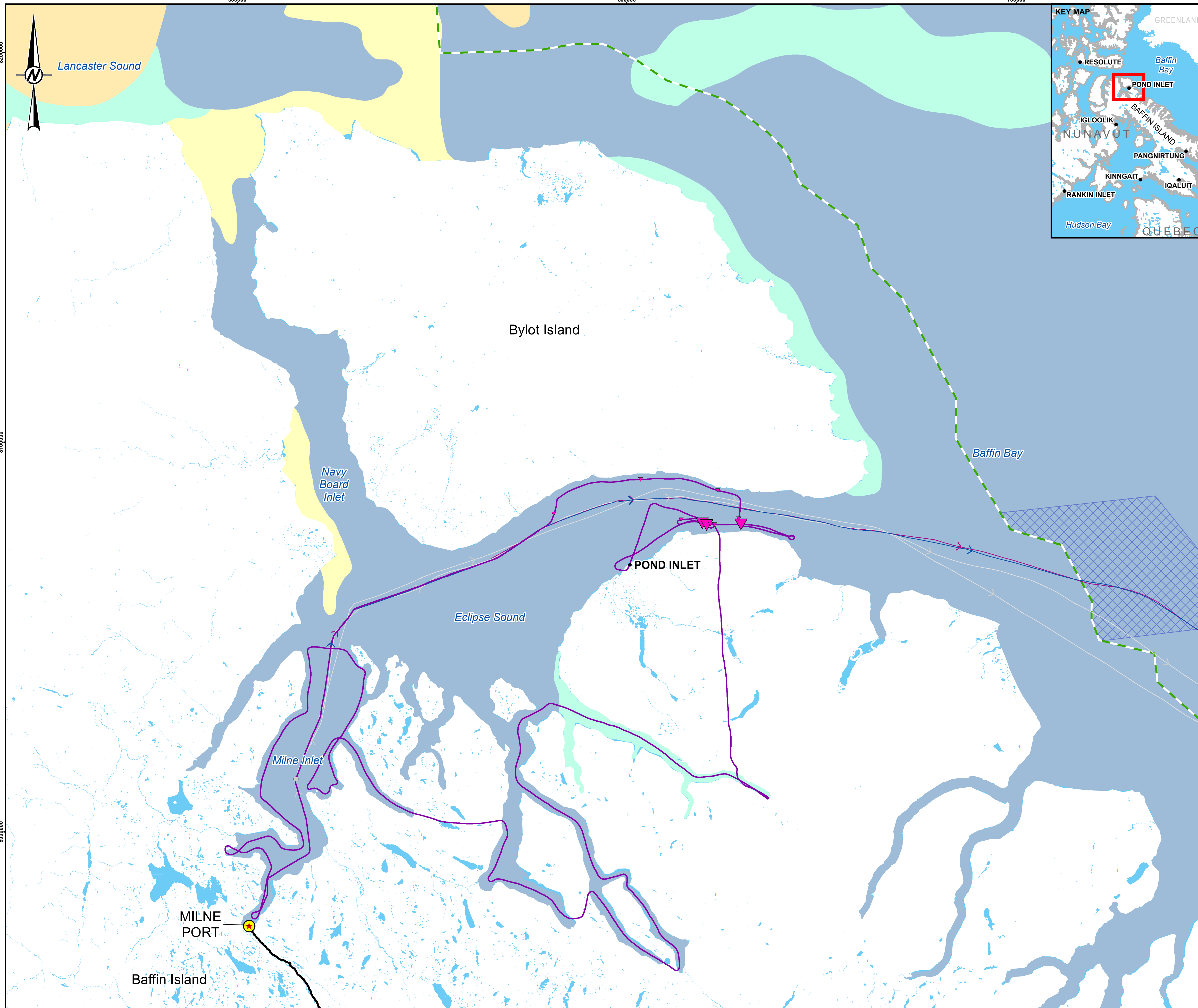
PROJECT
MARY RIVER PROJECT
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF SIGHTINGS DURING LEG 3 SURVEY ON 30 OCTOBER 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-21



LEGEND

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

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

NARWHAL

- 1
- 2-10

UNIDENTIFIED SEAL

- 1

PROJECT VESSEL SHIP TRACKS

- BULK (ORE) CARRIER
- ICEBREAKER (BOTNICA)
- SERVICE VESSEL
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

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 NOVEMBER 12, 2021. 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
2021 MARINE MAMMAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF SIGHTINGS DURING LEG 3 SURVEY ON 31 OCTOBER 2021

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-23
DESIGNED	KG
PREPARED	AA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	49000-07	0	B-22

APPENDIX C

Distance Sampling and Mark-Recapture Models

Table 1: Narwhal Distance Sampling and Mark-Recapture Models

Distance Sampling		Mark-Recapture	
AIC + key function	Model[1]	AIC	Model[1]
5310.136 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + RC30 + size	864.027	~distance + observer + ObsPair:distance + RC15 + size
5310.449 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + RC15 + size	864.831	~ distance + observer + ObsPair:distance + RC15 + size + Bft
5312.015 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + RC30 + Bft + size	865.284	~ distance + observer + ObsPair:observer + RC15 + distance : Bft
5312.211 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + size	865.582	~observer + ObsPair:distance + distance + RC15
5312.406 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + RC15 + Bft + size	865.587	~observer + ObsPair:distance + distance + RC15 + size + GlareInt
5313.446 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + RC45 + size	865.727	~ distance + observer + ObsPair:distance + RC15 + size + GlareAng
5313.646 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + GlareInt + size	865.813	~ distance + observer + ObsPair:distance + size
5313.89 hazard rate	~ObsPair + ObsPair:Bft + Bft + GlareAng:GlareInt:RC30 + GlareInt	865.992	~ distance + observer + ObsPair:distance + RC15 + size + GlareAng:GlareInt
5313.89 hazard rate	~ObsPair + ObsPair:Bft + GlareAng:GlareInt:RC30 + GlareInt	866.571	~ distance + observer + ObsPair:distance + RC15 + Bft
5313.955 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + RC30	866.735	~ distance + observer + ObsPair:distance
5314.084 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + RC60 + size	866.787	~ distance + observer + ObsPair:observer + distance:Bft
5314.116 hazard rate	~ObsPair + ObsPair:Bft + Bft + GlareAng:GlareInt:RC30	866.900	~ distance + observer + ObsPair:distance + RC15 + size + GlareAng:GlareInt + GlareInt

5314.116 hazard rate	~ObsPair + ObsPair:Bft + GlareAng:GlareInt:RC30		867.054	~ distance + observer + ObsPair:observer + distance:Bft + RC15 + Bft
5314.122 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + size + Bft		867.450	~observer + distance:Bft + ObsPair:observer
5314.122 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + Bft + size		867.509	~ distance + observer + ObsPair:distance + RC15 + size + GlareAng:GlareInt + GlareAng
5315.213 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + RC15		867.652	~ distance + observer + ObsPair:distance + RC30 + size
5315.303 half-normal	~ObsPair + GlareAng:GlareInt + GlareAng + RC45 + Bft + size		867.765	~ distance + observer + ObsPair:distance + RC45 + size
5315.469 hazard rate	~ObsPair + ObsPair:Bft + GlareAng:GlareInt:RC30 + GlareAng		868.098	~ distance + observer + ObsPair:distance + Bft
5315.469 hazard rate	~ObsPair + ObsPair:Bft + Bft + GlareAng:GlareInt:RC30 + GlareAng		868.105	~ distance + observer + ObsPair:distance + RC15 + size + GlareAng:GlareInt + GlareInt + GlareAng
5315.632 hazard rate	~ObsPair + ObsPair:Bft + Bft + GlareAng:GlareInt:RC30 + RC30 + GlareInt		868.464	~ distance + observer + ObsPair:distance + GlareAng

1) distance = horizontal distance, GlareAng = glare coverage angle, GlareInt = glare intensity, 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 2021 a total of 2,984.38 km of effort (2,352.08 km during visual surveys and 632.30 km during photographic surveys) was flown over one completed survey (Survey 4) in Eclipse Sound and Admiralty Inlet grids. The relative abundance of marine mammals in the Eclipse Sound and Admiralty Inlet grids for Survey 4, 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 (0.33 animals/km) of all the marine mammal species identified to the species level, followed by ringed seal, harp seal, bowhead whale, and then polar bear (Table 1). Unidentified seals had the fourth highest relative abundance of 0.03 animals/km in the Eclipse Sound grid.

Admiralty Inlet Grid: Narwhal had the highest relative abundance (11.65 animals/km) of all the marine mammal species identified to the species level, followed by harp seal, ringed seal, bowhead whale, and then killer whale (Table 2). Unidentified seals had the third highest relative abundance of 0.17 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, Survey 4.

	Visual Survey		Photographic Survey	Combined Visual and Photographic Survey
Species	No. of Sightings	No. of Animals	Surface Count	Animal Detection Rate (animals/km)
Narwhal	12	47	467	0.3270
Bowhead Whale	1	1	0	0.0006
Killer Whale	0	0	0	0.0000
Unidentified Whale	0	0	0	0.0000
Ringed Seal	77	85	–	0.0702
Harp Seal	2	40	–	0.0331
Unidentified Seal	31	35	–	0.0289
Polar Bear	1	1	0	0.0006

Table 2: Sighting and Animal Detection Rate (Relative Abundance) of Marine Mammals in Admiralty Inlet Grid during Leg 2, Survey 4.

	Visual Survey		Photographic Survey	Combined Visual and Photographic Survey
Species	No. of Sightings	No. of Animals	Surface Count	Animal Detection Rate (animals/km)
Narwhal	152	309	16,457	11.6507
Bowhead Whale	5	7	65	0.0510
Killer Whale	1	12	0	0.0085
Unidentified Whale	1	2	0	0.0014
Ringed Seal	90	105	–	0.0920
Harp Seal	43	1,078	–	0.9441
Unidentified Seal	167	195	–	0.1708
Polar Bear	0	0	0	0.0000

Comparison with 2020 and 2019 MMASP

The relative abundance for this section was calculated based on data collected for Survey 4 in 2021, 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 lower in 2021 (0.43 animals/km) compared to that observed in 2020 (1.05 animals/km) and 2019 (1.74 animals/km; Table 3). Narwhal relative abundance in 2021 (0.33 animals/km) was 2 times smaller than that seen in 2020 (0.77 animals/km) and five times smaller than that seen in 2019 (1.64 animals/km). Ringed seal relative abundance in 2021 (0.07 animals/km) was similar to that seen in 2020 (0.07 animals/km) (Table 3). Harp seals were observed in lower relative abundance in 2021 compared to 2020 and 2019. 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 higher in 2021 (12.69 animals/km) to that observed in 2020 (3.37 animals/km) and in 2019 (4.89 animals/km; Table 3). Much of this increase in abundance can be attributed to the higher number of narwhal observed in 2021. Narwhal relative abundance in 2021 (11.65 animals/km) was three to five times higher than that observed in 2020 and 2019 (2.07 animals/km and 3.44 animals/km, respectively). Ringed seals and harp seals were observed in higher relative abundance in 2021 compared to 2020 and 2019 (Table 3). Unidentified seals were observed in lower relative abundance in 2021 compared to 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)	2019 (animals/km)	2020 (animals/km)	2021 (animals/km)
Narwhal	1.6396	0.7682	0.3270	3.4363	2.0704	11.6507
Bowhead Whale	0.0003	0.0003	0.0006	0.0313	0.0087	0.0510
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	0.0000	0.0012	0.0014
Ringed Seal	0.0047	0.0736	0.0702	0.0122	0.0830	0.0920
Harp Seal	0.0527	0.0448	0.0331	0.1495	0.3685	0.9441
Bearded Seal	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
Hooded Seal	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
Unidentified Seal	0.0574	0.1829	0.0289	1.2938	0.9286	0.1708
Polar Bear	0.0000	0.0000	0.0006	0.0000	0.0032	0.0000
Total	**1.7396**	**1.0490**	**0.4301**	**4.8911**	**3.3705**	**12.6872**

APPENDIX E

EWI Tech Memo

TECHNICAL MEMORANDUM

DATE	26 October 2022	**Reference No.**	1663724-406-TM-Rev0-49000
TO	Lou Kamermans, Senior Director of Sustainable Development Baffinland Iron Mines Corporation		
CC	Lauren Corlett, Sustainability Specialist, BIMC		
FROM	Patrick Abgrall	**EMAIL**	**pabgrall@golder.com**

PROPORTION OF IMMATURE NARWHAL (EARLY WARNING INDICATOR) IN ECLIPSE SOUND AND ADMIRALTY INLET BASED ON 2020/2021 AERIAL SURVEY IMAGERY

Photographic aerial survey imagery collected at 305 m (1,000 ft) altitude during the 2020 and 2021 open-water seasons was analysed to evaluate the proportion of immature narwhal (calves and yearlings) relative to the observed population (i.e., Early Warning Indicator or EWI) within the Eclipse Sound and Admiralty Inlet narwhal summering ground areas. The present report summarizes the results of this EWI analysis with a comparison provided to analogous EWI results derived from 2014/2015 aerial surveys in Eclipse Sound (Moulton et al. 2019), and to EWI results recorded by shore-based observers in 2020/2021 as part of the Bruce Head Shore-based Monitoring Program in Milne Inlet. This work was completed in support of the Mary River Project (the Project), an operating iron ore mine owned by Baffinland Iron Mines Corporation (Baffinland) and located in the Qikiqtani Region of Baffin Island, Nunavut.

1.0 INTRODUCTION

Baffinland has developed a number of indicators in support of the Project aimed at the rapid identification of adverse impacts on narwhal along the Northern Shipping Route, consistent with requirements outlined in Project Certificate (PC) Condition No. 110 and 112. Many of these indicators, monitored across multiple monitoring programs, are suitable for the purpose of early detection of adverse effects on narwhal (i.e., early warning indicators or EWI) resulting from Project and/or other contributing factors in the marine environment. Of these, one indicator has been formally identified as the EWI for narwhal, based on consolidated input from members of the Marine Environmental Working Group (MEWG) since 2018. This EWI is defined as ‘a decrease in the proportion of immature narwhal (defined as calves and yearlings) relative to the observed population’. This EWI was originally proposed by Fisheries and Oceans Canada (DFO) and was also confirmed as being of high importance by the Mittimatalik Hunters and Trappers Organization (MHTO) (Golder 2020). A detailed description of the EWI selection process is presented in Golder (2020).

To date, the data used for deriving the EWI has been collected as part of the Bruce Head Shore-based Monitoring Program, and specifically from narwhal group compositional data collected in the defined Behavioural Study Area (BSA). The threshold for the EWI was originally defined as a '10% decrease in the proportion of immatures (i.e., calves and yearlings) observed at Bruce Head relative to the lowest available baseline value (0.152 recorded in 2014).' The 10% decrease was used to maintain consistency with the threshold level used in the marine mammal impact assessment as per the FEIS (Baffinland 2012) and the FEIS Addendum (Early Revenue Phase; Baffinland 2013). If potential Project-related effects (i.e., shipping noise) were shown to be responsible for an observed exceedance of the threshold (0.137), this would trigger EWI adaptive management practices as summarized in Section 5.4 of Golder (2020).

As part of the MEWG advisory process, DFO subsequently recommended that an index of variability be incorporated into the EWI calculation, along with an estimate of error associated with the measurement (Baffinland 2021). The EWI analysis method was thus modified in 2021 to include an index of variability in the annual EWI calculations. To achieve this, the number of narwhal groups recorded in each sampling year at Bruce Head was divided into ten bins with an equal number of groups assigned per bin. A set of planned contrasts was constructed, so that each sampling year was compared to the average of the 2014–2015 mean least squares. Since the question of interest was whether each sampling year was different from baseline levels (2014/2015) (and not whether a difference between years existed), an ANOVA was not run prior to performing the planned contrasts. An effect size was calculated as the difference between each year's least squares mean and the average of the 2014–2015 least squares mean values, expressed as a percentage of the average of the 2014–2015 least squares mean values. The EWI threshold was therefore revised to 'a statistically significant difference between the annual least squares mean value and the average of the 2014–2015 least squares mean values'.

Results from the 2021 Bruce Head Program indicated that the proportion of immature narwhal (i.e., calves and yearlings) in the observed population in 2021 was 0.102. This was lower than all previous sampling years, representing a 24% decrease from the 2014–2015 baseline condition. However, the observed change was not statistically significant from the baseline condition ($p=0.13$; Golder 2022a). The analytical model had sufficient statistical power (≥0.8) to detect effect sizes of -55% or +55% in the comparison of 2021 data relative to baseline (Golder 2022a). The effect size observed in 2021 (24%) may have been attributable to the low sample size observed in 2021 (i.e., few narwhals were present in the Bruce Head study area in 2021 compared to previous survey years). Although the 2021 EWI value did not exceed the defined threshold, the results did suggest a decreasing trend in the annual proportion of immatures relative to the observed population that warranted further investigation. As a result, Golder recommended that Baffinland undertake an equivalent EWI analysis using available photographic aerial survey data to investigate whether the observed change at Bruce Head in 2021 was likely a reflection of the low sample size observed in that year or was evidence of a decreasing proportion of immature narwhal within the Eclipse Sound summer stock regional population.

The current report presents results of the EWI analysis of photographic aerial survey data collected in the Project Area (i.e., Regional Study Area [RSA]) in 2020 and 2021. The data sources used for this analysis included targeted EWI photographic surveys (305 m or 1,000 ft. altitude) flown in Milne Inlet and Tremblay Sound during the 2020 and 2021 open-water seasons, and equivalent aerial surveys flown in Eclipse Sound in 2014 and 2015 (Moulton et al. 2019). A similar analysis was undertaken of photographic aerial survey data collected in Admiralty Inlet in 2020 and 2021 to compare the EWI results to an adjacent narwhal summering ground area where Project shipping does not occur.

