REPORT

Mary River Project

2019 Marine Mammal Aerial Survey

Submitted to:

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Executive Summary

From 12 to 26 July and 17 to 30 August 2019, Golder Associates Ltd. (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. Terms and conditions attached to Nunavut Impact Review Board (NIRB) Project Certificate No. 005 relevant to this program include requirements for Baffinland to collect additional baseline data along the Northern Shipping Route on narwhal abundance, distribution and habitat use; as well as implementation of a marine mammal monitoring program along the Northern shipping route to evaluate predictions in the Final Environmental Impact Statement (FEIS) with respect to potential disturbance effects on narwhal from ship noise. The MMASP was staged in two separate legs. Leg 1 targeted a 15-day window in mid-July and was designed to capture narwhal presence in the RSA prior to the start of the shipping season and to determine their relative number during this staging period. Leg 2 targeted a 15-day window in mid-August and was designed to obtain an abundance estimate of the combined Eclipse Sound and Admiralty Inlet narwhal stocks during the open-water season. Survey design and data collection methodology previously developed by Fisheries and Oceans Canada (Matthews et al. 2017; Marcoux et al. 2016; Doniol-Valcroze et al. 2015; Asselin and Richard 2011) 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 SLR cameras were installed on the aircraft to collect high definition photographic images of the survey area directly below the aircraft. Photographic surveys were only 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 1,871 sightings of 4,961 individual marine mammals were recorded by the observers during July and August 2019. A total of eight different species of marine mammals were observed during the surveys: narwhals (*Monodon Monoceros*; 1,356 sightings totalling 3,230 individuals), bowhead whales (*Balaena mysticetus*; 205 sightings totalling 299 individuals), ringed seals (*Pusa hispida*; 79 sightings totalling 121 individuals), harp seals (*Pagophilus groenlandicus*; 73 sightings totalling 1,002 individuals), killer whales (*Orcinus orca*; nine sightings totalling 44 individuals), polar bear (*Ursus maritimus*; 17 sightings totalling 29 individuals), bearded seals (*Erignathus barbatus*; four sightings of individual seals), and beluga (*Delphinapterus leucas*; four sighting of individual whales). Unidentified seals (110 sightings totalling 204 individuals) and whales (14 sightings totalling 24 individuals) were also recorded during the surveys.

During the photographic surveys, a total of 14,580 sightings of 27,795 individual marine mammals were recorded during the 2019 MMASP photo review. A total of three different species of marine mammals were recorded during the photographic surveys: narwhals (13,144 sightings totalling 23,136 individuals), bowhead whales (seven sightings totalling nine individuals), and polar bear (one sighting of an individual). Unidentified seals (1,482 sightings totalling 4,649 individuals) were also recorded during the surveys.

Narwhal were primarily concentrated in the Eclipse Sound and Milne Inlet strata during Leg 1, with numbers ranging from 5,793 (CV=0.23) prior to Baffinland vessel in the RSA to 15,591 (CV=0.19) after Baffinland vessels entered the RSA.

The narwhal abundance estimate calculated during Leg 2, for the combined Eclipse Sound and Admiralty Inlet stocks of 38,771 narwhals (Coefficient of Variation (CV) =0.12, 95% confidence interval (CI) of 30,667–49,016) from surveys on 21–22 August and 25–27 August 2019 fell within the range calculated during the previous Fisheries and Oceans Canada (DFO) survey conducted in August 2013 of (45,532 narwhals, CV=0.33, 95% CI of 22,440–92,384; Doniol-Valcroze et al. 2015). For Eclipse Sound stock alone, the narwhal abundance estimate of 9,931 narwhals (CV=0.05, 95% CI of 9,009–10,946) from surveys on 21–22 August and 25–27 August 2019 fell within the range calculated during a previous DFO surveys conducted in August 2016 of 12,093 narwhal (CV=0.23, 95% CI of 7,768–18,660; Marcoux et al. 2019) and in August 2013 of 10,489 narwhal (CV = 0.24, 95% CI of 6,342–17,347; Doniol-Valcroze et al. 2015). This finding is consistent with impact predictions made in the FEIS Addendum for the Early Revenue Phase (ERP) 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).

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ᓴᒡᒐᕈᑦ 12-ᒥᑦ 26-ᒧᑦ ᐊᒻᒪᓗ ᐊᑯᓪᓕᕈᕐᕕᒃ 17-ᒥᑦ 30-ᒧᑦ 2019, ᒨᓪᑐ ᑲᑐᔾᔨᖃᑎᒌᑦ (ᒨᓪᑐᒃᑯᑦ), ᐱᔾᔪᑎᖃᕐᓗᒋᑦ ᐹᕕᓐᓛᓐ ᓴᕕᖕᓂᑦ ᐅᔭᕋᒃᑕᕆᐊᓕᕆᔨᒃᑯᑦ (ᐹᕕᓐᓛᓐ),ᑕᕆᐅᕐᒥᐅᑕᓂᒃ ᓂᕐᔪᑎᓂᒃ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᐃᓂᖃᓚᐅᖅᑐᑦ ᑑᒑᓕᑦ ᓇᒧᙵᐅᓯᒪᖕᒪᖔᑕ ᐊᒻᒪᓗ ᐱᑕᖃᐅᕐᓂᖏᓐᓂᑦ ᖃᓂᑦᑐᒥᑦ ᖃᐅᔨᓴᐃᕝᕕᐅᔪᒥᑦ ᐊᒻᒪᓗ Admiralty Inlet-ᒥᑦ. ᑐᑭᐅᔪᑦ ᐊᒻᒪᓗ ᖃᓄᐃᖕᒋᓯᓇᐊᖃᕐᓂᐅᔪᑦ ᐃᓚᐅᔪᑦ ᐊᕙᑎᓕᕆᓂᒃᑯᑦ ᐱᓕᕆᐊᕐᒧᑦ ᓇᓗᓇᐃᒃᑯᑕᖅ ᓈᓴᐅᑎ 005-ᒥᑦ ᐱᔾᔪᑎᖃᖅᑐᑦ ᑖᒃᑯᖓ ᑐᕌᖓᔪᒧᑦ ᐃᓚᐅᔪᑦ ᐹᕕᓐᓛᓐᑯᑦ ᑲᑎᑎᓯᓇᐊᖅᑲᕐᓂᖏᑦ ᑮᓪᓕᐅᔪᒧᑦ ᓈᓴᐅᑎᒃᑲᓐᓂᕐᓂᖅ/ᑎᑎᖅᑲᐅᑎᒃᑲᓐᓂᕐᓂᒃ ᐅᐊᖕᓇᖅᐸᖓᓂᑦ ᐅᒥᐊᕐᔪᐊᑦ ᐊᐅᓚᑎᖏᓐᓂᒃ ᑑᒑᓕᒃᑕᖃᐅᕐᓂᖏᓐᓄᑦ, ᓇᒧᙵᐅᓯᒪᓂᖏᓐᓄᑦ ᐊᒻᒪᓗ ᐃᓂᖏᓐᓂᒃ ᐊᑐᖃᑦᑕᖅᑕᖏᓐᓂᑦ; ᐊᒻᒪᓗ ᐊᑐᓕᖅᑎᑦᑎᓂᖅ ᐃᒪᕐᒥᐅᑕᓂᒃ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᑐᕌᖓᔪᒥᒃ ᐅᐊᖕᓇᖅᐸᖓᓂᑦ ᐅᒥᐊᕐᔪᐊᓄᑦ ᐊᑉᑯᑎᒋᔭᐅᔪᒥᑦ ᕿᒥᕐᕈᓂᐊᕐᓗᒋᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᑭᒍᓪᓕᖅᐹᖅ ᐊᕙᑎᒥᒃ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᑎᑎᖅᑲᒥᑦ ᐱᔾᔪᑎᖃᖅᑐᓂᒃ ᐃᓗᐃᓯᓇᓂᕐᓂᒃ ᑑᒑᓕᖕᓂᒃ ᐅᒥᐊᕐᔪᐊᑦ ᓂᐱᖏᓐᓂᑦ ᐱᔪᓂᒃ. ᑕᕆᐅᕐᒥᐅᑕᓂᒃ ᓂᕐᔪᑎᓂᒃ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᐃᓂᖃᓚᐅᖅᑐᑦ ᒪᕐᕉᓗᒋᑦ. ᐃᖏᕐᕋᓂᖅ 1 ᑐᕋᖓᖅᑲᖅᓄᓂ 15 ᐅᓪᓗᓂᒃ ᕿᑎᐊᓂᑦ ᓴᒡᒐᕈᑦ ᐋᖅᑭᐅᒪᓪᓗᓂᓗ ᐃᓱᒃᑯᑦ ᑕᑯᓗᒋᑦ ᑑᒑᓕᑦ ᖃᓂᑦᑐᒥᑦ ᖃᐅᔨᓴᐃᕝᕕᐅᔪᒥᑦ ᐅᒥᐊᕐᔪᐊᑦ ᐃᖏᕐᕋᔅᓯᓐᓂᐊᕐᓴᖅᑎᓪᓗᒋᑦ ᐊᒻᒪᓗ ᖃᐅᔾᔨᓂᐊᕐᓗᑎᒃ ᖃᐳᔾᔨᐅᓂᖏᑦ ᐅᕐᓂᒃᑖᖏᓐᓃᑎᓪᓗᒋᑦ. ᐃᖏᕐᕋᓂᖅ 2 ᕿᑎᐊᓂᑦ ᐊᑯᓪᓕᕈᕐᕕᒃ ᑑᒑᓕᑦ ᐱᑕᖃᐅᕐᓂᖏᓐᓂᒃ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᓂᒃ ᑕᒪᐃᓐᓄᑦ ᑕᓯᐅᔭᖅ ᐊᒻᒪᓗ Admiralty Inlet-ᒥᑦ ᐊᐅᔭᐅᑎᓪᓗᒍ. ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᐋᖅᑭᐅᒪᔪᖅ ᐊᒻᒪᓗ ᓈᓴᐅᑎᓂᒃ/ᑎᑎᖅᑲᓂᒃ ᑲᑎᖅᓯᐃᓂᕐᒧᑦ ᐊᑐᖅᑕᐅᔪᑦ ᐱᓕᕆᐊᖑᓚᐅᖅᑐᑦ ᑲᓇᑕᒥᑦ ᐃᖃᓗᓕᕆᔾᔪᓄᑦ (Matthews et al. 2017; Marcoux et al. 2016; Doniol-Valcroze et al. 2015; Asselin ᐊᒻᒪᓗ Richard 2011) ᐊᑐᖅᑕᐅᓚᐅᖅᑐᑦ ᖃᓄᐃᓐᓂᖅᓴᐅᔪᓕᕆᓂᐊᕐᓗᓂ ᐱᑕᖃᐅᕐᓂᖏᓐᓄᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᓂᒃ.

ᒪᕿᒃ ᐊᔾᔨᒌᙱᑦᑐᑦ ᖃᖓᑕᓲᒃᑯᑦ ᐊᑐᖅᑕᐅᓚᐅᖅᑐᑦ: ᑕᑯᓪᓗᒋᑦ ᖃᐅᔨᓴᐃᓂᖅ ᑕᕆᐅᕐᒥᐅᑕᓂᒃ ᑲᑎᑕᐅᓪᓗᑎᒃ ᑎᑯᓕᐊᖅᑕᐅᓯᒪᔪᓂᑦ ᑲᑎᓐᓂᐅᔪᓂᑦ ᐊᑐᖅᓱᑎᒃ ᒪᕿᐃᖕᒋᔪᒥᒃ ᑕᕆᐅᕐᒥᐅᑕᓂᒃ ᓂᕐᔪᑎᓂᒃ ᖃᐅᔨᓴᐃᔨᖅᑲᖅᓱᓂ (MMOs) ᖃᐅᔨᓴᐃᔨᖅᑲᖅᓱᓂ ᓵᖕᒋᓂᑦ ᐊᒻᒪᓗ ᐃᖅᑯᐊᓂᑦ ᖃᖓᑕᓲᒃ, ᐊᒻᒪᓗ ᐊᔾᔨᓕᐅᕈᑎᒃᑯᑦ ᖃᐅᔨᓴᐃᔾᔪᑎ ᐃᓕᔭᐅᓪᓗᑎᒃ ᑎᖕᒥᓲᖅᒧᑦ ᑎᖕᒥᓲᒃ ᐊᑖᓃᓪᓗᓂ ᐊᔾᔨᓕᐅᕆᓂᐊᖅᑐᒥᒃ. ᐊᔾᔨᒃᑯᑦ ᖃᐅᔨᓴᐃᓃᑦ ᖃᖓᑕᓲᒃᑯᑦ ᑑᒑᓕᒃᑕᖃᐅᖅᑐᓂᑐᐃᓇᐅᓚᐅᖅᑐᖅ ᑕᑯᓗᒋᑦ ᓈᓴᐃᓂᖅ ᓇᓚᐅᑦᑎᔪᓂᒃ ᐊᔪᕐᓇᖅᑐᓂᑦ. ᑕᕆᐅᕐᑕᐃᑦ ᑕᑯᔭᐅᔪᑦ, ᓯᓚᐅᑉ ᖃᓄᐃᓐᓂᕆᓪᓗ ᐊᒻᒪᓗ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᓈᓴᐅᑏᑦ/ᑎᑎᖅᑲᐃᑦ ᐃᓕᔭᐅᖃᑦᑕᓚᐅᖅᑐᑦ Mysticetus© ᖃᕆᑕᐅᔭᒧᑦ.

ᑕᑯᔭᐅᓪᓗᑎᒃ ᖃᐅᔨᓴᐃᓂᖃᖅᑎᓪᓗᒋᑦ, ᑲᑎᖦᖢᒋᑦ 1,871-ᓂᒃ ᑕᑯᓚᐅᖅᑐᑦ 4,961-ᖑᔪᓂᑦ ᐊᑕᐅᓯᐅᓪᓗᑎᒃ ᑕᕆᐅᕐᑕᐃᑦ ᑎᑎᕋᐅᓯᐅᓚᐅᖅᑐᑦ ᖃᐅᔨᓴᐃᔨᓄᑦ ᓴᒡᒐᕈᑦ ᐊᒻᒪᓗ ᐊᑯᓪᓕᕈᕐᕕᒃ 2019-ᒥᑦ. ᑲᑎᖦᖢᒋᑦ 8 ᐊᔾᔨᒌᙱᑦᑐᑦ ᑕᕆᐅᕐᑕᐃᑦ ᑕᑯᔭᐅᓚᐅᖅᑐᑦ ᖃᐅᔨᓴᐃᑎᓪᓗᒋᑦ: ᑑᒑᓕᑦ (*Monodon Monoceros*, 1,356 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 3,230 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ), ᐊᕐᕚᑦ (*Balaena mysticetus*, 205 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 299 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ), ᓇᑦᑏᑦ (*Pusa hispida*, 79 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 121 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ), ᖃᐃᕈᓖᑦ (*Pagophilus groenlandicus*, 73 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 1,002 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ), ᐋᕐᓗᐃᑦ (*Orcinus orca*, 9 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 44 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ), ᓇᓄᐃᑦ (*Ursus maritimus*, 17 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 29 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ), ᐅᒡᔪᐃᑦ (*Erignathus barbatus*, ᓯᑕᒪᐃᑦ ᑕᑯᔭᐅᔪᑦ ᐊᑕᐅᓯᐅᓪᓗᒋᑦ), ᐊᒻᒪᓗ ᕿᓇᓗᒐᐃᑦ (*Delphinapterus leucas*, ᓯᑕᒪᐃᑦ ᑕᑯᔭᐅᔪᑦ ᐊᑕᐅᓯᐅᓪᓗᒋᑦ). ᐃᓕᑕᕆᔭᐅᓯᒪᙱᑦᑐᑦ ᓇᑦᑏᑦ (110 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 204 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ) ᐊᒥᓗ ᕿᓇᓗᒐᐃᑦ (14 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 24 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ) ᑎᑎᕋᐅᓯᐅᓚᐅᕐᒥᔪᑦ ᖃᐅᔨᓴᐃᓂᕐᓂᑦ.

ᐊᔾᔨᓕᐅᕆᓂᒃᑯᑦ ᖃᐅᔨᓴᐃᓂᖃᖅᑎᓪᓗᒋᑦ, ᑲᑎᖦᖢᒋᑦ 14,580-ᓂᒃ ᑕᑯᓚᐅᖅᑐᑦ 27,795-ᖑᔪᓂᑦ ᐊᑕᐅᓯᐅᓪᓗᑎᒃ ᑕᕆᐅᕐᑕᓂᒃ ᑎᑎᕋᐅᓯᐅᔪᓂᑦ 2019 ᑕᕆᐅᕐᑕᓂᒃ ᓂᕐᔪᑎᓂᒃ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᐊᔾᔨᓂᒃ ᕿᒥᕐᕈᕐᒥᑦ. ᑲᑎᖦᖢᒋᑦ ᐱᖓᓱᑦ ᐊᔾᔨᒌᙱᑦᑐᑦ ᑕᕆᐅᕐᑕᐃᑦ ᑎᑎᕋᐅᓯᐅᓚᐅᖅᑐᑦ ᐊᔾᔨᒃᑯᑦ ᖃᐅᔨᓴᐃᓂᖃᖅᑎᓪᓗᒋᑦ: ᑑᒑᓕᑦ (13,144 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 23,136 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ), ᐊᕐᕚᑦ (7 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 9 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ), ᐊᒻᒪᓗ ᓇᓄᐃᑦ (ᐊᑕᐅᓯᖅ ᑕᑯᔭᐅᔪᖅ). ᐃᓕᑕᕆᔭᐅᙱᑦᑐᑦ ᓇᑦᑏᑦ (1,482 ᑕᑯᔭᐅᔪᑦ ᑲᑎᖦᖢᒋᑦ 4,649 ᐊᑕᐅᓯᐅᓪᓗᒋᑦ) ᑎᑎᕋᐅᓯᐅᓚᐅᕐᒥᔪᑦ ᖃᐅᔨᓴᐃᓂᖃᖅᑎᓪᓗᒋᑦ.

ᑑᒑᓕᑦ ᑲᑎᓯᒪᓗᐊᓚᐅᖅᑐᖅ ᑕᓯᐅᔭᕐᒥᑦ ᐊᒻᒪᓗ ᕿᙲᐊᓂᑦ ᐃᖏᕐᕋᓂᖅ 1-ᒥᑦ, ᖃᑉᓯᐅᓂᖏᑦ 5,793-ᖑᐸᓗᑎᒃ (CV=0.23) ᓯᕗᓂᐊᒍᑦ ᐹᕕᓐᓛᓐᑯᑦ ᐅᒥᐊᕐᔪᐊᖏᑦ ᖃᓂᑦᑐᒥᑦ ᖃᐅᔨᓴᐃᕝᕕᐅᔪᒧᐊᖅᑳᖅᑎᓐᓇᒋᑦ 15,591-ᒧᑦ (CV=0.19) ᑭᖑᓂᐊᒍᑦ ᐹᕕᓐᓛᓐᑯᑦ ᐅᒥᐊᕐᔪᐊᖏᑦ ᖃᓂᑦᑐᒥᑦ ᖃᐅᔨᓴᐃᕝᕕᐅᔪᒧᐊᖅᑎᓪᓗᒋᑦ.

ᑑᒑᓕᑦ ᐱᑕᖃᐅᕐᓂᖏᓐᓄᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᓄᑦ ᓈᓴᐅᑏᑦ ᐃᖏᕐᕋᓂᖅ 2-ᒥᑦ, ᑲᑎᖦᖢᒋᑦ ᑕᓯᐅᔭᕐᒥᑦ ᐊᒻᒪᓗ Admiralty Inlet-ᒥᑦ 38,771 ᑑᒑᓕᑦ (ᓈᓴᐅᓯᕆᔭᐅᖅᑳᖅᑎᓇᒋᑦ ᐊᔾᔨᒌᖃᑦᑕᙱᓐᓂᖅ) (CV) =0.12, 95% ᓇᓗᓇᙱᑦᑐᑦ ᖃᖓᒃᑰᖃᑦᑕᕐᓂᖏᓐᓂᒃ 30,667-49,016)-ᓂᒃ ᖃᐅᔨᓴᐃᓂᕐᓄᑦ ᐊᑯᓪᓕᕈᕐᕕᒃ 21-ᒥᑦ 22-ᒧᑦ ᐊᒻᒪᓗ 25-ᒥᑦ 27-ᒧᑦ 2019 ᓈᓴᐅᓯᕆᔭᐅᔪᒧᐊᓚᐅᖅᑐᑦ ᖃᐅᔨᓴᐃᓂᖃᓚᐅᖅᑎᓪᓗᒋᑦ ᑲᓇᑕᒥᑦ

ᐃᖃᓗᓕᕆᔨᒃᑯᑦ ᐊᑯᓪᓕᑉᕝᕕᒃ 2013-ᒥᑦ (45,532 ᑐᒆᓖᑦ, CV=0.33, 95%-ᖑᔪᑦ CI 22,440-92,384-ᓂᑦ; Doniol-Valcroze et al. 2015). ᑕᓯᐅᔭᖅᒧᑦ ᑭᓯᒥ, ᑐᒆᓖᑦ ᐱᑕᖃᐅᕐᓂᖏᓐᓄᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ 9,931 ᑐᒆᓖᑦ (CV=0.05, 95% CI 9,009-10,946) ᖃᐅᔨᓴᐃᓂᕐᒥᑦ ᐊᑯᓪᓕᑉᕝᕕᒃ 21-ᒥᑦ 22-ᒧᑦ ᐊᒻᒪᓗ 25-ᒥᑦ 27-ᒧᑦ 2019 ᓈᓴᐅᓯᕆᓂᕐᒧᐊᓚᐅᖅᑐᑦ ᖃᐅᔨᓴᐃᓂᖃᓚᐅᖅᑎᓪᓗᒋᑦ ᑲᓇᑕᒥᑦ ᐃᖃᓗᓕᕆᔨᒃᑯᑦ ᐊᑯᓪᓕᑉᕝᕕᒃ 2016-ᒥᑦ 12,093-ᖑᐸᓗᑎᒃ ᑐᒆᓖᑦ (CV=0.23, 95%-ᖑᐸᓗᑎᒃ CI 7,768-18,660-ᖑᔪᓂᑦ; Marcoux et al. 2019) ᐊᒻᒪᓗ ᐊᑯᓪᓕᑉᕝᕕᒃ 2013-ᒥᑦ 10,489 ᑐᒆᓖᑦ (CV = 0.24, 95%-ᓂᒃ CI 6,342-17,347-ᖑᔪᓂᑦ; Doniol-Valcroze et al. 2015). ᑕᒪᓐᓇ ᖃᐅᔨᔭᐅᔪᖅ ᐊᔾᔨᒋᔭᖓ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᓂᒃ ᐊᕙᑎᒥᒃ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᑎᑎᖅᑲᒧᑦ ᐃᓚᒋᔭᐅᔪᒥᑦ ᑮᓇᐅᔭᓕᐅᖅᐸᓪᓕᐊᓕᕌᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᖅ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᕐᔪᐊᔾᔮᖏᓐᓂᖓᓄᑦ ᕿᒪᒃᑎᑐᓂᑦ ᐱᔪᓂᒃ ᑐᒆᓕᖕᓄᑦ ᖃᓄᑦᑎᒥᑦ ᖃᐅᔨᓴᐃᕝᕕᐅᔪᒥᑦ (ᑐᑭᓕᐅᖅᓯᒪᔪᖅ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐊᒃᑐᖅᓯᓇᔭᕐᓂᖏᑦ ᖃᐸᐅᑎᒋᓂᓚᔭᖏᓐᓂᒃ ᑐᖁᑦᓂᒃᑯᓪᓘᓐᓂᑦ ᐅᕝᕙᓘᓐᓂᑦ ᐊᒥᓱᐃᑦ ᐊᓯᐊᓄᐊᕐᓂᖏᓐᓄᑦ ᕿᒪᐃᓗᑎᒡᓘᓐᓂᑦ ᖃᓂᑦᑐᒥᑦ ᖃᐅᔨᓴᐃᕝᕕᐅᔪᒥᑦ).

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Abbreviation and Acronym list

AIC	Akaike's Information Criterion
AIN	Admiralty Inlet North stratum
AIS	Admiralty Inlet South stratum
Baffinland	Baffinland Iron Mines Corporation
BB	Baffin Bay stratum
C_a	Availability correction factor
CI	Confidence Interval
CV	Coefficient of Variation
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
km	Kilometres
km^2	square kilometres
km/h	Kilometers per hour
kn	knots
m	Metre
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 Plan
Mtpa	million tonnes per annum

MMOs	Marine Mammal Observers
MSV	Multipurpose support/supply vessel
NB	Navy Board Inlet stratum
n/a	not applicable
NIRB	Nunavut Impact Review Board
PI	Pond Inlet stratum
Project	Mary River Project
PC	Project Certificate No. 005
RSA	Regional Study Area
Steenbsy Port	port at Steensby Inlet
TS	Tremblay Sound stratum

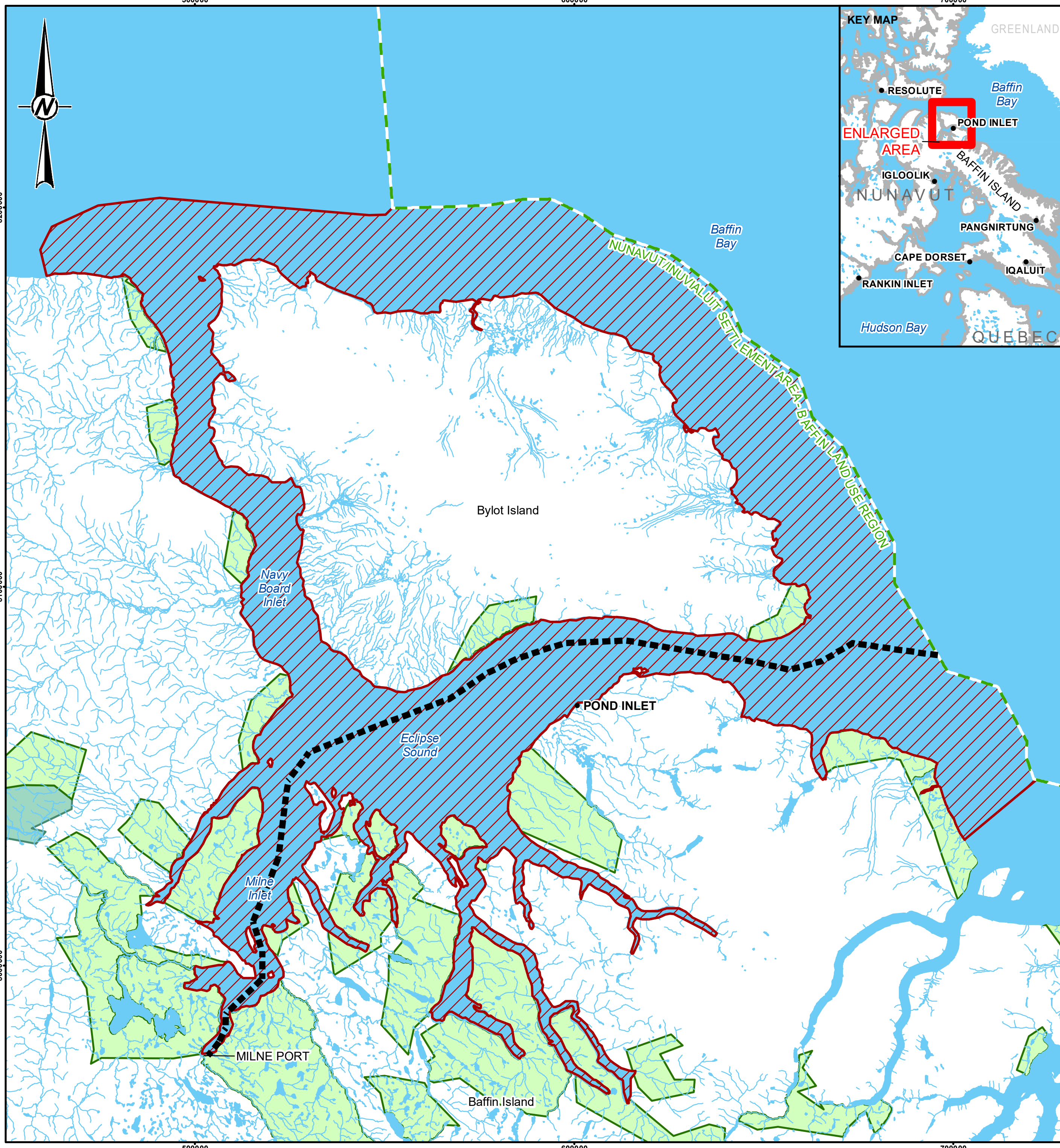
1.0 INTRODUCTION

This report presents the results of the 2019 Marine Mammal Aerial Survey Program (MMASP) conducted off North Baffin Island during July and August 2019. Marine mammal aerial surveys were conducted by Golder Associates Ltd. (Golder) in collaboration with Inuit researchers from Pond Inlet and Arctic Bay using distance-based line-transect sampling combined with high-resolution photography. The objectives of the surveys were to determine the relative abundance and distribution of narwhal near the Pond Inlet floe edge prior to and during initial shipping and icebreaking operations, and to obtain abundance estimates of narwhal (*Monodon monoceros*) during the open-water season for the Eclipse Sound and Admiralty Inlet summer stock areas.

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 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. Future, but yet 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 for 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. 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 Mtpa of ore was shipped via 71 return voyages in 2018 and 5.86 Mtpa of ore was shipped via 81 return voyages in 2019. The marine transportation of the ore takes place in waters inhabited by a variety of marine mammals, predominantly narwhal, ringed seal, harp seal, bowhead whale, polar bear, bearded seal, beluga, and walrus.



LEGEND

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

0 25 50

1:1,500,000 KILOMETRES

REFERENCE(S)

ABORIGINAL LANDS, HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. NUNAVUT SETTLEMENT AREA DATA OBTAINED FROM NUNAVUT TUNNGAVIK INC., OCTOBER 9, 2012.

PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
MARINE MAMMAL REGIONAL STUDY AREA

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

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1.2 Regulatory Drivers and Community Engagement

In accordance with existing Terms and Conditions of NIRB Project Certificate (PC) No. 005, Baffinland is responsible for the establishment and implementation of the Marine Monitoring Program (MMP) which comprises environmental effects monitoring studies that are conducted over a sufficient time period such 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 Marine Mammal Aerial Survey Program (MMASP) is one of several monitoring programs that collectively make up the Marine Monitoring Program (MMP) for marine mammals. The aerial survey study 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. 99 — "*The Proponent, working with the MEWG, shall consider and identify priorities for conducting the following supplemental baseline assessments:*
  - *b. The collection of additional baseline data:*
    - *ii. In Milne Inlet on narwhal, bowhead and anadromous Arctic Char abundance, distribution ecology and habitat use."*
- 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:

- Loss or alteration of narwhal 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). 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 narwhals are recognized by DFO as the Jones Sound the Smith Sound stocks (DFO 2015a). Their relationship 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 approximately 20,000 individuals in 2004 (NAAMCO 2010), approximately 10,489 in 2013 (DFO 2015a), and 12,039 in 2016 (Marcoux et al. 2019). Low numbers of narwhal observed in 2013 in the Eclipse Sound stock 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 narwhals between Eclipse Sound and Admiralty Inlet also raised the possibility of some degree of exchange between the two summering areas (Doniol-Valcroze et al. 2015). 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. 2015).

Available information on narwhals distribution (COSEWIC 2004a; DFO 2015a; Elliott et al. 2015; Golder 2018b, Heide-Jørgensen et al. 2002; Laidre et al. 2004; Marcoux et al. 2009; Richard et al. 1994; Richard et al. 2010; Thomas et al. 2015, 2016; Watt et al. 2012) indicated that the RSA is regularly used during summer and fall, although the distribution of narwhals varies throughout the season. In spring and early summer, narwhals 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.

Marine mammal aerial surveys in support of the Project were first conducted 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 in an effort 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 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 2018c). 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).

Bowhead whale

Bowhead whale aerial survey abundance estimates for the Eastern Canada-West Greenland (EC-WG) population in 2002–2004 and 2013 indicate 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 five consecutive years of shore-based monitoring conducted for Baffinland from 2013 to 2017, a total of 14 bowhead were recorded near Bruce Head (Thomas et al. 2014; Smith et al. 2015; 2016; 2017; Golder 2018a). 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 (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. 2015b).

Killer whale

Killer whale sightings in the Canadian Arctic have been reported throughout the year with the majority (87%) occurring during summer (Higdon 2007). 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 whale 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 whale 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).

In 2009, Argos tracking tags were simultaneously deployed on killer whales and narwhal in Admiralty Inlet to understand how predation risk from killer whales affects narwhal behaviour (Breed et al. 2017). Results from the study showed that the presence of killer whales strongly altered the behaviour and distribution of narwhal. Killer whale presence strongly altered apparent habitat preferences whereby narwhal moved closer to shore when killer whales were present. Dive behaviour was affected by causing narwhal to perform deeper dives and shorten their dives. Behavioural changes in narwhal extended beyond 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 belugas 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.

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 bear 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 bear also frequent fast-ice edges in this area (APP 1982). Polar bear 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).

Ringed seal

Population structures of ringed seal across the Canadian Arctic are poorly understood in general. No investigations of population structure specific to Baffin Bay have been done. Aerial surveys of ringed seals in the RSA have been undertaken during the molting period (spring) when ringed seals are largely on the sea ice and easy to count (Yurkowski et al. 2018). 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.