2.0 METHODS

2.1 Photographic Aerial Surveys

Photographic aerial surveys for deriving narwhal abundance estimates are typically flown at 610 m (2,000 ft) during the open water season. Given that the 610 m altitude surveys do not offer the proper resolution for informing narwhal group composition and age class, Golder conducted a limited number of dedicated EWI photographic aerial surveys at 305 m (1,000 ft) in the RSA during the 2020 and 2021 open-water seasons. The EWI aerial surveys were flown at a ground speed of 185 km/h (100 kn) and targeted areas associated with high narwhal concentrations, namely Tremblay Sound and Milne Inlet. As no dedicated EWI aerial surveys were flown in Admiralty Inlet, narwhal group composition was derived from photographs collected during visual-based surveys flown at 305 m (1,000 ft) in Admiralty Inlet in areas also associated with high narwhal concentrations.

The photographic surveys were flown in a de Havilland Twin Otter (DH-6) equipped with an optical glass covered camera hatch at the rear. 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 synced 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 1), calculated using (Covington 1985):

$$\alpha = \beta = arctan\left(\frac{SensorWidth}{FocalLength \times 2}\right)$$

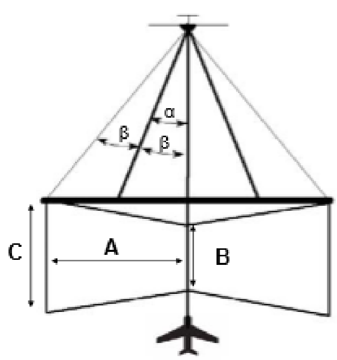


Figure 1 : Geometry of oblique aerial photos (modified from Grendzdörffer et al. 2008)

Using the methods described in Grendzdörffer et al. (2008), the photograph dimensions of the two-camera system (see Figure 1) and the necessary photographic interval were calculated to allow overlap of the photos while flying at 185 km/h (Table 1). 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 <1,200 m, resulting in no lateral overlap between photos from adjacent transects.

Table 1: Dimensions of images flown at 305 m (1,000 ft) altitude

	Altitude 305 m
A (m)	423
B (m)	186
C (m)	318
Interval (sec)	3

Photographs were orthorectified to create an orthophotograph prior to analysis. 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. Each photograph was orthorectified 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.

2.2 Photographic Imagery Analysis

The present analysis was limited to subsets of the 2020/2021 aerial imagery datasets that were associated with high narwhal concentrations. For each subset, all images recorded from one minute before the sighting to one minute following the sighting were carried forward for review by the photo analyst. Only narwhal clearly visible within the top 2 m of the water column were included in the counts. Information recorded for each narwhal group identified in the photographs is outlined in Tables 2 and 3.

Table 2: Data collection protocol for image analysis of narwhal group composition

Data to be recorded	Description
Survey ID	Survey name (eg. MIN_23AUG2020)
Photo ID	Photo name (eg. LFT_####)
Sighting #	A unique sighting number is assigned for each unique narwhal group observed. Repeat sightings of the same narwhal group in subsequent photographs were excluded from the analysis.
Group size	Number of narwhal within 1 body length of one another. Includes group size of 1.
Whale ID	For each narwhal observed in a group (i.e., sighting), a whale number is to be used as a unique identifier
Whale ID Quality	Clarity of Whale ID ■ Clear (at the surface) ■ Blurry (below the surface or out of focus)
Narwhal life stage	See Table 3 (Life stages).

Data to be recorded	Description
Tusk	■ Present ■ Absent ■ Unknown (i.e., head not visible).
x-coor (pixel location)	For the Sighting #
y-coor (pixel location)	For the Sighting #
Length (number of pixels)	For the Whale ID

Table 3: Identification of narwhal life stages

	Adult	Juvenile	Yearling	Calf
Length	4.2 – 4.7 m	80-85% length of adult	2/3 of accompanying female	½ length of accompanying female, usually in “baby” or “echelon” position close to mother. Newborn calves are ~1.6 m in length.
Colouration	Black and white spotting on their back, or mostly white (generally old whales)	Dark grey; no or only light spotting on their back	Light to uniformly dark grey	White or uniformly light (slate) grey, or brownish-grey

2.3 Data Analysis

To estimate the proportion of immatures in each survey (P_s), the total number of immatures (i.e., calves and yearlings) recorded in the photographs was divided by the total number of categorized narwhals (i.e., calves, yearlings, juveniles, and adults) in the photographs:

$$P_s = \frac{\sum N_i}{\sum N_t}$$

Where:

N_i = the number of immature narwhal (i.e., calves and yearlings) recorded in the photographs

N_t = the number of categorized narwhal (i.e., calves, yearlings, juveniles, and adults) recorded in the photographs

To estimate the weighted proportion of immatures in Eclipse Sound or Admiralty Inlet (P_A) area, the sum of the estimated number of immatures in the combined surveys was divided by the total number of whales estimated to have been present in the stratum during the abundance estimate surveys:

$$P_A = \frac{\sum (A_s \times P_s)}{\sum A_s}$$

Where:

A_s = narwhal abundance estimate for the stratum (from Golder 2021 and 2022b)

A total of 272 photo images (equivalent to >10% of total images) from one randomly selected survey (survey from 23 August 2020 in Milne Inlet North) was re-analyzed by a second photo analyst to provide an estimate of sighting reliability and repeatability in the animal counts. A simple linear regression was run to compare animal counts between the two analysts. Animal counts from the original photo analyst were carried forward in the analysis.

A modelling analysis was performed on the Eclipse Sound data, analysing data from two strata – Tremblay Sound and Milne Inlet (Milne Inlet South and North treated as a single entity), in 2020 and 2021. A significance level of alpha = 0.1 was used due to the low sample size. Changes in EWI in Milne Inlet and Tremblay Sound between 2020 and 2021 were assessed using a mixed effect model, to account for the repeated measures nature of the Tremblay Sound data, where the same transects were sampled in 2020 and 2021. The random effect was a Transect-specific intercept (nested within stratum [Milne or Tremblay]). The fixed effects were stratum (Milne and Tremblay), year (2020 and 2021, as a categorical variable), and the interaction between year and stratum. The modeling was performed using the package “glmmTMB” (Brooks et al. 2017) in R (R 2022). Significance of differences between strata within year and between years within stratum was tested using the package “emmeans” in R.

The overall difference in EWI between 2020 and 2021 for the Eclipse Sound stock as a whole (combined Milne Inlet and Tremblay Sound strata) was also assessed using a mixed model, with a random effect of Transect-specific intercept and a single fixed effect of year (2020 and 2021, as a categorical variable). Significance of differences 2020 and 2021 was tested using the package “emmeans” in R.

A modelling analysis was also performed on the Admiralty Inlet data (Admiralty Inlet South and North treated as a single entity) in 2020 and 2021. A significance level of alpha = 0.1 was used due to the low sample size. Changes in EWI in Admiralty Inlet between 2020 and 2021 were assessed using a mixed effect model, to account for the repeated measures on three of the Admiralty Inlet transects. The random effect was a Transect-specific intercept, and the fixed effect was year (2020 and 2021, as a categorical variable). The modelling was performed using the package “glmmTMB” (Brooks et al. 2017) in R (R 2022). Significance of differences between years was tested using the package “emmeans” in R.

Modelling was performed on transect-level data, and modelled estimates of EWI were calculated based on the transect-level resolution. That is, the modelled EWI values represent averaged transect-level EWI values, and the sample size for the modelled EWI estimates is the number of unique transects. In comparison, where raw EWI data were presented and discussed, the EWI values were calculated as a single value per stratum (or per all strata combined, where relevant) via summing all observed immature narwhal and dividing the results by all observed classified narwhal. That is, the EWI values from summaries of raw data are stratum- or area-level based, with a sample size of 1 for each summary (since each value is calculated across all animals observed within the stratum or within the area). These two calculations result in different EWI values, and as a result – in different percent changes between years and percent differences between strata. To maintain separation between the two values, EWI and percent changes calculated based on the statistical model are referred to as “modelled EWI” and “modelled percent changes”, respectively.

3.0 RESULTS

A total of 2,034 aerial survey images collected in 2020 and 2021 in the Eclipse Sound and Admiralty Inlet narwhal summer stock areas were orthorectified and analyzed for group composition (Table 4). For the replicate survey (23 Aug 2022; 272 photos), animal counts recorded by Analyst #2 closely matched those recorded by Analyst #1 (simple linear regression; $R^2 = 0.754$, $F_{1,270} = 826.3$, $p < 0.0001$). Animal counts were identical in 149 of the 272 photos, differed by one count for 52 photos, by two for 30 photos, by three for 18 photos, by four for seven photos, by five for seven photos, by six for eight photos, by eight for three photos, by seven and nine for one photo and by twelve for one photo. The original (Analyst #1) counts were kept for the group composition analysis.

Table 4: Total number of images analyzed for proportion of immature narwhal.

Study Area	Date	Stratum	Image Count
Eclipse Sound	23 August 2020	Milne Inlet North	272
Eclipse Sound	23 August 2020	Tremblay Sound	95
Eclipse Sound	16 August 2021	Tremblay Sound	92
Eclipse Sound	17 August 2021	Tremblay Sound	151
Eclipse Sound	17 August 2021	Milne Inlet South	315
Total Eclipse			**925**
Admiralty Inlet	21 August 2020	Admiralty Inlet North	353
Admiralty Inlet	28 August 2020	Admiralty Inlet North	413
Admiralty Inlet	16 August 2021	Admiralty Inlet South	51
Admiralty Inlet	19 August 2021	Admiralty Inlet South	292
Total Admiralty			**1,109**
Total Combined			**2,034**

3.1 Eclipse Sound

For the Eclipse Sound summer stock area, a total of 925 images were analyzed for group composition (367 in 2020 and 558 in 2021; Table 4). In 2020, images contained 590 narwhal group sightings comprising of 1,141 individuals; with 909 individuals successfully classified to life stage (Table 5). In 2021, images contained 317 group sightings comprising 510 individuals; with 428 individuals successfully classified to life stage (Table 5). Whales that could not be classified were either too far below the surface to reliably identify life stage (i.e., poor resolution), were obscured by another animal swimming above it, or were oriented too steeply in the water column to get a reliable measure of size or coloration. The proportion of immatures in Tremblay Sound in 2021 was based on the combined results of two separate surveys (16 and 17 August 2021).

Table 5: Number of narwhal by age class and 'proportion of immatures' in Milne Inlet and Tremblay Sound strata based on group composition analysis of 2020/2021 aerial survey data.

Date	Stratum	Calves	Yearlings	Juveniles	Adults	All classified narwhal	Proportion of Immatures
23 AUG 2020	Milne Inlet North	52	38	44	536	670	0.134
23 AUG 2020	Tremblay Sound	11	11	4	213	239	0.092
Combined (2020)		**63**	**49**	**48**	**749**	**909**	**–**
17 AUG 2021	Milne Inlet South	9	1	4	120	134	0.075
16–17 AUG 2021	Tremblay Sound	42	4	35	213	294	0.156
Combined (2021)		**51**	**5**	**39**	**333**	**428**	**–**

The EWI aerial survey results indicated that Milne Inlet supported a higher proportion of immatures (0.134) in 2020 compared to Tremblay Sound (0.092) (Table 5). The reverse was true in 2021 when a higher proportion of immatures was observed in Tremblay Sound (0.156) compared to Milne Inlet (0.075) (Table 5).

To evaluate if there was a decrease in the proportion of immature narwhal at the regional level (i.e., Eclipse Sound summer stock) between 2020 and 2021, the weighted proportion of immatures was calculated for the combined Milne Inlet and Tremblay Sound strata. This was calculated by dividing the total number of immatures recorded in the EWI aerial surveys by the combined abundance estimates for 'Milne Inlet South' and 'Tremblay Sound' as presented in the 2020/2021 Marine Mammal Aerial Survey Program (MMASP) reports (Golder 2021, 2022b). One exception to this was with the 2020 EWI results for Milne Inlet, where the EWI aerial survey (305 m or 1,000 ft altitude) was performed in Milne Inlet North and not Milne Inlet South (as intended and as completed in 2021). The EWI survey was completed in Milne Inlet North because no narwhal were present in Milne Inlet South on the day of the survey. Given this factor, the 2020 abundance estimates calculated for Milne Inlet South and Milne Inlet North (see results for Survey #3 in Golder [2021]) were blended to generate an overall 2020 abundance estimate of 2,959 individuals for Milne Inlet (Table 6), resulting in an estimated 396 immature narwhal in the blended strata (based on a relative proportion of immatures of 0.134).

Results of the weighted EWI analysis are summarized in Table 6. The proportion of immature narwhal at the regional level (i.e., Eclipse Sound summer stock area) was shown to increase from 0.117 in 2020 to 0.128 in 2021. The Milne Inlet North, Milne Inlet South and Tremblay Sound survey strata contained 97% of the narwhal that occupied the Eclipse Sound summer stock area in 2020 (Golder 2021). The Milne Inlet South and Tremblay Sound survey strata contained 66% of the narwhal that occupied the Eclipse Sound summer stock area in 2021 (Golder 2022b).

Table 6: Estimated number of immature narwhal in Eclipse Sound summer stock area based on EWI (proportion of immatures) and abundance estimates derived from 2020/2021 aerial surveys.

Year	Stratum	Abundance Estimate	Abundance Estimate Surface Count[a]	# Age Classified Narwhal for EWI	EWI (proportion of Immatures)	Estimated # Immatures
2020	Milne Inlet (blended)	2,959[a]	835[a]	686	0.134	396
2020	Tremblay Sound	1,919 [b]	547 [b]	239	0.092	176
2020	**Combined**	4,878	—	—	**0.117**	572
2021	Milne Inlet South	586 [c]	159 [c]	134	0.075	44
2021	Tremblay Sound	1,136[d]	308 [d]	294	0.156	177
2021	**Combined**	1,722	—	—	**0.128**	221

[a] Survey #3, summed values from Milne Inlet South (photo survey = 2,918) + Milne Inlet North (observer-based survey = 41) (Golder 2021)

[b] Survey #3, values from Tremblay Sound strata (photo survey) (Golder 2021)

[c] Survey #4, values from Milne Inlet South (photo survey) (Golder 2022b)

[d] Survey #4 values from Tremblay Sound (photo survey) (Golder 2022b)

Results from the modelling analysis indicated a significant interaction between stratum and year (P=0.025), indicating that the change in proportion immatures between 2020 and 2021 differed between the two strata (Milne Inlet and Tremblay Sound). At a significance level of 0.1, there was a significant difference between Milne Inlet and Tremblay Sound in 2021 (P=0.097; Milne Inlet modelled EWI 52% lower than Tremblay Sound) but not in 2020 (P=0.2; Milne Inlet modelled EWI 68% higher than Tremblay Sound). The overall difference in modelled EWI between 2020 and 2021 was significant in Tremblay Sound (P=0.09; 2021 modelled EWI 117% higher than 2020) but not in Milne Inlet (P=0.2; 2021 modelled EWI 39% lower than 2020). For the Eclipse Sound stock as a whole (combined strata), the overall difference in EWI between 2020 and 2021 was not significant (P=0.76; 2021 modelled EWI 9.7% higher than 2020).

The EWI aerial survey data were associated with high variability and low sample sizes, resulting in high uncertainty of the EWI estimates, and hence low ability to detect small- and medium-sized effect sizes.

3.2 Admiralty Inlet

In Admiralty Inlet, a total of 1,109 images were analyzed for group composition (733 in 2020 and 343 in 2021; Table 4). In 2020, images contained 289 sightings of 403 individual narwhal; with 329 of the 403 individuals successfully classified to life stage (Table 7). The proportion of immatures in 2020 was 0.094 and 0.208 in Admiralty Inlet North on the 21 and 28 August, respectively. In 2021, images contained 321 sightings of 615 individual narwhal; 518 of the 615 narwhal could be classified to the level summarized in Table 7. The proportion of immatures in 2021 was 0.159 and 0.132 in Admiralty Inlet South on the 16 and 19 August, respectively. Whales that could not be classified were either too far below the surface to reliably identify life stage (i.e., poor resolution), were obscured by another animal swimming above it, or were oriented too steeply in the water column to get a reliable measure of size or coloration.

Table 7: Number of narwhal by age class and 'proportion of immatures' in Admiralty Inlet strata based on group composition analysis of 2020/2021 aerial survey data.

Date	Stratum	Calves	Yearlings	Juveniles	Adults	All classified narwhal	Proportion of Immatures
21 AUG 2020	Admiralty Inlet North	5	7	12	103	127	0.094
28 AUG 2020	Admiralty Inlet North	31	11	14	146	202	0.208
Combined (2020)		**36**	**18**	**26**	**249**	**329**	**–**
16 AUG 2021	Admiralty Inlet South	10	0	4	49	63	0.159
19 AUG 2021	Admiralty Inlet South	47	13	27	368	455	0.132
Combined (2021)		**57**	**13**	**31**	**417**	**518**	**–**

To identify a change in the proportion of immatures in the study area between 2020 and 2021, the proportion of immatures in the combined survey areas was calculated. The proportion of immatures present in the combined Admiralty Inlet North surveys was calculated by summing the estimated number of immatures in each survey and dividing by the sum of the abundance estimate in each survey. The abundance estimates were extracted from the MMASP reports (Golder 2021 and 2022b) which calculate the abundance estimate for narwhal during the open water season in each stratum for the entire RSA.

EWI photographic surveys (305 m or 1,000 ft altitude) were not flown in the Admiralty Inlet grid, thus group composition data was taken from photographs collected during visual surveys flown at 305 m (1,000 ft) in areas of known high narwhal concentrations. In 2020, two surveys (21 and 28 August) were flown in Admiralty Inlet North. In 2020, the abundance estimate for the 21 August survey was 13,955 and for the 28 August survey was 17,734 (Golder 2021). Multiplying the abundance estimate by the proportion of immatures resulted in an estimated 1,319 and 3,687 immature narwhal on 21 and 28 August 2020, respectively (Table 8). The proportion of immatures for the combined surveys was 0.158 (5,006/31,689; Table 8).

In 2021, two surveys (16 and 19 August) were flown in Admiralty Inlet South. The abundance estimate for the 16 August survey was 7,434 and for the 19 August survey was 11,530 (Golder 2022b). Multiplying the abundance estimate by the proportion of immatures resulted in an estimated 1,180 and 1,520 immature narwhal on 16 August and 19 August, respectively (Table 8). The proportion of immatures for the combined surveys was 0.142 (2,700/18,964; Table 8).

Results from the modelling analysis indicated that the difference in the proportion of immatures between 2020 and 2021 was not significant (P=0.39; 2021 modelled EWI 26% lower than 2020). Similar to Eclipse Sound, the EWI aerial survey data in the Admiralty Inlet were associated with high variability and low sample sizes, resulting in high uncertainty of the EWI estimates, and hence low ability to detect small- and medium-sized effect sizes.

Table 8: Proportion of immature narwhal in Admiralty Inlet based on digital photographs and abundance estimates from aerial surveys flown in 2020 and 2021

Date	Stratum	Abundance Estimate	Abundance Estimate Surface Count	# Age Classified Narwhal for EWI	EWI (Proportion of Immatures)	Estimated # Immatures
21 AUG 2020	AIN	13,955[a]	314 [a]	127	0.094	1,319
28 AUG 2020	AIN	17,734 [a]	369 [a]	202	0.208	3,687
2020 Combined	**AIN**	**31,689**	**—**	**—**	**0.158**	**5,006**
16 AUG 2021	AIS	7,434 [b]	75 [b]	63	0.159	1,180
19 AUG 2021	AIS	11,530 [c]	143[c]	455	0.132	1,520
2021 Combined	**AIS**	**18,964**	**—**	**—**	**0.142**	**2,700**

Notes: AIN=Admiralty Inlet North; AIS=Admiralty Inlet South.

[a] Survey #3, values from Milne Inlet North (observer-based survey) + (Golder 2021)

[b] Survey #3, values from Milne Inlet North (observer-based survey) (Golder 2022b)

[c] Survey #4, values from Milne Inlet North (observer-based survey) (Golder 2022b)

4.0 DISCUSSION

When looking at the Milne Inlet strata independently, the aerial survey EWI results were in agreement with the Bruce Head EWI results in that they demonstrated a decrease in the proportion of immature narwhal in Milne Inlet from 0.134 in 2020 to 0.075 in 2021. A reverse pattern was observed in Tremblay Sound, where the proportion of narwhal increased from 0.092 in 2020 to 0.156 in 2021. The variability observed between strata does not appear to be shipping-related as shipping levels in the RSA were similar in 2020 (72 ore carriers) compared to 2021 (73 ore carriers).

When looking at the Eclipse Sound narwhal stock as a whole (represented by the combined proportion of immature narwhal for the Milne Inlet and Tremblay Sound strata), the proportion of immature narwhal was shown to increase by 9.4% between 2020 (0.117) and 2021 (0.128) (Table 6). This was largely driven by the 2021 EWI results for Tremblay Sound (0.156), given most narwhal present in the RSA occurred in the Tremblay stratum, and this stratum was associated with a higher EWI value in 2021 (0.156) (compared to an EWI value of 0.092 in 2020).

The 2020 and 2021 results were compared to analogous EWI results for Eclipse Sound narwhal derived from 2014 and 2015 photographic aerial surveys (Moulton et al. 2019). The proportion of immature narwhal in the Eclipse Sound summer stock area (combined strata) was 0.150 in 2014[1] and 0.110 in 2015[2] (Table 9). EWI values from 2020 (0.117) and 2021 (0.128) fall within range of the EWI estimates for 2014 and 2015 (Table 9). There does appear to be variability between years, but there is no indication that the proportion of immature narwhal in the RSA in 2021 has declined compared to 2020 or 2014–2015. A statistical comparison between the

[1] Proportion of calves and yearlings in Eclipse Sound summer ground was 0.094 and 0.060 respectively in Aug 2014 (Moulton et al. 2019)

[2] Proportion of calves and yearlings in Eclipse Sound summer ground was 0.067 and 0.043 respectively in Aug 2015 (Moulton et al. 2019)

2020/2021 EWI results and EWI results derived from Moulton et al. (2019) was not possible as the detailed 2014/2015 dataset was not available for analysis.

For narwhal in the Admiralty Inlet summer stock area, the proportion of immatures was shown to decrease by 10.1% between 2020 (0.158) and 2021 (0.142). No earlier EWI estimates were available for comparison for the Admiralty Inlet summer stock. Overall, Admiralty Inlet supported a higher proportion of immatures in both 2020 and 2021 compared to Eclipse Sound.

Table 9: Estimated proportion of immature narwhal in North Baffin Island based on photographic aerial imagery collected over four survey years.

Year	Stratum	Proportion of Immatures	Abundance Estimate	Estimated # Immatures in Stratum	Source
2014	Koluktoo Bay	0.112	574*	64	Moulton et al. 2019
	Milne Inlet South	0.162	3,107*	503	
	Milne Inlet North	0.154	5,814*	895	
	Tremblay Sound	0.103	716*	74	
	Combined (weighted)	**0.150**	**10,211***	**1,536**	
2015	Koluktoo Bay	0.295	152*	45	Moulton et al. 2019
	Milne Inlet South	0.181	1,211*	219	
	Milne Inlet North	0.071	1,067*	76	
	Tremblay Sound	0.089	3,495*	311	
	Combined (weighted)	**0.110**	**5,924***	**651**	
2020	Milne Inlet/Tremblay (combined)	0.117	4,878**	572	Present study
	Admiralty Inlet	0.158	31,689**	5,007	
2021	Milne Inlet/Tremblay (combined)	0.128	1,722**	221	Present study
	Admiralty Inlet	0.142	18,964**	2,693	

*mean abundance estimate based on multiple surveys. ** Confidence intervals for abundance estimates are presented in main body of this report.

One of the stated objectives of this exercise was to undertake an equivalent EWI analysis (to the Bruce Head EWI analysis) using available photographic aerial survey data to investigate whether the observed change at Bruce Head in 2021 was likely a reflection of the low sample size (n=263) observed in that year or was evidence of a decreasing proportion of immature narwhal within the regional population (i.e., Eclipse Sound summer stock). Although the EWI aerial data results do not support a declining proportion of immature narwhal at the regional level, sample sizes for the 2020/2021 aerial EWI analysis were similarly limited, and therefore results must be interpreted with caution.

In general, aerial surveys produced lower EWI estimates than the shore-based EWI surveys (i.e., Bruce Head Program) (Table 6). This is not unexpected, as aerial surveys offer a limited window of observation time (due to the speed of the aircraft) compared to shore-based surveys. This affected the available window of detection of marine mammals and particularly for nursing calves that are often obscured from view when feeding or travelling directly beneath their mothers. As such, the level of detection of nursing calves will naturally be lower in photographic aerial surveys compared to shore-based surveys due to their narrower window of available detection time (i.e., aerial imagery only offers a brief snapshot in time). Shore-based observers have a considerably longer window of opportunity to detect calves that may be temporarily obscured from view due to their inherent behaviour and relative placement to mother at the time of surveying. Thus, a direct comparison between photographic aerial results and the Bruce Head program is not advisable. It is also important to note that the sample size for the aerial survey dataset (for which the EWI estimates are based) was smaller than the shore-based dataset in both sampling years, largely due to the limited amount of 305 m (1,000 ft) survey data available in these years. However, the potential for duplicate counts in the shore-based dataset is considerably higher than the aerial surveys given the difference in sampling methodology.

5.0 SUMMARY

- For the Admiralty Inlet summer stock area (where no Project shipping occurs), EWI aerial survey results demonstrated that the proportion of immature narwhal decreased from 0.158 in 2020 to 0.142 in 2021.
- For the Eclipse Sound summer stock area (where Project shipping occurs), EWI aerial survey results demonstrated that the proportion of immature narwhal increased from 0.117 in 2020 to 0.128 in 2021.
- For comparative purposes, the proportion of immature narwhal in the Eclipse Sound stock was 0.15 in 2014 (pre-Project shipping) and 0.11 in 2015 (first year of iron ore shipping) (Moulton et al. 2019). The 2020 and 2021 EWI values therefore fall within range of the EWI estimates for 2014 and 2015.
- When looking at the Milne Inlet strata independently, the aerial survey EWI results were in agreement with the Bruce Head EWI results in that they demonstrated a decrease in the proportion of immature narwhal in Milne Inlet from 0.134 in 2020 to 0.075 in 2021. A reverse pattern was observed in Tremblay Sound, where the proportion of narwhal increased from 0.092 in 2020 to 0.156 in 2021. The variability observed between strata does not appear to be shipping-related as shipping levels in the RSA were similar in 2020 (72 ore carriers) compared to 2021 (73 ore carriers).
- There appeared to be variability between years, but there was no indication that the proportion of immature narwhal in the RSA in 2021 had declined compared to 2020 or 2014–2015 levels.
- The 2020 and 2021 EWI aerial survey data were associated with high variability and low sample sizes, resulting in high uncertainty of the EWI estimates, and hence low ability to detect small- and medium-sized effect sizes.

6.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional information, please contact the undersigned.

Golder Associates Ltd.

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APPENDIX F

Responses to MEWG Comments

Baffinland

Baffinland Mary River Project Report Working Group Comment Form

Reviewer Agency/Organization:	*Parks Canada Agency*
Reviewers:	*Allison Stoddart, Jordan Hoffman, Chantal Vis*
Document(s) Reviewed:	*2021 Bruce Head Shore Based Monitoring Program, 2021 MEEMP and AIS Monitoring Program, 2021 Marine Mammal Aerial Survey, 2021 Ringed Seal Aerial Survey, 2021 Underwater Acoustic Monitoring Program (Open-water Season), Year 2 Freight Dock Offset Habitat Monitoring Program*
Date Review Completed	*2022-05-17*

Comment No.:	PCA-03
Section Reference:	Marine Mammal Aerial Survey, page 79, Section 3.6.1, 'Discussion: Narwhal Abundance and Distribution', first bullet point Bruce Head Monitoring Report, page 155, Section 7.1, 'Discussion: Relative Abundance and Distribution'
Comment:	

One of the conclusions made in the Marine Mammal Aerial Survey report is that underwater noise from open-water shipping was not considered to be a likely cause of narwhal displacement from the Regional Study Area based on the available monitoring results to date. Instead, other factors lacking area-specific data in Admiralty Inlet and Eclipse Sound such as prey availability or predation pressure (i.e., more favourable ecological conditions) are suggested to be causing the observed large-scale distribution shift to Admiralty Inlet. These conclusions are based on the past tagging data, open-water acoustic monitoring, and the Bruce Head study area. There are multiple lines of evidence, including Inuit Qaujimajatuqangit, which suggest shipping has an impact on narwhal. Monitoring studies to date have been spatially restricted (e.g., Bruce Head shore-based monitoring and UAV studies) or temporally restricted (e.g., aerial surveys, UAV studies, and marine mammal tagging) to fully consider that shipping is not a contributing factor to any potential long-term movements and displacement of narwhal. Further, in the Bruce Head monitoring report (page 155) Golder States that, "While **underwater noise from open-water shipping cannot be ruled out as a potential cause of narwhal displacement from the RSA**, monitoring results collected to date demonstrate that there are likely other factors contributing to the observed change."

1. How does Baffinland plan to follow up with studies to determine the influence of other ecological factors that are suggested in the 2021 monitoring reports or to further investigate the impacts of shipping on movement in less spatially restricted areas of Eclipse Sound (i.e., outside of inlets such as Tremblay Sound and Milne Inlet)?
2. Will a precautionary approach be taken which considers the impacts of shipping in the absence of evidence that other factor(s) are contributing to the observed decline in narwhal?

Baffinland Response:

1. This question does not pertain directly to the 2021 Marine Mammal Aerial Survey Program (MMASP) or the 2021 MMASP Report. This comment was also provided by Parks Canada for the 2021 Bruce Head Shore-based Monitoring Report (see corresponding response to PCA-03 in the 2021 Bruce Head final report). The intent of this exercise is for MEWG members to provide comments and/or recommendations related to the MMASP, and/or request points of clarification around the 2021 MMASP (or recommendations for future monitoring under this program). We would ask Parks Canada to refer to BIMC's 2022 Narwhal Adaptive Management Response Plan (NAMRP; BIMC 2022) for further details about future monitoring and adaptive management initiatives regarding narwhal in the Regional Study Area (RSA) based on results available to date.

We would also like to highlight to Parks Canada that the MMASP is not spatially restricted in terms of its study area or its research scope. This program actively monitors narwhal abundance and distribution throughout all waters of the RSA and also monitors beyond the spatial boundaries of the RSA with systematic surveys also flown in Admiralty Inlet. The same applies to previous narwhal behavioural response monitoring programs undertaken by Baffinland Iron Mines Corp. (BIMC), including the Tremblay Sound Narwhal Tagging Program undertaken by BIMC in 2017 and 2018. As part of this research, narwhal behavioural responses to shipping were evaluated throughout all waters of the RSA, as well as beyond the spatial boundaries of the RSA (Admiralty Inlet, Lancaster Sound, Baffin Bay). BIMC had proposed to conduct an additional narwhal tagging program throughout the 2022 season, which would have allowed for greater spatial and temporal distribution of monitoring results including an assessment of icebreaking on narwhal during spring (ice break-up period). However, this program did not proceed due to lack of support from the Mittimatalik Hunters and Trappers Organization (MHTO).

2. Yes, a precautionary approach has been taken by BIMC based on evidence from its existing narwhal monitoring programs and uncertainties related to external factor(s) that may have contributed to the observed decline in narwhal. These are summarized in section 5.2 of BIMC's 2022 NAMRP (BIMC 2022).

For example, BIMC implemented adaptive management measures in 2021 (e.g., suspending icebreaking operations altogether during the 2021 early shoulder spring season) based on results of its 2020 monitoring programs to ensure that the Project continued to operate in a protective, precautionary and adaptive manner. The avoidance of icebreaking during the 2021 spring shoulder season eliminated the possibility of acoustic disturbance to narwhal from icebreaking during the timing of narwhal migration into Eclipse Sound in 2021, and also served to avoid the potential for cumulative noise effects associated with the Pond Inlet small craft harbour (SCH) Project. However, despite the suspension of icebreaking operations during the early shoulder season in that year, narwhal numbers in the RSA were not shown to increase in 2021 (relative to levels observed in 2019). Narwhal disturbance from icebreaking was therefore not considered to be an influencing factor on the observed decline in narwhal abundance in

Eclipse Sound during the 2021 season. It also provided additional confidence that the observed decline in 2020 was likely not a result of early shoulder season icebreaking in 2020.

A similar precautionary approach has been applied by BIMC in 2022. For example, adaptive management measures implemented in 2022 included suspending icebreaking operations altogether during the 2022 early shoulder (spring season), having ore carriers travel in convoys to reduce the overall number of vessel passages and cumulative noise exposure to narwhal, and limiting ore carriers to no more than 80 in the RSA under an approved six million tonnes per annum (6MTPA) scenario, versus a limit of 86.

Further to this, BIMC will continue Project-level effects monitoring in 2022 for assessing Project impacts on narwhal, including the Marine Mammal Aerial Survey Program (for deriving updated estimates of narwhal abundance in the RSA and in Admiralty Inlet), the Bruce Head Shore-based Monitoring Program and the Ship-based Observer (SBO) Program during the fall shoulder season. BIMC will also undertake an Underwater Acoustic Monitoring Program to continue to measure and evaluate sound levels from Project shipping and associated acoustic impacts on marine mammals throughout the RSA (noting however, this program has been reduced in scope due to a lack of program support by MHTO). Similarly, BIMC had further proposed to undertake a narwhal tagging study in 2022 to study the behavioural response of narwhal to shipping during the early shoulder season but this program was not supported by the MHTO and so was not implemented in 2022.

References:

BIMC. 2022. 2022 Narwhal Adaptive Management Response Plan (NAMRP). Document # BAF-PH1-830-P16-0024. Rev1. 19 July 2022.

Comment No.:	PCA-04
Section Reference:	Marine Mammal Aerial Survey, page 94, Section 5.0, 'Summary'
Comment:	

We recommend clarifying in the Discussion section that although both western science and Inuit Qaujimajatuqangit (IQ) have identified that there is a natural exchange of narwhal between putative summer stocks for the Baffin Bay narwhal population, the current **magnitude of exchange** on an annual basis and resulting large-scale distribution shift has not been observed to date with satellite tag data or aerial survey abundance estimates and to our knowledge has not been identified by IQ. For example, science evidence from DFO identified 16% of narwhal tagged in 2012, and from 2016-2018 visited other summer management areas during July 25-August 24 (i.e., the period corresponding to when aerial surveys typically take place) and 33% of narwhal travelled to one or more summer management areas during the typical open water season (DFO, 2020). Based on point estimates of abundance in Eclipse Sound from 2019 to 2021 (page 77, Table 20) the approximate decline on an annual basis from 2019-2021 ranges from 50-52% during the typical aerial survey period compared to 16% of narwhal tagged in 2012, and from 2016-2018.