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).

Bearded seal

The distribution of bearded seals 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 seals generally move into inlets and bays <200 m deep in order 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).

1.4 Study Objectives

The 2019 MMASP was staged in two separate survey legs. Leg 1 targeted a 15-day window in mid-July, during the staging period when narwhal and other marine mammals await ice break-out prior to their entry into Eclipse Sound and Milne Inlet. The objective of the Leg 1 surveys was to determine the relative abundance and distribution of narwhal near the Pond Inlet floe edge prior to and during initial shipping and icebreaking operations.

Leg 2 targeted a 15-day window during mid-August corresponding with the peak open-water period. The objective of Leg 2 surveys was to obtain an updated (2019) 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) (Figure 1). 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) was adopted to allow for a comparison to previously reported abundance estimates.

2.0 METHODOLOGY

2.1 Study Team and Training

The 2019 aerial surveys took place over two 14-day periods: Leg 1 (12–26 July 2019) and Leg 2 (17–30 August). The study team consisted of two Golder and five contracted marine biologists with previous marine mammal survey experience, and four Inuit researchers trained as Marine Mammal Observers (MMOs). Each survey team (i.e., aircraft) included one survey coordinator, two marine biologist MMOs and two Inuit MMOs.

Prior to mobilization, a two-day data collection and safety training workshop was held in Pond Inlet during 10–11 July 2019. The training and orientation session was led by a senior marine mammal biologist with Golder. The safety component of the workshop aimed to familiarize all Inuit researchers with the Health and Safety Plans that were 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.

2.2 Study Area and Design

Survey design was informed by MEWG members during the June 2019 meetings. Follow up with DFO resulted in modifications made to transect spacing and grid orientation in the Admiralty Inlet South stratum, and increasing the number of transects in Tremblay Sound, from one visual to four photographic. Admiralty Inlet was originally divided into three strata; this was changed to two strata based on recommendations from DFO and QIA. Baffinland also agreed to fly reconnaissance flights in Eskimo Inlet and White Bay if survey time allowed. At the recommendation of QIA, Tay Sound, Paquet Bay, and Oliver Sound were added to the fjord reconnaissance flights, along with the northern fjords in Admiralty Inlet.

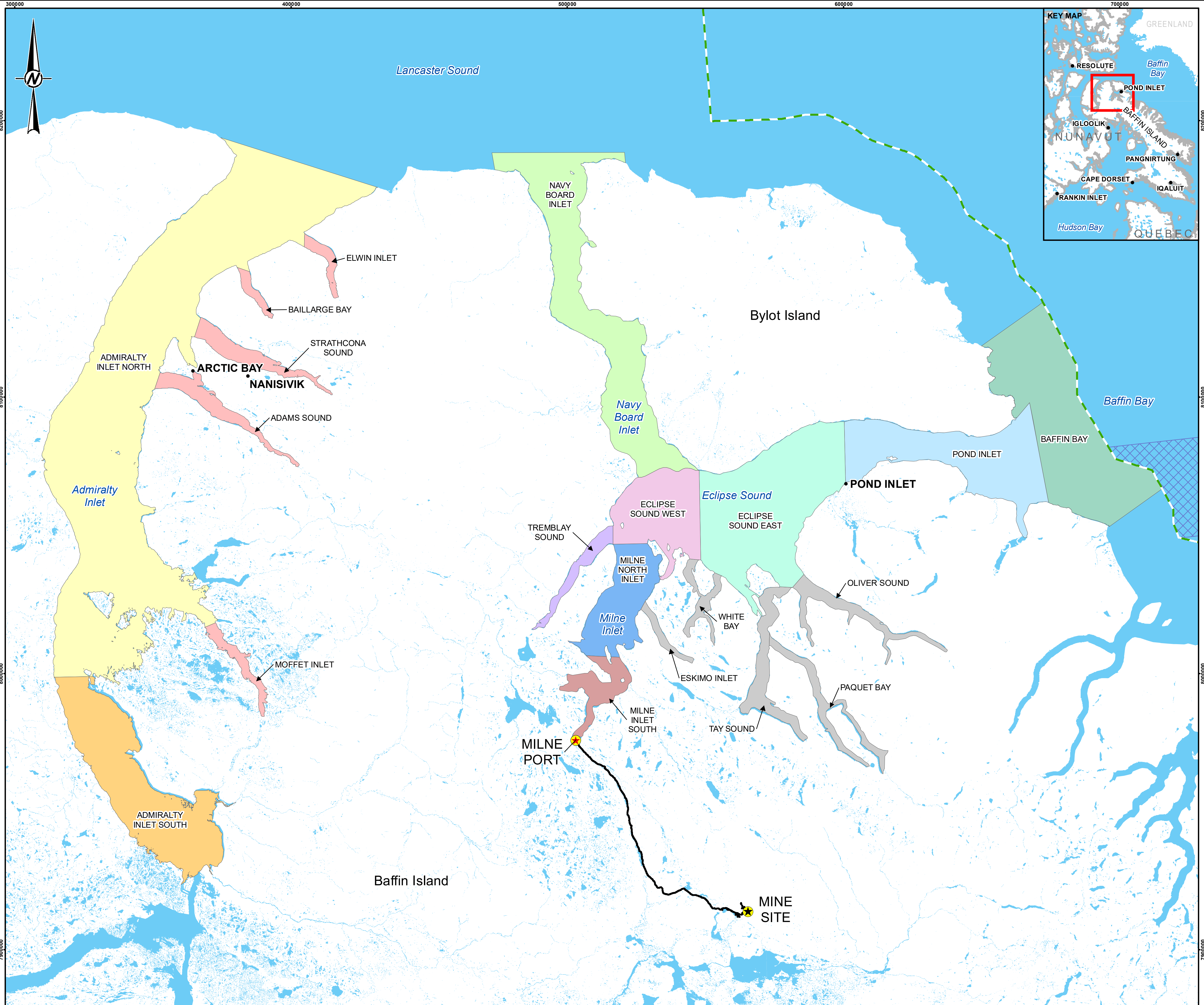
The study area for the Leg 1 surveys was based on the boundaries used in previous surveys from 2013–2016 (DFO 2017; Golder 2017), with the exception of adding an additional stratum in Baffin Bay (Figure 2). Leg 1 was designed to focus on the open-water area around the floe edge (Pond Inlet and Baffin Bay strata) where narwhal are known to stage prior to entering Eclipse Sound (blue transect lines in Figure 3). Reconnaissance flights were also flown periodically in Tremblay Sound and Milne Inlet to verify narwhal presence/absence in these areas. When narwhal were observed in Tremblay Sound or Milne Inlet, the entire survey grid was flown, including all strata (effort switched from blue transect lines to red transect lines identified in Figure 3).

Systematic random visual line-transect surveys were flown for all strata 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 ~4 km transect line spacing, was used for Milne Inlet North transects (see Figure 3).

Leg 2 surveyed Eclipse Sound and Admiralty Inlet 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 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 4). 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 past surveys (Doniol-Valcroze et al. 2015; Elliott et al. 2015; Marcoux et al. 2019; Thomas et al. 2015; 2016) had high concentrations of narwhals 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). Reconnaissance flights in Eclipse Fjords were flown when time and weather permitted.

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 4). Reconnaissance flights in the fjords were flown when time and weather permitted.

The survey design consisted of systematically placed and evenly distributed (when possible) line transects across the survey area (Figure 3 and Figure 4). Transects were generally straight and uniformly spaced across large waterbodies but were occasional skewed to follow the shoreline contour. This was necessary in areas where the survey aircraft could not safely perform the turns necessary to cross waterbodies perpendicular to shorelines.



LEGEND

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

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

0 25 50
1:1,400,000 KILOMETRES

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
GEOGRAPHIC STRATA FOR 2019 MARINE MAMMAL AERIAL SURVEYS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	KK
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000-07	0	2

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25mm
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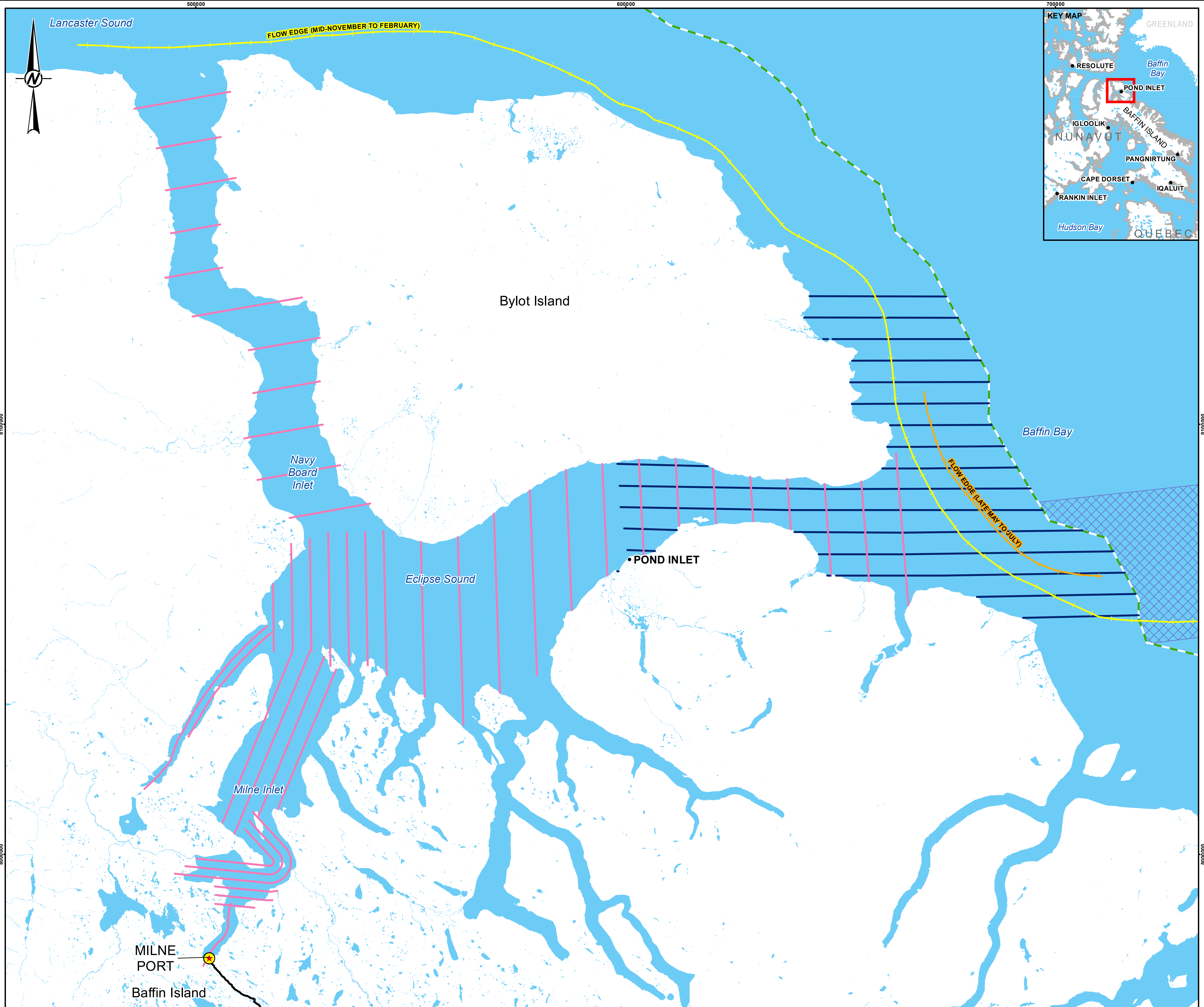


LEGEND

- 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

TITLE
TRANSECT LINES FOR ECLIPSE SOUND GRID DURING LEG 1

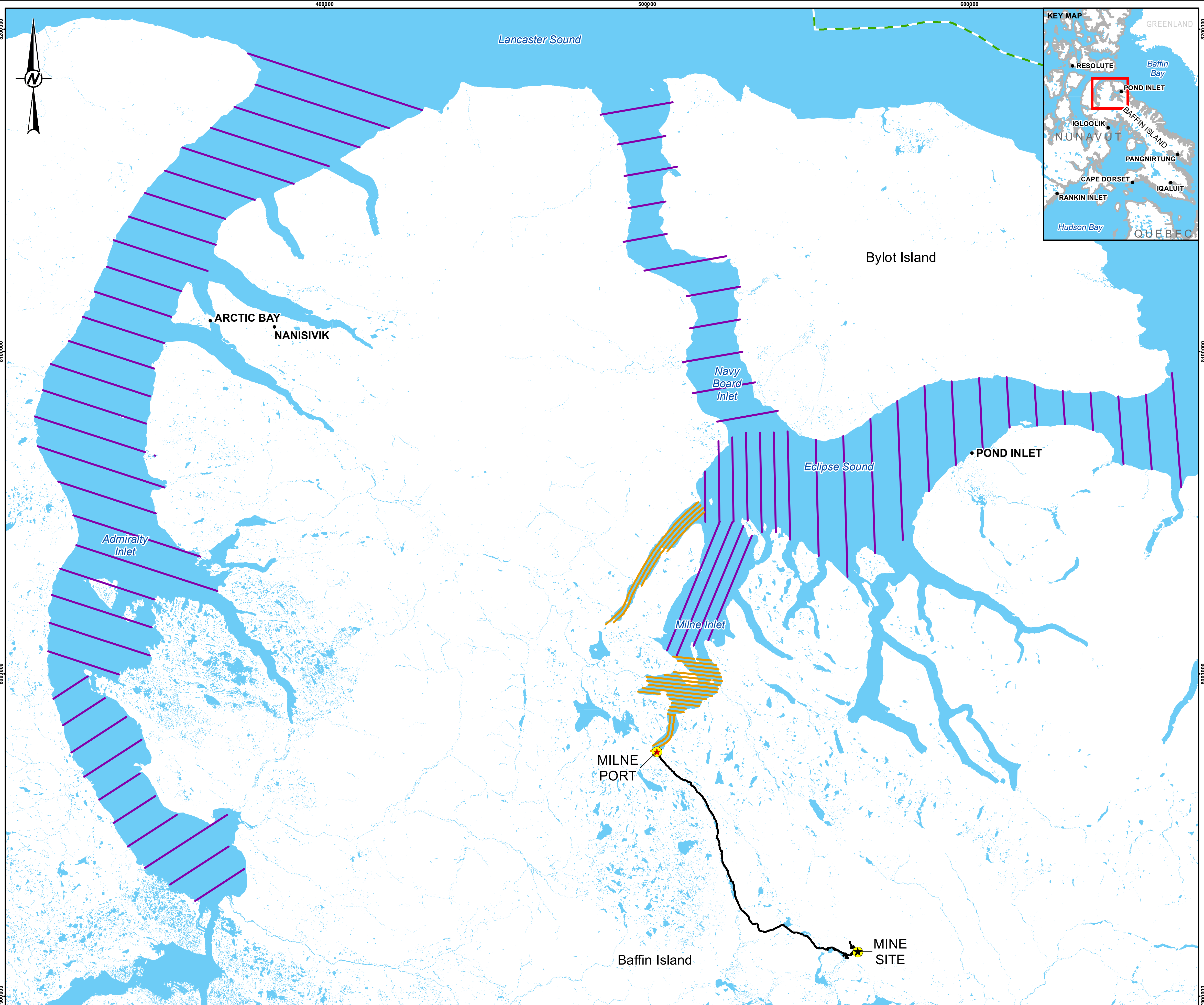
CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000-07	0	3

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



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

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

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000-07	0	4

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

During visual line-transect surveys, if large aggregations (e.g., >50 narwhals or when observers indicated that they could not accurately keep up with narwhal counts) were identified, 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 narwhals 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 4 (yellow transect lines) for the Milne inlet South and Tremblay Sound strata.

For navigation during the survey to follow the survey track lines and also 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.

2.3 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 MMOs. MMOs consisted of two experienced observers and two trained Inuit researchers 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 to the observer. MMOs noted the species and number of individuals 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 narwhals, 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 setting up the camera system, overseeing navigation along the survey grid, and entering sighting data obtained from the primary observers into the database.

The two experienced MMOs were designated as 'Primary' observers and the two trained Inuit researchers were designated as 'Secondary' observers. Primary observers, in addition to counting animals, 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 forward 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 2.4. Photographs taken during the visual surveys were used to supplement visual sightings for missed clinometer angles and group sizes.

Sighting data from Primary observers was entered into the Mysticetus program by the fifth member of the crew during the survey. 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. Declination angles of abeam sightings were collected using a geometer (connected to a laptop) and entered into the database at the end of each flight. Sightings where angles of declinations were not recorded, or were coded as ‘uncertain’, 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 told apart 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. 2015). 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 Photographic Survey

The aircraft was equipped with two identical camera systems. The systems used Canon EOS 5DS R DSLR cameras fitted with 35 mm lens (Sigma 35 mm f/1.4 DG HSM). 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 airport altitude at the start of every flight.

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 5), calculated using (Covington 1985):

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

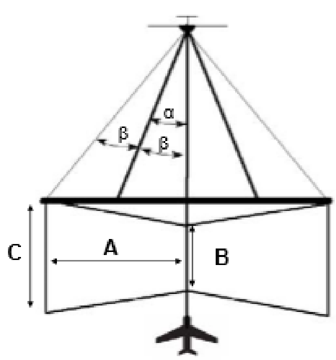


Figure 5: Geometry of oblique aerial photos (modified from Grendzdörffer et al. 2008).

Photographic surveys were conducted at an altitude of 305 m and 610 m (1,000 ft and 2,000 ft) and a ground speed of 185 km/h (100 km). Altitude of 305 m (1,000 ft) was only flown if conditions did not allow the higher altitude (610 m or 2,000 ft). Using the methods described in Grendzdörffer et al. (2008), the photograph dimensions of the two-camera system (Figure 5) and the necessary photographic interval were calculated to allow overlap of the photos while flying at 100 knots (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 600 m and 1200 m, the lateral overlap between photos from adjacent transects was approximately 30%.

Table 1: 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 6). 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.

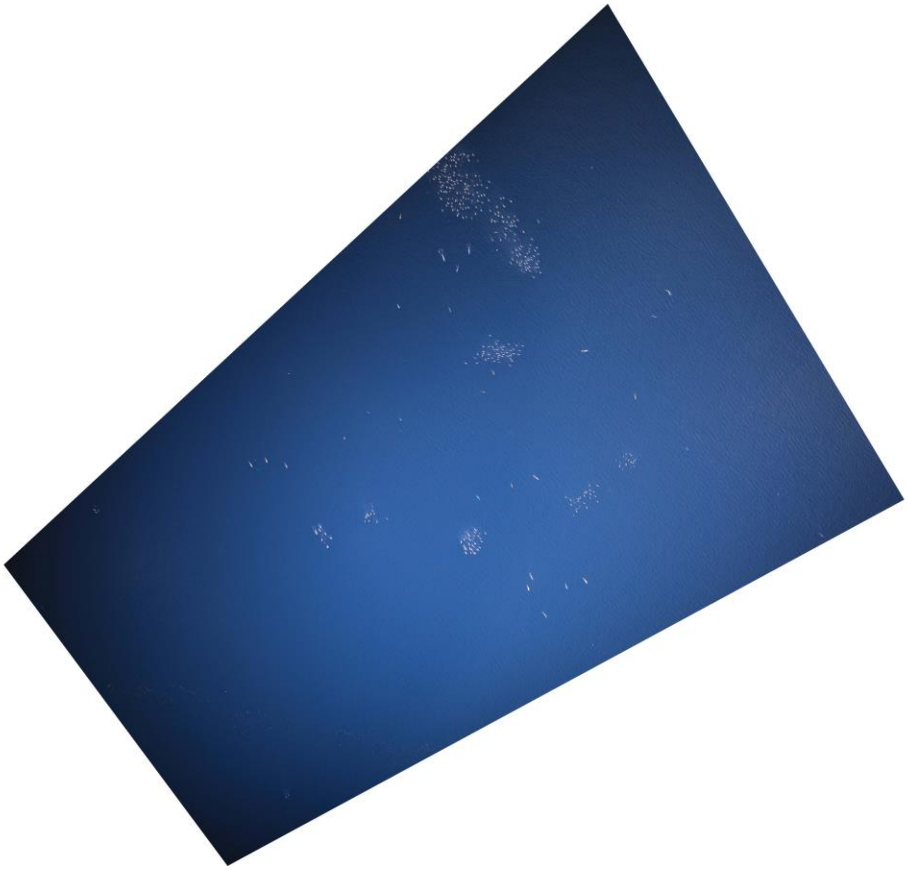


Figure 6: Orthophotograph of an image taken at 305 m (1,000 ft) in Admiralty Inlet on 26 August 2019.

2.5 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 and/or narwhal aggregations was used (Asselin and Richard 2011; Marcoux et al. 2016; Matthews et al. 2017).

2.5.1 Visual Survey

2.5.1.1 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, any observed change 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:

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

Where n is the number of observed objects (single or clusters of animals), f (0) is the estimated probability density function at zero distance, $\hat{\mathrm{E}}(s)$ 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 assumed that all animals on the transect line were detected with certainty (g (0) =1). In reality, this was 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 narwhals near Arctic Bay and Pond Inlet were used to apply a correction factor for availability bias in photographic data (Watt et al. 2015a; Table 2), as was used in the previous DFO narwhal abundance estimates (Doniol-Valcroze et al. 2015; 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. 2015a). As correction factors for July were not available, Leg 1 surveys applied mid-August correction factors. For narwhal visual surveys, correction factors (C_{α}) from Watt et al. (2015a) tagging data were used with an additional correction for time in view and animal dive cycle applied from Doniol-Valcroze et al. (2015) measurements (Table 2).

Time-series dive data collected from tagged bowhead whales in Foxe Basin and Cumberland Sound were used to apply a correction factor for availability bias in photographic and visual surveys (Watt et al. 2015b; Table 2). Bowhead data for correction of time in view and animal dive cycle was not available to be applied to the visual data.

Table 2: Availability bias correction factors

Species	Survey Type/Date	Correction Factor	CV	Source
Narwhal	Photo / Mid-Aug	3.18	0.03	Watt et al. 2015a
	Photo / Late Aug	3.16	0.03	Watt et al. 2015a
	Visual / Mid-Aug	2.94	0.03	Watt et al. 2015a; Doniol-Valcroze et al. 2015
	Visual / Late Aug	2.92	0.03	Watt et al. 2015a; Doniol-Valcroze et al. 2015
Bowhead Whale	Early Aug	4.12	0.21	Watt et al. 2015b
	Mid-Aug	3.98	0.21	Watt et al. 2015b

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

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

2.5.1.2 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 narwhals 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. 2015), 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 perpendicular declination angle as measured by the primary observer
- Used the group size as measured by the primary observer
- 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.

2.5.2 Photographic Survey

2.5.2.1 Narwhal

For the post season photographic analysis, an experienced analyst with eight years of aerial survey photographic analysis trained two biologists in the process and identification of images with narwhals using ArcGis. One of the trainees had previous experience with beluga and narwhal aerial survey photographs from work done through the Centre for Earth Observation Science, University of Manitoba, with DFO aerial survey photographs. Both trained readers worked together in the same room to allow collaboration and consistency in image analysis. A third reader was later brought on. The third reader was experienced in analysing aerial photos from previous DFO monodontid surveys.

A randomly selected photo survey was re-analyzed by the photo trainer to evaluate reliability and repeatability. A simple linear regression was run on the comparison of the photo survey readings. A fourth reader (Inuit researcher) was also brought into train on the photographic review process. The Inuit researcher re-analyzed two surveys and that data was assessed for reliability and repeatability using a linear regression analysis. 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 2018c). 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 narwhals in the photographic survey area.

Aerial photos were viewed in ArcMap (Esri Inc.) and all narwhals within the top 2 m of the water column were counted. Photographs were examined for narwhals on a high resolution 50” 4K television. Photographs were orthorectified prior to being examined in ArcMap 10.1 (Esri). Once a first reading of all the photos from a survey was achieved, the photo trainer reviewed all narwhal sightings for consistency across the three photo readers. Sightings where narwhals were deemed below the 2 m threshold by the photo trainer were removed from the analysis. Water clarity was subjectively evaluated in each photo and classified as either murky (water in which narwhals could only be observed at the surface) or clear (water in which narwhals 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 narwhals 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 narwhals 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 narwhals were photographed more than once. To estimate the total number of narwhals 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 narwhals 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 narwhals 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 narwhals 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. 2015a and b.

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 narwhals in survey corrected for availability bias

The variance of the the surface abundance of narwhals (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 narhwal 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 coefficient of variation (CV) of the estimate from the photographic survey was calculated:

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

2.5.2.2 Bowhead Whale

Few bowhead whales were recorded in the photographic surveys (i.e., one to two sightings per survey) which allowed the ability to identify re-sightings and remove them from the analysis. To calculate bowhead whale abundance in photographic surveys, the number of bowhead whales detected near or at the surface in each survey (with re-sightings removed) was corrected for the instantaneous availability bias:

$$N_{Btot} = C_a * N_{Bsurface}$$

Where:

$N_{Bsurface}$ is the total number of bowheads (with re-sightings removed) detected near or at the surface in a photographic survey

N_{Btot} = number of bowheads in photographic survey if corrected for availability bias

2.5.3 Abundance Estimate

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 narwhals) (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 narwhals or N_{Btot} to bowhead whales

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

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

The coefficient of variation (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 Survey 3 (Visual and Photo) and Survey 4 (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):

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

3.0 RESULTS

Aerial surveys for narwhal were conducted in the North Baffin area during July and August 2019. The objectives of the surveys were to determine the relative abundance and distribution of narwhal near the Pond Inlet floe edge prior to and during initial shipping and icebreaking operations, and to obtain abundance estimates of narwhal (*Monodon monoceros*) during the open-water season for the Eclipse Sound and Admiralty Inlet summer stock areas. Early shoulder season surveys (Leg 1) were flown in the Eclipse Sound grid from 12–26 July. A total of five surveys were attempted in Leg 1. Open-water surveys (Leg 2) were flown in the Eclipse Sound grid and Admiralty Inlet grid from 17–30 August. A total of five surveys were attempted in each survey grid during Leg 2.

3.1 Leg 1: Early Shoulder Season Surveys in Eclipse Sound

3.1.1 Survey Coverage

By the time surveys began on 12 July 2019, the floe edge had broken up and most of the ice was situated west of Pond Inlet and into North Milne Inlet (Figure 8). Five surveys were flown over 15 days during Leg 1 (see Appendix B, Figures B-1 to B-5). Over the course of the five surveys, a total of 4,605.2 km of survey effort was conducted. This effort included both visual and photographic surveys (Table 3). Visual surveys totaled 3,810.9 km and photographic surveys totaled 794.3 km of total effort. The first Baffinland vessel to enter the RSA in 2019 was the MSV *Botnica*. The MSV *Botnica* was used to escort Project vessels on the evening of 17 July 2019.

Table 3: Summary of survey flights during Leg 1. Reconnaissance (R), visual (V), and photographic (P) surveys were flown over five surveys in nine strata

	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5
Survey Stratum	12-13 Jul	15-16 Jul	17 Jul	21-22 Jul	25-26 Jul
Pond Inlet (PI)	R	V&P	V&P	V&P	—
Eclipse Sound East (ESE)	R	V	V	V	V
Eclipse Sound West (ESW)	R	V	V	V	V
Milne Inlet (MIN)	R&V	V	—	V	V
Milne Inlet South (MIS)	P	V	—	V	V&P
Tremblay Sound (TB)	R&P	—	—	P	V
Navy Board Inlet (NBI)	—	V&P	—		V&P
Baffin Bay (BB)	—	—	—	V	—
Fjords	R	—	—	—	—
Visual Effort (km)	**389.1**	**930.3**	**391.1**	**1,395.5**	**704.9**
Photographic Effort (km)	**211.5**	**285.4**	**10.9**	**173.0**	**113.5**
Total Effort (km)	**600.6**	**1,215.7**	**402.0**	**1,568.5**	**818.4**

3.1.2 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. For calculating abundance estimates, distances analyses used the sighting conditions as covariates in the model.

Ice Cover

Ice cover ranged from <1/10 to 10/10 ice cover during Leg 1 of the 2019 MMASP (Figure 7). Ice conditions changed substantially from the first survey on 12 July to the last survey on the 26 July (Figure 8 and Figure 9). Effort during the first three surveys varied in ice concentrations of <1/10 to 10/10 (Figure 7). By survey 4 and 5 most of the effort was in <1/10 ice waters.

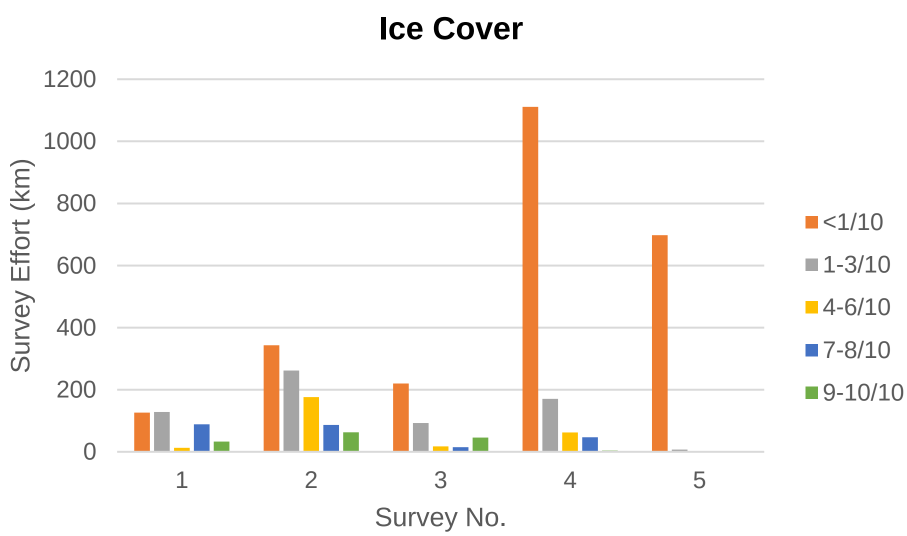


Figure 7: Ice Cover during Leg 1 of the 2019 MMASP

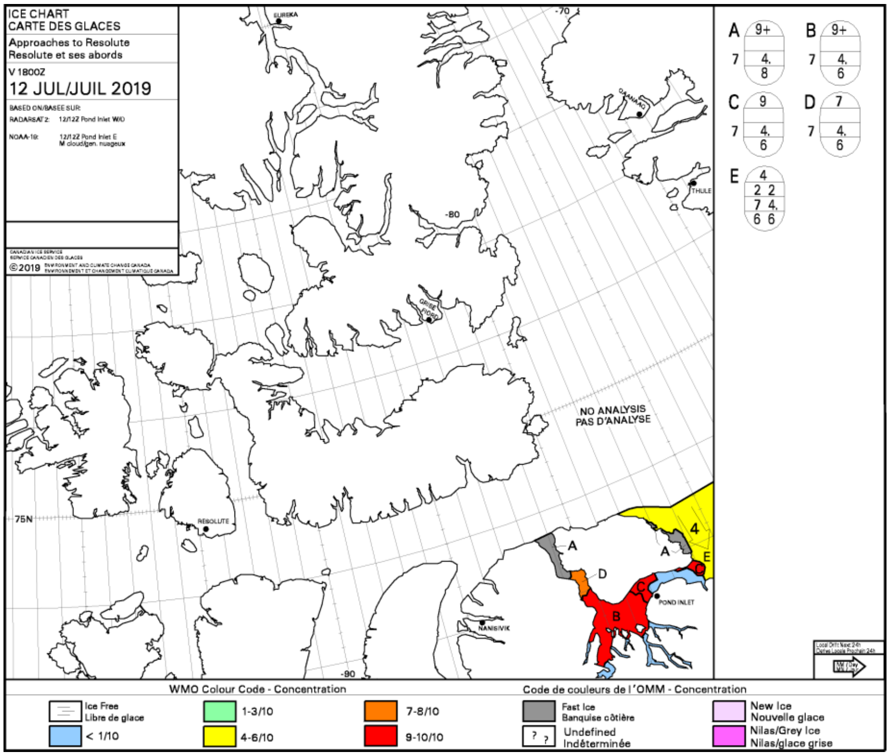


Figure 8: Canadian Ice Service chart for Leg 1 Survey No. 1 (12 July 2019) showing ice concentrations in Eclipse Sound area

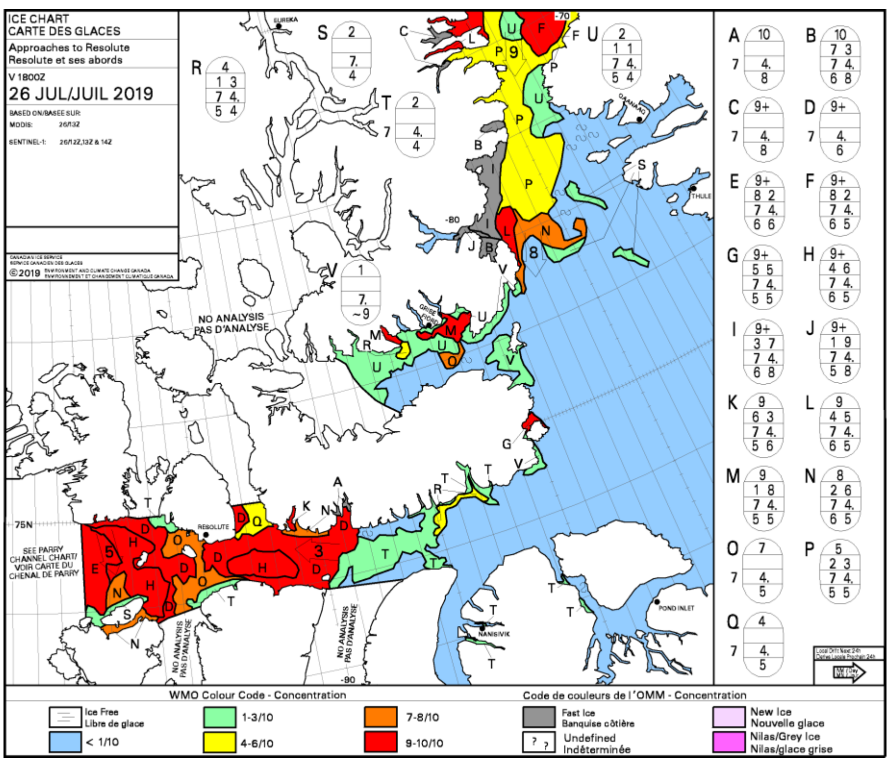


Figure 9: Canadian Ice Service chart for Leg 1 Survey 5 (26 July 2019) showing ice concentrations in Eclipse Sound area

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 10, ”Present” represent 1–100% of the viewing area was obscured with fog. Surveys 1 and 3 had the most fog present on a survey, but still encompassing less than half of the survey effort. Surveys 2, 4, and 5 had a fraction of the survey effort flown in fog.