Reference:

DFO (2020). Information Related to the Delineation of the Eclipse Sound and Admiralty Inlet Narwhal Stocks. Canadian Science Advisory Secretariat, Science Advisory Report 2020/048.

Baffinland Response:

We disagree with Parks Canada's suggestion that the current **magnitude of exchange** and resulting shift in summer narwhal distribution has not been observed to date in the region based on available data. Available historical aerial survey data indicate that a shift in narwhal distribution from Eclipse Sound to Admiralty Inlet has been progressively occurring since the early 2000s. In 2003, aerial surveys undertaken by DFO calculated narwhal abundance in Admiralty Inlet at 5,362 individuals (Richard et al. 2010). In 2010, aerial surveys conducted by DFO calculated narwhal abundance in Admiralty Inlet 18,049 (Asselin and Richard 2011). In 2013, aerial surveys conducted by DFO calculated narwhal abundance in Admiralty Inlet at 35,043 (Doniol-Valcroze et al. 2015). Thus, prior to any BIMC shipping activity in the RSA, narwhal abundance in Admiralty Inlet had increased from 5,362 to 35,043 individuals (i.e., this represents a >650% increase). The 2021 abundance estimate for Admiralty Inlet was 72,582 individuals (present report). This shows a trend of increasing narwhal abundance in the Admiralty Inlet area. The decreasing trend in Eclipse Sound from 2004 (20,225 individuals; Richard et al. 2010) to present (2,595 individuals), which was first identified in 2013 (10,489 individuals; Doniol-Valcroze et al. 2015) prior to BIMC shipping activity in the RSA, may be linked to the increasing trend in Admiralty Inlet, both of which occurred prior to the start of BIMC shipping activities in the RSA.

Also see response to QIA-05 and QIA-11.

References:

Asselin, N.C. and P.R. Richard, 2011. Results of narwhal (Monodon monoceros) aerial surveys in Admiralty Inlet, August 2010. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/065. iv + 26 p.

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Reviewer Agency/Organization:	*Oceans North*
Reviewers:	*Dr. Kristin Westdal, Dr. Josh Jones, & Amanda Joynt*
Document(s) Reviewed:	*Bruce Head Draft Report 2021,* *Open Water Acoustic Monitoring 2021 &* *MMASP Draft Report 2021*
Date Review Completed	*2022-05-27*

Comment No.:	ON-10
Section Reference:	2021 Marine Mammal Aerial Survey Draft Report
Comment:	

Issue:
The report suggests that a portion of the Eclipse Sound stock occupied the Admiralty Inlet summering ground but has no evidence to conclude that the larger number in Admiralty came from the Eclipse Sound area. Baffinland noted in the 2020 marine mammal aerial survey report that a decline in narwhal could be represented by a potential decrease in Eclipse Sound abundance. However, Baffinland does not apply this reasoning to the further decrease seen in 2021 in the current aerial survey report. From Baffinland's 2020 report: "These results suggest a potential displacement of a portion of the Eclipse Sound stock to the Admiralty Inlet summering ground during the summer of 2020 but cannot discount the possibility of a potential displacement of these animals to another area (e.g., Eastern Baffin Bay summering ground) or a potential decrease in the Eclipse Sound summer stock."

Additionally, in the 2020 report it was noted with respect to the decrease in narwhal in Eclipse Sound that "These findings are not consistent with impact predictions made in the Final Environmental Impact Statement (FEIS) Addendum for the Early Revenue Phase (ERP), which stated that the Project is unlikely to result in significant residual adverse effects on narwhal in the RSA (defined as effects that would compromise the integrity of the population either through mortality or via large-scale displacement or abandonment of the RSA)."

Recommendation:
These clarifications should be added to the 2021 report. In addition, it should be noted that there is no evidence to conclude that the Eclipse Sound narwhal simply shifted to Admiralty. Surrounding narwhal populations have not been taken into account and an abandonment of this area is not consistent with the company's predictions of short-term localized effects.

Baffinland Response:

A holistic review of the data from the 2021 shipping season does not conclude that the relatively lower number of narwhals observed in Eclipse Sound in 2020 and 2021 was Project-driven. Please refer to BIMC's response to QIA-05 for a detailed summary on this topic.

Overall, historical aerial survey results indicate a shift in narwhal distribution from Eclipse Sound to Admiralty Inlet which has been progressively occurring since the early 2000s. In 2003, aerial surveys undertaken by DFO calculated narwhal abundance in Admiralty Inlet at 5,362 individuals (Richard et al. 2010). In 2010, aerial surveys conducted by DFO calculated narwhal abundance in Admiralty Inlet 18,049 (Asselin and Richard 2011). In 2013, aerial surveys conducted by DFO calculated narwhal abundance in Admiralty Inlet at 35,043 (Doniol-Valcroze et al. 2015). Thus, prior to any BIMC shipping activity in the RSA, narwhal abundance in Admiralty Inlet had increased from 5,362 to 35,043 individuals. The 2021 abundance estimate for Admiralty Inlet was 72,582 individuals (as per the present report). This shows a trend of increasing narwhal abundance in the Admiralty Inlet area. The decreasing trend in Eclipse Sound from 2004 (20,225 individuals; Richard et al. 2010) to present (2,595 individuals; Golder 2022), which was first identified in 2013 (10,489 individuals; Doniol-Valcroze et al. 2015) prior to BIMC shipping activity in the RSA, may be linked to the increasing trend in Admiralty Inlet, both of which occurred prior to the start of BIMC shipping activities in the RSA.

There are also multiple lines of evidence supporting the notion that there is open exchange of animals between the Admiralty Inlet and Eclipse Sound summer stock areas:

- Firstly, historical tagging data confirms there is exchange occurring between the two adjacent putative stock areas (DFO 2020).
- Secondly, available IQ strongly supports the notion that there is open exchange between narwhal occurring in the Eclipse Sound, Admiralty Inlet and East Baffin Island summer stock areas and that DFO's consideration of the Eclipse Sound and Admiralty Inlet narwhal summering groups as two separate geographically and genetically distinct stocks is invalid (NWMB 2016a; 2016b; QWB 2022). See response to QIA-11 for a summary of IQ on this subject.
- Thirdly, previous DFO abundance estimates where lower numbers of narwhal observed in 2013 in the Eclipse Sound stock (~10,000 narwhal) compared to 2004 (~20,000 narwhal) 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. 2015). 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. 2015).
- Since the 2020 MMASP Report, BIMC has gained an additional year of data from the 2021 narwhal aerial surveys and Bruce Head shore-based monitoring program. The precautionary and temporary adaptive management measure of suspending icebreaking during the 2021 early shoulder season eliminated the possibility of disturbance of narwhal from icebreaking noise, and also served to avoid the potential for cumulative noise effects associated with the Pond Inlet small craft harbour (SCH) Project. However, despite the suspension of icebreaking in the early shoulder season of that year, narwhal numbers in the RSA did not increase in 2021. Narwhal disturbance from icebreaking was therefore considered unlikely to be the driver of the observed decline in narwhal abundance in Eclipse Sound during the 2021 season. It also provided additional confidence that the observed decline in 2020 was likely not a result of early shoulder season icebreaking in 2020.
- Underwater noise from open-water shipping was also not considered to be a likely cause of

narwhal displacement from the RSA based on the available acoustic monitoring results collected to date (Austin et al. 2022; Sweeney et al. 2022). Also see response to DFO-01 QIA-05.

References:

Austin, M.E., C.C. Wilson, K.A. Kowarski, and J.J.-Y. Delarue. 2022. Baffinland Iron Mines Corporation - Mary River Project: 2021 Underwater Acoustic Monitoring Program (Open-Water Season). Document 02633, Version 1.0. Technical report by JASCO Applied Sciences for Golder Associates Ltd.

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NWMB. 2016b. Public hearing to consider modifications to total allowable harvests for the Eclipse Sound and Admiralty Inlet Narwhal Management Units. 29 November 2016. 237 p.

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Sweeney, S.O., J.M. Terhune, H. Frouin-Mouy and P.A Rouget. 2022. Assessing potential perception of shipping noise by marine mammals in an arctic inlet. Journal of Acoustical Society of America. 151: 2310-2325.

Reviewer Agency/Organization:	*DFO*
Reviewers:	Marianne *Marcoux, Kimberly Howland, Joclyn Paulic, Daniel Coombs, Edyta Ratajczyk*
Document(s) Reviewed:	*2021 Marine Mammal Aerial Survey*
Date Review Completed	

Comment No.:	*DFO-1*
Section Reference:	*Executive Summary* *3.6.1 Narwhal Abundance and Distribution* *5.0 SUMMARY*
Comment:	

Issue:

"Underwater noise from open-water shipping was also not considered to be a likely cause of narwhal displacement from the RSA based on the available monitoring results collected to date (Austin et al. 2022; Baffinland 2021; Golder 2020d, 2021b)."

Clarification:

There is a disconnect between the results presented in the Acoustic Monitoring reports and the conclusions in the executive summary and section 3.6.1. and 5.0. There is no mention in any of the Acoustic Monitoring reports (Austin et al. 2022 and previous reports) that underwater noise from open-water shipping was not a likely cause of narwhal displacement. Therefore, this inference is not supported. There seems to be a disconnect between what the technical experts are reporting and the interpretation of the results in other reports.
Recommendation:
Provide supporting information for this conclusion or consider removing the conclusion from the different sections of the document.

Baffinland Response:

Results presented in JASCO's 2021 Acoustic Monitoring Report (Austin et al. 2022) demonstrate that narwhal would be exposed to sound levels exceeding the established acoustic disturbance for toothed whales (broadband sound pressure level {SPL} of 120 dB re 1 uPa) for less than one hour per day[1]. The report further states that these results are consistent with impact predictions in that

[1] This is considered a conservative estimate given it assumes that a narwhal (represented by the acoustic recorder) would remain stationary during the full acoustic exposure of a passing ship transit.

acoustic effects would be localized and temporary, and there would be substantial periods in each day when marine mammals are not disturbed by Project vessels.

As noted by Oceans North, results from the 2021 Bruce Head Program indicates that 56 min is the 'maximum period per day associated with vessel disturbance on narwhal travel speed', based on an average of two vessel transits per day in the SSA. As outlined in Section 1.1, the total duration of the 2021 shipping season was 96 days. As such, the maximum period of disturbance over the entire shipping season is therefore calculated at 88 hours (96 days x 56 min/day). This conservatively assumes that the exposed narwhal would remain stationary on the shipping lane for a consecutive 96-day period. This value represents 4.2% of the exposed narwhal's normal life cycle over the course of the shipping season (88 h out of a possible 2,304 h). In contrast, the minimum period of disturbance over the entire shipping season would be 0 min (in cases where an individual narwhal never approached closer than 4 km of the shipping lane during the 96-day shipping season and therefore was never exposed to ship noise at levels known to elicit disturbance). Therefore, the maximum cumulative period for which narwhal travel speed would be influenced by Project shipping ranges between 0 and 4.25% of an individual narwhal's normal life cycle over the course of the shipping season. We do not feel that a table is necessary to summarize this level of information.

Another acoustic study (Sweeney et al. 2022) in the North Baffin region was recently undertaken, in which weighted SPL (a metric that accounts for a narwhal's hearing abilities at different acoustic frequencies) were used to assess shipping noise impacts on narwhal in Milne Inlet. Results of this study demonstrated that shipping noise impacts on narwhal and other toothed whales would be negligible at distances beyond several kilometers from the shipping lane, as shipping noise beyond these distances would be largely inaudible to narwhal. The exposure duration associated with a disturbance zone of this size would be equivalent to approximately 20 min per ship transit (equivalent to daily cumulative disturbance period of ~40 min based on an average of two ship transits per day in the RSA). These results are consistent with impact predictions in that acoustic effects would be localized and temporary, and there would be substantial periods in each day when marine mammals are not disturbed by Project vessels.

These acoustic results, combined with results from BIMC's behavioural response studies referenced above, collectively suggest that open-water shipping is not the likely cause of narwhal displacement from the RSA based on the available monitoring results collected to date.

Also see response to QIA-05.

Reference:

Austin, M.E., C.C. Wilson, K.A. Kowarski, and J.J.-Y. Delarue. 2022. Baffinland Iron Mines Corporation - Mary River Project: 2021 Underwater Acoustic Monitoring Program (Open-Water Season). Document 02633, Version 1.0. Technical report by JASCO Applied Sciences for Golder Associates Ltd.

Sweeney, S.O., J.M. Terhune, H. Frouin-Mouy and P.A Rouget. 2022. Assessing potential perception of shipping noise by marine mammals in an arctic inlet. Journal of Acoustical Society of America. 151: 2310-2325.

Baffinland

Comment No.:	*DFO-2*
Section Reference:	*Executive Summary* *3.6.1 Narwhal Abundance and Distribution* *5.0 SUMMARY*
Comment:	

Issue:

"That is, it is possible that the ecological conditions in Admiralty Inlet are currently favourable to Eclipse Sound narwhal due to factors such as changing ice conditions, prey availability and/or predation pressure (Chambault et al. 2020; Franeira et al. 2017; Heide-Jorgensen et al. 2021; Higdon et al. 2012; Laidre et al. 2008, 2015; Lefort et al. 2020; Steiner et al. 2019, 2021)"

Clarification:

BIM provides general references about changes in the Arctic. However, none of the references are specific to changes in the condition between Eclipse Sound and Admiralty Inlet. To our knowledge, there is not data to show a change in the presence of predator between Admiralty and Eclipse Sound.

In addition, we are not aware of data that suggest changes in prey species or ice condition between Eclipse Sound and Admiralty Inlet. Given the lack of data, this is a hypothesis and does not have more weight than the hypothesis that shipping has caused the displacement of narwhals.

Recommendation:
-Provide data or references that are specific to Eclipse Sound and Admiralty Inlet or consider changing the conclusions of this paragraph in the four sections. At the moment, there is no support for the hypothesis that the conditions have changed between Eclipse Sound and Admiralty Inlet and are the cause of the change in distribution of narwhals.
-The reference to Heide-Jorgensen et al 2021 is not in the reference list. Please add the reference to the list

Baffinland Response:

Additional text and context (with references) have been provided in the updated report. Also see response to QIA-02 and QIA-05. The Heide-Jorgensen et al. 2021 paper has been added to the reference list.

Comment No.:	*DFO-3*
Section Reference:	3.5.5.2 Photographic Survey Data Characteristics
Comment:	

Issue:

"On average, 2.3% of the photos had murky water (see Tables 14 and 17 in Section 3.5.5.3), and 13.5% of the photos had glare (see Tables 14 and 17 in Section 3.5.5.3). Photographs overlapped by an average of 45%."

Clarification:

The percentage of overlap between the photos is large. Photo-analysts are more likely to detect narwhals in the overlapping part of the photos since they have two instances to detect the animals.

Question:

How was this bias considered in the results?

Recommendation:
- Please clarify if the 45% overlap is between two consecutive photos? Is it correct that photos overlap 90% in total (with the previous and subsequent photo).
-This bias can be dealt in two different ways:
1) Crop the overlapping portions of the photos and only count narwhals in one photos.
2) Create a subset of the photos. Compare the ability of the analyst to detect narwhals when there are overlapping photos to when there are no overlap.

Baffinland Response:

No, a photo overlap of 90% is incorrect. The photo overlap was 45% in total (with previous, subsequent, and adjacent photos). 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) were followed to allow for a comparison to previous DFO survey abundance estimates. Transect spacing and timing of photographs likewise followed DFO survey design and data collection methodology.

References:

Asselin, N.C. and P.R. Richard, 2011. Results of narwhal (Monodon monoceros) aerial surveys in Admiralty Inlet, August 2010. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/065. iv + 26 p.

Doniol-Valcroze, T, Gosselin, J.F., Pike, D., Lawson, J., Asselin, N., Hedges, K., and S. Ferguson. 2015. Abundance estimates of narwhal stocks in the Canadian High Arctic in 2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/060. v + 36 p.

Marcoux, M., B. Young, N. C. Asselin, C. A. Watt, J. B. Dunn, and S. H. Ferguson. 2016. Estimate of Cumberland Sound beluga (Delphinapterus leucas) population size from the 2014 visual and photographic aerial survey. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/037. Iv + 19 p.

Matthews, C.J.D., Watt, C.A., Asselin, N.C., Dunn, J.B., Young, B.G., Montison, L.M., Westdal, K.H., Hall, P.A., Orr, J.R., Ferguson, S.H., and M. Marcoux. 2017. Estimated abundance of the Western Hudson Bay beluga stock from the 2015 visual and photographic aerial survey. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/061. v + 20 p.

Comment No.:	*DFO-4*
Section Reference:	3.5.5.3 2021 Narwhal Abundance 3.5.5.3.1 Eclipse Sound Stock 3.5.5.3.2 Admiralty Inlet Stock 3.5.5.3.3 Combined Eclipse Sound and Admiralty Inlet Stocks
Comment:	

Issue:

"The abundance estimate for the combined Eclipse Sound and Admiralty Inlet stocks was 75,177 narwhal (CV = 0.08, 95% CI of 63,795 88,590; Table 20) based on aerial surveys conducted on 19-21 August 2021. This estimate is statistically higher 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 = 1.82, p = 0.042), the 2019 Baffinland estimate of 38,677 (CV = 0.11, 95% CI of 31,155 48,015) (t-test = 4.64, p < 0.001), and the 2020 Baffinland estimate of 36,044 (CV = 0.12, 95% CI of 28,267 45,961) (t-test = 5.06, p < 0.001). This suggests that narwhal from Eclipse Sound, Admiralty Inlet, and potentially from proximal summer stock areas (i.e., Somerset Island, East Baffin Island) may have used Admiralty Inlet in 2021.

Clarification:

There is an important assumption that has not been mentioned in the text. The proportion of time narwhals spend at the surface is highly variable. The correction factor that is used to adjust the surface estimate for the proportion of narwhals that were not visible to survey analysts is based on an average the time that narwhals spend at the surface. It is possible that narwhals were spending more time at the surface of the water at the time of the survey than on average. Therefore, it is better practice to average the different survey replicates.

For both the Eclipse Sound and Admiralty Inlet stock, the abundance estimate is based on only on one replicate of the survey. It is better practice to average all the valid replicates to estimate the abundance. For both stocks, the abundance is lower when we take an average.

As noted, the abundance estimates for each stock and the estimate for the two stocks combined should be based on an average of the survey repeats. Therefore, their combined estimate for Eclipse Sound and Admiralty Inlet should be 50,374 which is not statistically different from previous survey.

Baffinland

Recommendation:
Please revise this section according to the abundance estimate based on averages of survey repeats.
-For the Eclipse Sound stock, the abundance estimate should be based on the average of surveys 1/2, 4 and 5 (average = 2,059)
-For the Admiralty Inlet stock, the abundance estimate should be based on the average of survey 3 and 4 (average = 48,315)
- For the combined stock, the total should be the sum of the two averages above (combined average= 50,374)

Baffinland Response:

The availability bias correction factor (i.e., proportion of time narwhals spend at the surface) has a CV, standard deviation and variance associated with the average used in the estimate. The variation associated with the mean is incorporated into the abundance estimate calculation and accounts for the variability in the proportion of time narwhals spend at the surface.

The survey protocol for Leg 2 was to survey both the Eclipse Sound and the Admiralty Inlet grids within a 2–3 day period. This was only accomplished for one survey (i.e. Survey 4). Because narwhal are known to move between the two survey grids (Eclipse and Admiralty), surveying the area within a narrower window of time minimizes the potential for re-sightings/double-counts, and thus will produce a more reliable abundance estimate for the combined stock.

Comment No.:	*DFO-5*
Section Reference:	3.5.6 Abundance Comparison with Previous Years 5.0 Summary
Comment:	

Issue:

Clarification:
Could you provide the sample size that was used to generate the abundance estimates and how they were calculated.

TC 111: states "Develop clear thresholds for determining negative impacts as a result of vessel noise are occurring": the statistical analysis provides some input towards population trends, however how is it being used to determine thresholds?

Baffinland Response:

The degrees of freedom (df) for the visual survey results was calculated from the sample sizes of the various components of the density estimate and correction factors (e.g. encounter rate, detection function, availability bias, etc.; Buckland et al. 2001). The calculated degrees of freedom of the combined density estimate were based on the Satterthwaite approximation (Satterthwaite 1946) as adopted by the program Distance (Thomas et al. 2010) and also described in Introduction to Distance Sampling (Buckland et al. 2001). The addition of paired visual and photographic survey estimates to form an overall estimate also used the Satterthwaite method, except that CV^4 is replaced by $variance^2$ in the equation to calculate df when adding estimates, as also used by the Distance program.

The sample size (n) and corresponding df for each photographic survey was based on the number of photos used to calculate the estimate (df = n-1). As was the case for visual survey estimates, the df of the combined photo estimate (photo abundance corrected for availability bias) was also calculated using the Satterthwaite approximation method.

The estimated df for the 2021 narwhal abundance estimates, for survey where comparisons were made to other estimates, are provided in the table below. The sample sizes used to generate the photo survey abundance estimates are provided in Tables 14 and 17 in the main body of this report. The samples sizes for the availability correction factors were based on Watt et al. (2015) where samples sizes for mid-August and late-August were 23 and 24 narwhals, respectively (df = n-1).

Section 3.4.2 provides a detailed explanation, along with equations, as to how the abundance estimates were calculated. These methods follow the 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 was implemented in this report to allow for comparable abundance estimates.

2021 narwhal abundance estimates

Stock	Year	Survey Dates (Survey #)	Abundance	CV	95% CI	df
Eclipse Sound	2021	20-21 Aug (#4)	2,595	0.33	1,369 – 4,919	3.88
Admiralty Inlet	2021	19Aug (#4)	72,582	0.09	61,333 – 85,895	14.5
Combined	2021	19-21 Aug (#4)	75,177	0.08	63,795 – 88,590	15.1

References:

Asselin, N.C. and P.R. Richard, 2011. Results of narwhal (Monodon monoceros) aerial surveys in Admiralty Inlet, August 2010. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/065. iv + 26 p.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, xv + 432 p.

Doniol-Valcroze, T., J.F. Gosselin, D. Pike, J. Lawson, N. Asselin, K. Hedges and S. Ferguson. 2015. Abundance estimates of narwhal stocks in the Canadian High Arctic in 2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/060. v + 36 p.

Marcoux, M., B. Young, N. C. Asselin, C. A. Watt, J. B. Dunn, and S. H. Ferguson. 2016. Estimate of Cumberland Sound beluga (Delphinapterus leucas) population size from the 2014 visual and photographic aerial survey. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/037. Iv + 19 p.

Matthews, C.J.D., C.A. Watt, N.C. Asselin, J.B. Dunn, B.G. Young, L.M. Montison, K.H. Westdal, P.A. Hall, J.A. Orr, S.H. Ferguson and M. Marcoux. 2017. Estimated abundance of the Western Hudson Bay beluga stock from the 2015 visual and photographic aerial survey. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/061. v + 20 p.

Satterthwaite, F.E. 1946. An approximate distribution of estimates of variance components. Biometric Bulletin 2: 110-114.

Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47: 5-14.

Watt, C.A., Marcoux, M., Asselin, N.C., Orr, J.R., and Ferguson, S.H. 2015. Instantaneous availability bias correction for calculating aerial survey abundance estimates for narwhal (Monodon monoceros) in the Canadian High Arctic. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/044. v + 13 p.

Reviewer Agency/Organization:	QIA
Reviewers:	Jeff W. Higdon, D. Bruce Stewart
Document(s) Reviewed:	Mary River Project 2021 Marine Mammal Aerial Survey ("2021 MMASP Report Draft for MEWG.pdf") 23 March 2022
Date Review Completed	2022-06-06

Comment No.:	QIA-01
Section Reference:	General (e.g., section 1.3, page 4; section 3.6.1, page 79)
Comment:	

The draft notes that Inuit Quajimajatuqangit (IQ) supports Eclipse Sound and Admiralty Inlet as comprising one stock. The example statements provided (e.g., "Narwhal go through Pond Inlet first before they get to Arctic Bay. Whales are like that too. They migrate…") often refer to migration patterns. The same IQ holder also noted that Eclipse Sound might have fewer narwhals due to increased marine traffic, and that impacts to Pond Inlet were already occurring (in 2015). Other examples are similar (e.g., page 5 - "But since the Baffinland is carry ships, most of the narwhal are now like away from the area they usually be… I think the shipping route is the effect of the animals.") and very clearly show that Inuit have observed Project-impacts on Eclipse Sound narwhal.

IQ and scientific research support some degree of natural exchange between the two summer stock areas, but there is no evidence to support the widespread abandonment of one area as a natural phenomenon. Aerial surveys do not show this type of natural movement, they instead show a one-way change in abundance continuing across multiple years. None of the IQ examples provided confirm that such large-scale movements are natural or have occurred in the past, and several point out that ship traffic causes animals to move.

What specific IQ has the Proponent collected and compiled that indicates long-term significant declines in one key summering area are a natural phenomenon? When and where has this happened before?

Baffinland Response:

A progressive shift in narwhal abundance from Eclipse Sound to Admiralty Inlet appears to be occurring since the early 2000s. In 2003, aerial surveys undertaken by Fisheries and Oceans Canada (DFO) calculated narwhal abundance in Admiralty Inlet at 5,362 individuals (Richard et al. 2010). In 2010, aerial surveys conducted by DFO calculated narwhal abundance in Admiralty Inlet 18,049 (Asselin and Richard 2011). In 2013, aerial surveys conducted by DFO calculated narwhal abundance in Admiralty Inlet at 35,043 (Doniol-Valcroze et al. 2015). Thus, prior to any BIMC shipping activity in the RSA, narwhal abundance in Admiralty Inlet had increased from 5,362 to 35,043 individuals. The 2021 abundance estimate for Admiralty Inlet was 72,582 individuals (as per the current report). This shows a trend of increasing narwhal abundance in the Admiralty Inlet area. The decreasing trend in Eclipse Sound from 2004 (20,225 individuals; Richard et al. 2010) to present (2,595 individuals), which was first identified in 2013 (10,489 individuals; Doniol-Valcroze et al. 2015) prior to BIMC shipping activity in the RSA, may be linked to the increasing trend in Admiralty Inlet, both of which occurred prior to the start of BIMC shipping activities in the RSA.

Long-term significant declines in other key narwhal summering areas have been observed in the East Greenland narwhal management areas (NAMMCO Ad hoc Meeting 2021). In the NAMMCO Ad hoc Meeting in October 2021, it was reported that the Ittoqqortoormiit narwhal population has been depleted to 10% of its historic (i.e., 1955) levels, with no more than 207 (90% CI:42-441) individuals remaining (NAMMCO 2021). The Kangerlussuaq narwhal population in 1955 was estimated at 1,050 individuals; current abundance estimates of this stock is 260 individuals (90% CI_142-442). The Tasiilaq narwhal population has also been depleted to 16% of its historic (i.e.,1955) levels with no more than 123 (90% CI: 12-394) individuals remaining (NAMMCO 2021). Available evidence suggests that the drivers of these observed declines in narwhal numbers in Greenland is a combination of overharvesting and climate change effects including a lack of pack ice in summer and increasing sea temperatures (NAAMCO 2021).

Also see response to QIA-05 and QIA-11.

References:

Asselin, N.C. and P.R. Richard, 2011. Results of narwhal (Monodon monoceros) aerial surveys in Admiralty Inlet, August 2010. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/065. iv + 26 p.

Doniol-Valcroze, T, Gosselin, J.F., Pike, D., Lawson, J., Asselin, N., Hedges, K., and S. Ferguson. 2015. Abundance estimates of narwhal stocks in the Canadian High Arctic in 2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/060. v + 36 p.

North Atlantic Marine Mammal Commission (NAMMCO). 2021. Report of the Ad hoc Working Group on Narwhal in East Greenland. October 2021, Copenhagen, Denmark. Available at https://nammco.no/topics/narwhal_beluga_reports/

Richard, P., J.L. Laake, R.C. Hobbs, M.P. Heide-Jørgensen, N.C. Asselin and H. Cleator. 2010. Baffin Bay narwhal population distribution and numbers: Aerial surveys in the Canadian High Arctic, 2002-04. Arctic. 63: 85-99.

Comment No.:	QIA-02
Section Reference:	General (e.g., s. 2.5.1, 2.6.1, 3.5.2)
Comment:	

How do ice conditions compare across the different surveys that have been conducted in Eclipse Sound and Admiralty Inlet since 2004?

As examples, section 2.5.1 notes that leg 1 ice conditions "were similar to those observed in 2019…", how does 2020 compare? Section 3.5.2 notes that no ice was present during leg 2 surveys, how does this compare with surveys conducted in other years? Section 2.6.1 says that "[n]arwhal distribution appeared to have differed between 2019, 2020, and 2021 Leg 1 surveys possibly due to different ice conditions in the study area."

The draft speculates that changing ice conditions could be a factor in narwhal abandonment of Eclipse Sound, but no evidence is provided. An analysis of sea ice conditions should be included to reduce speculation. Some of the quotes provided (e.g., page 81) provide information on ice breakup and its influence on narwhal movements, which should be examined in detail.

Baffinland Response:

The mention of 'changing ice conditions' in the draft report refers generally to reduced sea ice conditions occurring in the Arctic that are likely having local and regional impacts on marine mammal populations, but for which are not presently quantified on a micro-geographic scale (i.e., Eclipse Sound vs. Admiralty Inlet vs. Somerset Island, etc). These changes may affect Eclipse Sound and Admiralty Inlet differently. A recent paper looked at changes in sea ice in the Eclipse Sound region from the 1900s to 2010s and found a decrease in the yearly median mid-month day sea ice concentration in Eclipse Sound and an increase in the number of months with a mid-month day average sea ice concentration of zero, particularly in the last decade (Posdaljian et al. 2022). How this compares to ice conditions in Admiralty Inlet is presently unknown.

Notwithstanding, it is well documented that oceanic warming and associated reductions in sea ice over the last several decades has resulted in notable shifts in species distributions for both marine mammals in the

Arctic (Albouy et al. 2020; Chambault et al. 2022; Frederiksen and Haug 2015; Nøttestad et al. 2015; Posdaljian et al. 2022; Víkingsson et al. 2015;) and their prey (Frainer et al. 2017; Møller and Nielsen 2020).

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 suggest that the current distribution of Baffin Bay narwhal during summer will undergo a +200 km northward shift 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 by between 31 and 66% over this period (depending on the climate model)[2]. 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 explanation of recently observed changes in summer narwhal distribution in Eclipse Sound.

A full understanding of external contributing factors (and their potential influence on the distribution, abundance and behaviour of Baffin Bay narwhal) is not required to determine if Project shipping is contributing or not to the observed shift in narwhal distribution in the North Baffin region as reported in 2021 and 2022. BIMC's monitoring studies are designed to test if its shipping activities are modifying narwhal movements and behaviour in the RSA and to what degree this may be occurring (i.e, spatial and temporal characterization of effects, severity of effects, etc). It is beyond the scope of the Project (or the responsibly of BIMC) to test for the effects of external (non-Project) stressors on narwhal or other receptors in the Eastern Canadian Arctic region. As such, no studies are currently being initiated by BIMC to further investigate the role of other potential contributing external factors (i.e. prey availability, changing ice conditions) on narwhal distribution in the North Baffin region.

As noted in the 2022 NAMRP (BIMC 2022), BIMC remains committed to supporting the responsible agencies and local communities on any such regional monitoring initiatives, but should not be the lead on

[2] Sea ice was not included as a potential driver of narwhal distribution in the models given climate models project a complete disappearance of sea ice in summer by 2060 (Senftleben et al. 2020) and because sea ice is nearly absent in the summer habitat of most narwhal stocks. Sea surface temperature (SST), which is highly correlated with sea ice, was the key predictor in the models.

this work (as this would fall under the mandated responsibility of DFO). For example, effects of fine-scale changes in prey availability on the behaviour and distribution of marine mammals are difficult to project, especially at high latitudes given the lack of prey data for these remote locations. To better understand what is occurring with narwhal numbers in the RSA, additional engagement and monitoring with Inuit stakeholders and regulatory agencies is needed, inclusive of collaborative regional scape monitoring that looks at population dynamics of the entire Baffin Bay narwhal population and their prey species.

References:

Albouy, C., V. Delattre, G. Donati, T. L. Frölicher, S. Albouy-Boyer, M. Rufino, L. Pellissier, D. Mouillot and F. Leprieur. 2020. Global vulnerability of marine mammals to global warming. Sci. Rep. 10: 548.

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Chambault, P., K.M. Kovacs, C. Lydersen, O. Shpak, J. Teilmann, C.M. Albertsen and M.P. Heide-Jorgensen. 2022. Future seasonal changes in habitat for Arctic whales during predicted ocean warming. Science Advances. 8(29).

Frainer, A., R. Primicerio, S. Kortsch, M. Aune, A. V. Dolgov, M. Fossheim and M. M. Aschan. 2017. Climate-driven changes in functional biogeography of Arctic marine fish communities. Proc. Natl. Acad. Sci. U.S.A. 114: 12202–12207.

Frederiksen, M. and T. Haug. 2015. Editorial: climate change and marine top predators. Front. Ecol. Evol. 3: 136

Møller, E.F. and T. G. Nielsen. 2020. Borealization of Arctic zooplankton—Smaller and less fat zooplankton species in Disko Bay, Western Greenland. Limnol. Oceanogr. 65: 1175–1188.

NAMMCO. 2021. Report of the Ad hoc Working Group on Narwhal in East Greenland. October 2021, Copenhagen, Denmark. Available at https://nammco.no/topics/narwhal_beluga_reports/

Nøttestad, L., B. Krafft, V. Anthonypillai, M. Bernasconi, L. Langárd, H.L., Mørk and Fernö. 2015. Recent changes in distribution and relative abundance of cetaceans in the Norwegian Sea and their relationship with potential prey. Front. Ecol.Evol. 2: 150-160.

Posdaljian, N., C. Soderstjerna, J.M. Jones, A. Solsona-Berga, J.A. Hildebrand, K. Westdal, A. Ootoowak, and S. Baumann-Pickering. 2022. Changes in sea ice and range expansion of sperm whales in the eclipse sound region of Baffin Bay, Canada. Global Change Biology.

Senftleben, D., A. Lauer and A. Karpechko. 2020. Constraining uncertainties in CMIP5 projections of september arctic sea ice extent with observations. J. Climate. 33: 1487–1503.

Víkingsson, G.A., D.G. Pike, H. Valdimarsson, A, Schleimer, T. Gunnlaugsson, T. Silva, B.P. Elvarsson, B. Mikkelsen, N. Øien, G. Desportes, V. Bogason and P.S. Hammond. 2015. Distribution, abundance, and feeding ecology of baleen whales in Icelandic waters: have recent environmental changes had an effect? Front. Ecol. Evol. 2: 161-172.