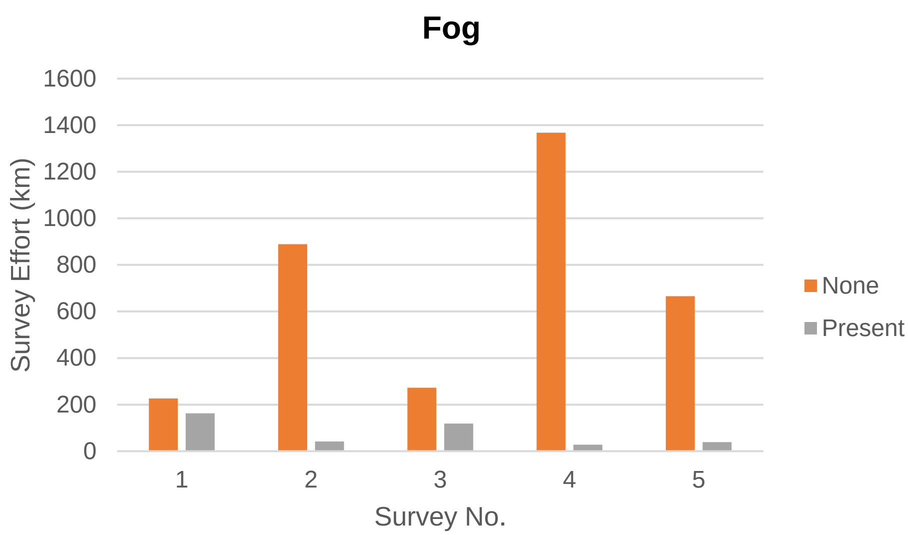


Figure 10: Fog Cover During the 2019 MMASP

Beaufort Sea State

On a scale of 0 to 12, Beaufort Sea State (BF) ranged from BF 0 (glassy mirror) to BF 6 (large waves) throughout the 2019 MMASP (Figure 11). Most sea state conditions were recorded between BF 0 (glassy mirror) and BF 3 (large wavelets, scattered whitecaps). Areas that were forecasted to have high sea states were avoided when daily surveys were planned. If sea state conditions exceeded a BF 4, the area was generally abandoned, and the survey was resumed in an area with better environmental conditions.

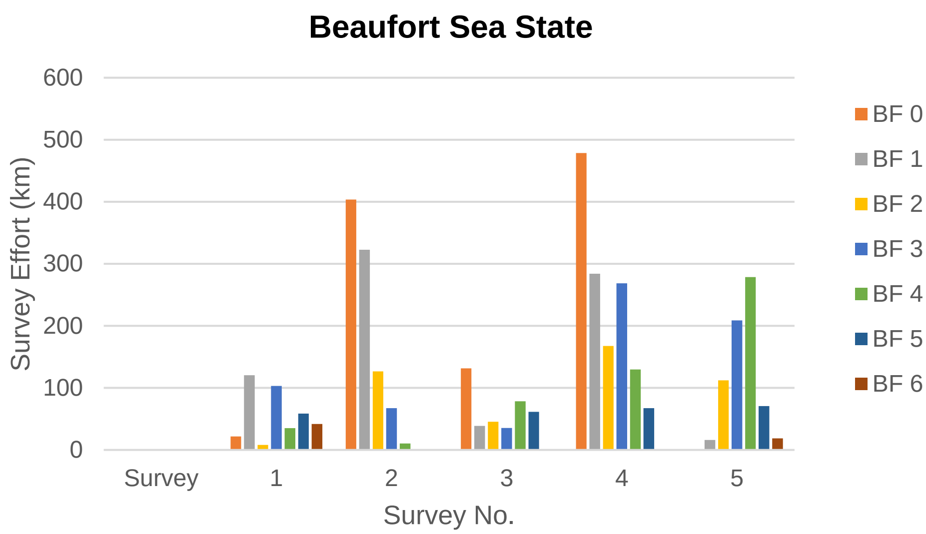


Figure 11: Beaufort Sea State During Leg 1 of the 2019 MMASP

Glare

Two measurements of glare were used as sighting conditions. Glare angle (0–90 degrees) was the angle 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). Survey 1 was flown during overcast conditions and therefore glare angle and intensity was recorded as ”None” for the duration of the survey (Figure 12 and Figure 13). Surveys 2 and 3 were flown during overcast and partial cloudy conditions with glare recorded as “None” for over half (71% and 57%, respectively) of the survey effort (Figure 12 and Figure 13). Surveys 4 and 5 were flown during sunny conditions with glare recorded as “None” for less than half (33% and 29%, respectively) of the survey effort (Figure 12 and Figure 13).

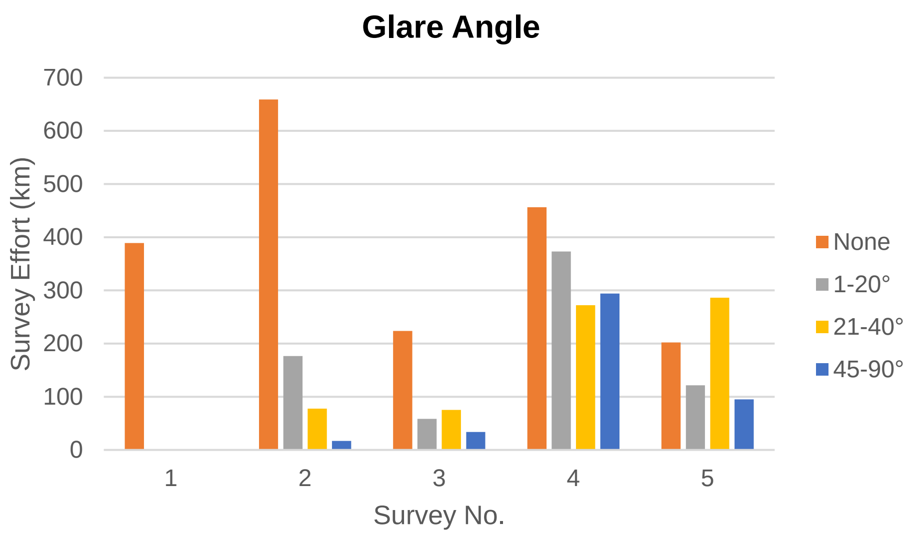


Figure 12: Glare Angle During Leg 1 of the 2019 MMASP

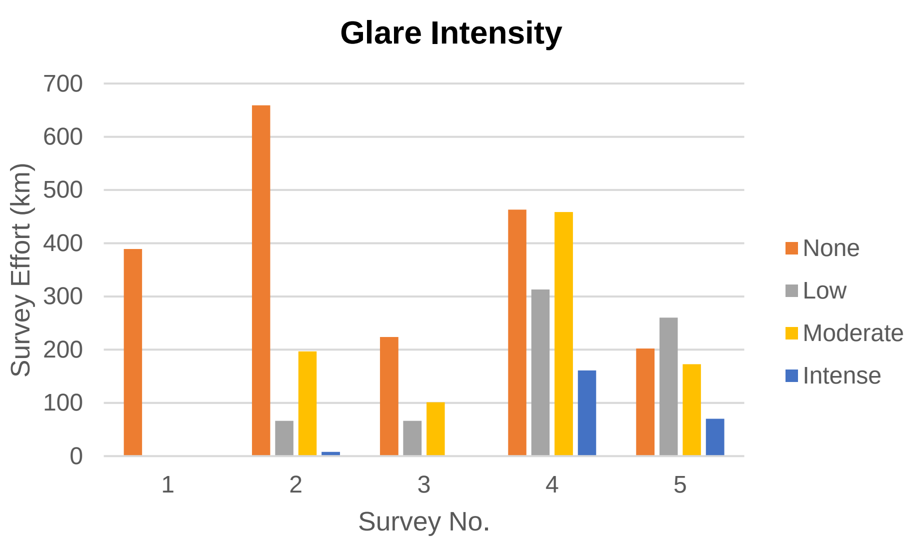


Figure 13: Glare Intensity During Leg 1 of the 2019 MMASP

3.1.3 Visual Survey Sightings

Eight different marine mammal species were observed during Leg 1 of the 2019 MMASP: 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 4 summarizes the number of marine mammal sightings and animals recorded during visual surveys for each species by survey number. A total of 755 sightings of 1,713 individual marine mammals were recorded during Leg 1 visual surveys.

Table 4: All visual sightings (including off-effort) in Eclipse Sound grid during Leg 1 (early shoulder season)

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	21	51	120	391	74	133	290	582	52	154
Bowhead Whale	0	0	5	8	14	27	75	104	13	17
Beluga Whale	1	1	0	0	1	1	1	1	0	0
Killer Whale	0	0	0	0	0	0	3	10	0	0
Dolphin	0	0	0	0	0	0	0	0	1	1
Unidentified Whale	0	0	2	2	1	2	0	0	0	0
Ringed Seal	0	0	9	10	4	7	24	54	6	8
Harp Seal	0	0	0	0	0	0	8	107	2	10
Bearded Seal	0	0	1	1	0	0	1	1	0	0
Unidentified Seal	0	0	6	7	0	0	10	10	6	7
Polar Bear	0	0	0	0	0	0	1	1	3	5
Total	**22**	**52**	**143**	**419**	**94**	**170**	**413**	**870**	**83**	**202**

Narwhal

During the early shoulder season (Leg 1), narwhal were primarily sighted in Eclipse Sound East and West, Pond Inlet, Navy Board Inlet and Milne Inlet North strata (Appendix B, Figures B-1 to B-5). No narwhal were observed in Tremblay Sound during the early shoulder season, possibly due to the large amount of sea ice present at the entrance of Tremblay Sound, which may have impeded access. One narwhal sighting (four individuals) was observed in South Milne Inlet stratum during Leg 1 Survey 1 (Appendix B, Figure B-1). None were observed again in the South Milne Inlet stratum until Leg 1 Survey 5 (Appendix B, Figure B-5), when a photographic survey was flown due to the high number of narwhal observed.

A total of 557 sightings and 1,311 individual narwhals were recorded during the Leg 1 visual surveys (Table 4). Narwhal group sizes ranged from single animals to a group size of 21, with mean and median group sizes of 2.2 and 1.0, respectively. Twenty-two mother/calf pairs and one lone calf were recorded during the visual surveys. Two mother/calf pairs were observed on 15 July, one mother/calf pair in Pond Inlet stratum and one mother/calf pair in the Eclipse Sound East stratum. On 16 July, one mother/calf pair was observed at the northern end on Navy Board Inlet. One mother/calf pair were observed on 17 July in Eclipse Sound West stratum. On 21 July, seventeen mother/calf pairs and one lone calf were observed in Pond Inlet, Eclipse Sound East, and Eclipse Sound West strata. One mother/calf pair was also observed on 17 July in the central portion of Navy Board Inlet stratum.

Bowhead whale

Bowhead whales were observed in every strata except the Fjord stratum during the early shoulder season (Appendix B, Figures B-1 to B-5). They were most commonly observed in Eclipse Sound West and East, Milne Inlet, and at the mouth of Tremblay Sound (Appendix B, Figures B-1 to B-5).

A total of 107 sightings of 156 individual bowhead whales were recorded during the Leg 1 visual surveys (Table 4). Bowhead group sizes ranged from single animals to a group size of eight, with mean and median group sizes of 1.5 and 1.0, respectively. Two mother/calf pairs were recorded during the surveys. The first mother/calf pair was observed in the Eclipse Sound East stratum on 17 July. The second mother/calf pair was observed in Eclipse Sound West stratum on 21 July.

Beluga whale

During the Leg 1 visual surveys, there was a total of three beluga sightings (all single animals). The first sighting was observed during Survey 1 (12 July) in the Pond Inlet stratum (Appendix B, Figure B-1). The second sighting was observed during Survey 3 (17 July), again in the Pond Inlet stratum (Appendix B, Figure B-3). The last beluga sighting occurred in the Milne Inlet South/Koluktoo Bay stratum during Survey 4 (22 July; Appendix B, Figure B-4).

Killer whale

Killer whales were seen on one occasion during the Leg 1 visual surveys. During Survey 4, three sightings, all roughly in the same location in the Baffin Bay stratum, were observed on 22 July (Appendix B, Figure B-4). The three sightings consisted of one, two, and seven individuals. They were likely all from the same pod based on the close proximity to each other.

Unidentified whale

There were three sightings of four unidentified whales during the Leg 1 visual surveys. The first unidentified whale was observed during Survey 2 in the Pond Inlet stratum close to the south shore of Bylot Island. A second sighting of an individual whale was also observed during Survey 2 at the mouth of Tremblay Sound (Appendix B Figure B-2). One sighting of two unidentified whales was observed during Survey 3 in the Eclipse Sound East stratum (Appendix B, Figure B-3).

There was one sighting of a dolphin in Navy Board Inlet during Survey 5 (Appendix B, Figure B-5). The aircraft circled back to confirm the identification, but the animal was not seen again. There were many harp seals in the area at the time. The observer later indicated that he may have miss identified a harp seal as a dolphin.

Ringed seal

Ringed seals were observed throughout the survey area during the Leg 1 visual surveys (Appendix B, Figures B-2 to A-5). Forty-three sightings totalling 79 ringed seals recorded during Leg 1 visual surveys (Table 4). Ringed seal sightings in the water were primarily of single animals (30 out of 33 sightings). The remaining ringed seal groups observed in the water consisted of groups of two or three individuals. Ringed seals on the ice were observed with group sizes ranging from one to 15 seals, with mean and median group sizes of 4.1 and 2.5, respectively.

Harp seal

Ten sightings totalling 117 harp seals were recorded during Leg 1 visual surveys (Table 4). Harp seals were only observed during two of the surveys. During Survey 4, harp seals were observed in the Baffin Bay and Eclipse Sound West strata (Appendix B, Figure B-4). During Survey 5, harp seals were only observed in northern Navy Board Inlet (Appendix B, Figure B-5). All harp seals were observed in the water with group sizes that ranged from five to 25 individuals and with mean and median group sizes of 11.7 and 8.5, respectively.

Bearded seal

Two sightings of individual bearded seals were recorded during Leg 1 visual surveys (Table 4). One was observed during Survey 2 in Navy Board Inlet (Appendix B, Figure B-2). The second was observed during Survey 4 in Milne Inlet North stratum (Appendix B, Figure B-4).

Unidentified seal

Unidentified seals were observed throughout the survey area during Leg 1 visual surveys (Appendix B, Figures B-2 to B-5). There were 22 sightings totalling 24 individuals (Table 4).

Polar bear

Four polar bear sightings were made during Leg 1 visual surveys (Table 4). The first sightings were of an individual swimming in the Milne Inlet South stratum during Survey 4 (Appendix B, Figure B-4). The last three sightings were observed during Survey 5 in the Eclipse Sound West stratum. One was of an individual bear walking on the shore and the other two sightings were of animals in the water swimming.

3.1.4 Photographic Survey Sightings

Nine photographic surveys were flown during Leg 1 of the of 2019 MMASP. Surveys 2 and 4 were chosen to calculate abundance estimates in the RSA along the shipping corridor. Survey 2 (15–16 July) was chosen because it had the most complete coverage of the shipping corridor prior to Baffinland vessels entering the RSA, and Survey 4 (21–23 July) had the most complete coverage after Project vessels had entered the RSA. The first vessel to enter the RSA in 2019 was the MSV *Botnica*. The MSV *Botnica* was used to escort Project vessels on the evening of 17 July.

Two photographic surveys were flown during Survey 2 (Figure 14). One at the top of Navy Board Inlet and one in Pond Inlet stratum. The photographic survey flown at the top of Navy Board Inlet was not analyzed because it was not in the shipping corridor and Navy Board Inlet was not flown during Survey 4. Two photographic surveys were flown during Survey 4 (Figure 15). One in Tremblay Sound and one in Pond Inlet stratum. The photographic survey flown in Tremblay Sound was not analyzed because observers did not see narwhal in the area while the photographic survey was being flown, it was not in the shipping corridor, and it was not flown during Survey 2.

Table 5: Photographic survey sightings in the Eclipse Sound grid during Leg 1 (early shoulder season)

Species	Survey 2		Survey 4	
	No. Sightings	No. Animals	No. Sightings	No. Animals
Narwhal	218	431	127	262
Bowhead Whale	0	0	2	3
Unidentified Seal	0	0	4	71

Narwhal

During Survey 2, a large concentration of narwhals was photographed along the northern shore of Baffin Island, east of Pond Inlet (Figure 14). The area was ice free at the time of the survey. During Survey 4, another large concentration of narwhals was photographed along the southern shore of Bylot Island, east of Pond Inlet (Figure 15). The ice coverage ranged from 0 to 50% in the photographs.

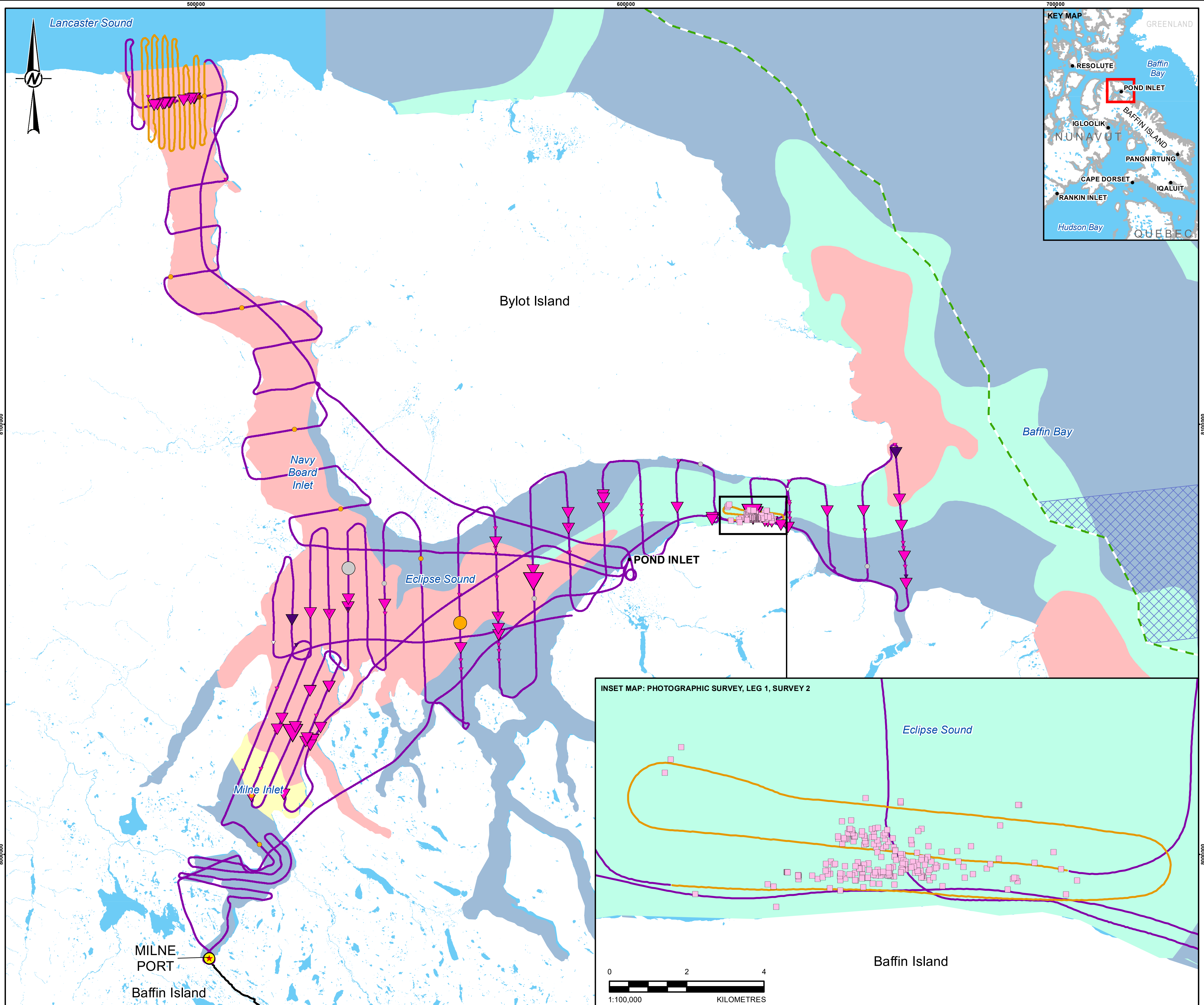
A total of 345 sightings and 693 individual narwhals were recorded during the two Leg 1 photographic surveys (Table 5). Narwhal group sizes ranged from single animals to a group size of 12, with mean and median group sizes of 2.0 and 1.0, respectively. Two mother/calf pairs were recorded, one during Survey 2 and one during Survey 4.

Bowhead whale

Two sightings totalling three bowhead whales were recorded during the two Leg 1 photographic surveys (Table 5). The first sighting was of a single animal and the second sighting was of a pair of bowhead whales. They were both recorded during Survey 4 within nine seconds of each other. All three animals were identified as adults.

Unidentified seal

Unidentified seals were recorded during one of the two Leg 1 photographic surveys. There was a total of four sightings and 71 individuals (mean group size of 17.7; Table 5). Based on the large group sizes, these sightings were likely of harp seals.



LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- NARWHAL

VISUAL SURVEY MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL

- 1

BOWHEAD WHALE

- 1
- 2 - 10

NARWHAL

- 1
- 2 - 10
- 10+

RINGED SEAL

- 1
- 2 - 10

UNIDENTIFIED SEAL/PINNIPED

- 1
- 2 - 10

UNIDENTIFIED WHALE/CETACEAN

- 1

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- 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

1:900,000 KILOMETRES

NOTE(S)

PRIOR TO SHIPPING ACTIVITIES. CONDITIONS GOOD WITH BF 0-4 AND SOME FOG IN NAVY BOARD INLET AND TREMBLAY SOUND. NARWHALS ABSENT IN SOUTH MILNE INLET/KOLUKTOO BAY. LARGE CONCENTRATION OF NARWHAL OBSERVED IN NORTH NAVY BOARD INLET IN HIGH ICE CONDITIONS (PHOTOGRAPHIC SURVEY FLOWN).

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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

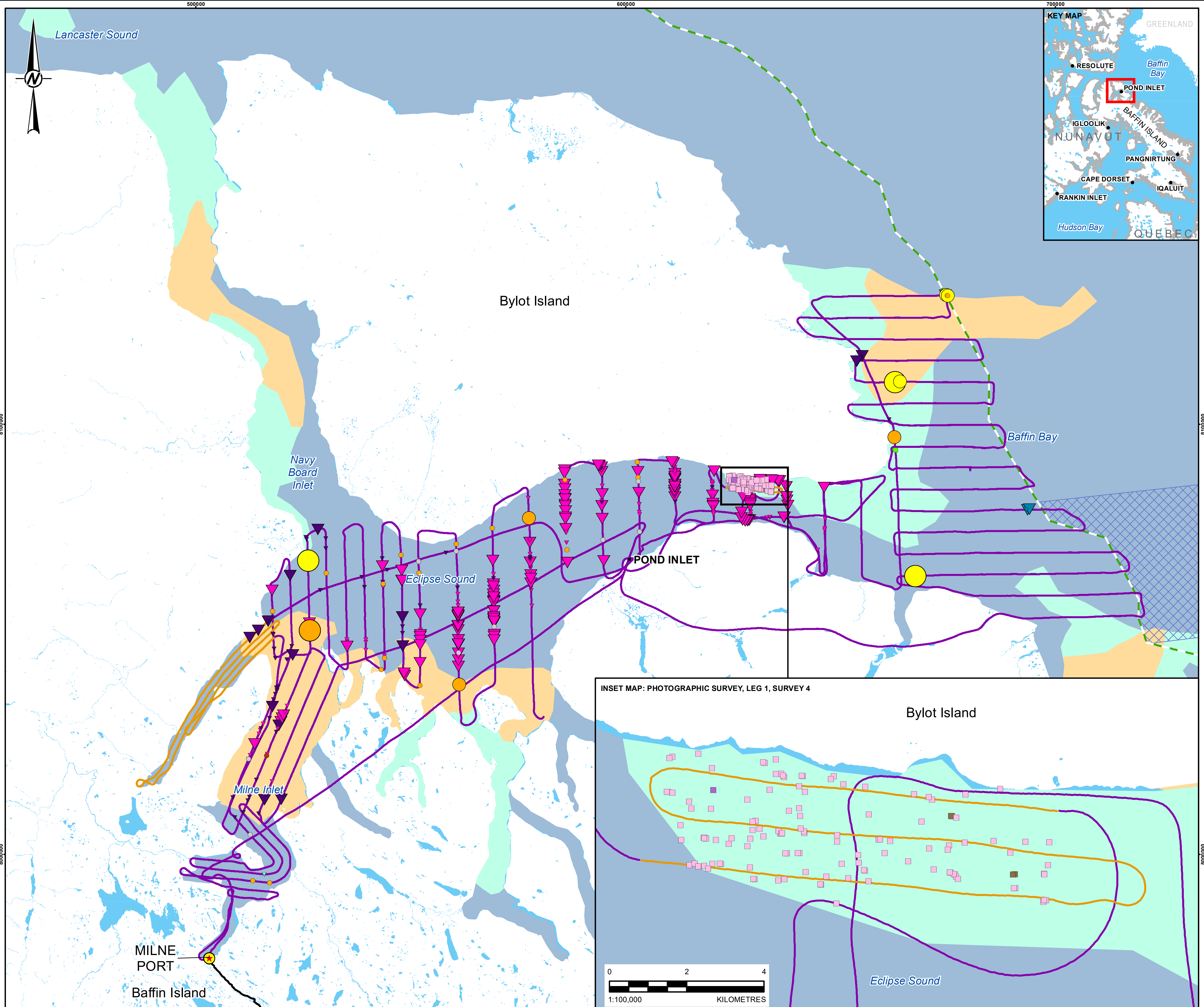
PROJECT
MARY RIVER PROJECT

TITLE
DISTRIBUTION OF MARINE MAMMAL SPECIES DURING LEG 1, SURVEY 2 ON JULY 15-16, 2019 IN THE ECLIPSE SOUND GRID

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	KK
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000-07	0	14



LEGEND

- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD
- NARWHAL
- SEAL

VISUAL SURVEY MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BELUGA
- 1

BOWHEAD WHALE
- 1
- 2 - 10

HARP SEAL
- 2 - 10
- 10+

KILLER WHALE
- 1
- 2 - 10

NARWHAL
- 1
- 2 - 10

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2 - 10
- 10+

UNIDENTIFIED SEAL/PINNIPED
- 1

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- 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

1:900,000 KILOMETRES

NOTE(S)

DURING SHIPPING ACTIVITIES. CONDITIONS GOOD WITH BF 0-3 FOR MUCH OF SURVEY AREA. FOG PRESENT ON ONE TRANSECT IN EASTERN ECLIPSE SOUND. BF 4-5 ON PORTIONS OF THE BAFFIN BAY TRANSECTS. NO NARWHALS SEEN IN TREMBLAY SOUND OR SOUTH MILNE INLET/KOLUKTOO BAY.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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

TITLE
DISTRIBUTION OF MARINE MAMMAL SPECIES DURING LEG 1, SURVEY 4 ON JULY 21-23, 2019 IN THE ECLIPSE SOUND GRID

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	KK
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000-07	0	15

3.1.5 Abundance Estimates

3.1.5.1 Data Characteristics

See Section 3.2.5.1 for a detailed description of the model selection and detection function fitting for each of the four models used in his report.

See Section 3.2.5.2 for detailed photographic survey data characteristics results.

Overall, there were 308 sightings of narwhal groups while on-effort for the combined visual surveys 2 and 4 (Table 6) during Leg 1. Initially, 98 of the sightings were missing perpendicular distances due to a technical malfunction of the geometers. After photo-verification of sightings with missing measurements 56 perpendicular distances were recovered from the photographs, with the remaining 42 left as missing values.

3.1.5.2 Narwhal Abundance

As indicated (see Section 3.1.4), Surveys 2 and 4 of Leg 1 were chosen to calculate abundance estimates in the RSA along the shipping corridor. During visual Survey 2 on 15–16 July, a total of 796.2 km of transects were visually surveyed (Table 6). The total count of narwhal sightings observed on-effort in the visual survey area was 68 sightings before truncation and 67 after truncation (Table 6). Although variation of the abundance estimate was a combination of the variation from detection function, encounter rate, cluster size and availability bias, the overall variation in abundance estimates came primarily from the encounter rate and cluster size component (Table 6). Total narwhal abundance for the visually surveyed area of Survey 2 was 4,578 (CV=0.29; see Table 6).

The total length of transect lines visually surveyed during Survey 4 on 21–22 July was 1,377.0 km (Table 6). The total count of narwhal sightings observed on-effort in the visual survey area was 240 sightings before truncation and 237 after truncation (Table 6). For this survey, the overall variation in abundance estimates came primarily from the encounter rate and/or cluster size component (Table 6). Total narwhal estimate for the visually surveyed area of Survey 4 was 14,945 (CV=0.19; see Table 6).

Table 6: Narwhal abundance estimates from visual surveys in Eclipse Sound grid during Leg 1

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	BB	2,087.4	0	—	—	—	—	—	—
2	PI	1,343.4	133.1	20	20	1,430	0.34	59.1	36.6
2	ESE	2,066.5	216.1	27	27	2,258	0.52	76.6	21.4
2	ESW	841.0	176.1	8	7	338	0.37	64.5	31.6
2	MIN	681.3	145.7	13	13	552	0.50	46.1	51.9
2	MIS	272.1	125.2	0	0	—	—	—	—
2	*Total*	—	*796.2*	*68*	*67*	*4,578*	*0.29*	—	—

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
4	BB	2,087.4	526.6	1	1	62	1.00	99.5	0
4	PI	1,335.2	129.4	88	88	6,093	0.39	90.4	6.1
4	ESE	2,066.5	251.4	125	122	8,121	0.21	79.0	8.8
4	ESW	841.0	173.9	10	10	247	0.29	45.0	48.8
4	MIN	681.3	158.8	16	16	422	0.25	30.6	60.9
4	MIS	272.1	136.9	0	0	—	—	—	—
4	*Total*	—	*1,377*	*240*	*237*	*14,945*	*0.19*	—	—

[a] BB=Baffin Bay, PI=Pond Inlet, ESE=Eclipse Sound East, ESW=Eclipse Sound West, MIN=Milne Inlet North, MIS=Milne Inlet South

During photographic Survey 2 on 15 July, 134 photographs were taken to capture the narwhal aggregation, with a total area photographed of 37.9 km^2 (Table 7). The total count of narwhals in the photographed area was 431 animals (Table 5). The sum of the area of the individual photographs totaled 51.4 km^2 resulting in an average density of 8.4 narwhals/km^2 within survey area. Multiplying the average density (8.4 narwhals/km^2) by the total area (37.9 km^2) resulted in a surface estimate of 318 narwhals. The surface estimate was then corrected for availability bias using C_α = 3.18 (correction from Watt et al. 2015a), and detectability bias of 1.20 (see section 3.2.5.2), resulting in a total narwhal estimate for the photographed area of Survey 2 of 1,215 (CV=0.05; Table 7).

During Survey 4 on July 21, 192 photographs were taken to capture the narwhal aggregation, with a total area photographed of 46.1 km^2 (Table 7). The total count of narwhals in the photographed area was 262 animals (Table 5). The sum of the area of the individual photographs totaled 71.3 km^2 resulting in an average density of 3.7 narwhals/km^2 within the images. Multiplying the average density (3.7 narwhals/km^2) by the total area (46.1 km^2) resulted in a surface estimate of 169 narwhals. The surface estimate was then corrected for availability bias using C_α = 3.18 (correction from Watt et al. 2015a), and detectability bias of 1.20, resulting in a total narwhal estimate for the photographed area of Survey 4 of 646 (CV=0.04; Table 7).