Comment No.:	QIA-03
Section Reference:	Executive Summary (page iii) and s.3.5.5.3.3 (page 76)
Comment:	

The ES survey had CV = 0.33, and the AI survey had CV = 0.09. Why is the CV (0.08) for the combined estimate lower than that from the two individual areas? Some explanation should be provided (or if it was and we missed it, please confirm location in the draft).

Baffinland Response:

The formula that is used to calculate the variance of combined estimates is presented in Section 3.4.2.3 ($va(N_i) = var(N_{iV}) + var(N_{iP})$). This is the same formulate used by Asselin et al. (2011) and Matthews et al. (2017). When the combined variance is calculated in this manner, the resulting CV is often lower than the CV of the input abundances.

References:

Asselin, N.C. and P.R. Richard, 2011. Results of narwhal (*Monodon monoceros*) aerial surveys in Admiralty Inlet, August 2010. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/065. iv + 26 p.

Matthews, C.J.D., Watt, C.A., Asselin, N.C., Dunn, J.B., Young, B.G., Montison, L.M., Westdal, K.H., Hall, P.A., Orr, J.R., Ferguson, S.H., and M. Marcoux. 2017. Estimated abundance of the Western Hudson Bay beluga stock from the 2015 visual and photographic aerial survey. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/061. v + 20 p.

Comment No.:	QIA-04
Section Reference:	Executive Summary (and elsewhere)
Comment:	

"The results also suggest that there is potentially greater mixing between neighbouring summer stocks (i.e., Admiralty Inlet, Somerset Island and/or East Baffin Island) than is currently recognized."

Not necessarily, the animals that normally summer in Eclipse Sound might have abandoned it due to disturbance, not by choice. This interpretation is supported by IQ. Mixing would require animals to move back and forth between the two summer aggregation areas, not make unidirectional movements.

Baffinland Response:

Please see responses to QIA-05 and QIA-11.

Comment No.:	QIA-05
Section Reference:	Executive Summary (and elsewhere)
Comment:	

"Underwater noise from open-water shipping was also not considered to be a likely cause of narwhal displacement from the RSA based on the available monitoring results collected to date (Austin et al. 2022; Baffinland 2021; Golder 2020d, 2021b)."

What results provide evidence that underwater noise was not a likely cause? Icebreaking was suspended but narwhal numbers still declined significantly from the 2020 aerial survey estimate, when open-water shipping continued as usual. If not noise from open-water shipping, what factors are likely causes for the large-scale abandonment of Eclipse Sound, and what supporting evidence exists? The IQ reported does not indicate that this is natural exchange (see above and below).

Baffinland Response:

A holistic review of the data from the 2021 shipping season does not conclude that the relatively lower number of narwhals observed in Eclipse Sound in 2020 and 2021 was Project-driven. The first documented decline of the Eclipse Sound narwhal stock occurred between 2004 and 2013 (Richard et al. 2010; Doniol-Valcroze et al. 2015), which was a period before Project shipping or icebreaking occurred in the RSA. Narwhal numbers in the RSA decreased by 50% from 20,225 animals in 2004 to 10,489 animals in 2013. In this occurrence, DFO proposed that natural exchange between the two summering areas was a possible reason for this observed decline in 2013 (Doniol-Valcroze et al. 2015), implying that some portion of the 'missing' animals in Eclipse in 2013 may have been present in Admiralty at the time of the Eclipse Sound aerial survey.

Overall, the results indicate a shift in narwhal distribution from Eclipse Sound to Admiralty Inlet which has been progressively occurring since the early 2000s. In 2003, aerial surveys undertaken by Fisheries and Oceans Canada (DFO) calculated narwhal abundance in Admiralty Inlet at 5,362 individuals (Richard et al. 2010). In 2010, aerial surveys conducted by DFO calculated narwhal abundance in Admiralty Inlet at 18,049 (Asselin and Richard 2011). In 2013, aerial surveys conducted by DFO calculated narwhal abundance in Admiralty Inlet at 35,043 (Doniol-Valcroze et al. 2015). Thus, prior to any BIMC shipping activity in the RSA, narwhal abundance in Admiralty Inlet had increased from 5,362 to 35,043 individuals. The 2021 abundance estimate for Admiralty Inlet was 72,582 individuals (as per the current report). This shows a trend of increasing narwhal abundance in the Admiralty Inlet area. The decreasing trend in Eclipse Sound from 2004 (20,225 individuals; Richard et al. 2010) to present (2,595 individuals; Golder 2022), which was first identified in 2013 (10,489 individuals; Doniol-Valcroze et al. 2015) prior to BIMC shipping activity in the RSA, may be linked to the increasing trend in Admiralty Inlet, both of which occurred prior to the start of BIMC shipping activities in the RSA.

Contrary to QIA's comment above, the available IQ does support that narwhal move freely between both Eclipse Sound and Admiralty Inlet and that narwhal occurring in both areas during summer belong to the same stock (see response to QIA-11 for a summary of IQ on this subject). For the past three consecutive years (2019–2021), BIMC has undertaken combined surveys of both Admiralty Inlet and Eclipse Sound summering stock areas. 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 is invalid (NWMB 2016a; 2016b; QWB 2022). The combined narwhal abundance in Eclipse Sound and Admiralty Inlet was shown to be similar in 2020 (36,044 individuals) to that observed in previous survey years (45,532 individuals in 2013 and 38,677 individuals in 2019); and was statistically higher in 2021 (75,177 individuals) than in previous survey years (2013, 2019 and 2020). To date, aerial surveys have not identified a net decrease in the combined Eclipse Sound / Admiralty Inlet stock. What is currently being observed may be a continuation of a shift in narwhal summer distribution from Eclipse Sound to Admiralty Inlet observed since the early 2000s.

Nonetheless, BIMC was concerned by the lower numbers of narwhal observed in Eclipse Sound in 2020 and 2021, and the potential impact this may have on Inuit harvest and culture. In the face of this uncertainty and as requested by some Inuit and Inuit groups, BIMC elected to implement several additional precautionary-based adaptive management measures in 2021 and 2022, which included 1) no icebreaking during the 2021 and 2022 early shoulder shipping season; 2) the use of convoys throughout the 2022 season to further reduce total sound exposure, and 3) no more than 80 ore carriers during the 2022 season in a six million ton approval scenario, versus 86.

Avoiding icebreaking during the 2021 early shoulder season eliminated the possibility of acoustic disturbance to narwhal from icebreaking during the timing of narwhal migration into Eclipse Sound in 2021. However, despite this mitigation measure being implemented, narwhal numbers in the RSA did not increase in 2021. Narwhal disturbance from icebreaking was therefore not considered to be an influencing factor on the observed decline in narwhal abundance in Eclipse Sound during the 2021 season. It also provided additional confidence that the observed decline in 2020 was likely not a result of early shoulder season icebreaking in 2020.

Open-water shipping was not identified as a likely contributing factor to the observed decline in 2021 for several reasons. Firstly, open-water shipping levels were slightly lower in 2020 (72 return ore carrier voyages) and 2021 (73 voyages) compared to 2019 (81 voyages). In 2019, narwhal numbers in the RSA were shown to be stable (9,931 individuals) relative to baseline condition (10,489 individuals in 2013) and relative to previous survey years when shipping was occurring (12,039 individuals in 2016). Therefore, it is considered unlikely that open-water shipping in 2021 would suddenly trigger a high severity response in narwhal (such as a large-scale displacement from the RSA), when shipping levels were in fact slightly reduced that year. Secondly, the type of behavioural responses observed in narwhal to date from open-water shipping suggests that this is not the cause of the observed decrease in 2021. Behavioural responses to shipping have been limited to temporary and localized disturbance effects at close range to vessels (up to 5 km distance). These effects, when present, last for a short duration with animals quickly returning to their pre-response behaviour following exposure. These are considered to be low to moderate severity responses that are not thought to result in any significant biological consequences on reproduction or survival, and hence on the stock or population. In comparison, narwhal responses to killer whales in the North Baffin region consist of rapid dispersal to shallow water nearshore areas, freeze behaviour and suspension of vocal activity, with effects persisting for periods beyond the discrete predation events (Lairdre et al. 2006; Breed et al. 2017). These would be considered high severity responses with potential significant biological consequences. To date, no similar anti-predator response has been demonstrated by narwhal to shipping as part of BIMC's monitoring programs.

As stated in the draft report, it is possible that changing ecological conditions (i.e., ocean temperature, sea ice coverage, prey availability, predation pressure) in the Arctic associated with climate change could result in more favorable conditions in Admiralty Inlet than Eclipse Sound. For example, it is well documented that ocean warming has resulted in species distribution shifts for both marine mammals in the Arctic (Albouy et al. 2020; Chambault et al. 2022; Frederiksen and Haug 2015; Nøttestad et al. 2015; Víkingsson et al. 2015;) and their prey (Frainer et al. 2017; Møller and Nielsen 2020), including narwhal in Southeast Greenland (NAAMCO 2021, see detailed BIMC response to QIA-02). How this might be manifesting on a micro-geographic scale in the North Baffin region is presently unclear. 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 suggest that the current distribution of Baffin Bay narwhal during summer will undergo a +200 km northward shift 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 by between 31 and 66% over this period (depending on the climate model)[3]. 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 explanation of recently observed changes in summer narwhal distribution in Eclipse Sound).

A full understanding of external contributing factors (and their potential influence on the distribution, abundance and behaviour of Baffin Bay narwhal) is not required to determine if Project shipping is contributing or not to the observed shift in narwhal distribution in the North Baffin region as reported in 2021 and 2022. BIMC's monitoring studies are designed to test if its shipping activities are modifying narwhal movements and behaviour in the RSA and to what degree this may be occurring (i.e, spatial and temporal characterization of effects, severity of effects, etc). It is beyond the scope of the Project (or the responsibly of BIMC) to test for the effects of external (non-Project) stressors on narwhal or other receptors in the Eastern Canadian Arctic region. As such, no studies are currently being initiated by BIMC to further investigate the role of other potential contributing external factors (i.e. prey availability, changing ice conditions) on narwhal distribution in the North Baffin region.

As noted in the NAMRP (BIMC 2022), BIMC remains committed to supporting the responsible agencies and local communities on any such regional monitoring initiatives but should not be the lead on this work (as

[3] Sea ice was not included as a potential driver of narwhal distribution in the models given climate models project a complete disappearance of sea ice in summer by 2060 (Senftleben et al. 2020) and because sea ice is nearly absent in the summer habitat of most narwhal stocks. Sea surface temperature (SST), which is highly correlated with sea ice, was the key predictor in the models.

this would fall under the mandated responsibility of DFO). For example, effects of fine-scale changes in prey availability on the behaviour and distribution of marine mammals are difficult to project, especially at high latitudes given the lack of prey data for these remote locations. To better understand what is occurring with narwhal numbers in the RSA, additional engagement and monitoring with Inuit stakeholders and regulatory agencies is needed, inclusive of collaborative regional scape monitoring that looks at population dynamics of the entire Baffin Bay narwhal population and their prey species.

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Albouy, C., V. Delattre, G. Donati, T. L. Frölicher, S. Albouy-Boyer, M. Rufino, L. Pellissier, D. Mouillot and F. Leprieur. 2020. Global vulnerability of marine mammals to global warming. Sci. Rep. 10: 548.

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Breed, G.A., C.J.D. Matthews, M. Marcoux and S.H Ferguson. 2017. Sustained disruption of narwhal habitat use and behavior in the presence of Arctic killer whales. Proceedings of the National Academy of Sciences of the United States of America. 114(10): 2628-2633.

Chambault, P., K.M. Kovacs, C. Lydersen, O. Shpak, J. Teilmann, C.M. Albertsen and M.P. Heide-Jorgensen. 2022. Future seasonal changes in habitat for Arctic whales during predicted ocean warming. Science Advances. 8(29).

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Frainer, A., R. Primicerio, S. Kortsch, M. Aune, A. V. Dolgov, M. Fossheim and M. M. Aschan. 2017. Climate-driven changes in functional biogeography of Arctic marine fish communities. Proc. Natl. Acad. Sci. U.S.A. 114: 12202–12207.

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Møller, E.F. and T. G. Nielsen. 2020. Borealization of Arctic zooplankton—Smaller and less fat zooplankton species in Disko Bay, Western Greenland. Limnol. Oceanogr. 65: 1175–1188.

NAMMCO. 2021. Report of the Ad hoc Working Group on Narwhal in East Greenland. October 2021, Copenhagen, Denmark. Available at https://nammco.no/topics/narwhal_beluga_reports/

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NWMBa. 2016a. Public Hearing to Consider Modifications to Total Allowable Harvests for the Eclipse Sound and Admiralty Inlet Narwhal Management Units. Volume 1 (28 Nov 2016) and Volume 2 (29 Nov 2016) – Hearing Transcripts. Adele Jones Court Reporting.

NWMB. 2016b. Public hearing to consider modifications to total allowable harvests for the Eclipse Sound and Admiralty Inlet Narwhal Management Units. 29 November 2016. 237 p.

Qikiqtaaluk Wildlife Board (QWB). 2022. Establishment of an Inuit System of Narwhal Management in the Waters of Northern and Eastern Baffin Island, 2022. Submission to the Nunavut Wildlife

Richard, P., J.L. Laake, R.C. Hobbs, M.P. Heide-Jørgensen, N.C. Asselin and H. Cleator. 2010. Baffin Bay narwhal population distribution and numbers: Aerial surveys in the Canadian High Arctic, 2002-04. Arctic. 63: 85-99.

Víkingsson, G.A., D.G. Pike, H. Valdimarsson, A, Schleimer, T. Gunnlaugsson, T. Silva, B.P. Elvarsson, B. Mikkelsen, N. Øien, G. Desportes, V. Bogason and P.S. Hammond. 2015. Distribution, abundance, and feeding ecology of baleen whales in Icelandic waters: have recent environmental changes had an effect? Front. Ecol. Evol. 2: 161-172.

Comment No.:	QIA-06
Section Reference:	Executive Summary (and elsewhere)
Comment:	

"Given that the combined stock estimate for Admiralty Inlet and Eclipse Sound indicated that the combined narwhal population remained stable relative to pre-shipping conditions, and in consideration of the available Inuit Quajimajatuqangit (IQ) regarding the degree of exchange between narwhal groups on their summering grounds, the observed decrease in narwhal relative abundance in Eclipse Sound likely reflects natural exchange between the two putative stock areas."

What IQ or other evidence on exchange supports such large-scale abandonment of Eclipse Sound?

This isn't a "combined stock" estimate, it is an estimate for two summer stock aggregation areas in combination (or possibly a combination of animals from these plus other summer stocks, e.g., Somerset Island). Admiralty Inlet and Eclipse Sound are still managed by DFO as separate summer stocks, pending additional information, and the decline in abundance in the Eclipse Sound summer aggregation area has significant consequences for Inuit culture, harvesting, food security, and land use.

Baffinland Response:

The first documented narwhal decline occurred between 2004 and 2013 (Richard et al. 2010; Doniol-Valcroze et al. 2015), which was a period before Project shipping or icebreaking first occurred in the RSA. Narwhal numbers in the RSA decreased by 50% from 20,225 animals in 2004 to 10,489 animals in 2013. In this occurrence, DFO proposed that natural exchange between the two summering areas was a possible reason for this observed decline in 2013 (Doniol-Valcroze et al. 2015), implying that some portion of the 'missing' animals in Eclipse in 2013 may have been present in Admiralty at the time of the Eclipse Sound aerial survey.

For the past three consecutive years (2019–2021), 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). A summary of publicly available IQ regarding the degree of exchange between narwhal occurring in the Eclipse Sound, Admiralty Inlet and East Baffin Island summer stock areas and Inuit insight on what drives the summer distribution and abundance of narwhal in these areas of North Baffin Island is provided in our response to QIA-11.

References:

Doniol-Valcroze, T, Gosselin, J.F., Pike, D., Lawson, J., Asselin, N., Hedges, K., and S. Ferguson. 2015a. Abundance estimates of narwhal stocks in the Canadian High Arctic in 2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/060. v + 36 p.

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NWMB. 2016b. Public hearing to consider modifications to total allowable harvests for the Eclipse Sound and Admiralty Inlet Narwhal Management Units. 29 November 2016. 237 p.

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Comment No.:	QIA-07
Section Reference:	Executive Summary (and elsewhere, e.g. section 3.6.1, p. 79; section 3.6.2, p. 84; section 5.0, page 94)
Comment:	

“That is, it is possible that the ecological conditions in Admiralty Inlet are currently favourable to Eclipse Sound narwhal due to factors such as changing ice conditions, prey availability and/or predation pressure (Chambault et al. 2020; Franeira et al. 2017; Heide-Jorgensen et al. 2021; Higdon et al 2012; Laidre et al. 2008, 2015; Lefort et al. 2020; Steiner et al. 2019; 2021), all of which are known to be influenced by a rapidly changing climate in the Arctic (Stroeve et al. 2012; IPCC 2013; Overland and Wang 2013).”

Some of these references do not support this speculative statement. For example, the killer whale papers published through DFO and the University of Manitoba do not support a decrease in predation pressure for Admiralty Inlet cf Eclipse Sound.

Lefort et al. (2020) used photo-identification images of killer whales from both Admiralty Inlet and Eclipse Sound. The paper does not note this specifically, but many of the re-sights occurred between the two areas, and there is one regional population of killer whales that moves around the local area following narwhal and other prey.

Data from IQ interviews in Pond Inlet were not available when we wrote Higdon et al. (2012), but we did include information from 11 interviews with hunters and elders in Arctic Bay. Higdon et al. (2012)

assigned killer whale sighting records to ecoregion, and all records from Eclipse Sound and Admiralty Inlet are in the Lancaster Sound ecoregion. The Lancaster Sound ecoregion was characterized by a large percentage of the overall sighting records (24%) and larger killer whale group sizes, but this paper does not provide any data to suggest that predation pressure between the two survey areas has changed.