The combined visual and photographic narwhal abundance estimate was 5,793 (CV=0.23) for Survey 2, and 15,591 (CV=0.19) for Survey 4 (Table 8). Survey 4 saw more narwhals in the RSA after the icebreaker had entered the area. There was also less ice >10% during Survey 4 (see Figure 7), which may have contributed to the higher numbers of narwhal seen.

Table 7: Narwhal abundance estimates from photographic survey in Eclipse Sound grid during Leg 1

Survey	Stratum[a]	No. Photos	No. Photos Murky Water	No. Photos Glare	No. Photos with Ice	Area (km^2)	Surface Count	Corrected Abundance	CV
2	PI	134	1	82	0	37.9	318	1,215	0.05
4	PI	192	29	105	62	46.1	169	646	0.04

[a] PI=Pond Inlet

Table 8: Narwhal abundance estimates from combined visual and photographic surveys during Leg 1

Survey #	Survey Type	Estimate	CV	95% CI
2	Visual	4,578	0.29	2,647 – 7,918
2	Photographic	1,215	0.05	1,109 – 1,331
2	**Combined**	**5,793**	**0.23**	**3,744 – 8,964**
4	Visual	14,945	0.19	10,248 – 21,796
4	Photographic	646	0.04	593 – 704
4	**Combined**	**15,591**	**0.19**	**10,856 – 22,391**

3.1.5.3 Bowhead Abundance

During visual Survey 2 on 15–16 July, a total of 796.2 km of transects were visually surveyed (Table 9). The total count of bowhead sightings observed on-effort in the visual survey area was four sightings before and after truncation (Table 9). Although variation of the abundance estimate was a combination of the variation from detection function, encounter rate, cluster size and availability bias, the overall variation in abundance estimates came primarily from the encounter rate followed by the cluster size component and detection function (Table 9). Total bowhead abundance for the visually surveyed area of Survey 2 was 176 (CV=0.64; Table 10).

During visual Survey 4 on 21–22 July, a total of 1,377.0 km of transects were visually surveyed (Table 9). The total count of bowhead sightings observed on-effort in the visual survey area was 47 sightings before truncation and 42 after truncation (Table 9). The overall variation in abundance estimates came from the encounter rate, cluster size, and detection function component (Table 9). Total bowhead abundance for the visually surveyed area of Survey 4 was 1,279 (CV=0.30; Table 10).

Table 9: Bowhead abundance estimate from visual survey - Leg 1

Survey	Stratum[a]	Area (km²)	Effort (km)	No. Sight. Before Trunc.	No. Sight. After Trunc.	Corrected Abundance	CV	% CV Encounter Rate	% CV Cluster Size	% CV Detection Function
2	BB	2,087.4	0	—	—	—	—	—	—	—
2	PI	1,343.4	133.1	2	2	108	0.88	71.2	14.4	14.2
2	ESE	2,066.5	216.1	0	0	—	—	—	—	—
2	ESW	841.0	176.1	2	2	68	0.88	53.6	32.1	14.1
2	MIN	681.3	145.7	0	0	—	—	—	—	—
2	MIS	272.1	125.2	0	0	—	—	—	—	—
2	*Total*	—	*796.2*	*4*	*4*	*176*	*0.64*	—	—	—
4	BB	2,087.4	526.6	2	2	71	1.09	87.4	3.3	9.2
4	PI	1,335.2	129.4	3	3	111	0.55	62.7	0	36.8
4	ESE	2,066.5	251.4	8	8	559	0.57	54.9	10.4	34.2
4	ESW	841.0	173.9	17	12	139	0.46	34.8	12.0	52.5
4	MIN	681.3	158.8	17	17	399	0.43	0.4	39.4	59.4
4	MIS	272.1	136.9	0	0	—	—	—	—	—
4	*Total*	—	*1377*	*47*	*42*	*1,279*	*0.30*	—	—	—

[a] BB=Baffin Bay, PI=Pond Inlet, ESE=Eclipse Sound East, ESW=Eclipse Sound West, MIN=Milne Inlet North, MIS=Milne Inlet South

No bowhead whales were sighted in the photographic area during Survey 2 on 15 July. During Survey 4 on 21–22 July, two sightings of bowhead whales were observed in the photographic area. One sighting of an individual whale and a second sighting of a pair of animals, resulting in a total count of three animals. Since we can confirm they were not re-sightings based on the low numbers and timing of the sightings, the surface estimate was then corrected for availability bias using C_α = 4.12 (early August correction from Watt et al. 2015b), resulting in a total bowhead whale estimate for the photographed area of 12 animals (CV=0.19). The combined visual and photographic bowhead abundance estimate was 176 (CV=0.64) for Survey 2, and 1,291 (CV=0.29) for Survey 4 (Table 10). Similarly to the narwhal, Survey 4 saw more bowhead whales in the RSA after the icebreaker had entered the area.

Table 10: Bowhead abundance estimates from combined visual and photographic surveys during Leg 1

Survey #	Survey Type	Estimate	CV	95% CI
2	**Visual**	**176**	**0.64**	**56 – 553**
2	Photographic	0	—	—
4	Visual	1,279	0.30	724 – 2,258
4	Photographic	12	0.19	8 – 17
4	**Combined**	**1,291**	**0.29**	**735 – 2,267**

3.2 Leg 2: Open-Water Surveys in Eclipse Sound and Admiralty Inlet

3.2.1 Survey Coverage

Five surveys over 15 days were attempted during the open-water season in the Eclipse Sound and Admiralty Inlet grids (Appendix B, Figures B-6 to B-15). Over the course of the five surveys, a total of 9,903.3 km of survey effort was conducted which included both visual and photographic surveys (Table 11).

Eclipse Sound Grid: Visual surveys totaled 4,443.3 km and photographic surveys totaled 1,583.7 km of survey effort (Table 11). Three of the five surveys (Surveys 1,3, and 5) achieved complete coverage of the survey grid (Appendix B, Figures B-6, B-8, and B-10). Survey 4 was missing two transects in Eclipse Sound East stratum (Appendix B, Figure B-9). Survey 2 could not be completed due to an aviation fuel closure at the Pond Inlet airport.

Admiralty Inlet Grid: Visual surveys totaled 3,287.7 km and photographic surveys totaled 518.2 km of survey effort (Table 11). Survey 5 achieved complete coverage of the survey grid (Appendix B, Figure B-15). Surveys 1 and 4 were missing five and seven transects, respectively, in the central portion of Admiralty Inlet North stratum (Appendix B, Figures B-11 and B-14). Survey 2 could not be completed due to logistical limitations (aviation fuel closure at Pond Inlet airport). Survey 3 was missing five transects at the northern portion of Admiralty Inlet North stratum (Appendix B, Figure B-13).

Table 11: Summary of visual (V) and photographic (P) surveys undertaken during Leg 2

Survey Stratum	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5
	17–18 Aug	19 Aug	21–22 Aug	25–27 Aug	29–30 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&P	V
Milne Inlet South (MIS)	P	—	P	P	P
Tremblay Sound (TS)	P	—	P	P	P
Navy Board Inlet (NBI)	V	—	V	V	V
Eclipse Fjords	—	—	V	V	—
Eclipse Visual Effort (km)	**875.6**	**555.5**	**1,070.8**	**1,036.5**	**904.9**
Eclipse Photographic Effort (km)	**375.8**	**0**	**373.5**	**461.3**	**373.1**
Eclipse Total Effort (km)	**1,251.4**	**555.5**	**1,444.3**	**1,497.8**	**1,278.0**
Admiralty Inlet North (AIN)	V	—	V&P	V&P	V&P
Admiralty Inlet South (AIS)	V&P	V&P	V&P	V&P	V
Admiralty Fjords	—	—	—	—	V
Admiralty Visual Effort (km)	**708.7**	**179.6**	**714.1**	**516.8**	**1,168.5**
Admiralty Photographic Effort (km)	**135.1**	**64.4**	**168.7**	**134.6**	**15.4**
Admiralty Total Effort (km)	**843.8**	**244.0**	**882.8**	**651.4**	**1,183.9**
Combined Total Effort (km)	**2,095.1**	**799.5**	**2,327.1**	**2,149.2**	**2,461.9**

3.2.2 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, see Appendix A). Sightings conditions were evaluated based on survey effort when each condition was observed. For calculating abundance estimates, distance analyses used the sighting conditions as covariates in the model.

Ice Cover

Ice was not present in Eclipse Sound Grid during Leg 2 of the 2019 MMASP. In Admiralty Inlet grid, ice cover ranged from Ice Free to 2/10 ice cover during Leg 2 of the 2019 MMASP. Ice was present during ~2% of the survey effort in the northern stratum of Admiralty Inlet during Surveys 1, 3, and 5 (Figure 16).

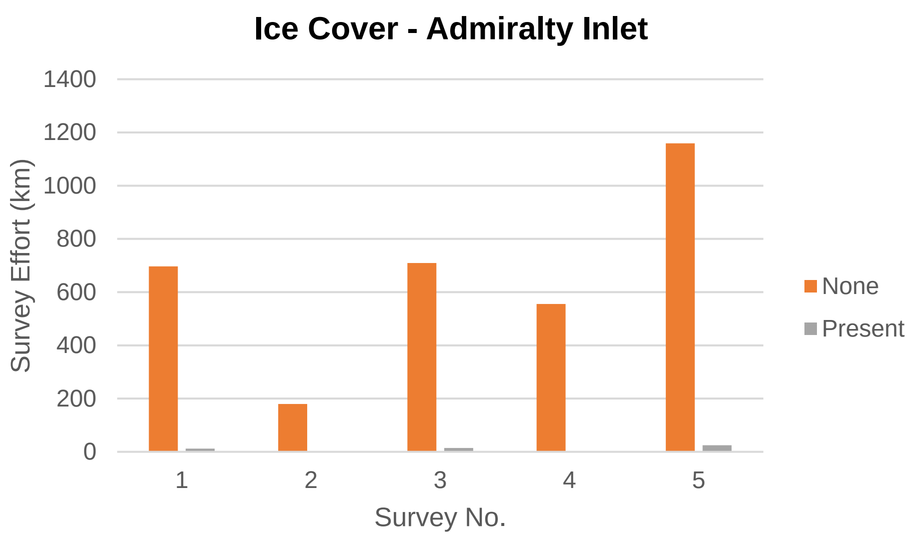


Figure 16: Ice Cover in the Admiralty Inlet Grid During Leg 2 of the 2019 MMASP

Fog

Two measurements of fog were used as sighting conditions. Fog cover was assessed as the percent (0–100%) of fog obscuring the viewing area and fog intensity (four levels: “none” when there was no fog, “light” fog that animals were visible through, “moderate” when animals were likely missed in the fog, and “thick” when animals were certainly missed in the fog). Areas that were forecasted to be foggy were avoided when daily surveys were planned. Fog was not present in Eclipse Sound Grid during Leg 2 of the 2019 MMASP. In Admiralty Inlet Grid, fog ranged from None to 100% cover during Leg 2 of the 2019 MMASP. In Figure 17, “Present” represent 1–100% of the viewing area was obscured with fog. Fog was only present during Surveys 1 and 5 and accounted for ~5% of the effort of each survey.

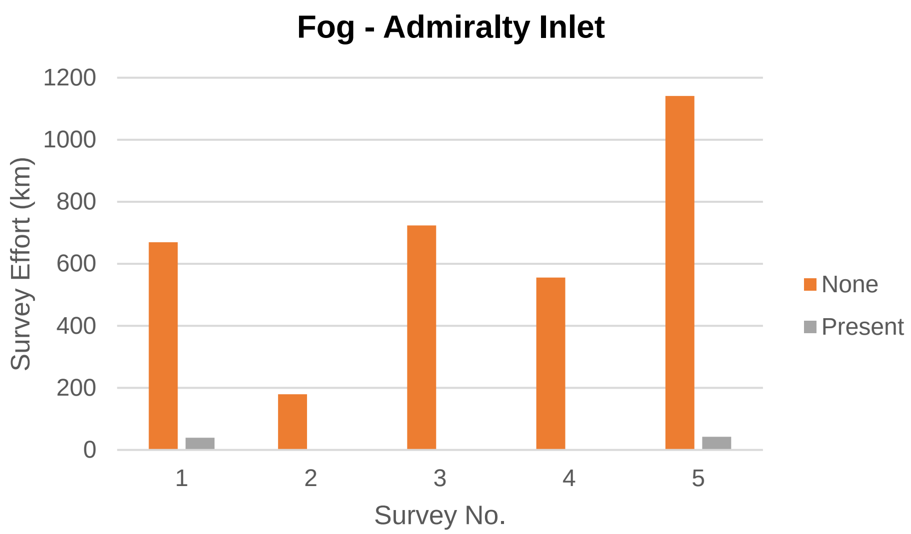


Figure 17: Fog Presence in the Admiralty Inlet Grid During Leg 2 of the 2019 MMASP

Beaufort Sea State

On a scale of 0 to 12, Beaufort Sea State (BF) ranged from BF 0 (glassy mirror) to BF 5 (moderate waves) during Leg 2 of the 2019 MMASP (Figure 18 and Figure 19). 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 better environmental sighting conditions.

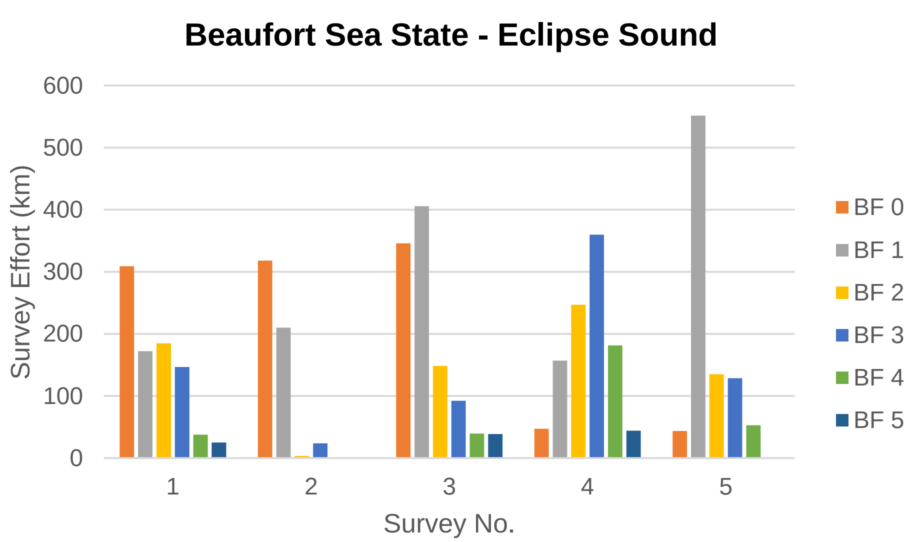


Figure 18: Beaufort Sea State in the Eclipse Sound Grid During Leg 2 of the 2019 MMASP

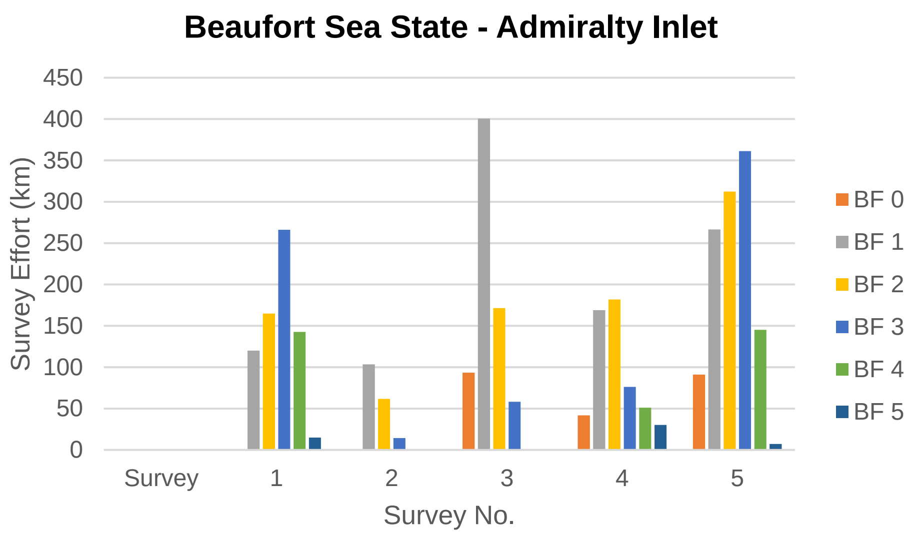


Figure 19: Beaufort Sea State in the Admiralty Inlet Grid During Leg 2 of the 2019 MMASP

Glare

Two measurements of glare were used as sighting conditions. Glare angle (0–90 degrees) was the angle 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 23% to 55% of the survey effort in each survey (Figure 20 to Figure 23).

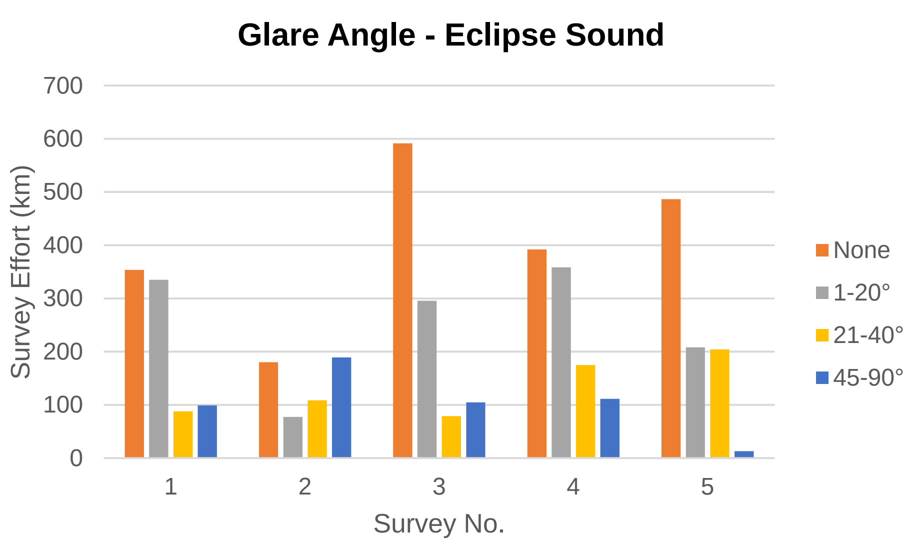


Figure 20: Glare Angle in the Eclipse Sound Grid During Leg 2 of the 2019 MMASP

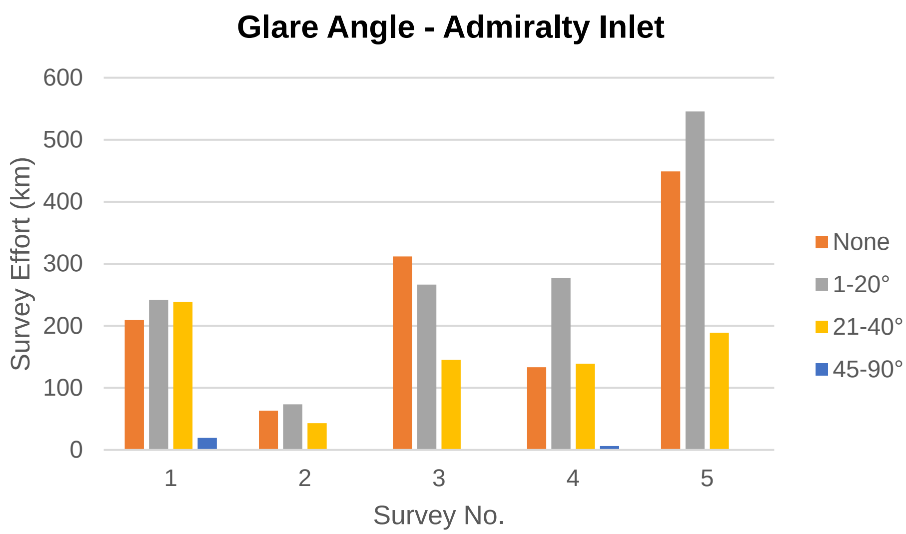


Figure 21: Glare Angle in the Admiralty Inlet During Leg 2 of the 2019 MMASP

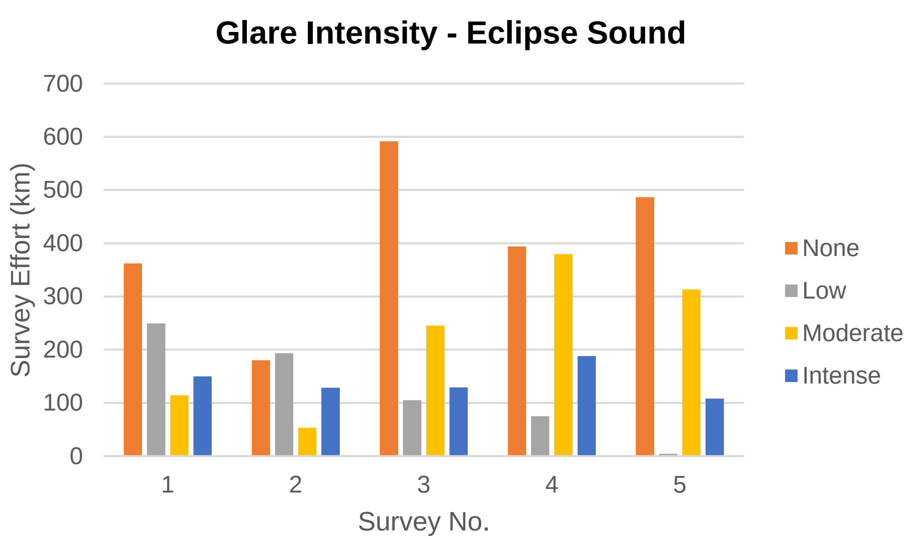


Figure 22: Glare Intensity in the Eclipse Sound Grid During Leg 2 of the 2019 MMASP

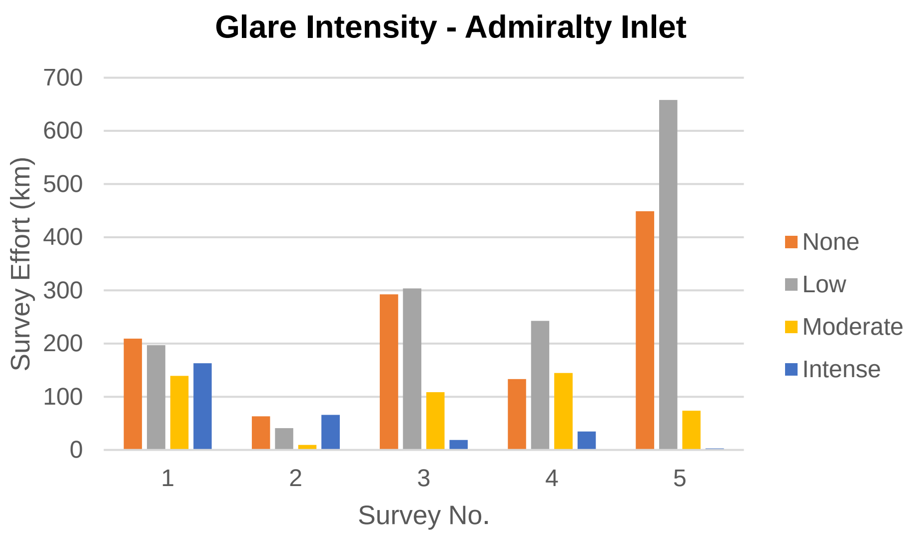


Figure 23: Glare Intensity in the Admiralty Inlet During Leg 2 of the 2019 MMASP

3.2.3 Visual Survey Sightings

Eclipse Sound Grid: Eight different species of marine mammals were observed during Leg 2 visual surveys of the 2019 MMASP in the Eclipse Sound 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 visual surveys.

Table 12 summarizes the number of marine mammal sightings and animals recorded for each species in each of the five surveys. A total of 349 sightings and 1,420 individual marine mammals were recorded during Leg 2 visual surveys in the Eclipse Sound grid. The most commonly sighted species was narwhal (190 sightings totalling 516 individuals), followed by harp seal (45 sightings totalling 669 individuals), ringed seal (17 sightings totalling 23 individuals), polar bear (seven sightings totalling 14 individuals), bowhead whale (four sightings of individual whales), killer whale (three sightings totalling 29 individuals), bearded seal (two sightings of individual seals), and beluga whale (one sighting of a single whale). There were also 79 unidentified seal sightings totalling 161 individuals and one sighting of an unidentified whale.

Table 12: All marine mammal sightings (including off-effort) in Eclipse Sound grid during Leg 2 (open-water season)

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	39	172	4	4	9	11	101	265	37	64
Bowhead Whale	4	4	0	0	0	0	0	0	0	0
Beluga Whale	1	1	0	0	0	0	0	0	0	0
Killer Whale	0	0	0	0	1	11	1	3	1	15
Unidentified Whale	1	1	0	0	0	0	0	0	0	0
Ringed Seal	5	5	0	0	8	14	0	0	4	4
Harp Seal	30	404	0	0	1	15	8	96	6	154
Bearded Seal	0	0	0	0	0	0	0	0	2	2
Unidentified Seal	9	11	23	23	26	72	5	9	16	46
Polar Bear	2	4	0	0	1	1	2	7	2	2
Total	**91**	**602**	**27**	**27**	**46**	**124**	**117**	**380**	**68**	**287**

Admiralty Inlet Grid: Five different species of marine mammals were observed during Leg 2 visual survey of the 2019 MMASP in the Admiralty Inlet grid: narwhal, bowhead whale, ringed seal, harp seal, and polar bear. Unidentified whales and seals were also recorded during the surveys. Table 13 summarizes the number of marine mammal sightings and animals recorded for each species by survey number. A total of 764 sightings and 1,823 individual marine mammals were recorded during Leg 2 visual surveys in the Admiralty Inlet grid.

The most commonly identified species was narwhal (609 sightings totalling 1,403 individuals), followed by bowhead whale (94 sightings totalling 139 individuals), ringed seal (19 sightings totalling 19 individuals), harp seal (18 sightings totalling 216 individuals), and polar bear (six sightings totalling nine individuals). There were also nine sightings of unidentified seals totalling 19 individuals and nine sightings of unidentified whales totalling 18 individuals.

Table 13: All marine mammal sightings in Admiralty Inlet grid during Leg 2 (open-water season)

Species	Survey 1		Survey 2		Survey 3		Survey 4		Survey5	
	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals
Narwhal	54	299	41	98	197	404	129	236	188	366
Bowhead Whale	33	62	7	9	20	29	16	20	18	19
Unidentified Whale	8	17	0	0	0	0	0	0	1	1
Ringed Seal	0	0	0	0	9	9	6	6	4	4
Harp Seal	1	20	0	0	11	151	4	34	2	11
Unidentified Seal	8	9	0	0	1	10	0	0	0	0
Polar Bear	1	1	0	0	0	0	3	4	2	4
Total	**105**	**408**	**48**	**107**	**238**	**603**	**158**	**300**	**215**	**405**

Narwhal

Eclipse Sound Grid: During the open-water season (Leg 2) narwhal were primarily sighted in Milne Inlet South and North and Tremblay Sound strata as evident in the photographic coverage of the areas (Appendix B, Figures B-6 to B-10). Relatively few narwhal were recorded in Eclipse Sound or Navy Board Inlet during the five Leg 2 surveys conducted in August.

A total of 190 sightings and 516 individual narwhals were recorded during the Leg 2 visual survey of the Eclipse Sound grid (Table 12). Narwhal group sizes ranged from single animals to a group size of 20, with mean and median group sizes of 2.7 and 1.5, respectively. Seventeen mother/calf pairs were recorded during the surveys. Four mother/calf pairs were observed during Survey 1 (17–18 August) in Eclipse Sound West and Milne Inlet South strata. During Survey 4 (25 August), seven mother/calf pairs were observed in Milne Inlet North. Six mother/calf pairs were observed during Survey 5 (29 August) in Eclipse Sound West and Milne Inlet North strata.

Admiralty Inlet Grid: Narwhal were observed throughout the central and southern portion of Admiralty Inlet. In Admiralty Inlet South stratum, narwhals were observed on several occasions clumped close to shore on the western side of the inlet (as evident in the photographic coverage for Leg 2 Surveys 1 to 4; Appendix B, Figures B-11 to B-15).

A total of 609 sightings and 1,403 individual narwhal were recorded during the Leg 2 visual surveys of the Admiralty Inlet grid (Table 13). Narwhal group sizes ranged from single animals to a group size of 16, with mean and median group sizes of 2.1 and 1.0, respectively. Thirty-five mother/calf pairs were recorded during the surveys. Three mother/calf pairs were observed during Survey 2 (19 August) in Admiralty Inlet South stratum. During Survey 3 (21 August), eleven mother/calf pairs were observed in Admiralty Inlet North and South strata (two and nine mother/calf pairs, respectively). Three mother/calf pairs were observed during Survey 4 (26–27 August) in Admiralty Inlet North and South strata (one and two mother/calf pairs, respectively). During Survey 5 (29 August), eighteen mother/calf pairs were observed in Admiralty Inlet North stratum.

Bowhead Whale

Eclipse Sound Grid: Four bowhead whale were observed in the RSA during the open-water surveys on August 17 (Table 12). Three of the bowhead whales were observed opportunistically by observers during a photographic survey in Tremblay Sound and one was observed on-transect near the entrance to Tremblay Sound (Appendix B, Figure B-6).

Admiralty Inlet Grid: Bowhead whale were observed in Admiralty Inlet during every Leg 2 survey flown in August. All bowhead whale sightings (except for one) were located in the southern portion of Admiralty Inlet, south of Yeoman Island (Appendix B, Figures B-11 to B-15). A total of 94 sightings and 139 individual bowhead whales were recorded during the Leg 2 visual surveys of the Admiralty Inlet grid (Table 13). Bowhead group sizes ranged from single animals to a group size of 10, with mean and median group sizes of 1.5 and 1.0, respectively. Three mother/calf pairs were recorded during the surveys, all in Admiralty Inlet South stratum on different days (18, 19, and 21 August).

Beluga Whale

Eclipse Sound Grid: During the open-water season there was one beluga sighting of a single animal observed during Leg 2 Survey 1 in Navy Board Inlet stratum (Appendix B, Figure B-6).

Admiralty Inlet Grid: No beluga whales were observed in Admiralty Inlet during the Leg 2 visual surveys.

Killer Whale

Eclipse Sound Grid: Killer whales were observed on three of the five surveys flown during Leg 2 visual surveys. During Surveys 3 and 5, a pod of 11 and 15 killer whales, respectively, were observed in Milne Inlet North stratum (Appendix B, Figures B-8 and B-10). A small pod of three killer whales was observed in Navy Board Inlet during Survey 4 (Appendix B, Figure B-9).

Admiralty Inlet Grid: No killer whales were observed in Admiralty Inlet during Leg 2 visual surveys.

Unidentified Whale

Eclipse Sound Grid: A single unidentified whale was observed in Pond Inlet stratum during Leg 2 Survey 1 (Appendix B, Figure B-6). The observer noted that it was probably a bowhead whale based on its size.

Admiralty Inlet Grid: There were nine sightings totalling 18 unidentified whales observed during Leg 2 visual surveys in the Admiralty Inlet grid. Eight of the sightings occurred during Survey 1 and ranged in group size of one to six animals. They were all observed in areas where narwhals and/or bowheads were present, which would have made a re-sighting difficult to confirm. The last sighting was observed during Survey 5 in Admiralty Inlet North stratum in an area with high numbers of narwhal present (Appendix B, Figure B-15).

Ringed Seal

Eclipse Sound Grid: Ringed seals were observed during Surveys 1, 3 and 5 of the Leg 2 visual surveys in Eclipse Sound East and Pond Inlet strata (Appendix B, Figures B-6, B-8 and B-10). They were also observed in the Eclipse Fjords stratum during Survey 3.There was a total of 17 sightings totalling 23 individual ringed seals recorded during visual surveys (Table 12). Ringed seals sightings were primarily of single animals (13 of 17 sightings). The remaining ringed seal sightings observed consisted of groups of two or three individuals.

Admiralty Inlet Grid: Ringed seals were observed on Surveys 3, 4 and 5, during Leg 2 visual surveys of the Admiralty Inlet grid (Appendix B, Figures B-13, B-14 and B-15).There was a total of 19 sightings of individual ringed seals recorded during visual surveys (Table 13).

Harp Seal

Eclipse Sound Grid: Harp seals were observed on four of the Leg 2 visual surveys. During Surveys 1, 4, and 5, harp seals were observed in the Navy Board Inlet stratum (Appendix B, Figures B-6, B-9, and B-10). During Survey 3, one sighting of 15 seals was observed in the Pond Inlet stratum (Appendix B, Figure B-8). A total of 45 sightings and 669 individual harp seals were recorded during Leg 2 visual surveys (Table 12). Harp seals were observed with group sizes that ranged from 1 to 60 individuals, and with mean and median group sizes of 14.9 and 15.0, respectively.

Admiralty Inlet Grid: Harp seals were observed on four of the Leg 2 visual surveys in Admiralty Inlet North stratum (Appendix B, Figures B-11, B-13, B-14, and B-15). A total of 18 sightings and 216 individual harp seals were recorded during Leg 2 visual surveys (Table 13). Harp seals were observed throughout the survey area with group sizes ranging from 1 to 40 individuals, and with mean and median group sizes of 12.0 and 10.0, respectively.

Bearded Seal

Eclipse Sound Grid: Two sightings of individual bearded seals were recorded in Navy Board Inlet during Leg 2 Survey 5 visual surveys (Table 12; Appendix B, Figure B-10).