Higdon et al. (2014) (not cited by Golder, citation below) included IQ observations from 11 communities including 8 interviews in Mittimatalik (in addition to those from Arctic Bay). Their analysis grouped both communities (plus Qikiqtarjuaq) for regional analysis ("North Baffin" region), but provided some relevant information on differences in killer whale relative abundance between communities. Arctic Bay interviewees reported that they see killer whales more often than Pond Inlet interviewees did, and it is widely acknowledged and understood among North Baffin Inuit that the same killer whales historically and routinely visit both areas. Furthermore, Admiralty Inlet has always been recognized as an area with greater prevalence of killer whales.

Ice conditions are variable but have not changed significantly in one region compared to the other based on work we have seen.

QIA requests that the text here and in other sections of the report be revised to accurately reflect the information in the cited studies, and that more information on sea ice conditions be reported.

Higdon, J.W., K.H. Westdal, and S.H. Ferguson. 2014. Distribution and abundance of killer whales (*Orcinus orca*) in Nunavut, Canada – an Inuit knowledge survey. Journal of the Marine Biological Association of the United Kingdom 94(6): 1293-1304.

Baffinland Response:

The text has been revised to reflect the information in the cited studies with additional information from other literature sources also included (along with respective citations). We note that the statement in question was not intended to suggest that there are known differences in ice conditions, prey availability and/or predation pressure that exist between Eclipse Sound and Admiralty Inlet. It refers to general changes occurring in these parameters across the Arctic that are predicted to have adverse impacts on marine mammal populations (including shifts in species distributions, changes in population size and loss of habitats) that are presently not quantified on a microgeographic scale. For example, it is well documented that ocean warming is causing shifts in the distribution of marine mammal species (Albouy et al. 2020; Chambault et al. 2022; Frederiksen and Haug 2015; Nøttestad et al. 2015; Víkingsson et al. 2015;) and their prey (Frainer et al. 2017; Møller and Nielsen 2020), including narwhal in Southeast Greenland (NAAMCO 2021). However, how this is manifesting in more localized areas of North Baffin Island is still presently unclear. 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 suggest that the current distribution of Baffin Bay narwhal during summer will undergo a +200 km northward shift 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 by between 31 and 66% over this same period (depending on the climate model).

These changes are likely already underway in the Eastern Canadian Arctic and may affect Eclipse Sound and Admiralty Inlet differently (again, this is currently unknown). Our statement is simply intended to indicate this is a possibility (i.e., potential driver of change in local narwhal distribution as observed in Eclipse).

References:

Albouy, C., V. Delattre, G. Donati, T. L. Frölicher, S. Albouy-Boyer, M. Rufino, L. Pellissier, D. Mouillot and F. Leprieur. 2020. Global vulnerability of marine mammals to global warming. Sci. Rep. 10: 548.

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Nøttestad, L., B. Krafft, V. Anthonypillai, M. Bernasconi, L. Langárd, H.L., Mørk and Fernö. 2015. Recent changes in distribution and relative abundance of cetaceans in the Norwegian Sea and their relationship with potential prey. Front. Ecol.Evol. 2: 150-160.

Víkingsson, G.A., D.G. Pike, H. Valdimarsson, A, Schleimer, T. Gunnlaugsson, T. Silva, B.P. Elvarsson, B. Mikkelsen, N. Øien, G. Desportes, V. Bogason and P.S. Hammond. 2015. Distribution, abundance, and feeding ecology of baleen whales in Icelandic waters: have recent environmental changes had an effect? Front. Ecol. Evol. 2: 161-172.

Comment No.:	QIA-08
Section Reference:	Section 1.2, page 3 (and elsewhere as noted in the comment text)
Comment:	

One of the listed objectives includes “[t]o assess the accuracy of the predictions contained in the Final Environmental Impact Statement (FEIS) for the Project.”

Section 3.6.2 (page 83) re: program integration states that “[n]o evidence was observed of large-scale avoidance behaviour, displacement effects, or abandonment of the summering grounds (i.e., high severity responses)…” (in regards to Bruce Head data). How is abandonment defined?

The FEIS (2012, Volume 8, Table 8-5.13) threshold for disturbance caused by underwater noise is “≥10 % of narwhals in the RSA exhibit strong disturbance and avoidance reactions that lead to (seasonal) abandonment of areas identified as important habitat”, applied on a “per year” basis. No definition of “abandon" or "abandonment” is provided in FEIS, but 10% change is the threshold used. Narwhal numbers in the RSA have declined over 10% on a per year basis.

For PCC 101, Table 21 (section 5.0, page 93) states that aerial surveys allow for "evaluation of narwhal large-scale displacement effects, abandonment of the RSA, moderate to large changes in stock size" (also see PCC 109). The Eclipse Sound narwhal stock (and it is managed as a single stock for narwhal quota allocations) has declined 97% since the 2004 survey, with declines > 10% recorded in multiple years. Is this not compelling evidence of large-scale displacement effects, large changes in stock size, and potential for abandonment of the RSA?

Baffinland Response:

The terms "large-scale avoidance behaviour", "displacement effects", and "abandonment" are defined in the draft Marine Monitoring Plan (MMP), and specifically in the Threshold Action and Response Plan (TARP) table for marine mammals (BIMC 2021). This information has also provided in the 2022 Narwhal Adaptive Management Response Plan (BIMC 2022). An overview is provided as follows:

- Large-scale avoidance behaviour: All high-level severity responses (Level 7, 8 or 9) or moderate-level severity responses (Level 5 or 6) that fall under 'sustained avoidance behaviour', 'prolonged displacement' and/or 'prolonged separation of females and depending offspring', as defined by Southall et al. (2007; 2021) and Finneran et al. (2017) – the moderate-level responses would need to be sustained over a long duration (lasting over a period of several hours, or enough time to significantly disrupt a narwhal's daily routine).
- Large-scale displacement effect: same as above for large-scale avoidance (terms are used interchangeably).
- Abandonment: >25.0% decrease in stock size (abundance) relative to 2019 aerial survey abundance with the trend maintained in at least two consecutive monitoring programs, whether during the regular monitoring schedule or confirmed through a special study.

The first documented decline of the putative Eclipse Sound narwhal stock (as defined by DFO for quota management purposes) was between 2004 and 2013 (Richard et al. 2010; Doniol-Valcroze et al. 2015), which was a period before Project shipping or icebreaking occurred in the RSA. Narwhal numbers in the RSA decreased by 50% from 20,225 animals in 2004 to 10,489 animals in 2013. In this occurrence, DFO proposed that natural exchange between the two summering areas was a possible reason for this observed decline in 2013 (Doniol-Valcroze et al. 2015), implying that some portion of the 'missing' animals in Eclipse in 2013 may have been present in Admiralty at the time of the Eclipse Sound aerial survey. The available IQ also support that narwhal move freely between both Eclipse Sound and Admiralty Inlet and that narwhal occurring in both areas during summer belong to the same stock (see response to QIA-11 for a summary of IQ on this subject). For these reasons, BIMC began surveying both the Eclipse Sound and Admiralty Inlet narwhal stocks in 2019 to assess changes in the combined Eclipse Sound and Admiralty Inlet narwhal abundance. The combined narwhal abundance in Eclipse Sound and Admiralty Inlet was shown to be similar in 2020 (36,044 individuals) to that observed in previous survey years (45,532 individuals in 2013 and 38,677 individuals in 2019); and was statistically higher in 2021 (75,177 individuals) than in previous survey years (2013, 2019 and 2020). To date, aerial surveys have not identified a net decrease in the combined Eclipse Sound / Admiralty Inlet stock. What is currently being observed may be a continuation of a shift in narwhal summer distribution from Eclipse Sound to Admiralty Inlet observed since the early 2000s.

Nonetheless, BIMC remains concern by the lower numbers of narwhal observed in Eclipse Sound in 2020 and 2021, and the potential impact this has on Inuit harvest and culture. In the face of this uncertainty and as requested by some Inuit and Inuit groups, BIMC has elected to implement additional precautionary-based several adaptive management measures in 2021 and 2022 which included:

- No icebreaking during the 2021 and 2022 early shoulder shipping season.
- Use of convoys throughout the 2022 season to further reduce total sound exposure
- No more than 80 ore carriers will be chartered during the 2022 season to transport 6 Mtpa, if approved.

References:

BIMC. 2021. Marine Monitoring Plan (MMP) - DRAFT. Marine Mammal TARP and Action Toolkits. NIRB File # 334146.

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Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A. and Tyack, P. L. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals. 33 (4)

Southall, B.L., D.P. Nowacek, A.E. Bowles, V. Senigaglia, L. Bejder, and P.L. Tyack. 2021. Marine Mammal Noise Exposure Criteria: Assessing the Severity of Marine Mammal Behavioral Responses to Human Noise. Aquatic Mammals. 47(5): 421-464.

Comment No.:	QIA-09
Section Reference:	Section 1.3, page 4
Comment:	

Re: killer whales, this section should note (and reference appropriate sources) that killer whales have been historically present in the north Baffin region since at least the mid-1800s, and they were regularly recorded by whaling vessels on the "Pond's Bay" whaling ground.

Baffinland Response:

Comment noted. We understand that the earliest historical killer whale sightings recorded in the 1800s occurred in Baffin Bay and Davis Strait (Reeves and Mitchell 1988). Notwithstanding, there is little dispute in the scientific (Moore and Huntington 2008; Higdon and Ferguson 2009; Higdon et al. 2011) or available IQ record (NWMB 2016c; QIA 2019) in that killer whale presence in the Arctic has markedly increased over the last several decades; and this pattern is strongly associated with reductions in seasonal sea ice extent and duration (Moore and Huntington 2008; Hidgon et al. 2009). Additional text has been added to Section 1.3 of the report acknowledging the historical record of killer whales in the Arctic (Reeves and Mitchell 1988).

References:

Higdon, J.W. and S. Ferguson. 2009. Loss of Arctic sea ice causing punctuated change in sightings of killer whales (Orcinus orca) over the past century. Ecological Applications. 19(5): 1365-1375.

Higdon, J.W., D. Hauser and S. Ferguson. 2011. Killer whales (Orcinus orca) in the Canadian Arctic: distribution, prey items, group sizes, and seasonality. Marine Mammal Science. 28(2): 93-109.

Moore, S.E. and H.P. Huntington. 2008. Arctic marine mammals and climate change: impacts and resilience. Ecological Applications. 18(2): 157-165.

NWMB. 2016c. Submission to the Nunavut Wildlife Management Board: Inuit Qaujimajatuqangit narwhal interviews. Prepared by Sheila Oolayou. November 2016.

Qikiqtani Inuit Association (QIA). 2019. Tusaqtavut Study for Phase 2 Application of the Mary River Project. Final Report. 14 June 2019. 181 p.

Reeves R.R. and Mitchell E. 1988. Distribution and seasonality of killer whales in the eastern Canadian Arctic. Rit Fiskideildar 11: 136–160.

Comment No.:	QIA-10
Section Reference:	Section 3.5, page 57; section 3.6.3.5, page 87
Comment:	

The polar bears sighted during Eclipse Sound leg 2 surveys (13 sightings of 22 individuals) were reported as 10 single bears and four mothers with pairs of cubs (also note - should this be 14 sightings?). Were all the female-cub groups confirmed as containing cubs of the year (COY), with no pairs of yearlings?

Admiralty Inlet leg 2 surveys recorded 23 sightings of 46 individual bears - 11 singles, 10 sightings of mothers plus 1 or 2 cubs, and two sightings of 3 bears of unknown age class. Are photos available to determine whether these were females with yearlings? And were all 10 sightings of family groups confirmed as COY?

Information on the demographic characteristics of polar bears is useful for monitoring Project effects including icebreaking.

Baffinland Response:

Eclipse Sound: A total of thirteen polar bear sightings were recorded. One of the observers recorded a sighting consisting of one single bear along with a mother with two cubs in close proximity. All the female-cub groups were recorded as cubs. Yearlings were not sighted during the Eclipse Sound surveys. Photos were not taken of the unknown age classes, as animals were either outside of the field of view of the camera or the animals were observed during transits when active surveying was not occurring and the cameras were not collecting photographs.

Admiralty Inlet: All 10 sightings of family groups were confirmed as cubs. Yearling were not sighted during the Admiralty Inlet surveys.

Comment No.:	QIA-11
Section Reference:	Section 3.5.6, page 76
Comment:	

"This suggests that narwhal from Eclipse Sound, Admiralty Inlet, and potentially from proximal summer stock areas (i.e., Somerset Island, East Baffin Island) may have used Admiralty Inlet in 2021."

What information have Inuit provided? What efforts have been made to gather IQ and observations related to 2021 narwhal distribution and environmental conditions?

Baffinland Response:

With respect to available IQ that supports the assertion that movement of narwhal from Eclipse Sound to

Admiralty Inlet (and vice versa) is a natural phenomenon that has occurred in the past, we refer QIA to the following information:

In the November 2016 NWMB Public Hearing for considering modifications to the total allowable harvests for the Eclipse Sound and Admiralty Inlet Narwhal Management Units, extensive IQ was shared from various community members and Elders that spoke to natural fluctuations of narwhal between Eclipse Sound and Admiralty Inlet (due to food resources, ice conditions and other factors) and the recognition of Admiralty Inlet and Eclipse Sound narwhal as a single stock (NWMB 2016a, 2016b).

- "I'm sure that you're going to keep saying that Pond Inlet and Arctic Bay narwhal are different stock, different population, but as our Elders have observed and we keep saying at HTO, that is not the case; they're one population. But you don't want to admit that, and we cannot change your mind, because it's been conceived that way. That's that one." Eric Ootoova, Pond Inlet community member, 28 November 2016 (NWMB 2016a).
- "Long before Qallunaat arrived, Inuit survived solely on wildlife by daily hunting and harvesting, and as observers of these wildlife and these whales, we know that there's peaks and lows of the number of whales, both migratory and summer stocks. And if in a particular year they happen to migrate somewhere else, the department or scientists would say that they decreased, but Inuit would know that they're migrating through somewhere else or for food. And Inuit know that. We Inuit have that knowledge." Gamailie Kilukshak, Pond Inlet community member, 28 November 2016 (NWMB 2016a).
- "Before I ask, I just want to make a comment. Inuit say, especially our Elders say that a species of wildlife, they go everywhere. They don't have a specific area where they call home. Yeah, they can go elsewhere in another year and come back another year. They'll stay there for -- they will stay around that area, but they will leave it right away…" Jaykolassie Killiktee, Pond Inlet community member, 28 November 2016 (NWMB 2016a).
- "According to the Inuit knowledge, I don't think that is included in this estimate. And they say that there's only one stock, one stock of narwhal from Eclipse Sound and Admiralty Inlet narwhal, one stock. But DFO is considering they're two different stocks, and what was mentioned that the -- are you going to be looking at this when you have that workshop? I know that the communities don't agree with that because you have separated the two stocks. Are you going to be looking at that during the workshop, whether it's one stock or two?" Paul Irngaut, Director of Wildlife, NTI, 28 November 2016 (NWMB 2016a).
- "Go back to the table and really look at the narwhal population. They're not separate. They're not a separate stock like Eclipse Sound or Admiralty Inlet. If there was no more polar bear or narwhal, we wouldn't be having this discussion or debate; but fortunately, there are, so that's why we're talking about summer and migratory stocks. So I give it back to you to recommend to you to put it into one stock because they're not separate." Mr. Tango, 28 November 2016 (NWMB 2016a)
- "Just to supplement that. When there's early ice breakup, the Lancaster Sound to Kitikmeot area, when we didn't have narwhal in our area we heard from Kitikmeot that they have lots of narwhal now. And it's not only the shipping traffic that is contributing to the movement of narwhal. It's early ice breakup that it's obvious they're going further into the western area. Especially this summer, we observed it. It depends year to year, as we keep saying, ever since I can remember as a child, every year is different. And I know that what we're presenting might be of some use." E. Ootoova; 28 November 2016 (NWMB 2016a)

- "And our Elders keep saying that whales are continuously moving, and I believe what they're saying that, when there was a whale harvested with a harpoon – in Arctic Bay there was a harpooned narwhal, and that narwhal had moved down to Pond Inlet and was harvested from Pond. So there's also narwhals that have nice tusks, and some don't. And our Elders are very aware of the significant numbers of whales that come here, and I'm sure that you heard from them earlier. They often move to different places, and they don't go to the same channels or the same sounds or inlets. And it seemed to indicate that your 2013 survey was only one year, since the number of whales that come here are not ours, the same, and they arrive at different times of the year to year. So that's why we could not agree with the DFO's findings. And our narwhal go back and forth between Arctic Bay and Pond Inlet. And when we have a lot of narwhal in Pond Inlet, there's nothing in Arctic Bay; and when they're through Arctic Bay, there's nothing here in Pond Inlet. So I urge you to listen to that comment from our Elders, and that is coming from Inuit knowledge…" Eric Ootoova, Pond Inlet community member, 28 November 2016 (NWMB 2016a).
- "Yes, it was mentioned the other day, but I want to reiterate that the narwhal, they don't go back and forth. And I know it will be different in years, because sometimes there are more in Eclipse Sound, and some years there are more in Admiralty Inlet. I know that there's going to be a narwhal in Eclipse Sound all the time, and I know that because there's just one stock that go back and forth between Admiralty Inlet and Eclipse Sound, and when they were -- we're not trying to distinguish the two different ones, and I know they are the same population. When they come through Eclipse Sound, some stay around, and some go over to Admiralty Inlet, and then they come back to Eclipse Sound after Admiralty Inlet. But nowadays there are more migratory narwhal perhaps because the sea ice is decreasing. So they are migrating west, more west. And if there were no more narwhal in Pond Inlet -- and I know that our narwhal would also decrease, but now we're not concerned about that right now because they keep going back and forth, depends what kind of a year it is. There was lots of narwhal in Admiralty Inlet, so they're increasing, and maybe they had moved over to Admiralty Inlet from Eclipse Sound. The traditional Inuit knowledge and the scientific knowledge are never the same, will never be the same, so according to the Inuit knowledge and the scientific knowledge, they will never be balanced. I hope that's what -- if the narwhal were decreasing both in Eclipse Sound and Admiralty Inlet, stocks would be decreasing at the same time." Olayuk Naqitarvik, Arctic Bay community member, 29 November 2016 (NWMB 2016b).
- "What Naqitarvik was just mentioning, it is nice to hear. To the people of Pond Inlet and to DFO, it is clear. You make it really clear to everybody, because they know that they have the same stock of narwhal between the two communities, but one of them is increasing and the other is been decreasing. Naqitarvik made it really clear that there's only one stock. Maybe they were doing a survey when the narwhal were over in Admiralty Inlet, and he mentioned that there will always be narwhal in Eclipse Sound as long as there are narwhal in Admiralty Inlet. I like to hear that, so I'm just making a comment..." Simeonie Keenainak, 29 November 2016 (NWMB 2016b).
- "Yes, we believe that it is one stock going to Admiralty Inlet and Eclipse Sound." Jobie Attitaq, Arctic Bay community member, 29 November 2016 (NWMB 2016b).
- "Our recommendation that is before you, it's for recommendation for Pond Inlet only. That's why we've been asking Inuit what they think. We keep asking whether they think it's one stock or two separate stocks to have it on record, and when DFO has been saying that it's two different stocks for Pond Inlet and Arctic Bay, that's why we're trying to ask questions and to make sure that it was on record on the response from the Inuit. And we recommended that we defer the decision because there's two opinions on the table from DFO saying that it's two different stocks, and the

other opposing opinion is that, from Inuit perspective, that it's one stock…" Paul Irngaut, Director of Wildlife, NTI, 29 November 2016 (NWMB 2016b).

- "When Arctic Bay and Pond Inlet have stated that it's one stock, they usually migrate through Pond Inlet waters, and then they dive and go to Arctic Bay, Admiralty Inlet, and there's no more whales in Pond because they're in Arctic Bay area; and then when they migrate back -- when there's none left in Arctic Bay, there's lots of whales in Pond Inlet. That's how they're always continuously moving forward, moving forward. Sometimes they will go to other inlets and sounds, and some of them keep going to the wintering ground, some of them go to Qaanaaq, to Greenland. And when they go to their wintering grounds, it's obvious they congregate in one place…" Sakiasie Qaunaq, Artic Bay community member, 29 November 2016 (NWMB 2016b).

In more recent (March 2022) submissions to the Nunavut Wildlife Management Board (NWMB) on the matter of narwhal hunting tag management by HTOs (QWB 2022), the Qikiqtaaluk Wildlife Board (QWB) (which is comprised of the MHTO Chair as well as all other HTO Chairs in the region) presented IQ that refuted the existence of a distinct "Eclipse Sound summering stock" in the North Baffin region:

- In January 2020, Eric Ootoovak, then Chairperson of the Mittimatalik HTO, told DFO scientists and managers repeatedly and emphatically that "there are no summer stocks" during a survey planning workshop in Winnipeg. Mr. Ootoovak was referring to three hypothetical summer stocks delineated by DFO in 2013 (Doniol-Valcroze et al. 2015). According to IQ, the three summer stocks of narwhal do not actually exist in reality within the waters of NEBI (QWB 2022).
- In January 2020, DFO could not provide the needed evidence showing multi-year fidelity of narwhal to any one of the three hypothetical parts of North East Baffin Island (NEBI) waters. DFO offered no clear methods or plans to obtain the required information (C. Watt, DFO, Winnipeg, pers. com. in QWB 2022). DFO's telemetry data (DFO 2020) shows that narwhal may move from one area to other areas in the same open-water season in which they were tagged within and beyond NEBI waters (QWB 2022).
- At that 2020 workshop, delegates from all six HTOs (Arctic Bay, Pond Inlet, Clyde River, Qikiqtarjuaq, Pangnirtung and Iqaluit) agreed that DFO's 2013 hypothetical summer stock management system was not supported by IQ, and unduly restricted harvesting by Inuit in contravention of sections 5.3.3 and 5.6.50 of the Nunavut Agreement (QWB 2022).

The March 2022 Qikiqtani Wildlife Board (QWB) submissions also provided the following conclusions about narwhal occurring in the waters of NEBI based on generations-old, up-to date, peer-reviewed IQ:

- Narwhal move freely throughout the NEBI area. Their distributions and abundances change across NEBI waters between years, showing that individual narwhal do not always return to the same specific areas within NEBI waters every year (QWB 2022).
- Narwhal also move freely and widely from day to day, from week to week and from month to month in NEBI waters, and their local distributions and abundances change accordingly. Groups of narwhal are seen moving out of and into major inlets and sounds, and among various smaller fiords and bays, throughout the open-water period (QWB 2022).
- In spring, narwhal arrive at various areas in NEBI waters at varying times each year, depending on the development of open water within variable patterns at the floe edges, leads in the ice in various areas, and ice break-up into summer. These patterns and their timing vary from year to year, and can affect the abundance and distributions of narwhal across NEBI waters into August and September (QWB 2022).

- Throughout the open-water period, narwhal move as needed for their biological needs like birthing and mating, as well as in response to environmental factors like changing food concentrations, killer whales, and ships (QWB 2022). Narwhal also probably move in response to factors largely unknown to humans (QWB 2022).
- Underwater sounds are probably important factors that influence the real-world, real-time distributions and abundances of the narwhal because narwhal can hear other narwhal, other whales, predators, ships and other sources of sound across very long distances (QWB 2022).
- Inuit manage their harvesting in real time as narwhal move throughout the open-water season because the movements, distributions and abundances of NEBI narwhal cannot be predicted accurately months in advance (QWB 2022).

For the convenience of the MEWG and the NIRB, BIMC attached the March 2022 QWB submissions to the NWMB in a letter sent to the NIRB in May 2022 (Appendix B in BIMC 2022). This information is also available on the NWMB registry at the following link:

https://www.nwmb.com/en/public-hearings-a-meetings/meetings/regularmeetings/2022/rm-001-2022-march-9-2022/english-19.

In summary, the available IQ also support that narwhal move freely between both Eclipse Sound and Admiralty Inlet and that narwhal occurring in both areas during summer belong to the same stock. For these reasons, BIMC started surveying both the Eclipse Sound and Admiralty Inlet stocks in 2019 to assess changes in the combined Eclipse Sound and Admiralty Inlet narwhal abundance. The combined narwhal abundance in Eclipse Sound and Admiralty Inlet was shown to be similar in 2020 (36,044 individuals) to that observed in previous survey years (45,532 individuals in 2013 and 38,677 individuals in 2019); and was statistically higher in 2021 (75,177 individuals) than in previous survey years (2013, 2019 and 2020). To date, aerial surveys have not identified a net decrease in the combined Eclipse Sound / Admiralty Inlet stock. What is currently being observed may be a continuation of a shift in narwhal summer distribution from Eclipse Sound to Admiralty Inlet observed since the early 2000s.

References:

BIMC. 2022. 220510_BIM Response on MHTO Letter_signed.pdf. 10 May 2022. 42 p.

Doniol-Valcroze, T, Gosselin, J.F., Pike, D., Lawson, J., Asselin, N., Hedges, K., and S. Ferguson. 2015. Abundance estimates of narwhal stocks in the Canadian High Arctic in 2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/060. v + 36 p.

NWMBa. 2016. Public Hearing to Consider Modifications to Total Allowable Harvests for the Eclipse Sound and Admiralty Inlet Narwhal Management Units. Volume 1 (28 Nov 2016) and Volume 2 (29 Nov 2016) – Hearing Transcripts. Adele Jones Court Reporting.

NWMB. 2016b. Public hearing to consider modifications to total allowable harvests for the Eclipse Sound and Admiralty Inlet Narwhal Management Units. 29 November 2016. 237 p.

Qikiqtaaluk Wildlife Board (QWB). 2022. Establishment of an Inuit System of Narwhal Management in the Waters of Northern and Eastern Baffin Island, 2022. Submission to the Nunavut Wildlife Management Board (NWMB). Regular Meeting No. RM 001-2022.

Comment No.:	QIA-12
Section Reference:	Section 3.5.6, page 77
Comment:	

"... suggests a shift of a portion of the Eclipse Sound stock to the Admiralty Inlet summering ground during the summer of 2021."

This is a continuation of previous years' patterns, not a shift that is specific to 2021.

Baffinland Response:

Agreed, the pattern observed in 2021 follows that of 2020. As stated in the report, narwhal stock abundance in the Eclipse Sound grid was significantly lower in 2020 (5,018 individuals) and 2021 (2,595 individuals) than in previous survey years (10,489 individuals in 2013, 12,039 individuals in 2016 and 9,931 individuals in 2019), including years prior to the start of BIMC's iron ore shipping operations in 2015. However, the combined narwhal abundance in Eclipse Sound and Admiralty Inlet was shown to be similar in 2020 (36,044 individuals) to that observed in previous survey years (45,532 individuals in 2013 and 38,677 individuals in 2019); and was statistically higher in 2021 (75,177 individuals) than in previous survey years (2013, 2019 and 2020). What is currently being observed may be a continuation of a shift in narwhal summer distribution from Eclipse Sound to Admiralty Inlet observed since the early 2000s. Also see BIMC response to QIA-05 and QIA-11.

Comment No.:	QIA-13
Section Reference:	Section 5.0, page 93
Comment:	

The conclusions here are largely dependent on the acoustic thresholds used, and IQ clearly indicates that narwhal are highly sensitive to noise and that the 120 dB threshold used as a standard may not be representative of narwhal acoustic sensitivity.

How does BIMC reconcile their monitoring program results given extensive Inuit knowledge on narwhal sensitivity to noise and observations of shipping-related impacts, including open-water shipping?

Baffinland Response:

This question does not pertain to the 2021 Marine Mammal Aerial Survey Program (MMASP) or the 2021 MMASP Report. The conclusions in Section 5.0 of the 2021 MMASP Report are based on the results of the 2021 marine mammal aerial surveys. Acoustic thresholds are not factored into the calculations of narwhal abundance.

Comment No.:	QIA-14
Section Reference:	Section 6.0, page 95
Comment:	

QIA's supports Golder's recommendation that photo-analysis of 2020 and 2021 aerial survey data for EWI metrics be conducted to help substantiate the values obtained through the Bruce Head program.

The Bruce Head study (section 6.5.2.1, pages 80-87 of 2021 Bruce Head Draft Report) recorded a lower proportion of immature narwhal than in any previous year. It is our understanding from a May 2022 MEWG call that analysis of the aerial survey photographs has shown similar patterns. When will these numbers be made available?

Changes in the proportion of immature narwhal is the only Early Warning Indicator (EWI) in place. To date it has failed to provide any early warning of a change in population status, and numerous MEWG member organizations have questioned its utility.

1. Has this EWI not been adequately monitored to provide comparative indices?
2. Is the indicator not sensitive enough to detect rapid changes in abundance?
3. Are additional EWIs being considered?
4. What adaptive management responses are proposed to address changes in the EWI?

Baffinland Response:

The EWI results from the 2021 aerial survey data have been included as an appendix to this report.

1. Yes, the EWI has been adequately monitored through data made available through the Bruce Head Shore-based Monitoring Program and the MMASP. However, a direct comparison of EWI values between the photographic aerial data and the shore-based observer data is not advisable given the difference in survey methods. Aerial surveys offer a limited window of observation time (due to the speed of the aircraft) compared to shore-based surveys. This affects the available window of detection of marine mammals and particularly for nursing calves that are often obscured from view when feeding or travelling directly beneath their mothers. As such, the level of detection of nursing calves will naturally be lower in photographic aerial surveys compared to shore-based surveys due to their narrower window of available detection time (i.e., aerial imagery only offers a brief snapshot in time). Shore-based observers have a considerably longer window of opportunity to detect calves that may be temporarily obscured from view due to their inherent behaviour and relative placement to mother at the time of surveying.

2. The principal indicator that is actively monitored in the MMASP is a 'change in abundance'. This indicator is clearly sensitive enough to detect a rapid change in abundance because this is precisely what it has done. The specific purpose of this indicator is to inform if narwhal numbers are changing (and by how much), but it does not provide information on why a change in numbers might be occurring. The latter is addressed through other indicators incorporated into BIMC's programs including, but not limited to, the primary EWI (change in proportion of immature narwhal). BIMC's other behavioural-based indicators (e.g., change in travel speed, dive duration, surface time, bottom time, orientation) also provide timely information on whether an observed change in narwhal abundance or in the proportion of immature narwhal is Project-driven or not.

A full understanding of external contributing factors (and their potential influence on the distribution, abundance and behaviour of Baffin Bay narwhal) is not required to determine if Project shipping is contributing or not to the observed shift in narwhal distribution in the North Baffin region as reported in 2021 and 2022. BIMC's monitoring studies are designed to test if its shipping activities are modifying narwhal movements and behaviour in the RSA and to what degree this may be occurring (i.e, spatial and temporal characterization of effects, severity of effects, etc).

It is beyond the scope of the Project (or the responsibly of BIMC) to test the effect of external (non-Project) stressors on narwhal or other receptors in the Eastern Canadian Arctic region. As noted in the NAMRP (BIMC 2022), BIMC remains committed to supporting DFO and other regulators on any such regional monitoring, but should not be the lead on this work (as this would fall under the mandated responsibility of DFO).

BIMC will continue to engage with the MEWG for the potential development of additional EWIs. To date, no additional EWIs with identified available baseline data and corresponding thresholds have been proposed by the MEWG. BIMC welcomes MEWG members to provide detailed written recommendations with regards to EWIs implemented for the Project, including available baseline data and proposed thresholds that would support using such indicators. These recommendations can be provided to BIMC's Senior Director of Sustainable Development, Lou Kamermans, lou.kamermans@baffinland.com.

3. We take this opportunity to remind the QIA that the proportion of immature narwhal is not the only indicator being monitored for the Project. BIMC has incorporated multiple indicators into its ongoing marine monitoring programs beyond the primary EWI (i.e., proportion of immatures). This includes numerous behavioural response indicators for narwhal, as summarized in the marine mammal Trigger, Action and Response Plan (TARP) which is integrated in BIMC's draft Marine Monitoring Plan (MMP) (BIMC 2021). This information has and continues to be available to the NIRB and to members of the MEWG. These are also summarized in BIMC's 2022 Narwhal Adaptive Management Response Plan (NAMRP) (BIMC 2022a), which was submitted to the NIRB (and MEWG members) as part of its 2022 Marine Shipping and Vessel Management Report (BIMC 2022b – see Appendix D). Also see response to #2 above.

4. The observed decline in the primary EWI, as reported in the 2021 Bruce Head Program, triggered adaptive management in the form of the additional analysis of the 2021 aerial survey data for specific evaluation of the EWI metric (using dedicated 1,000 ft survey data) to evaluate if the decline observed at Bruce Head was a reflection of the low samples size encountered during the 2021 program and not an actual pattern of decreasing proportion of immature narwhal in the RSA. Results of this analysis suggest the former, in that the data do not indicate a decreasing proportional representation of immature narwhal in the Eclipse Sound region.

References:

BIMC. 2021. Marine Monitoring Plan (MMP). Marine Mammal TARP and Action Toolkits. NIRB File # 334146.

BIMC. 2022a. 2022 Narwhal Adaptive Management Response Plan (NAMRP). Document # BAF-PH1-830-P16-0024. Rev1. 19 July 2022.

BIMC. 2022b. Marine Shipping and Vessel Management Report to the Nunavut Impact Review Board. 19 July 2022. 301 p.

Comment No.:	QIA-15
Section Reference:	Section 6.0, page 95
Comment:	

"2021 Leg 1 and 2 surveys were flown as two consecutive three-week surveys as an adaptive management measure…".

These surveys are a monitoring tool that can inform adaptive management, they are not adaptive management per se. How did monitoring (i.e., survey results) inform adaptive management in 2021, and how will it inform adaptive management in the future?

Baffinland Response:

The text has been revised to indicate to: "2021 Leg 1 and 2 surveys were flown as two consecutive three-week surveys as an adaptive monitoring tool…".

The 2021 Narwhal Adaptive Management Response Plan (NAMRP) (BIMC 2021) provides a detailed summary on how monitoring results from 2020 (and earlier programs) informed adaptive management measures implemented by BIMC in 2021. The 2022 NAMRP (BIMC 2022a) (see Section 5.1 of BIMC 2022b) provides a detailed summary on how monitoring results from 2021 (and earlier programs) informed adaptive management measures implemented by BIMC in 2022.

References:

BIMC. 2021. 2021 Narwhal Adaptive Management Response Plan (NAMRP). 14 July 2021. Appendix D of BIMC 2021 Shipping and Marine Wildlife Management Plan (Document No. BAF-PH1-830-P16-0024, dated 12 July 2021) which is Appendix 1 of 2021 BIMC Marine Shipping and Vessel Management Report, dated 14 July 2021.

BIMC. 2022a. 2022 Narwhal Adaptive Management Response Plan (NAMRP). Document # BAF-PH1-830-P16-0024. Rev1. 19 July 2022.

BIMC. 2022b. Marine Shipping and Vessel Management Report to the Nunavut Impact Review Board. 19 July 2022. 301 p.

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