Admiralty Inlet Grid: Bearded seals were not observed in Admiralty Inlet during Leg 2 visual surveys.

Unidentified Seal

Eclipse Sound Grid: Unidentified seals were observed throughout the survey area during Leg 2 visual surveys (Appendix B, Figures B-6 to B-10). A total of 79 sightings and 161 individuals were recorded with mean and median group sizes of 2.0 and 1.0, respectively (Table 12). Seals can be difficult to identify to the species level when flying at 1000 ft.

Admiralty Inlet Grid: Unidentified seals were observed during two Leg 2 visual surveys (Appendix B, Figures B-11 and B-13). A total of nine sightings and 19 individuals were recorded with mean and median group sizes of 2.1 and 1.0, respectively (Table 13).

Polar Bear

Eclipse Sound Grid: Seven polar bear sightings were made during Leg 2 visual surveys in the Eclipse Sound grid (Table 12). During Survey 1, a sighting of an individual polar bear swimming in the water was observed in Navy Board Inlet and a sighting of a mother with two cubs walking on the shore was observed in Pond Inlet stratum (Appendix B, Figure B-6). During Survey 3, a single polar bear was observed running on the shore in the Eclipse Sound East stratum (Appendix B, Figure B-8). Two sightings of a mother with cubs were observed during Survey 4 within a minute of each other (Appendix B, Figure B-9). Both sightings were recorded in Navy Board Inlet. One observer indicated that the bears were walking on shore. The other sighting was also observed on shore but no associated behaviour was recorded with the sighting. During Survey 5, two sightings of individual polar bears were observed (Appendix B, Figure B-10). Both of these bears were observed on land.

Admiralty Inlet Grid: Six polar bear sightings were made during Leg 2 visual surveys in the Admiralty Inlet grid (Table 13). During Survey 1, an individual polar bear was observed swimming in the Admiralty Inlet North stratum (Appendix B, Figure B-11). During Survey 4, three polar bear sightings were observed. The first sighting was of an individual polar bear swimming at the south end of Admiralty Inlet South stratum (Appendix B, Figure B-14). The second sighting was of a mother with a cub on the shore. The second sighting was in close proximity to the third sighting which was of an individual bear, also on the shore (Appendix B, Figure B-14). During Survey 5, two polar bear sightings were observed (Appendix B, Figure B-15). The first sighting was of an individual polar bear on the west shore in the southern portion of the Admiralty Inlet North stratum. The second sighting was of a mother and cub on the west shore in the northern portion Admiralty Inlet North stratum.

3.2.4 Photographic Survey Sightings

Photographic images were analyzed for surveys with complete coverage and good sighting conditions. During Leg 2, four of the five Eclipse Sound grid surveys and three of the five Admiralty Inlet grid surveys had almost complete coverage of the survey area and good sighting conditions. Surveys 3, 4, and 5 were chosen as the best candidates for calculating narwhal abundance estimates in the combined Eclipse Sound and Admiralty Inlet grids based on survey coverage and sighting conditions. All but three photographic surveys were flown at 610 m (2000 ft). Three photographic surveys in Admiralty Inlet were flown at 305 m (1000 ft) due to low ceilings (see Table 14).

Narwhal

Eclipse Sound Grid: During the open-water season (Leg 2), narwhal were primarily sighted in Milne Inlet South and North, and Tremblay Sound strata as evident in the photographic coverage of the areas (Figure 24A–B, Figure 25 A–B, and Figure 26 A–B). A total of 5,467 sightings and 10,502 individual narwhals were recorded during photographic surveys in Eclipse Sound grid (Table 14). Narwhal group sizes ranged from single animals to a group size of 16, with mean and median group sizes of 1.9 and 1.0, respectively. A total of 309 calves were recorded during Leg 2 photographic surveys.

Admiralty Inlet Grid: In Admiralty Inlet South stratum, two of the three photographic surveys were conducted along the western shore (Figure 24 A–B and Figure 25 A–B). In Admiralty Inlet North stratum, all three photographic surveys were conducted in the middle of the inlet (Figure 24 A–B, Figure 25 A–B and Figure 26A–B).A total of 7,332 sightings and 11,941 individual narwhals were recorded during the photographic surveys in the Admiralty Inlet grid (Table 14). Narwhal group sizes ranged from single animals to a group size of 17, with mean and median group sizes of 1.6 and 1.0, respectively. A total of 429 calves were recorded during Leg 2 photographic surveys.

Table 14: Photographic survey sightings in the Eclipse Sound and Admiralty Inlet grids during Leg 2

Grid	Survey	Stratum[a]	Narwhal		Bowhead[b]		Polar Bear[b]		Unidentified Seal	
			No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals
Eclipse	3	MIS	1,417	3,176	1	1	0	0	0	0
Eclipse	3	TS	93	240	0	0	0	0	0	0
Eclipse	4	MIS	1,901	3,644	0	0	0	0	85	87
Eclipse	4	MIN	751	997	0	0	0	0	15	15
Eclipse	4	TS	218	424	0	0	1	1	57	58
Eclipse	5	MIS	924	1,558	0	0	0	0	107	129
Eclipse	5	TS	163	463	0	0	0	0	43	57
Admiralty	3	AIS	612	1,362	2	2	0	0	0	0
Admiralty	3	AIN	540	1,094	0	0	0	0	10	145
Admiralty[c]	3	AIN	882	1,030	0	0	0	0	22	303
Admiralty[c]	4	AIS	1,654	3,688	2	3	0	0	7	7
Admiralty[c]	4	AIN	3,042	4,114	0	0	0	0	1,075	3,743
Admiralty	5	AIN	602	653	0	0	0	0	3	34

[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
[c] Survey flown at 310 m (1000 ft) due to low ceilings

Bowhead Whale

Eclipse Sound Grid: A single adult bowhead whale was recorded during Leg 2 photographic surveys in the Eclipse Sound grid (Figure 24A–B). It was recorded during Survey 3 (21 August) in Milne Inlet South stratum.

Admiralty Inlet Grid: Four bowhead whale sightings were recorded on two of the Leg 2 photographic surveys in the Admiralty Inlet grid (Table 14). During Survey 3, two sightings of single animals were observed in Admiralty Inlet South stratum (Figure 24A–B). During Survey 4, two sightings, one of a single animal and one of a pair of animals, were recorded in Admiralty Inlet South stratum (Figure 25 A–B). All five animals were identified as adults.

Polar Bear

Eclipse Sound Grid: A single polar bear was recorded during Leg 2 photographic surveys in the Eclipse Sound grid (Figure 25 A–B). It was recorded in the water during Survey 4 (26 August) in Tremblay Sound stratum.

Admiralty Inlet Grid: No polar bears were recorded during Leg 2 photographic surveys in the Admiralty Inlet grid.

Unidentified Seal

Eclipse Sound Grid: Unidentified seals were recorded on Surveys 4 and 5 of Leg 2 photographic surveys in the Eclipse Sound grid (Figure 25 A–B and Figure 26 A–B). There was a total of 307 sightings and 346 individuals recorded during the Leg 2 photographic surveys (Table 14). Seal group sizes ranged from single animals to a group size of 15, with mean and median group size of 1.1 and 1.0, respectively.

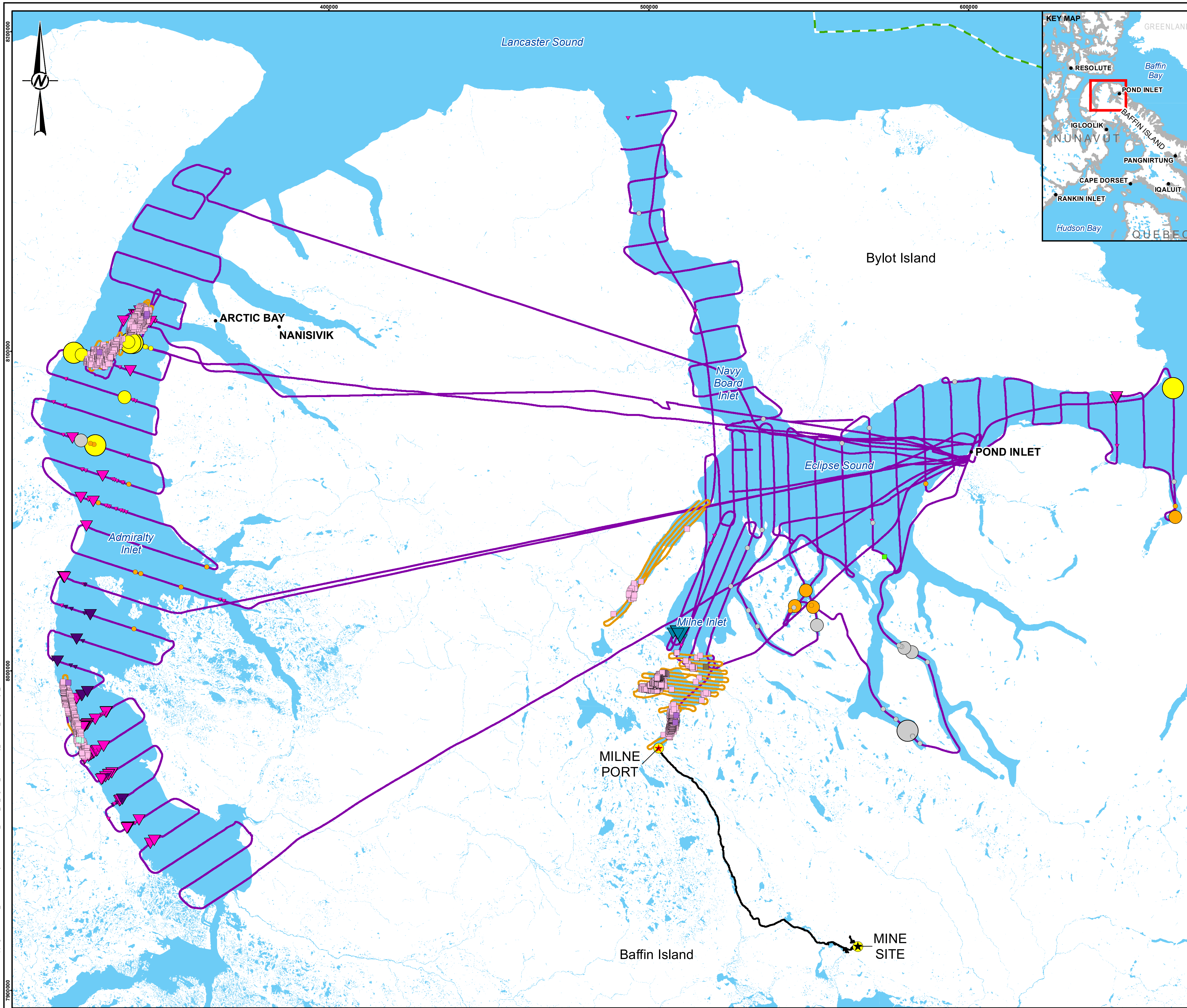
Admiralty Inlet Grid: Unidentified seals were recorded on Surveys 3, 4, and 5 of Leg 2 photographic surveys in the Admiralty Inlet grid (Figure 24A–B, Figure 25 A–B, and Figure 26 A–B). There was a total of 1,117 sightings and 4,232 individuals recorded during the Leg 2 photographic surveys (Table 14). Seal group sizes ranged from single animals to a group size of 202, with mean and median group size of 3.8 and 1.0, respectively.

3.2.5 Abundance Estimate

3.2.5.1 Visual Survey Data Characteristics

Separate density analyses were conducted for each survey. When appropriate, sightings data from combined datasets supplemented one another to provide for more robust models of probability detection functions (i.e., data from Leg 1 and Leg 2 in the Eclipse Sound grid). Re-sightings were not used for the estimation of any variables.

Separate detection functions were created for each species (narwhal and bowhead whale) and for each area (Eclipse Sound and Admiralty Inlet grids), for a total of four detection functions. Sightings data was pooled between dates to increase sample size in order to meet the assumptions of the detection probability model, but only if the spatial distribution of species detections (sightings) were similar between those days (i.e., the ability to detect animals at a distance did not change under the available sighting conditions, including altitude). Combining survey data for days with apparent variability in detectability can skew findings and result in either an over- or under-estimation of true animal density for a specific date. Environmental conditions were good for all the surveys chosen to calculate abundances. Survey data collected from survey days within each area (Eclipse Sound and Admiralty Inlet grids) were combined to increase the sample size of that detection function.



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BELUGA
- BOWHEAD
- NARWHAL
- SEAL

VISUAL SURVEY MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1
- 2 - 10

HARP SEAL
- 1
- 2 - 10
- 10+

KILLER WHATE
- 1
- 2 - 10
- 10+

NARWHAL
- 1
- 2 - 10

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2 - 10

UNIDENTIFIED SEAL/PINNIPED
- 1
- 2 - 10
- 10+

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 25 50
1:1,200,000 KILOMETRES

NOTE(S)

1. CONDITIONS GOOD WITH BF 0-3 FOR MUCH OF THE SURVEY AREA AND NO FOG. BF 4-5 ENCOUNTERED ON EASTERN THREE TRANSECTS IN ECLIPSE SOUND. NARWHALS CONCENTRATED IN SOUTHERN END OF TREMBLAY SOUND AND DISPERSED THROUGHOUT SOUTH MILNE INLET/KOLUKTOO BAY AREA.
2. CONDITIONS GOOD WITH BF 0-3 AND FOG ON THREE OF THE NORTHERN TRANSECTS. NARWHALS CONCENTRATED IN THE SOUTHERN PORTION OF ADMIRALTY INLET ALONG THE WESTERN SHORE AND IN THE CENTRAL PORTION OF THE INLET CLOSE TO ARCTIC BAY. FOUR PHOTOGRAPHIC SURVEYS WERE FLOWN.

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

TITLE
DISTRIBUTION OF MARINE MAMMAL SPECIES DURING LEG 2, SURVEY 3 ON AUGUST 21-22, 2019 IN THE ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	KK
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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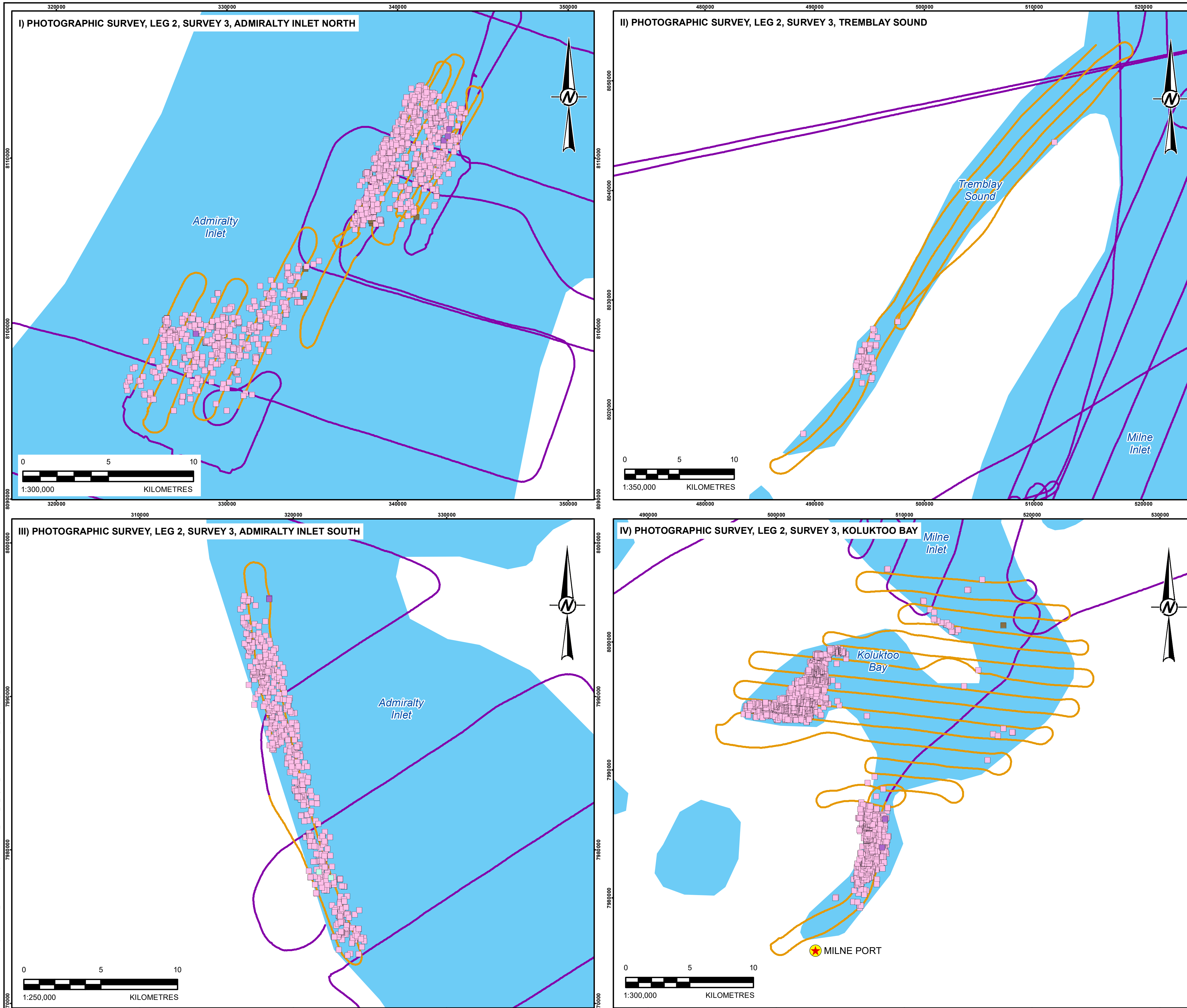


LEGEND

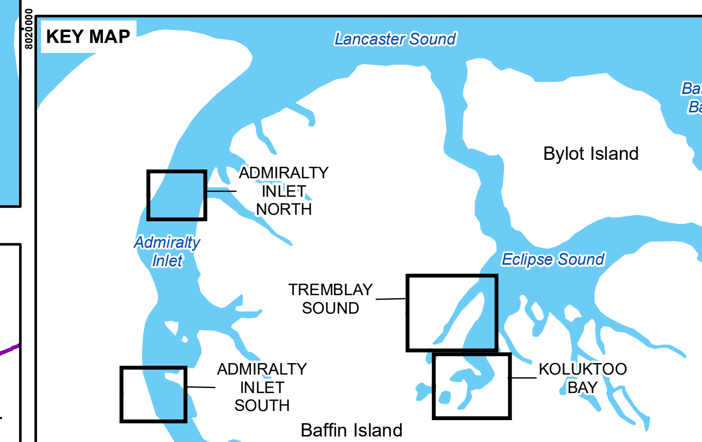
- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BELUGA
- BOWHEAD
- NARWHAL
- SEAL

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- WATERBODY



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PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
PHOTOGRAPHIC SURVEYS DURING LEG 2, SURVEY 3 ON AUGUST 21-22, 2019 IN THE ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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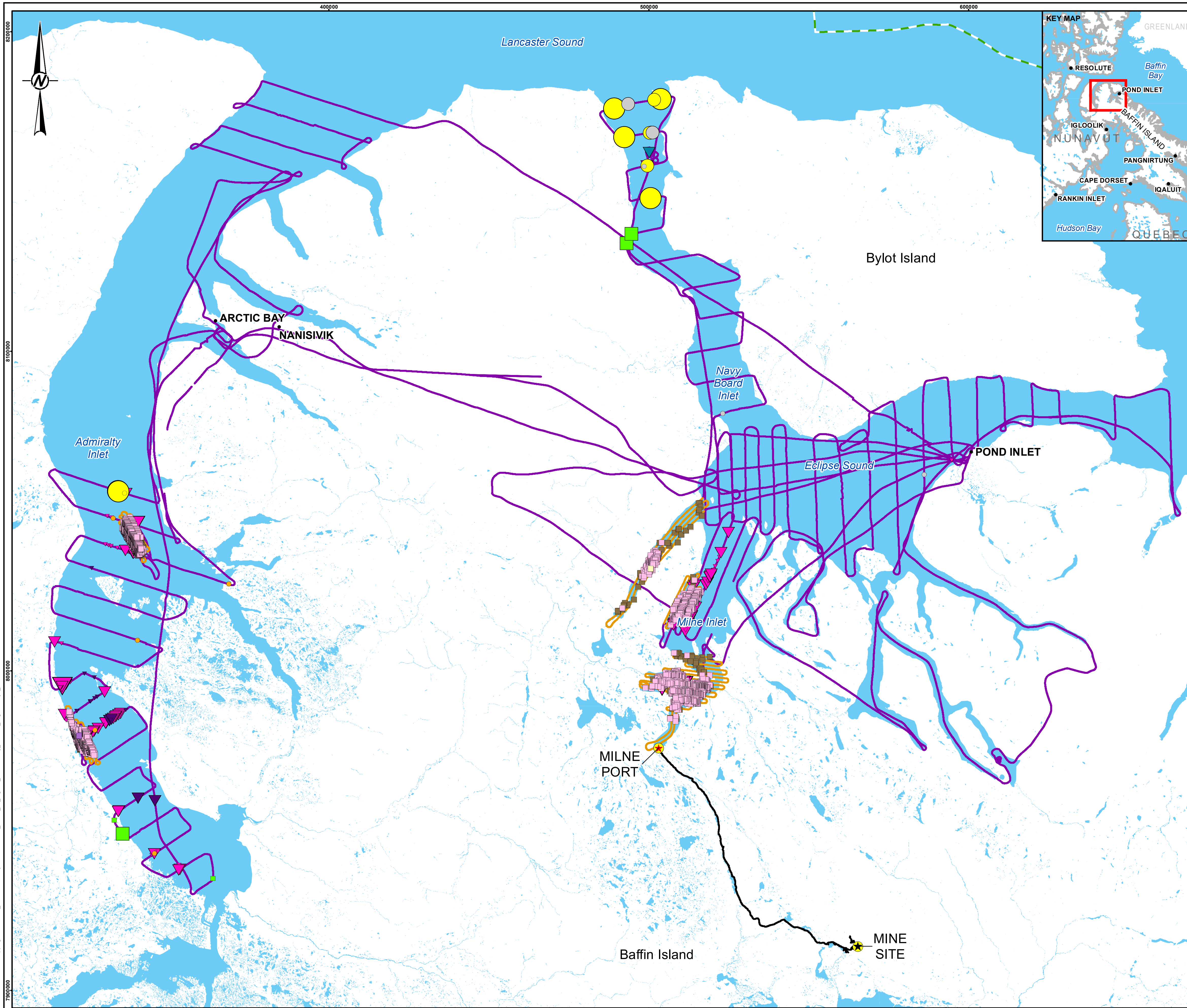

LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD
- NARWHAL
- POLAR BEAR
- SEAL

VISUAL SURVEY MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE

- 1
- 2 - 10

HARP SEAL

- 1
- 2 - 10
- 10+

KILLER WHATE

- 2 - 10

NARWHAL

- 1
- 2 - 10
- 10+

POLAR BEAR

- 1
- 2 - 10

RINGED SEAL

- 1

UNIDENTIFIED SEAL/PINNIPED

- 1
- 2 - 10

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 25 50

1:1,200,000 KILOMETRES

NOTE(S)

1. CONDITIONS GOOD WITH BF 0-3 FOR MUCH OF THE SURVEY AREA AND NO FOG. BF 4-5 ENCOUNTERED ON EASTERN PORTION OF ECLIPSE SOUND AND PORTIONS OF NAVY BOARD INLET. NARWHALS CONCENTRATED IN THE CENTRAL PORTION OF TREMBLAY SOUND AND DISPERSED THROUGHOUT SOUTH MILNE INLET/KOLUKTOO BAY AREA. KILLER WHALES OBSERVED IN NORTHERN NAVY BOARD INLET.
2. CONDITIONS MODERATE WITH BF 0-5 AND NO FOG. NARWHALS CONCENTRATED IN THE SOUTHERN PORTION OF ADMIRALTY INLET ALONG THE WESTERN SHORE AND IN THE CENTRAL PORTION OF THE INLET NORTH OF YEOMAN ISLAND. TWO PHOTOGRAPHIC SURVEYS WERE FLOWN.

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

TITLE
DISTRIBUTION OF MARINE MAMMAL SPECIES DURING LEG 2, SURVEY 4 ON AUGUST 25-27, 2019 IN THE ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	KK
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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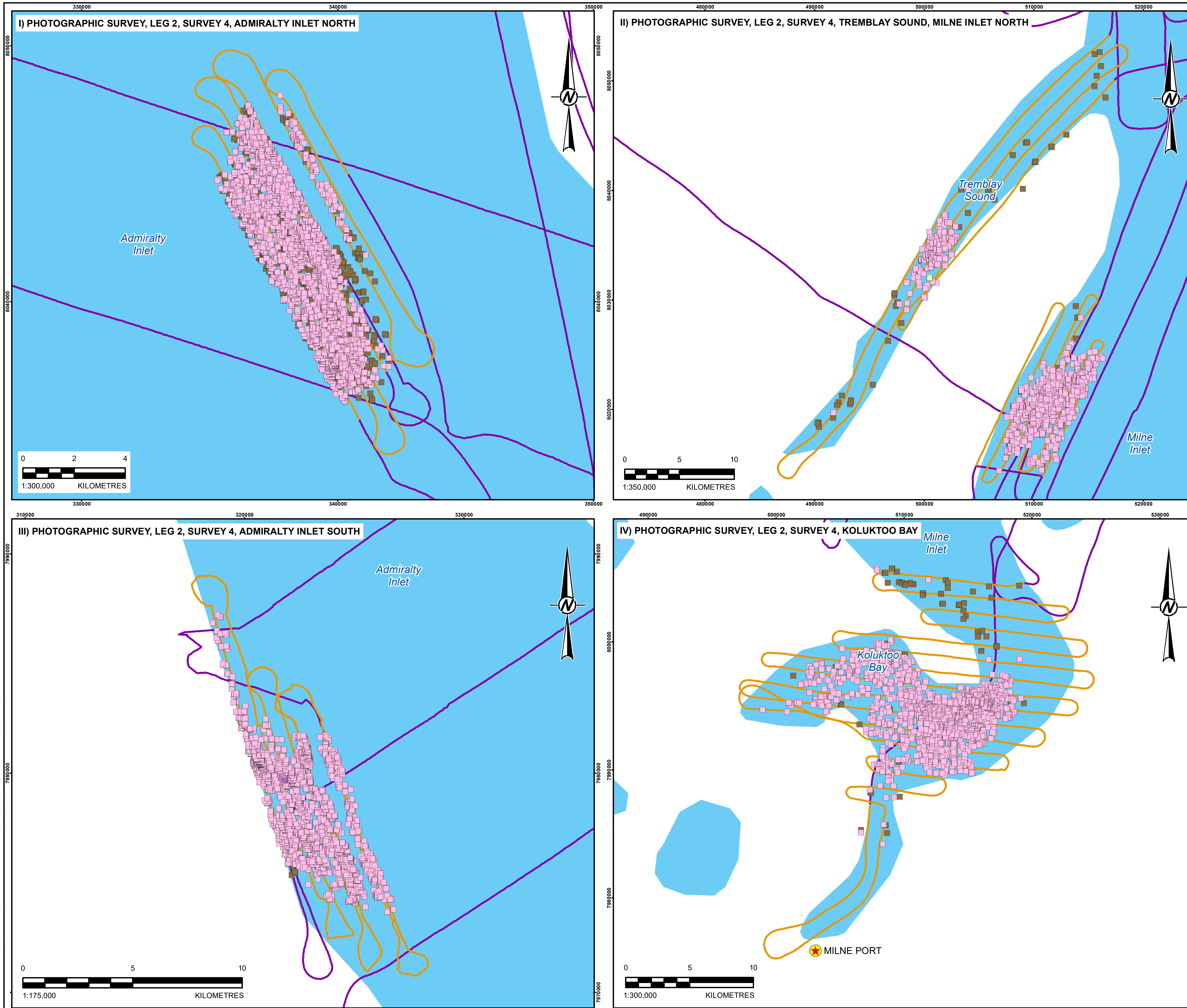


LEGEND

- COMMUNITY
- MILNE PORT

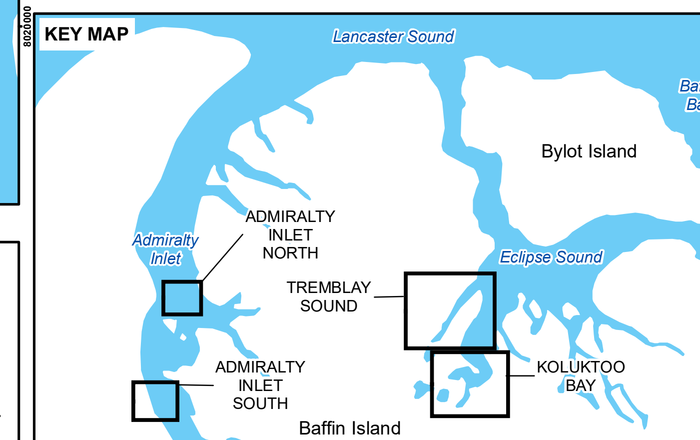
PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD
- NARWHAL
- POLAR BEAR
- SEAL

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- WATERBODY

KEY MAP



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PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

TITLE
PHOTOGRAPHIC SURVEYS DURING LEG 2, SURVEY 4 ON AUGUST 25-27, 2019 IN THE ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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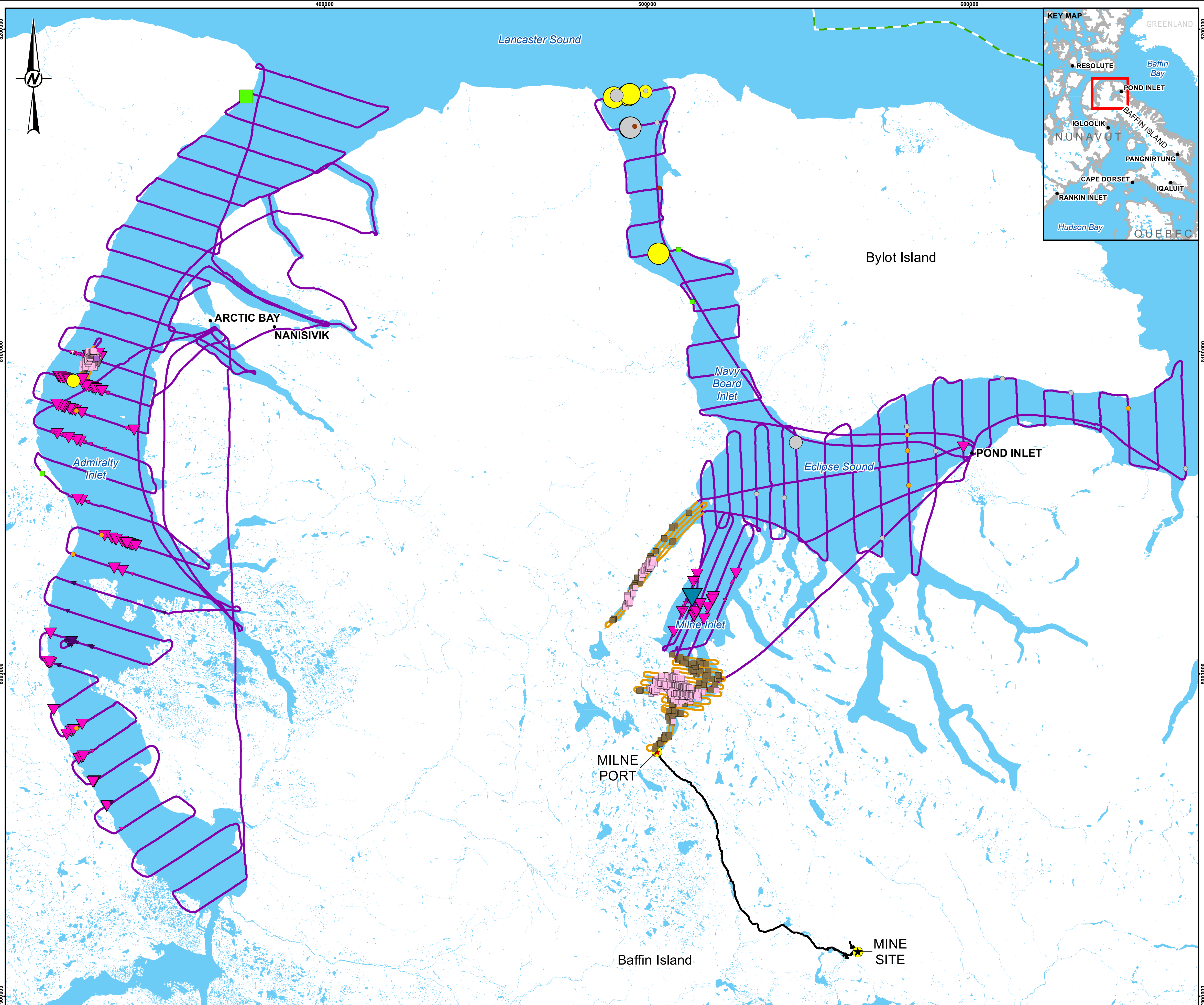

LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD
- NARWHAL
- SEAL

VISUAL SURVEY MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BOWHEAD WHALE
- 1
- 2 - 10

HARP SEAL
- 1
- 2 - 10
- 10+

KILLER WHATE
- 10+

NARWHAL
- 1
- 2 - 10
- 10+

POLAR BEAR
- 1
- 2 - 10

RINGED SEAL
- 1

UNIDENTIFIED SEAL/PINNIPED
- 1
- 2 - 10
- 10+

UNIDENTIFIED WHALE/CETACEAN
- 1

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 25 50
1:1,200,000 KILOMETRES

NOTE(S)
1. CONDITIONS GOOD WITH BF 0-3 FOR MUCH OF THE SURVEY AREA AND NO FOG. BF 4 ENCOUNTERED ON PORTIONS OF EASTERN ECLIPSE SOUND. NARWHALS CONCENTRATED IN THE CENTRAL PORTION OF TREMBLAY SOUND AND DISPERSED THROUGHOUT SOUTH MILNE INLET/KOLUKTOO BAY AREA. KILLER WHALES OBSERVED IN NORTH MILNE INLET.
2. CONDITIONS MODERATE WITH BF 0-5 AND FOG ON PORTIONS OF THE NORTHERN FOUR TRANSECTS. NARWHALS CONCENTRATED IN THE CENTRAL PORTION OF ADMIRALTY INLET. ONE PHOTOGRAPHIC SURVEY WAS FLOWN.

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

TITLE
DISTRIBUTION OF MARINE MAMMAL SPECIES DURING LEG 2, SURVEY 5 ON AUGUST 29-30, 2019 IN THE ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	KK
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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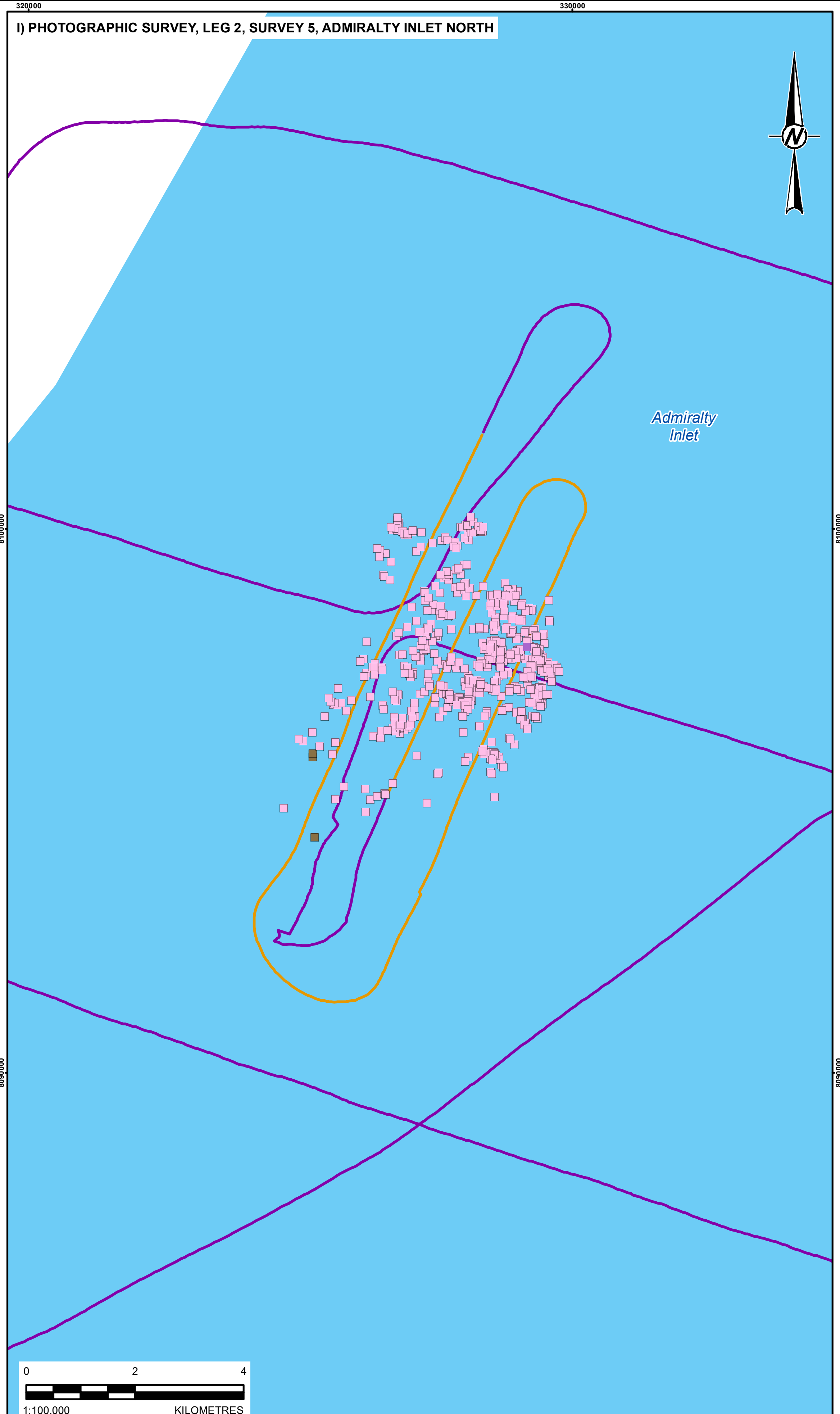
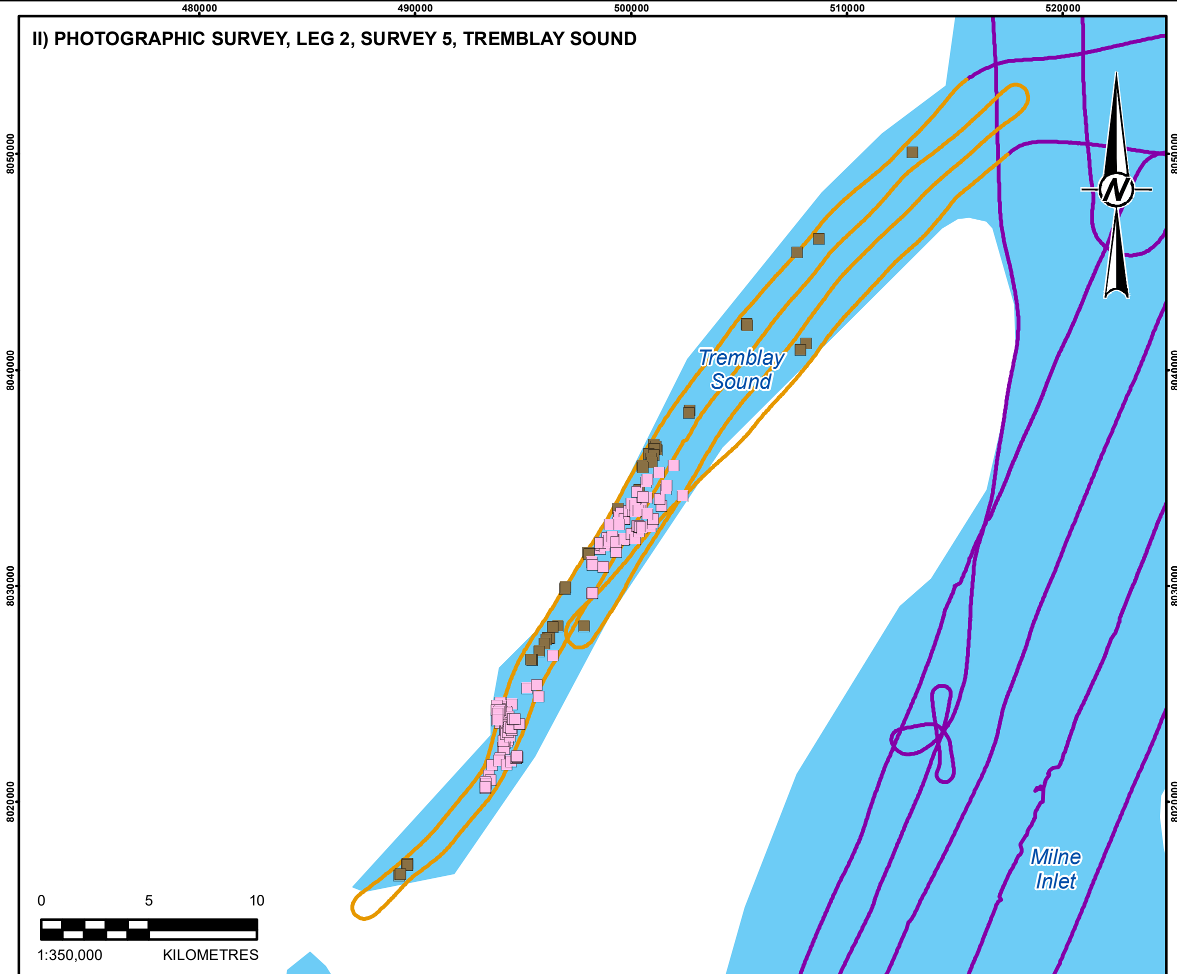
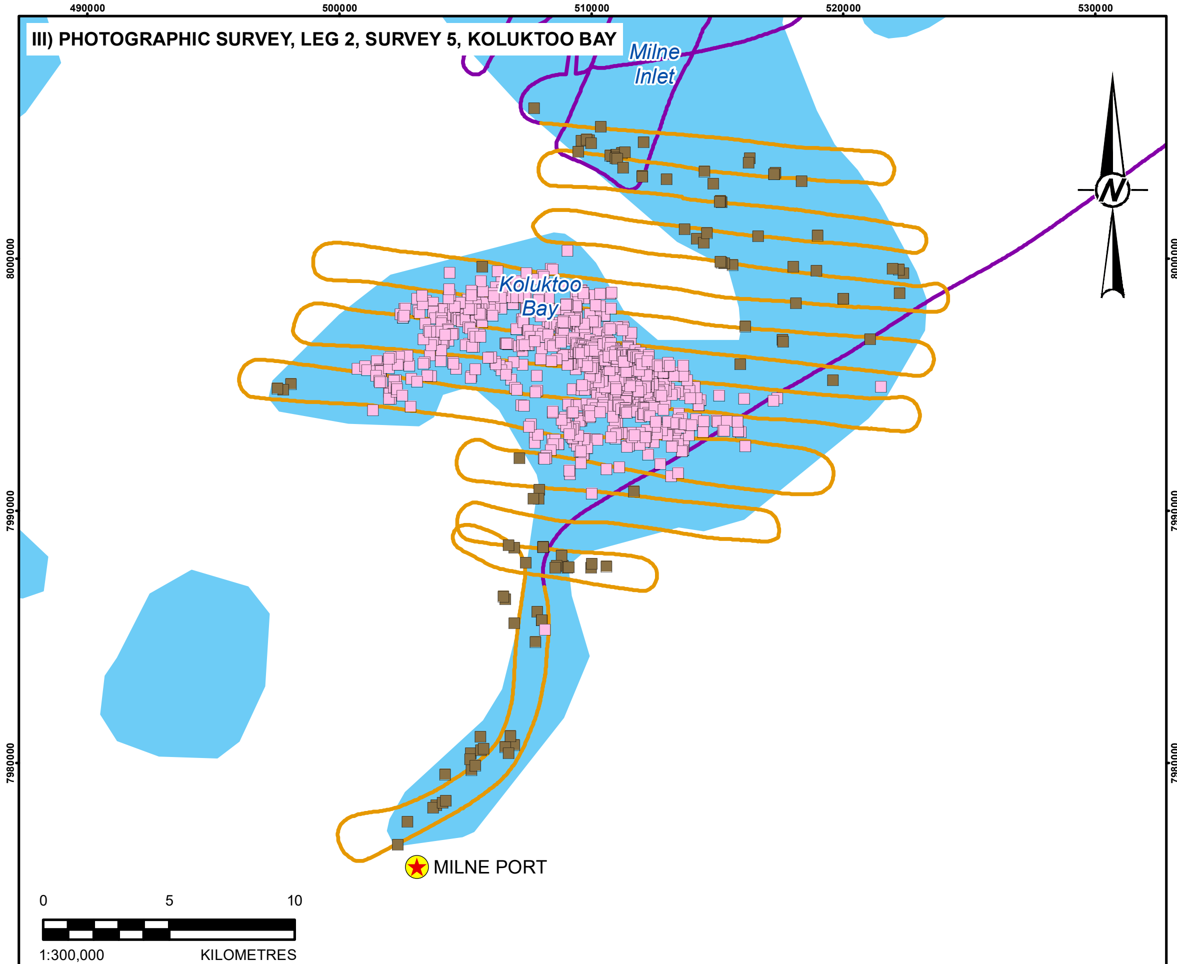






LEGEND

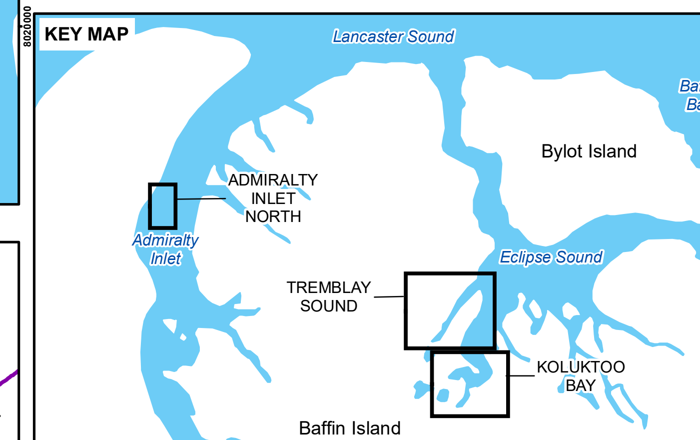
- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD
- NARWHAL
- SEAL

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- WATERBODY



REFERENCE(S)
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

TITLE
PHOTOGRAPHIC SURVEYS DURING LEG 2, SURVEY 5 ON AUGUST 29-30, 2019 IN THE ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000-07	0	26-B

Analysis of sightings data was performed using the Mark-Recapture Distance Sampling (MRDS) analysis package (Laake et al. 2018) within R version 3.6.2 (R Core Team 2019). 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 was applied to the gamma detection function data since that key function assumes zero detections at zero distance. Environmental and observer covariates were included for fitting the detection function and mark-recapture models. Models were selected using the minimum AIC (Akaike's Information Criterion).

Narwhal

The combined narwhal sightings (n=414) for the Eclipse Sound survey grid from both the early shoulder season survey (Leg 1) and the open-water season survey (Leg 2) were used for estimating the detection function and mark-recapture detection probabilities for narwhal in Eclipse Sound (Figure 27). This was because sample sizes for the open-water period alone were too low to reliably estimate these parameters (n=64). Examination of the histogram of the perpendicular distances of unique sightings suggested right-truncating the data at 1,200 m (i.e., discarding sightings beyond 1,200 m).

Model selection was performed on the three key functions and all the combinations of environmental covariates. A gamma key function with an offset of 30 m and covariates for glare rank, aircraft side and Beaufort scale had the lowest AIC for detection function models: (g(x)=0.42 and CV=0.04%; Appendix E).

Selection among mark-recapture models was performed on all combinations of environmental covariates. The lowest AIC was a model with covariates for the number of observer sightings in the previous 30 seconds, and the interaction between aircraft side and observer (Appendix E). It resulted in a p(0) of 0.60 for observers 1 (Figure 28) and 0.38 for observers 2 (Figure 29), and a combined p(0) of 0.74 and (CV=0.07). The combined models resulted in a detection probability of 0.31 (CV=0.07).

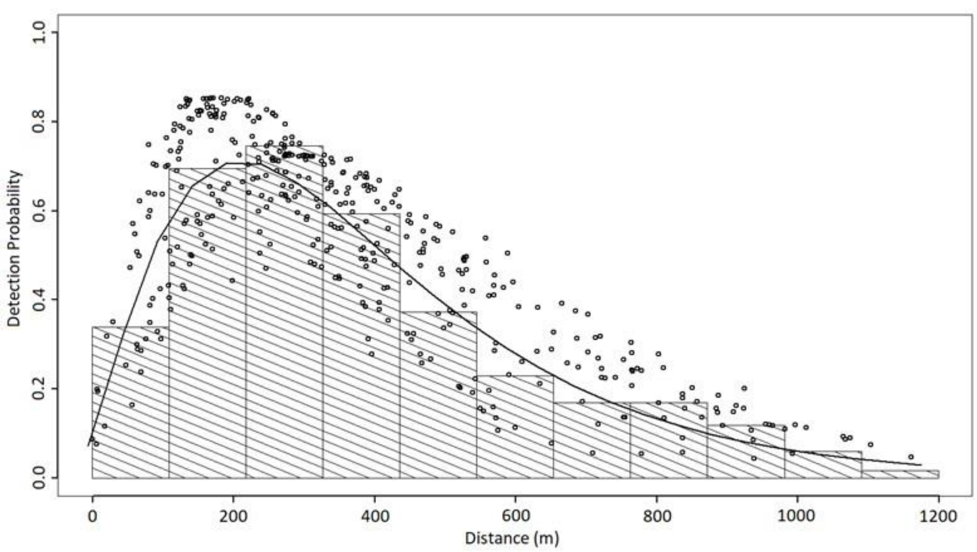


Figure 27: Histogram showing perpendicular distances of narwhal sightings in Eclipse Sound survey grid. Note: Fitted gamma detection function is shown with right truncation at 1,200 m (no left truncation). O = probability of detection for each sighting based on perpendicular distance and other covariates.

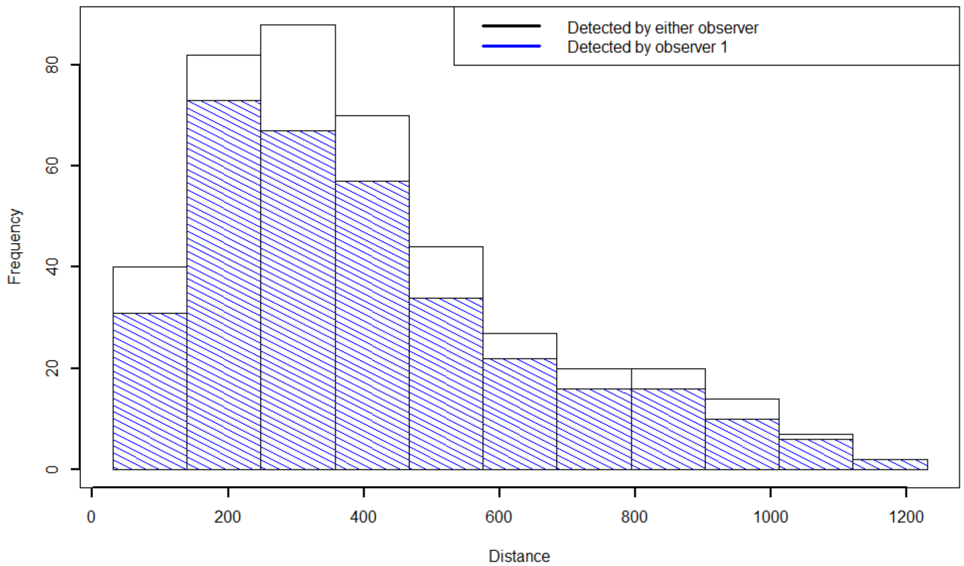


Figure 28: Distribution of narwhal sightings distances for Observer 1 and Combined (Observers 1 and 2) in Eclipse Sound survey grid

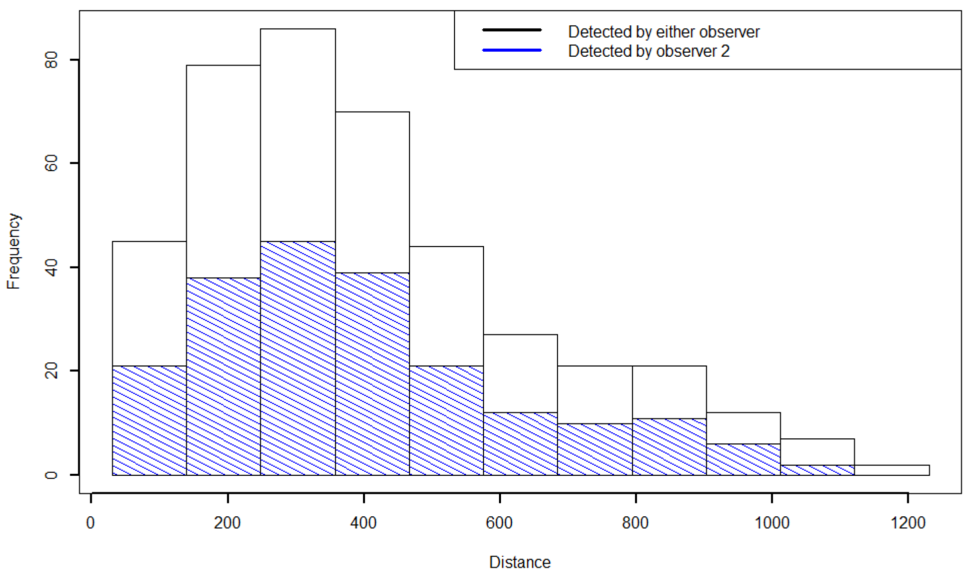


Figure 29: Distribution of narwhal sightings distances for Observer 2 and Combined (Observer 1 and 2) in Eclipse Sound survey grid

Narwhal sightings (n=473) for the Admiralty Inlet survey grid were used for estimating the detection function and mark-recapture detection probabilities for narwhal in Admiralty Inlet (Figure 30). Examination of the histogram of the perpendicular distances of unique sightings suggested right-truncating the data at 900 m (i.e., discarding sightings beyond 900 m). Model selection was performed on the three key functions and all the combinations of environmental covariates. A gamma key function with an offset of 45 m and covariates for the interaction between observer and Beaufort scale, glare rank, the number of observer sightings in the previous 30 seconds had the lowest AIC for detection function models: (g(x)=0.39 and CV=0.03; Appendix E).

Selection among mark-recapture models was performed on all combinations of environmental covariates. The lowest AIC was a model with covariates for observer, the number of observer sightings in the previous 30 seconds, and aircraft side (Appendix E). It resulted in a p(0) of 0.60 for observers 1 (Figure 31) and 0.16 for observers 2 (Figure 32), and a combined (p(0)= 0.64 and CV=0.17%). The combined models resulted in a detection probability of 0.25 (CV=0.16).

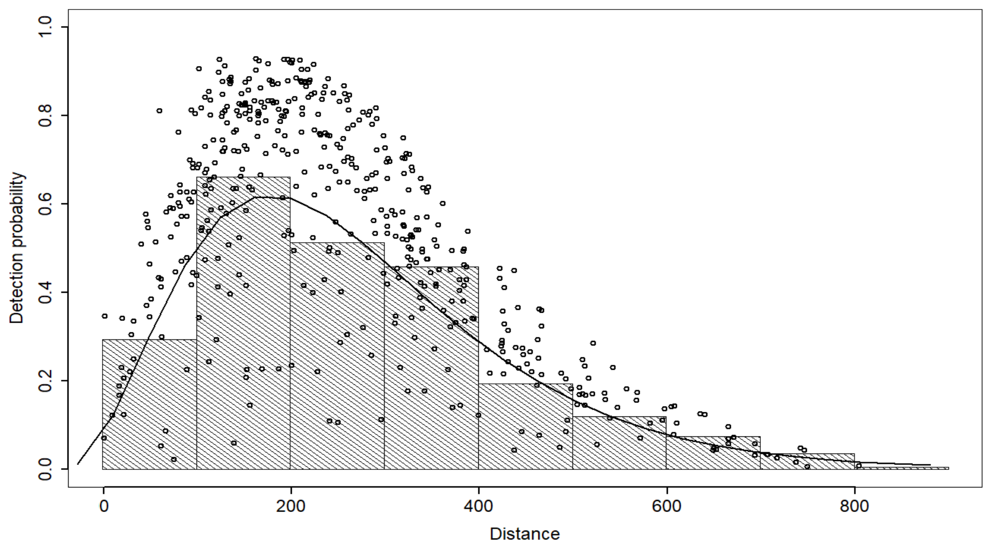


Figure 30: Histogram showing perpendicular distances of narwhal sightings in Admiralty Inlet survey grid. Note: Fitted gamma detection function is shown with right truncation at 900 m (no left truncation). O = probability of detection for each sighting based on perpendicular distance and other covariates.

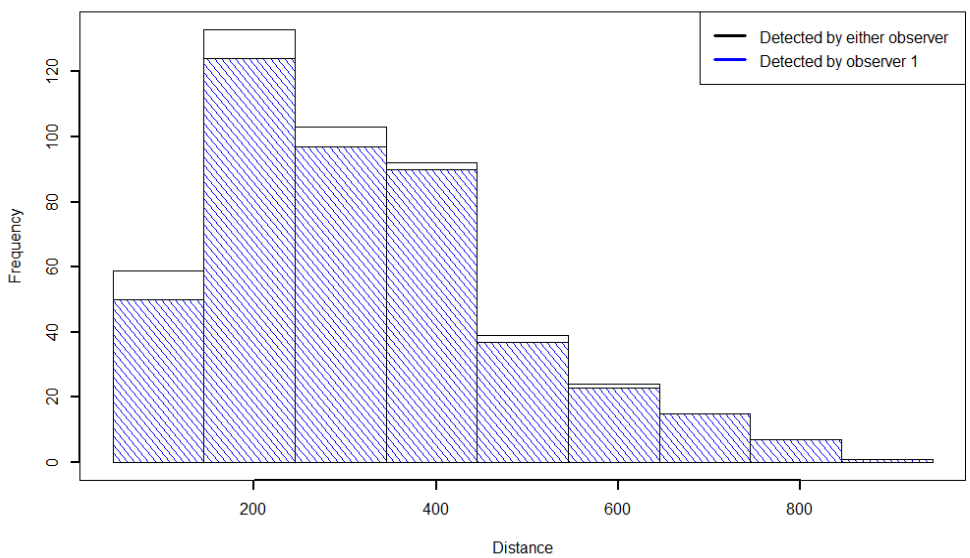


Figure 31: Distribution of narwhal sightings distances for Observer 1 and Combined (Observers 1 and 2) in Admiralty Inlet survey grid.

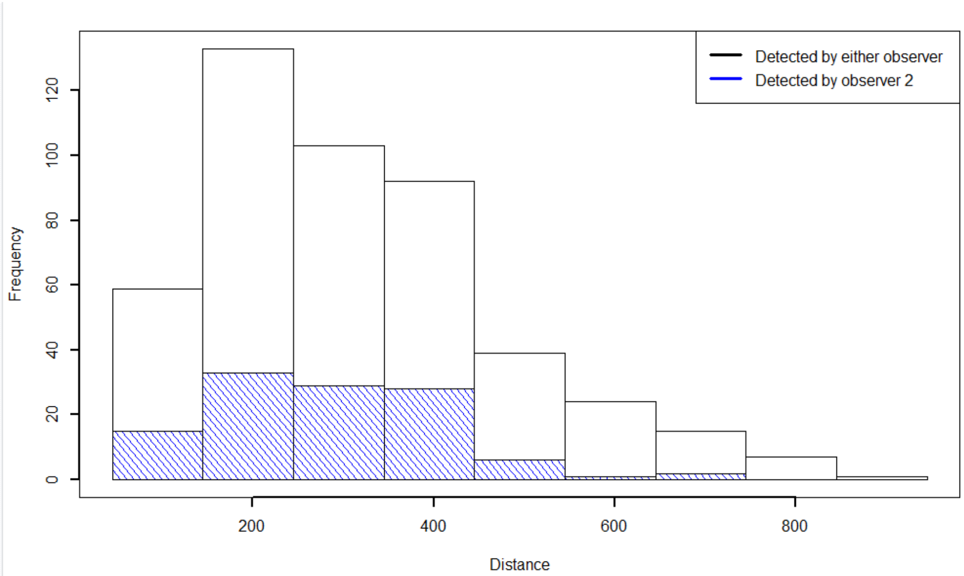


Figure 32: Distribution of narwhal sightings distances for Observer 2 and Combined (Observer 1 and 2) in Admiralty Inlet survey grid

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. 2015; Watt et al. 2015a).

Bowhead Whale

The combined bowhead sightings (n=49) for the Eclipse Sound survey grid from both the early shoulder season survey (Leg 1) and the open-water season survey (Leg 2) were used for estimating the detection function and mark-recapture detection probabilities for bowhead whale (Figure 33). This was because sample sizes for the open-water period alone were too low to reliably estimate these parameters (n=1). Examination of the histogram of the perpendicular distances of unique sightings suggested right-truncating the data at 1,700 m (i.e., discarding sightings beyond 1,700 m).

Model selection was performed on the three key functions and all the combinations of environmental covariates. A hazard rate key function with an offset of 0 m and covariates for the interaction between glare rank and glare angle had the lowest AIC for detection function models: (g(x)=0.46 and CV=0.25; Appendix E). Selection among mark-recapture models was performed on all combinations of environmental covariates. The lowest AIC was a model with covariates for distance and the interaction between observer and side (Appendix E). It resulted in a p(0) of 0.65 for observers 1 (Figure 34) and 0.25 for observers 2 (Figure 35), and a combined p(0) of 0.73 and (CV=0.21). The combined models resulted in a detection probability of 0.34 (CV=0.33).

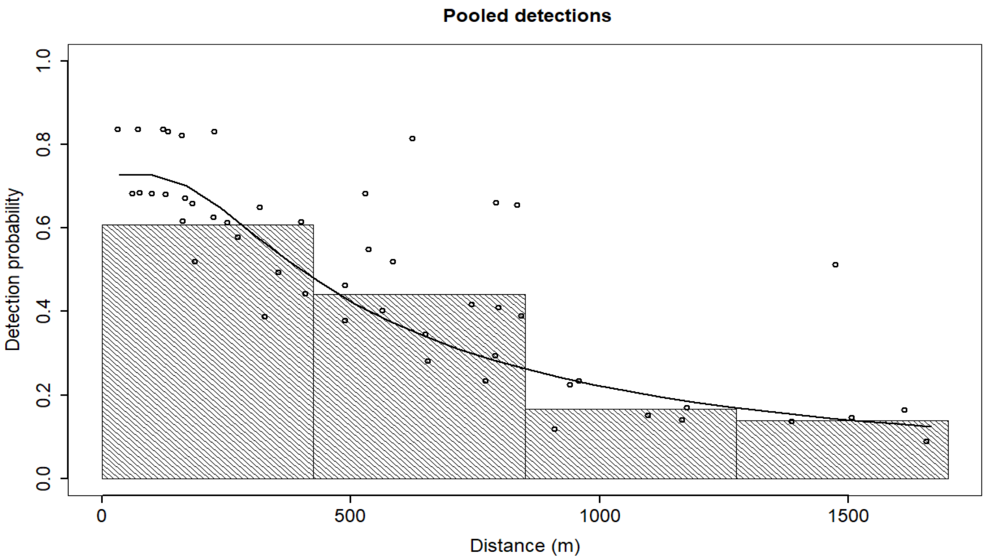


Figure 33: Histogram showing perpendicular distances of bowhead whale sightings in Eclipse Sound survey grid. Note: Hazard rate detection function is shown with right truncation at 1,700 m (no left truncation). O = probability of detection for each sighting based on perpendicular distance and other covariates.

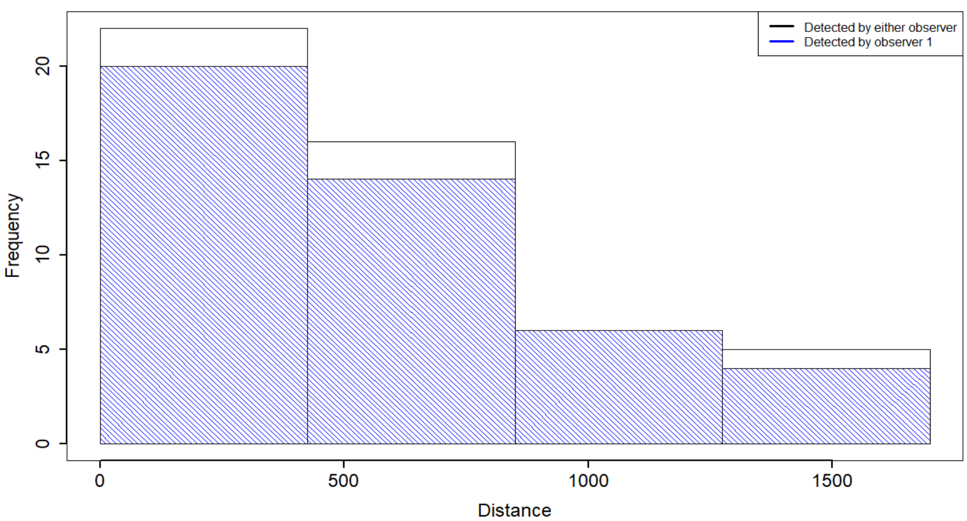


Figure 34: Distribution of bowhead whale sightings distances for Observer 1 and Combined (Observers 1 and 2) in Eclipse Sound survey grid.

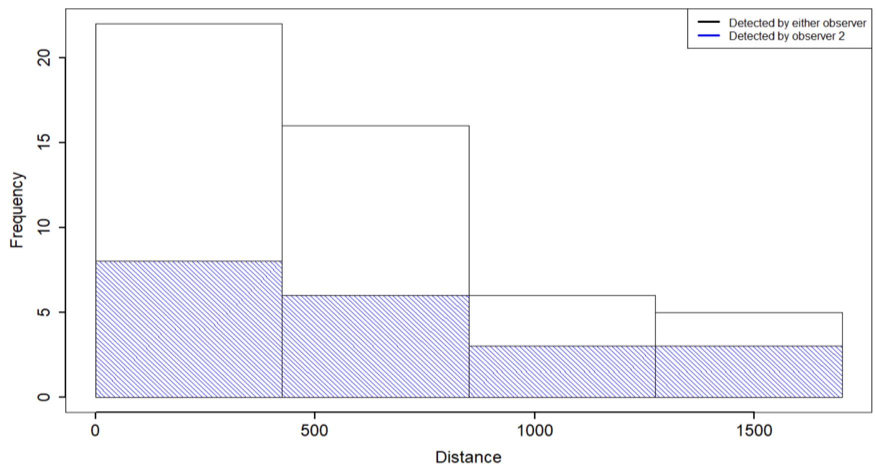


Figure 35: Distribution of bowhead whale sightings distances for Observer 2 and Combined (Observers 1 and 2) in Eclipse Sound survey grid.

Bowhead sightings (n=56) for the Admiralty Inlet survey grid were used for estimating the detection function and mark-recapture detection probabilities for bowhead whale (Figure 36). Examination of the histogram of the perpendicular distances of unique sightings suggested right-truncating the data at 1,500 m (i.e., discarding sightings beyond 1,500 m).

Model selection was performed on the three key functions and all the combinations of environmental covariates. A gamma key function with an offset of 0 m and covariate for Beaufort scale had the lowest AIC for detection function models: (g(x)=0.37 and CV=0.10; Appendix E). Selection among mark-recapture models was performed on all combinations of environmental covariates. The lowest AIC was a model with covariates for observer, distance, and glare rank (Appendix E). It resulted in a p(0) of 0.84 for observers 1 (Figure 37) and 0.60 for observers 2 (Figure 38), and a combined (p(0)=0.92 and CV=0.07). The combined models resulted in a detection probability of 0.35 (CV=0.14).

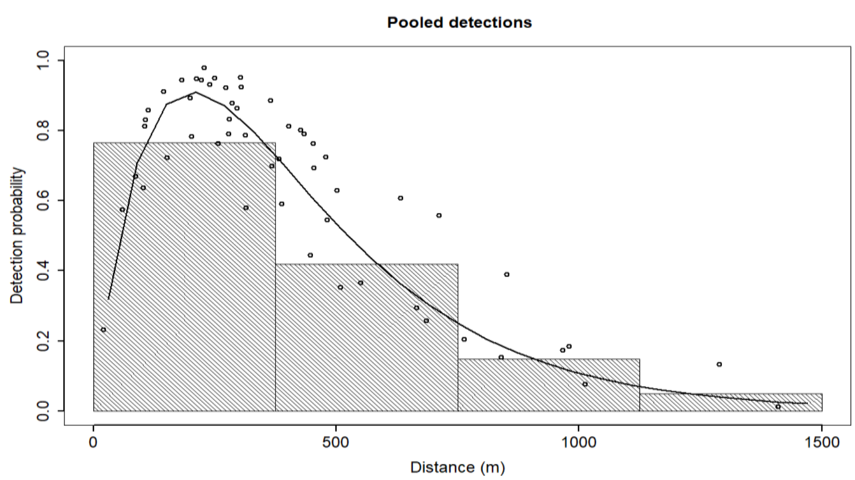


Figure 36: Histogram showing perpendicular distances of bowhead whale sightings in Admiralty Inlet survey grid. Note: Fitted gamma detection function is shown with right truncation at 1,500 m (no left truncation). O = probability of detection for each sighting based on perpendicular distance and other covariates.

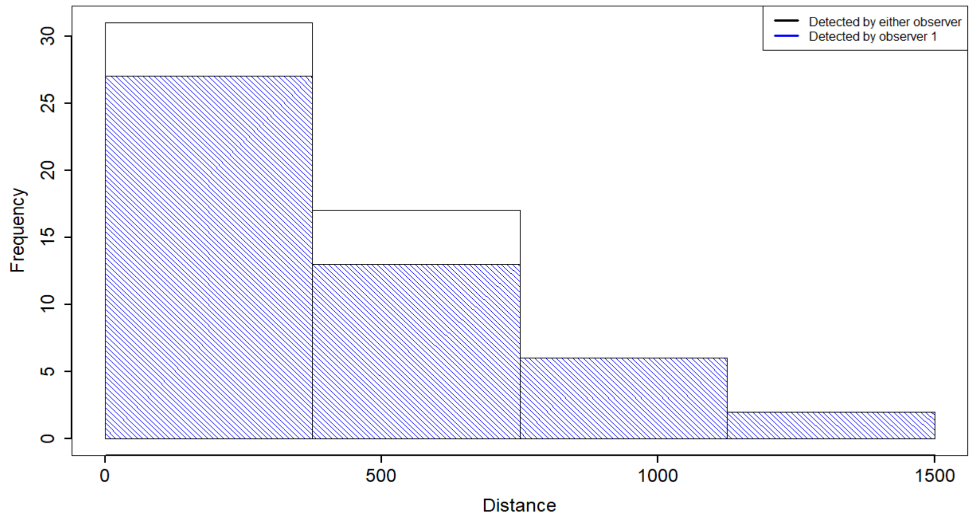


Figure 37: Distribution of bowhead whale sightings distances for Observer 1 and Combined (Observers 1 and 2) in Admiralty Inlet survey grid.

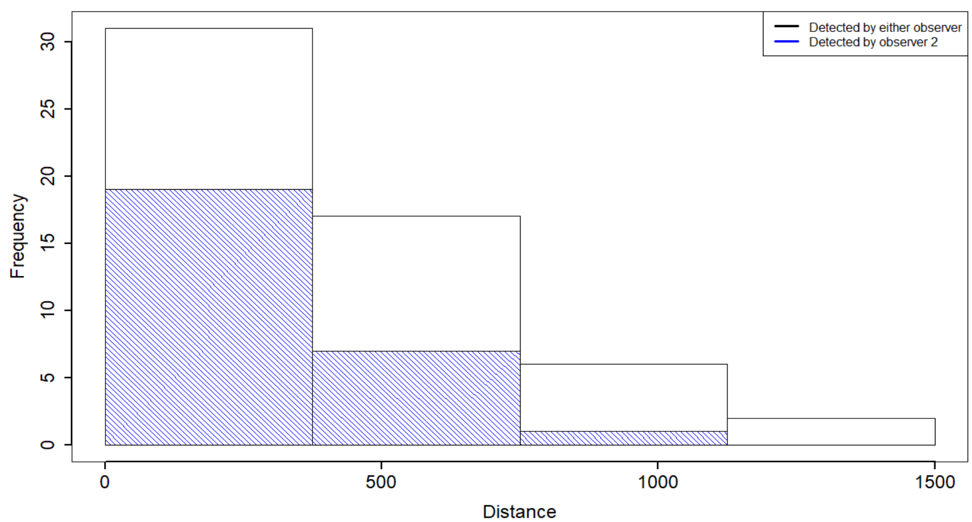


Figure 38: Distribution of bowhead whale sightings distances for Observer 2 and Combined (Observers 1 and 2) in Admiralty Inlet survey grid.

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 (4.12, CV=0.21 for mid August and 3.98, CV=0.21 for late August), based on previously reported bowhead whale dive data (Watt et al. 2015b) was applied to the data to account for potential availability bias for this species.

3.2.5.2 Photographic Survey Data Characteristics

For the assessment of reliability and repeatability of the photographic data, a simple linear regression of the comparison of the trained photo reader with the photo trainer was run. Repeat counts of 313 photos were highly correlated (simple linear regression; $R^2 = 0.959$, $F_{1,311} = 7.216 \times 10^3$, $p < 0.0001$). Counts for the first and repeat reads were the same for 273 of the 313 photos, differed by one for 37 photos, and by two for three photos. The original counts were kept for the abundance analysis.

For the assessment of the reliability and repeatability of the photographic data between the trained photo reader and the trained Inuit researcher, a simple linear regression was run. For the first survey analyzed, repeat counts of 593 photos were highly correlated (simple linear regression; $R^2 = 0.872$, $F_{1,591} = 4.027 \times 10^3$, $p < 0.0001$). Counts for the first and repeat reads were the same for 461 of the 593 photos, differed by one for 102 photos, by two for 22 photos, by three for two photos, by four for five photos, and by six for one photo. The original counts were kept for the abundance analysis. For the second survey re-analyzed, repeat counts of 134 photos were highly correlated (simple linear regression; $R^2 = 0.970$, $F_{1,132} = 4.338 \times 10^3$, $p < 0.0001$). Counts for the first and repeat reads were the same for 96 of the 134 photos, differed by one for 21 photos, by two for eight photos, by three for three photos, by four for four photos, by six for one photo, and by seven for one photo. The original counts were kept for the abundance analysis.

On average, 2.1 % of the photos had murky water (Table 7, Table 16, and Table 19), 0.6 % of the photos had ice (Table 7), and 16.0 % of the photos had glare (Table 7, Table 16, and Table 19). Photographs overlapped by an average of 52.0 % (Figure 39).

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 40 and Figure 41). 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 narwhals 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 305 m (1000 ft) resulted in a probability of detection of 0.8579 ($C_d =$ detectability bias correction factor of 1.17, n=571), CV=0.03 (Figure 40). A hazard rate key function with no adjustments had the lowest AIC of 6863.56 for the detection function model.

A detection model fitted to the photographic data for two surveys flown at 610 m (2000 ft) resulted in a probability of detection of 0.8323 ($C_d =$ detectability bias correction factor of 1.20, n=987), CV=0.02 (Figure 41). A hazard rate key function with no adjustments had the lowest AIC of 13271.78 for the detection function model. Note there is a noticeable drop close to the track line in narwhal sightings, which is counter intuitive given the better photo resolution closer to the track line. Clumping behaviour of narwhal could be the contributing factor. A visual inspection of sightings in the survey (Figure 26BI) showed clumping of narwhal between the track lines and less sightings on the track line.

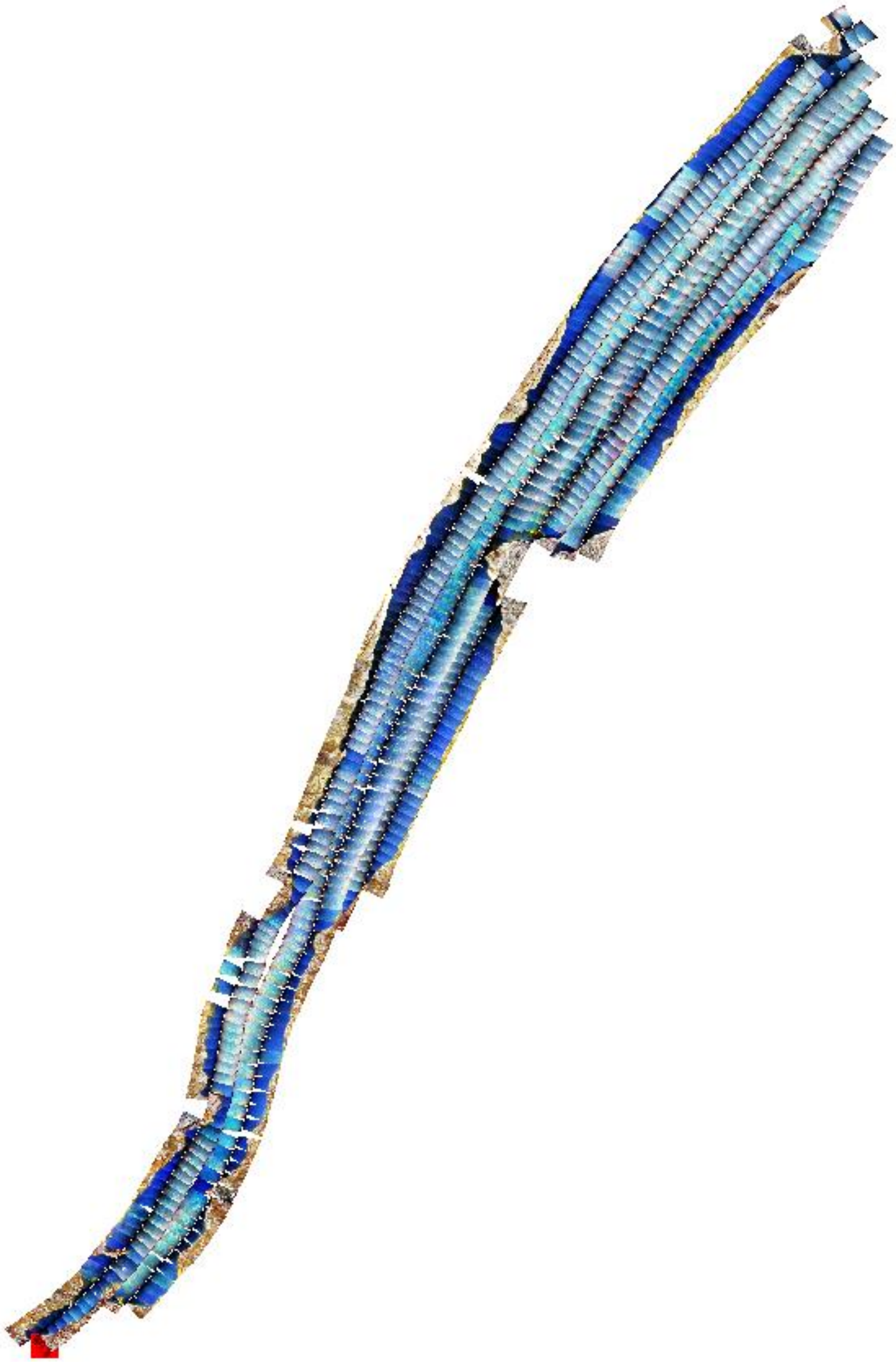


Figure 39: Photographic survey of Tremblay Sound stratum on 21 August 2019 showing footprint of each photograph.

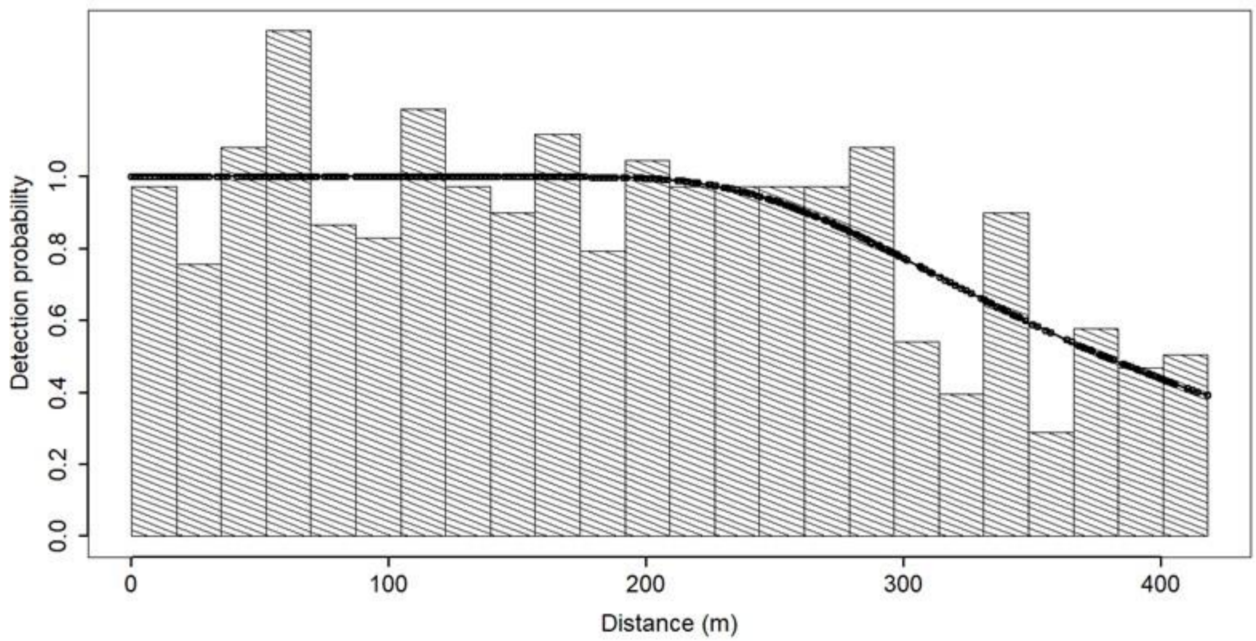


Figure 40: Detection Function for Photographic Survey Data at 305 m (1000 ft).

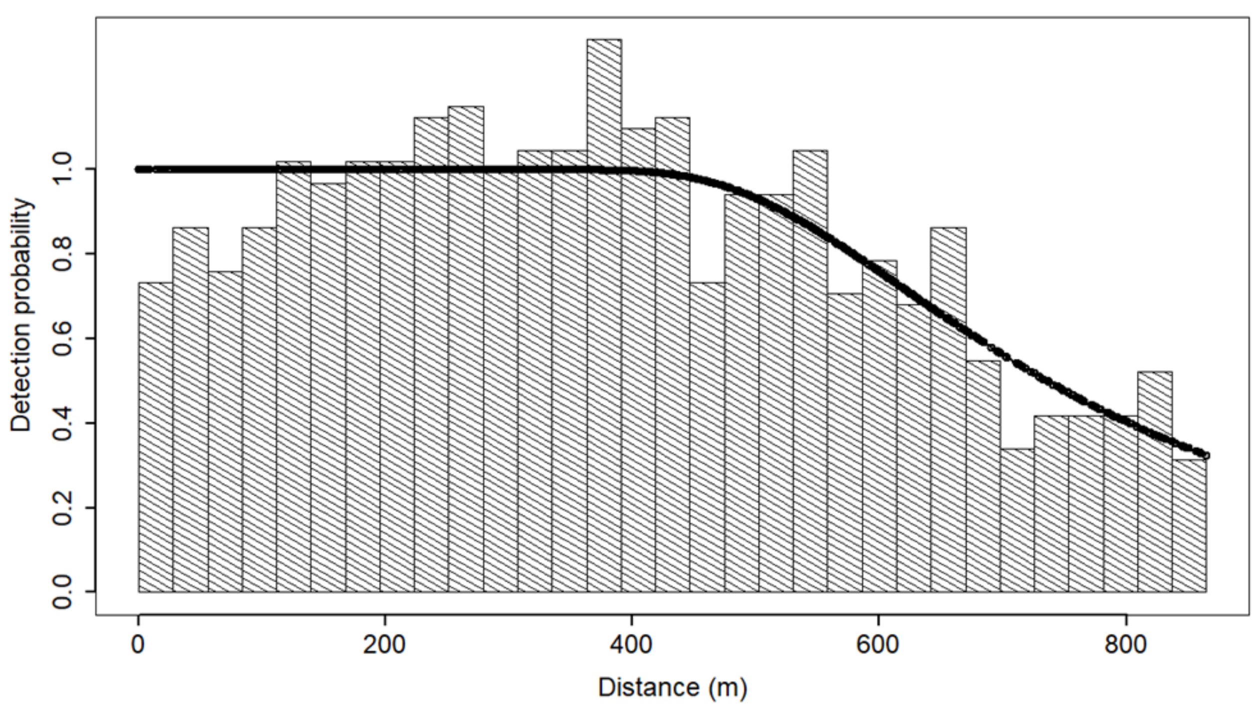


Figure 41: Detection Function for Photographic Survey Data at 610 m (2000 ft).

3.2.5.3 Narwhal Abundance

3.2.5.3.1 Eclipse Sound Stock

Overall, there were 73 narwhal sightings for Surveys 3, 4 and 5 combined (Table 15). Three of the sightings were missing perpendicular distances and could not be recovered with the photographs.

During Survey 3 (21–22 August), a total of 1,070.8 km of transects were visually surveyed (Table 15). The total count of narwhal sightings observed on-effort in the visual survey area was seven sightings before and after truncation (Table 15). Although variation of the abundance estimate was a combination of the variation from detection function, encounter rate, cluster size and availability bias, the overall variation in abundance estimates came primarily from the encounter rate, followed by cluster size component (Table 15). The total narwhal abundance for Survey 3 visual surveys was estimated at 223 narwhals (CV=0.40) (Table 15).

The total length of transect lines visually surveyed during Survey 4 (25–27 August) was 1,036.5 km (Table 15). The total count of narwhal sightings observed on-effort in the visual survey area was 30 sightings before and after truncation (Table 15). For this survey, the overall variation in abundance estimates came primarily from the encounter rate and/or cluster size component. The total narwhal abundance for Survey 4 visual surveys was estimated at 1,514 narwhals (CV=0.59) (Table 15).

During Survey 5 (29–30 August), a total of 944.9 km of transects were visually surveyed (Table 15). The total count of narwhal sightings observed on-effort in the visual survey area was 36 sightings before and after truncation (Table 15). Overall variation in abundance estimates came primarily from the encounter rate, followed by cluster size component. The total narwhal abundance for Survey 5 visual surveys was estimated at 1,090 narwhals (CV=0.25) (Table 15).

Table 15: 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
3	PI	1,381.3	147.8	2	2	110	0.72	77.3	21.6
3	ESE	2,066.5	233.7	1	1	14	1.17	99.6	0
3	ESW	841.0	181.2	0	0	—	—	—	—
3	MIN	681.3	158.0	3	3	51	0.40	96.7	0
3	NBI	2,007.8	163.2	1	1	48	0.68	98.9	0
3	Fjords	957.5	186.9	0	0	—	—	—	—
3	*Total*	—	*1,070.8*	*7*	*7*	*223*	*0.40*	—	—
4	PI	1,381.3	103.2	0	0	—	—	—	—

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
4	ESE	2,066.5	227.0	0	0	—	—	—	—
4	ESW	841.0	180.2	0	0	—	—	—	—
4	MIN	481.0	118.0	28	28	871	0.84	95.8	3.4
4	NB	2,007.8	158.7	2	2	643	0.79	52.6	46.6
4	Fjords	957.5	249.4	0	0	—	—	—	—
4	*Total*	—	*1,036.5*	*30*	*30*	*1,514*	*0.59*	—	—
5	PI	1,381.3	139.3	0	0	—	—	—	—
5	ESE	2,066.5	266.6	1	1	143	1.13	99.6	0
5	ESW	841.0	208.3	0	0	—	—	—	—
5	MIN	681.3	165.9	35	35	947	0.24	79.6	11.2
5	NB	2,007.8	164.8	0	0	—	—	—	—
5	*Total*	—	*944.9*	*36*	*36*	*1,090*	*0.25*	—	—

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

During Survey 3 (21 August), two photographic surveys were undertaken, one in Milne Inlet South (MIS) stratum and one in the Tremblay Sound (TS) stratum (Figure 24). A total of 2,100 photographs were taken to capture the narwhal aggregations in the two areas. The total area photographed was 441.14 km^2 (270.8 km^2 in MIS and 170.34 km^2 in TS; Table 16). The total count of narwhals in the photographed areas was 3,416 narwhals (3,176 in MIS and 240 in TS; Table 14). The sum of the area of the individual photographs totaled 467.2 km^2 in MIS and 304.6 km^2 in TS, resulting in an average density of 6.8 narwhals/km^2 in MIS and 0.8 narwhals/km^2 in TS. Multiplying the average density by the total area photographed resulted in a surface estimate of 1,841 narwhals in MIS and 132 narwhals in TS. The surface estimate was then corrected for availability bias using C_α=3.18 (correction from Watt et al. 2015a), and detectability bias of 1.20, resulting in a total narwhal estimate for the photographed areas for Survey 3 of 7,034 narwhals (CV=0.04) in MIS and 508 narwhals (CV=0.04) in TS (Table 16).

During Survey 4 (25–26 August), three photographic surveys were conducted in the Eclipse Sound study area in each of the following strata, MIS, Milne Inlet North (MIN), and TS (Figure 25). A total of 2,555 photographs were taken to capture the narwhal aggregations in the three areas. The total area photographed was 536.2 km^2

(269.9 km^2 in MIS 97.2 km^2 in MIN, and 168.1 km^2 in TS; Table 16). The total count of narwhals in the photographed areas was 5,065 narwhals (3,644 in MIS, 997 in MIN, and 424 in TS; Table 14). The sum of the area of the individual photographs totaled 477.4 km^2 in the MIS, 200.3 km^2 in MIN, and 295.9 km^2 in TS, resulting in an average density of 7.6 narwhals/km^2 in MIS, 5.0 narwhals/km^2 in MIN and 1.4 narwhals/km^2 in TS. Multiplying the average density by the total area photographed resulted in a surface estimate of 2,060 narwhals in MIS, 484 narwhals in MIN, and 241 narwhals in TS. The surface estimate was then corrected for availability bias using C_α=3.16 (correction from Watt et al. 2015a), and detectability bias of 1.20, resulting in a total narwhal estimate for the photographed areas for Survey 4 of 7,821 narwhals (CV=0.04) in MIS, 1,838 narwhals (CV=0.04) in MIN, and 915 narwhals (CV=0.04) in TS (Table 16).

During Survey 5 (29 August), two photographic surveys were undertaken in the Eclipse Sound study area, one in MIS stratum and one in the TS stratum (Figure 26). A total of 2,083 photographs were taken to capture the narwhal aggregations in the two areas. The total area photographed was 431.3 km^2 (264.2 km^2 in MIS and 167.2 km^2 in TS; Table 16). The total count of narwhals in the photographed areas was 2,021 narwhals (1,558 narwhals in MIS and 463 narwhals in TS; Table 14). The sum of the area of the individual photographs totaled 498.9 km^2 in the MIS and 448.5 km^2 in TS, resulting in an average density of 3.1 narwhals/km^2 in MIS and 1.0 narwhals/km^2 in TS. Multiplying the average density by the total area photographed resulted in a surface estimate of 825 narwhals in MIS and 173 narwhals in TS. The surface estimate was then corrected for availability bias using C_α = 3.16 (correction from Watt et al. 2015a), and detectability bias of 1.20, resulting in a total narwhal estimate for the photographed areas for Survey 5 of 3,132 narwhals (CV=0.04) in MIS and 657 narwhals (CV=0.04) in TS (Table 16).

Table 16: Narwhal abundance estimates from photographic survey in Eclipse Sound grid during Leg 2

Survey	Stratum[a]	# Photos	# Photos with Murky Water	# Photos with Glare	Photo Area (km^2)	Surface Count	Corrected Abundance	CV
3	MIS	1,322	63	0	270.80	1,841	7,034	0.04
3	TS	778	1	0	170.34	132	508	0.04
4	MIS	1,311	54	123	269.93	2,060	7,821	0.04
4	MIN	483	0	129	97.22	484	1,838	0.04
4	TS	761	12	237	169.09	241	915	0.04
5	MIS	1,288	43	0	264.15	825	3,132	0.04
5	TS	795	0	0	167.18	173	657	0.04

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

For the Eclipse Sound Stock, narwhal abundance estimates were calculated for three surveys (Table 17). Narwhal abundance estimates for the Eclipse Sound grid ranged from 4,879 to 12,088 narwhals (CV=0.06 and 0.08, respectively; Table 17). Survey 3 and 4 were completed within a total of six days, and the difference in the abundance estimates may be due to sampling variation (resulting from non random movements of narwhal withing the survey period) or influences from killer whales which may have positively or negatively biased the numbers, as opposed to real changes in the stock. Survey 5 may have missed an aggregation of narwhals which resulted in the low abundance estimate. Consequently, we averaged the two abundance estimates from survey 3 and 4 using an effort-weighted mean, where effort was measured by the area covered over the total area of the survey. This resulted in a final stock estimate of 9,931 narwhals (CV=0.05; Table 17).

Table 17: Narwhal abundance estimates from combined visual and photographic surveys in Eclipse Sound grid during Leg 2

Survey #	Survey Type	Estimate	CV	95% CI
3	Visual	223	0.40	105 – 475
3	Photographic	7,542	0.04	6,983 – 8,145
3	Combined	7,765	0.04	7,182 – 8,396
4	Visual	1,514	0.59	522 – 4,390
4	Photographic	10,574	0.03	10,004 – 11,176
4	Combined	12,088	0.08	10,388 – 14,066
3 and 4	**Combined Average**	**9,931**	**0.05**	**9,009 – 10,946**
5	Visual	1,090	0.25	667 – 1781
5	Photographic	3,789	0.03	3,562 – 4,030
5	Combined	4,879[a]	0.06	4,322 – 5,507

[a] Possible narwhal aggregation missed during survey according to local hunters.

3.2.5.3.2 Admiralty Inlet Stock

Overall, there were 450 narwhal sightings while on-effort for Survey 3, 4 and 5 (Table 18). Initially, 30 of the sightings were missing perpendicular distances. After photo-verification of sightings with missing measurements, 21 perpendicular distances were recovered from the photographs, with the remaining nine left as missing values.

During Survey 3 (21 August), a total of 714.1 km of transects were visually surveyed (Table 18). The total count of narwhal sightings observed on-effort in the visual survey area was 165 sightings before truncation and 160 after truncation (Table 18). 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 encounter rate and detection function, followed by cluster size. The total narwhal abundance for Survey 3 visual surveys was estimated at 20,396 narwhals (CV=0.19) (Table 18).

The total length of transect lines visually surveyed during Survey 4 (25 August) was 516.8 km (Table 18). The total count of narwhal sightings observed on-effort in the visual survey area was 117 sightings before truncation and 113 after truncation (Table 18). The overall variation in abundance estimates came primarily from the encounter rate followed by the detection function and cluster size component. The total narwhal abundance for Survey 4 visual surveys was estimated at 19,918 narwhals (CV=0.44) (Table 18).

During Survey 5 (29 August), a total of 1,168.5 km of transects were visually surveyed (Table 18). The total count of narwhal sightings observed on-effort in the visual survey area was 168 sightings before and after truncation (Table 18). Variation of abundance estimate was primarily from the encounter rate and the detection function, followed by cluster size. The total narwhal abundance for Survey 5 visual surveys was estimated at 17,621 narwhals (CV=0.21) (Table 18).

Table 18: 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	6,731.0	524.0	86	81	10,366	0.31	61.4	10.7
3	AIS	1,588.6	190.1	79	79	10,030	0.20	20.0	14.2
3	*Total*	—	*714.1*	*165*	*160*	*20,396*	*0.19*	—	—
4	AIN	6,720.4	385.4	51	49	9,194	0.62	85.5	7.2
4	AIS	1,562.2	131.4	66	64	10,724	0.63	89.0	3.9
4	*Total*	—	*516.8*	*117*	*113*	*19,918*	*0.44*	—	—
5	AIN	6,806.9	769.7	146	146	13,944	0.25	52.3	4.9
5	AIS	1,651.7	196.1	22	22	3,677	0.31	51.1	21
5	Fjords	912.0	202.7	0	0	0	0	—	—
5	*Total*	—	*1,168.5*	*168*	*168*	*17,621*	*0.21*	—	—

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

During Survey 3 (21–22 August), three photographic surveys were undertaken in the Admiralty Inlet study area, one in Admiralty Inlet South (AIS) stratum and two in Admiralty Inlet North (AIN-1 and AIN-2) stratum (Figure 24). A total of 1,111 photographs were taken to capture the narwhal aggregations in the three areas. The total area photographed was 167.6 km^2 (63.1 km^2 in AIS, 65.6 km^2 in AIN-1, and 38.9 km^2 in AIN-2; Table 19). The total count of narwhals in the photographed areas was 3,486 narwhals (1,362 in AIS, 1,094 in AIN-1, and 1,030 in AIN-2; Table 14). The sum of the area of the individual photographs totaled 123.1 km^2 in the AIS, 109.6 km^2 in

AIN-1, and 79.4 km^2 in AIN-2, resulting in an average density of 11.1 narwhals/km^2 in AIS, 10.0 narwhals/km^2 in AIN-1, and 13.0 narwhals/km^2 in AIN-2. Multiplying the average density by the total area photographed resulted in a surface estimate of 699 narwhals in AIS, 654 narwhals in AIN-1, and 504 narwhals in AIN-2. The surface estimate was then corrected for availability bias using C_α=3.18 (correction from Watt et al. 2015a), and detectability bias of 1.20 and 1.17, resulting in a total narwhal estimate for the photographed areas for Survey 3 of 2,671 narwhals (CV=0.04) in AIS, 2,499 narwhals (CV=0.04) in AIN-1, and 1,870 narwhals (CV=0.05) in AIN-2 (Table 19).

During Survey 4 (25 August), two photographic surveys were undertaken in the Admiralty Inlet study area, one in AIS stratum and one in AIN stratum (Figure 25). A total of 1,432 photographs were taken to capture the narwhal aggregations in the two areas, with a total area photographed of 75.6 km^2 (37.4 km^2 in AIS and 38.2 km^2 in AIN; Table 19). The total count of narwhals in the photographed areas was 7,802 narwhals (3,688 in AIS and 4,114 in AIN; Table 14). The sum of the area of the individual photographs totaled 89.45 km^2 in AIS and 114.97 km^2 in AIN, resulting in an average density of 41.2 narwhals/km^2 in AIS and 35.8 narwhals/km^2 in AIN. Multiplying the average density by the total area resulted in a surface estimate of 1,541 narwhals in AIS and 1,367 narwhals in AIN. The surface estimate was then corrected for availability bias using C_α=3.16 (correction from Watt et al. 2015a), and detectability bias of 1.17, resulting in a total narwhal estimate for the photographed areas for Survey 4 of 5,681 narwhals (CV=0.04) in AIS and 5,039 narwhals (CV=0.04) in AIN (Table 19).

During Survey 5 (29 August), 112 photographs were taken to capture a narwhal aggregation in AIN, with a total area photographed of 28.5 km^2 (Table 19; Figure 26). The total count of narwhals in the photographed area was 653 animals (Table 14). The sum of the area of the individual photographs totaled 52.3 km^2 resulting in an average density of 12.5 narwhals/km^2 within the survey area. Multiplying the average density (12.5 narwhals/km^2) by the total area (28.5 km^2) resulted in a surface estimate of 357 narwhals. The surface estimate was then corrected for availability bias using C_α=3.16 (correction from Watt et al. 2015a), and detectability bias of 1.20, resulting in a total narwhal estimate for the photographed area for Survey 5 of 1,355 narwhals (CV=0.04; Table 19).

Narwhal abundance estimates for the Admiralty Inlet stock were calculated for three surveys (Table 20) in 2019. Narwhal abundance estimates in Admiralty Inlet grid ranged from 18,976 to 30,638 (CV=0.20 and 0.29, respectively; Table 20).

Table 19: 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	222	0	213	63.12	699	2,671	0.04
3	AIN-1	263	0	263	65.57	654	2,499	0.04
3	AIN-2	626	0	0	38.87	504	1,870	0.05
4	AIS	701	0	349	37.37	1,541	5,681	0.04
4	AIN	731	0	52	38.20	1,367	5,039	0.04
5	AIN	112	0	0	28.54	357	1,355	0.04

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

Table 20: 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	20,396	0.19	14,134 – 29,432
3	Photographic	7,040	0.03	6,697 – 7,400
3	**Combined**	**27,436**	**0.14**	**20,860 – 36,084**
4	Visual	19,918	0.44	8,727 – 45,459
4	Photographic	10,720	0.03	10,094 – 11,385
4	**Combined**	**30,638**	**0.29**	**17,668 – 53,129**
5	Visual	17,621	0.21	11,697 – 26,545
5	Photographic	1,355	0.04	1,250 – 1,468
5	**Combined**	**18,976**	**0.20**	**12,963 – 27,779**

3.2.5.3.3 Combined Eclipse Sound and Admiralty Inlet Stocks

Narwhal abundance estimates for the combined Eclipse Sound and Admiralty Inlet stock were calculated for three surveys in 2019 (Table 21). Narwhal abundance estimates in the combined Eclipse Sound and Admiralty Inlet stocks ranged from 23,855 to 42,726 (CV=0.16 and 0.21, respectively; Table 21). Survey 3 and 4 were completed within a total of six days, and the difference in the abundance estimates may be due to sampling variation or influences from killer whales (in Eclipse Sound Stock) which may have positively or negatively biased the numbers, as opposed to real changes in the stock. Survey 5 had a low abundance estimate for both Eclipse Sound and Admiralty Inlet stocks which may indicate that some of the animals may have left the study area, or in the case of the Eclipse Sound stock a portion of the stock was not counted. Consequently, we averaged the two abundance estimates from survey 3 and 4 using an effort-weighted mean, where effort was measured by the area covered over the total area of the survey. This resulted in a final stock estimate of 38,771 narwhals (CV=0.12; Table 21).

Table 21: Narwhal abundance estimates from combined Eclipse Sound and Admiralty Inlet stocks during Leg 2

Survey #	Stock	Estimate	CV	95% CI
3	Eclipse Sound	7,765	0.04	7,182 – 8,396
3	Admiralty Inlet	27,436	0.14	20,860 – 36,084
3	*Combined*	*35,201*	*0.11*	*28,401 – 43,629*
4	Eclipse Sound	12,088	0.08	10,388 – 14,066
4	Admiralty Inlet	30,638	0.29	17,668 – 53,129
4	*Combined*	*42,726*	*0.21*	*28,620 – 63,786*
3 and 4	***Combined Average***	***38,771***	***0.12***	***30,667 – 49,016***
5	Eclipse Sound	4,879[a]	0.06	4,322 – 5,507
5	Admiralty Inlet	18,976	0.20	12,963 – 27,779
5	*Combined*	*23,855*	*0.16*	*17,580 – 32,368*

[a] Possible narwhal aggregation missed during survey based on radio communications with local Inuit hunters (names unknown).

3.2.5.4 Bowhead Abundance

3.2.5.4.1 Eclipse Sound

No bowhead whale were observed during on-effort visual surveys in the Eclipse Sound grid during Leg 2. During Survey 3 on 21 August, one sighting of an individual bowhead whale was observed in the photographic survey area. The surface estimate of one animal was then corrected for availability bias using C_{α} = 3.98 (mid August correction from Watt et al. 2015b), resulting in a total bowhead whale estimate for the photographed area of four bowhead whales (CV=0.21; 95% CI of 3–6).

3.2.5.4.2 Admiralty Inlet

During visual Survey 3 on 21 August, a total of 714.1 km of transects were visually surveyed (Table 22). The total count of bowhead sightings observed on-effort in the visual survey area was 18 sightings before truncation and 14 after truncation (Table 22). Variation of the abundance estimate is 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 encounter rate, followed by cluster size. The total bowhead abundance for Survey 3 visual surveys was estimated at 699 bowhead whales (CV=0.36) (Table 22).

The total length of transect lines visually surveyed during Survey 4 on 25 August was 516.8 km (Table 22). The total count of bowhead sightings observed on-effort in the visual survey area was 14 sightings before and after truncation (Table 22). Although variation of the abundance estimate was a combination of the variation from detection function, encounter rate, cluster size and availability bias, the overall variation in abundance estimates came primarily from the encounter rate, followed by cluster size component. The total bowhead abundance for Survey 4 visual surveys was estimated at 822 bowhead whales (CV=0.50) (Table 22).

During Survey 5 on 29 August, a total of 1,168.5 km of transects were visually surveyed (Table 22). The total count of bowhead sightings observed on-effort in the visual survey area was 13 sightings before and after truncation (Table 22). Variation of abundance estimate is primarily from the encounter rate. The total bowhead abundance for Survey 5 was estimated at 472 bowhead whales (CV=0.35) (Table 22).

Table 22: Bowhead Abundance Estimates from Visual Surveys in Admiralty Inlet 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	6,731.0	524.0	10	8	443	0.38	75.5	8.7
3	AIS	1,588.6	190.1	8	6	256	0.75	91.7	4.4
3	*Total*	—	*714.1*	*18*	*14*	*699*	*0.36*	—	—
4	AIN	6,720.4	385.4	1	1	68	1.11	98.2	0
4	AIS	1,562.2	131.4	13	13	754	0.54	88.8	3.4
4	*Total*	—	*516.8*	*14*	*14*	*822*	*0.50*	—	—

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
5	AIN	6,806.9	769.7	11	11	407	0.38	79.3	4.9
5	AIS	1,651.7	196.1	2	2	65	1.02	97.8	0.2
5	Fjords	912.0	202.7	0	0	—	—	—	—
5	*Total*	—	*1,168.5*	*13*	*13*	*472*	*0.35*	—	—

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

During Survey 3 on 21 August, one sighting of two bowhead whales was observed in the photographic survey areas. The surface number of two animal was then corrected for availability bias using C_a=4.12 (mid-August correction from Watt et al. 2015b), resulting in a total bowhead whale estimate for the photographed survey areas of eight bowheads (CV=0.21; 95% CI of 5–12; Table 23). During Survey 4, two sightings totalling five bowheads were observed in the photographic survey areas. The surface number of five animals was then corrected for availability bias using C_α=3.98 (correction from Watt et al. 2015b), resulting in a total bowhead whale estimate for the photographed areas of 12 bowheads (CV=0.21; 95% CI of 8–18; Table 23).

Bowhead whale abundance estimates for Admiralty Inlet were calculated for three surveys (Table 23) in 2019. Bowhead whale abundance estimates in the Admiralty Inlet grid ranged from 472 to 834 (CV=0.35 and 0.50, respectively; Table 23).

Table 23: Bowhead abundance estimates from combined visual and photographic surveys in Admiralty Inlet during Leg 2

Survey #	Survey Type	Estimate	CV	95% CI
3	Visual	699	0.36	349–1,399
3	Photographic	8	0.21	5–12
3	**Combined**	**707**	**0.36**	**355–1405**
4	Visual	822	0.50	325–2,074
4	Photographic	12	0.21	8–18
4	**Combined**	**834**	**0.50**	**334–2,080**
5	**Visual**	**472**	**0.35**	**240–926**
5	Photographic	0	-	-

3.3 Inuit Researcher Questionnaires

Upon completion of the 2019 MMASP Program, Inuit researchers who had participated in both legs of the program completed a questionnaire. The questionnaire (see Appendix D) was presented in the form of an in-person group interview performed in Pond Inlet. The intent of the questionnaire was to provide Inuit researchers an opportunity to provide feedback on the MMASP Program. Questions were qualitative and open-ended relating to program design, data analysis, and reporting.

Program Design

Questions were asked of the Inuit researchers regarding their general opinions and attitude around the MMASP itself and its design (Appendix D).

- When asked whether they thought that aerial survey programs helped understand how shipping activities may impact marine mammals, the Inuit researchers responded that they felt that aerial surveys were a good tool to count whales and that it was very good to conduct surveys. They indicated that when there are no speed limits for ships, the narwhal will move. Where there are speed limits, the narwhal are not as afraid. It was suggested that the speed limits are helping the narwhal.
- Inuit researchers indicated that narwhal used to come in the channel between Ragged Island and the mainland. When killer whales came in, the narwhal would huddle between Ragged Island and the mainland. But that has changed with the use of Ragged Island as an anchorage location. One Inuit researcher said that as Baffinland started the mine, they started seeing narwhal in different places such as Resolute. That there is a location near Somerset Island where narwhal like to give birth and eat fish. They had never seen the narwhal before but now they are starting to.
- The Inuit researchers were asked what they thought of the distance between transects, the areas surveyed, and the elevation the planes flew at during the surveys. They indicated the distance between transects was okay. They suggested it may be of use to conduct a survey between Devon Island and Baffin Island, as well as along the coast of Somerset Island and Devon Island. The Inuit researchers felt that at 1,000 feet they could see so clearly that they could even see the narwhal's tusks while 2,000 feet was all camera surveys. When orca were around they wanted to fly at 500 feet. They indicated that seals were easy to spot at 1,000 feet.
- When asked when the best time was to conduct aerial surveys to count narwhal, the Inuit researchers were conflicted. Some observers indicated that the first leg was well timed and others thought it should start earlier in May, when the ice starts opening up because then you could see the narwhal migrating past the floe edge and moving towards Arctic Bay. The Inuit researchers suggested the second leg be conducted earlier, that the timing was good, and that it should be done later in the year. It was also suggested that the length of the second leg be increased and that when a weather day occurs the survey should be conducted on another day. They indicated that they heard the ships were drifting at the floe edge in 2018 and that they were not sure if the narwhal would come back as a result. Given that there were no ships at the floe edge in 2019 and the whales came in, they believe the mitigation was working as intended.
- The Inuit researchers were asked what areas they thought were important to narwhal or other marine mammals and why. They responded that Koluktoo Bay was an important breeding area and that Tremblay Sound was an important feeding and breeding area. They indicated that there were no narwhal south of Pond Inlet (e.g., Oliver Sound area). The floe edge was also an important area for narwhal, seals, and

walrus. They indicated that when narwhal first start coming in, they travel along the shoreline. Before the start of Project shipping, narwhal used to fill up the whole fjord but now with the shipping they hug the shore. One Inuit researcher shared that Low Point in Navy Board Inlet is where his grandfather went hunting, but that the new generation tends to go to Saviit (Bruce Head) for easier hunting.

- The Inuit researchers were asked what knowledge they felt was shared between themselves and the biologists. They indicated they had learned how to use the instruments and conduct the aerial surveys. They felt that the biologists learned about hunting camps important to the local communities. The Inuit researchers appreciated that when they saw something, they could ask the biologists and the pilots to go investigate what it was. They were also grateful to have the knowledge of where things are on the land and felt that aerial surveys were a good way to see the land.

Data Analysis

Questions were asked regarding general information related to data analysis for the MMASP (Appendix D).

- When asked when narwhal typically gather at the floe edge, Inuit researchers agreed that narwhal generally gathered in late May and June. The Inuit researchers could see marine mammals in and around the ice breakups during the first leg of aerial surveys. They could see narwhal using leads in the ice, as well as using holes in the ice to breath before diving under again. They also indicated that they had seen narwhal following the ship coming through the ice.
- When asked what they would consider to be one group of narwhal, the Inuit researchers responded that they viewed a group of whales as those that stay and move together. If there is a large group that has some separations, it would be four groups of five whales instead of one group of 20 whales.
- The Inuit researchers were asked whether the number of narwhal observed from the plane was a good indicator of the number of narwhal that hunters observe on the water. They responded that narwhal observed during the aerial surveys were generally in the same areas where hunters observe them. However more narwhal could be seen from the air compared to when you are on the water.
- The Inuit researchers indicated that they had observed both cruise ships and ore ships during the aerial surveys. The cruise ships were going faster than the ore ships. They did not observe narwhal near the faster moving cruise ships, while they felt that the ore carriers were going slow enough that they did not change the behaviour of the narwhal. One Inuit researcher thought that the ships could go faster than they are going now.
- When asked whether they observed anything during the program that they did not expect to see, the Inuit researchers said yes. They were surprised to observe one beluga hanging out with approximately 80–100 narwhal, as well as observing an estimated 50 bowhead whales. They indicated that they saw lots of seals everywhere and felt that their numbers were not down due to hunting or boating. They also noticed that the narwhals were not going close to JASCO AMAR near the Bruce Head Behavioural Study Area.

Reporting

Questions were asked about reporting for the MMASP (Appendix D).

- The Inuit researchers felt that maps and figures showing the flight transects and marine mammal observations would be the best way to describe the studies undertaken for the 2019 MMASP Program. When asked what they thought people would be most interested in hearing regarding the MMASP Program, they said what species were observed, where narwhal were located, where narwhal were coming from and moving towards, and what narwhal were eating.

Adaptive Management

Questions were asked regarding whether Inuit researchers had any suggestions for improving the monitoring program and whether their views on the impacts of shipping activities on marine mammals had changed since conducting the aerial surveys (Appendix D).

- Inuit researchers indicated that overall the MMASP was good. Suggestions for improvements on the monitoring approach included improving instruments used for counting marine mammals during the aerial surveys, as well as surveying the RSA when the floe edge was beginning to open but before the whales had moved in. They indicated that people were also interested in the activity of bowhead whales in the RSA. Some Inuit researchers shared that they still had questions regarding how monitoring for shipping effects on narwhal and other marine mammals worked.
- When asked whether their opinion of the impact of shipping on marine mammals had changed since conducting the aerial surveys, the Inuit researchers said it was hard to tell whether the shipping activities had changed whale behaviour.

4.0 DISCUSSION

4.1 Narwhal Abundance

The Canadian High Arctic Cetacean Survey conducted by DFO in August 2013 was the first complete survey flown in a single season of the four major narwhal summer stock areas belonging to the Baffin Bay population (Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island; DFO 2015a). The most current abundance estimate for the Baffin Bay population, corrected for availability and observer bias, is 141,909 individuals (DFO 2015a). The abundance of the Eclipse Sound summering stock was estimated to be approximately 20,000 individuals in 2004 (Richard et al. 2010), approximately 10,489 in 2013 (DFO 2015a), and approximately 12,039 in 2016 (Marcoux et al. 2019; Table 24). The 2016 abundance estimate of 12,039 narwhals is currently considered by DFO to be the most accurate estimate for the Eclipse Sound summering stock (Marcoux et al. 2019).

Given the relatively lower number of narwhal observed in Eclipse Sound in 2013 compared to the 2004 stock estimate (which corresponded with increased narwhal numbers in Admiralty Inlet at this time), it was suggested that mixing between the stocks might have occurred (Doniol-Valcroze et al. 2015). The combined abundance for the Eclipse Sound and Admiralty Inlet stocks was estimated at 45,532 animals (CV=0.33, 95% CI = 22,440– 92,384; Doniol-Valcroze et al. 2015; Table 24).

Table 24: Comparison of narwhal abundance estimates for Eclipse Sound, Admiralty Inlet, and both stocks combined

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. 2015
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 2018
Eclipse Sound	2016	21 Aug	12,955	0.16	7,245–23,166	Golder 2018
Eclipse Sound	2019	21–22 Aug (#3)	7,765	0.04	7,182–8,396	Golder 2020
Eclipse Sound	2019	25–27 Aug (#4)	12,088	0.08	10,388–14,066	Golder 2020
Eclipse Sound	**2019**	**21–27 Aug (#3&4)**	**9,931**	**0.05**	**9,009–10,946**	**Golder 2020**
Eclipse Sound	2019	29–30 Aug (#5)	4,879[a]	0.06	4,322–5,507	Golder 2020
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

Stock	Year	Survey Dates (Survey #)	Abundance	CV	95% CI	Source
Admiralty Inlet	2013	12–17 Aug	35,043	0.42	14,188–86,553[b]	Doniol-Valcroze et al. 2015
Admiralty Inlet	2019	21–22 Aug (#3)	27,436	0.14	20,860–36,084	Golder 2020
Admiralty Inlet	2019	25–26 Aug (#4)	30,638	0.29	17,668–53,129	Golder 2020
Admiralty Inlet	2019	29–30 Aug (#5)	18,976	0.20	12,963–27,779	Golder 2020
Combined	**2013**	**12–19 Aug**	**45,532**	**0.33**	**22,440–92,384[b]**	**Doniol-Valcroze et al. 2015**
Combined	2019	21–22 Aug (#3)	35,201	0.11	28,401–43,629	Golder 2020
Combined	2019	25–27 Aug (#4)	42,726	0.21	28,620–63,786	Golder 2020
Combined	**2019**	**21–27 Aug (#3&4)**	**38,771**	**0.12**	**30,667–49,016**	**Golder 2020**
Combined	2019	29–30 Aug (#5)	23,855	0.16	17,581–32,368	Golder 2020

[a] Possible narwhal aggregation missed during survey personal comms. local hunters.
[b] T. Doniol-Valcroze, Pers. Comm. 2020.

Leg 1 – Early Shoulder Season

In 2019, Baffinland undertook an early shoulder season survey to assess the presence and numbers of narwhal at the floe edge prior to the commencement of Baffinland activities in the RSA. By the time surveys began on 12 July, the floe edge had already broken up and most of the ice was situated west of Pond Inlet and into North Milne Inlet. The focus of the early shoulder season survey therefore shifted to obtaining abundance estimates of marine mammals in the Eclipse Sound survey grid (minus the Navy Board Inlet and Tremblay Sound strata) prior to and during ice breaking activities. Prior to 2019, marine mammal aerial surveys had not previously been undertaken by Baffinland this early in the season. The first Baffinland vessel to enter the RSA in 2019 was the icebreaker MSV *Botnica* on the evening of 17 July 2019, which escorted two bulk carriers and two tugs along the Northern Shipping Route to Milne Port. Two complete aerial surveys were conducted during the early shoulder season (Figure 14 and Figure 15). The first complete survey in 2019 was undertaken on 15–16 July (Survey 2) prior to the start of 2019 shipping operations in the RSA. At this time, narwhal were primarily distributed in the Pond Inlet, Eclipse Sound East, Eclipse Sound West and Milne Inlet North strata. Narwhal abundance during this period was estimated at 5,793 animals (CV=0.23, 95% CI of 3,744–8,964). The second complete survey was undertaken on 21–22 July (Survey 4), after shipping operations in the RSA had begun. At this time, narwhal were primarily distributed in the Pond Inlet, Eclipse Sound East, Eclipse Sound West, and Milne Inlet North strata. The abundance estimate for this survey was 15,591 animals (CV=0.19, 95% CI = 10,856–22,391).

Factors that may have contributed to the higher numbers of narwhal observed on Survey 4 included:

- Sea ice conditions - more sea ice was present during Survey 2, which could have lowered detectability

- Presence of narwhal in the RSA belonging to other adjacent stocks - as animals migrated to their respective summering areas (i.e., entering through Eclipse Sound and exiting via Navy Board Inlet)
- Presence of killer whales in Baffin Bay during Survey 4 – It is possible that the killer whales observed in Baffin Bay may have influenced normal migratory movements and distribution of marine mammals in this area (i.e., potentially leading to higher than normal numbers of narwhal and/or bowhead in the RSA)

Leg 2 – Open-water Season

For the three complete aerial surveys conducted in the Eclipse Sound grid during Leg 2, narwhal abundance estimates ranged from 4,879 to 12,088 (CV=0.06 and 0.08, respectively; Table 24). The variation in abundance estimates between the three surveys suggested narwhal distribution was inconsistent and patchy during the survey period. The difference in abundance estimates between Survey 3 and Survey 4 may have been attributed to the balance between photographic and visual-based surveys on each of the surveys, and/or changes in normal narwhal distribution due to killer whale presence (resulting in non-random movements in RSA which can positively or negatively bias estimates). Survey 5 had the lowest abundance estimate (4,879 narwhals, CV=0.06, 95% CI of 4,322–5,507: Table 24). Three factors may have contributed to this:

- Firstly, one or more narwhal aggregations may have went undetected during the survey. When the survey crew landed in Pond Inlet on 29 August after completing the survey, they were told by several Pond Inlet residents that a large aggregation of narwhal had passed Pond Inlet that afternoon. During the aerial survey, only one sighting of four narwhal was made near Pond Inlet (see Figure 26A), so it was likely that the majority of narwhal in this aggregation were missed. The aggregation reported by the Pond Inlet residents may have occurred between adjacent transects while the survey was being flown and therefore missed. Alternatively, animals may have been travelling in one of the small fjord waterways (i.e., Tay Sound) during the active survey. The fjord stratum was not flown on Survey 5.
- A portion of the Eclipse Sound narwhal stock may have already migrated out of the RSA prior to Survey 5 (Aug 29 and 30). In Admiralty Inlet, Survey 5 was also associated with a low abundance estimate compared to Survey 3 and Survey 4 (Table 24), suggesting some of the Admiralty Inlet narwhal stock may have also migrated out of the survey area prior to Survey 5.
- The third factor was the presence of killer whales in Milne Inlet North stratum during Surveys 3 and 5, both of which had the lower abundance estimates compared to Survey 4. Breed et al. (2017) indicated that the presence of killer whales can strongly alter the distribution and behaviour of narwhal. Figure 42 illustrates the change in narwhal habitat use in the presence and absence of killer whales (Breed et al. 2017). When killer whales are present, narwhal move closer to shore and into the fjords. In the presence of killer whales within Admiralty Inlet, narwhal perform deeper dives and shorten their dive duration (Breed et al. 2017), which could have a significant impact on the availability correction factor. Breed et al. (2017) also found that the effects extended beyond predatory events and persisted steadily for 10 days, the duration that killer whales remained in Admiralty Inlet. The impact of the presence of killer whales on abundance estimates for Surveys 3 and 5 was unclear and resulted in an unmeasurable uncertainty for these two surveys. Killer whales were also present during Survey 4, but they were located in the northern portion of Navy Board Inlet (Figure 25A).

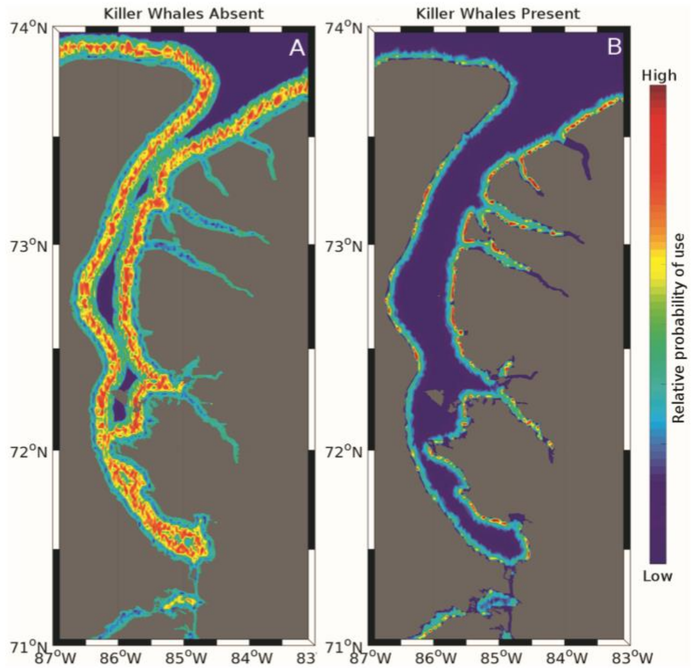


Figure 42: Habitat use by narwhal as a function of distance from shore during the exposure and post-exposure periods of killer whales (from Breed et al. 2017).

Surveys 3 and 4 had the most complete coverage of the area, including the fjords and possible the best estimates of the stock size. For these reasons, an average abundance estimate for surveys 3 and 4 was calculated at 9,931 narwhals (CV = 0.05, 95% CI of 9,009–10,946) and is the best estimate for the Eclipse Sound Stock during the open-water season from the 2019 MMASP (Table 24). Comparing the Marcoux et al. (2019) estimate of 12,039 (CV = 0.23, 95% CI of 7,768–18,660) to the current estimate of 9,931 (CV = 0.05, 95% CI of 9,009–10,946) found the current estimate was not significantly less (Z-test = 0.749, p = 0.227). The current abundance estimate of 9,931 (CV = 0.05, 95% CI of 9,009–10,946) was also not statistically significantly lower than the pre-shipping abundance estimate of 10,489 (CV = 0.24, 95% CI of 6,342–17,347; Doniol-Valcroze et al. 2015) (Z-test = 0.218, p = 0.414). The sample sizes used to generate narwhal abundance estimates for DFO's previous surveys (Doniol-Valcroze et al. 2015; Marcoux et al. 2019) were not reported. The use of the Z-statistic may represent a higher precision than is warranted by the DFO data.

The abundance estimate for the combined Eclipse Sound and Admiralty Inlet stocks was calculated as 38,771 narwhals (CV=0.12) for the averaged Survey 3 and Survey 4 (Table 24). Both the combined (Eclipse Sound and Admiralty Inlet) and single (Eclipse Sound) stock abundance estimate for the averaged Survey 3 and 4 were within the 95% CI ranges calculated during previous DFO surveys (combined stock estimate of 45,532, CV=0.33, 95% CI of 22,440–92,384; Doniol-Valcroze et al. 2015, and Eclipse Sound stock estimate of 12,093, CV=0.23, 95% CI of 7,768–18,660; Marcoux et al. 2019).

Because narwhal were distributed in a relatively small area (mostly in Milne Inlet and Tremblay Sound where most sightings were captured by photographic surveys), low CVs were achieved in the August surveys which provided the best abundance estimate. Narwhals concentrated in areas where shipping activities were high (Milne Inlet South) rather than moving to areas with low shipping activities. This is a sign that the level of shipping activity is not causing displacement. This is consistent with impact predictions made in the FEIS Addendum for the ERP that the Project was 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).

Summary

Although full surveys were completed in both legs, Leg 2 surveys were selected for calculating abundance estimates given consistency with previous surveys (open-water conditions). The average of Survey 3 and 4 was also identified as providing the most accurate abundance estimate of both the combined (Eclipse Sound and Admiralty Inlet) and single (Eclipse Sound) stock for the reasons described above.

Results of the 2019 MMASP are therefore consistent with impact predictions made in the FEIS Addendum for the ERP that the Project was 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).

4.2 Narwhal Distribution

Leg 1 – Early Shoulder Season

During aerial surveys on 1–4 August 2014, narwhals were primarily observed in Eclipse Sound (Thomas et al. 2015). A similar distribution was observed during Leg 1 of the 2019 MMASP (see Appendix B, Figures B-1 to B-5).

Leg 2 – Open-water Season

In 2013, 2014, 2015 and 2016, aerial surveys conducted in mid to late August found narwhals distributed in Milne Inlet, Tremblay Sound and Koluktoo Bay (Elliott et al. 2015; Thomas et al. 2015; Thomas et al. 2016; Golder 2018c). Similarly, during Leg 2 of the 2019 MMASP (mid to late August), narwhals were observed primarily in Milne Inlet, Tremblay Sound and Koluktoo Bay in 2019. Results from the 2017 Tremblay Sound tagging program indicate that tagged narwhals concentrated in Milne Inlet, Tremblay Sound, and Koluktoo Bay during the second half of August (Golder 2018b).

Narwhal were observed in Assomption Harbour, near Milne Port on two occasions. The first time was on 18 August 2019 (during Leg 2 Survey 1; see Appendix B, Figure B-6) and the second time was on 21 August 2019 (during Leg 2 Survey 3; see Figure 24B,IV). On both occasions, killer whales were observed in Milne Inlet. Observers with the Bruce Head shore-based monitoring program observed killer whales in southern Milne Inlet on 18 August 2019 and the aerial survey crew observed killer whales in northern Milne Inlet on 21 August 2019. Seeing how the presence of killer whale can strongly alter the distribution and behaviour of narwhal (Breed et al. 2017), it is possible that the presence of narwhal in Assomption Harbour may have been influenced by the presence killer whales in Milne Inlet. Killer whales had not been observed in southern Milne Inlet area during the Bruce Head study from 2013 to 2017 (Thomas et al. 2014; Smith et al. 2015, 2016, 2017; Golder 2018a). Similarly, killer whales had not been observed by Baffinland aerial survey study teams in 2013–2015 (Elliott et al. 2015; Thomas et al. 2015, 2016). Killer whales have been observed in the RSA during other studies. Ferguson (2019) noted an increasing presence of killer whales in the Eclipse Sound region, most recently in 2017. Sportelli et al. (2019) detected killer whale vocalizations in underwater acoustic recordings made near Pond Inlet between August and September of 2017. SPOT-5 instrumentation tags were deployed on five killer whales in Milne Inlet in mid-August 2013, where the tagged animals remained together while travelling in Eclipse Sound, Admiralty Inlet, Prince Regent Inlet, and the Gulf of Boothia until early September (Lefort et al. 2020). A satellite tag was deployed on an adult male killer whale in Eclipse Sound in late August 2018, with the animal remaining in the Eclipse Sound and Milne Inlet area for several weeks (along with other pod members), until it departed the region via Navy Board Inlet in mid-September (Lefort et al. 2020).

Summary

Distributional changes observed between Leg 1 (e.g., concentration of narwhal in Eclipse Sound) and Leg 2 (e.g., spread across Milne Inlet and Tremblay Sound) are consistent with seasonal use of the area and are likely a result of the general migration of the animals through Eclipse Sound and into Milne Inlet and Tremblay Sound. Given that observed distribution is consistent with baseline, data does not indicate that narwhal distribution or use of preferred summering habitat is changing throughout the shipping season or as a result of a greater increase in vessel transits following ice break-up.

4.3 Narwhal Group Size and Composition

Previous aerial survey studies reported average group sizes of 2.26 (range: 1–20; Thomas et al. 2016), 3.57 (range: 1–20; Thomas et al. 2015), 3.23 (range: 1–21; Elliott et al. 2015), 2.30 (Asselin and Richard 2010), and 1.95 (Asselin and Richard 2010). Observations in 2019 were consistent with past studies with observed average group sizes ranging from 2.2 during Leg 1 in Eclipse Sound grid, 2.1 during Leg 2 in Admiralty Inlet grid to 2.7 during Leg 2 in Eclipse Sound grid for visual surveys. For photographic surveys, observed group sizes ranged from 2.0 during Leg 1 in Eclipse Sound grid, 1.6 during Leg 2 in Admiralty Inlet grid, and 1.9 during Leg 2 in Eclipse Sound grid.

Twenty-four narwhal mother/calf pairs and one lone calf were recorded during the early shoulder season surveys (Leg 1) in the Eclipse Sound grid. During the open-water season (Leg 2), 17 calves were recorded in the Eclipse Sound grid during visual surveys and 309 calves were recorded from photographic surveys. In the Admiralty Inlet grid, 35 calves were recorded during visual surveys and 429 calves were recorded from photographic surveys. It is important to note that for photographic surveys, re-sightings were not identified and that some of these sightings would have been re-sightings. It is also important to note that three of the photographic surveys in Admiralty Inlet were flown at 305 m (1,000 ft), whereas all of the photographic surveys flown in Eclipse Sound were at 610 m (2,000 ft). Narwhal calves can be difficult to detect during aerial surveys, including photographic surveys. A change in surveying altitude would affect calve detection rates. The 2016 photographic surveys analyzed by Golder (2018c) recorded 184 calves in a total of 2,618 individual narwhals from a survey flown at 915 m (3,000 ft) and recorded 190 calves in a total of 1,659 individual narwhals for a survey flown at 2000 ft. Calves represented 7% of the narwhals for the survey flown at 915 m and 11% of the narwhals for the survey flown at 610 m. A comparison with the current survey data is not appropriate because of the different data collection methodology. Surveys flown at 305 m (1000 ft) or lower would be preferred for counting narwhal calves due to the difficulty of sighting calves. Higher altitudes would underestimate calf numbers. Composition data from the Bruce Head Shore-Based Monitoring Program may yield more useful insights into relative group size and composition for comparative analyses.

4.4 Other Marine Mammal Sightings

Although calculating abundance estimates for narwhals were the main focus of the 2019 MMASP, other marine mammals were also observed in the RSA. Their distribution and abundance are discussed below.

Bowhead Whale

Leg 1: Bowheads were present in the RSA in high numbers. During Leg 1 Survey 2 (15–16 July), bowhead whale abundance was estimated at 176 bowheads (CV=0.64, 95% CI of 56–553) in the shipping corridor strata. During Survey 4 (21–22 July), bowhead whale abundance was estimated at 1,291 bowheads (CV=0.29, 95% CI of 735–2,267) in the shipping corridor strata. Survey 4 reported the highest number of bowhead whales ever recorded in the Eclipse Sound grid during Baffinland aerial surveys. This was also the first year that cetacean aerial surveys were flown this early in the season. When talking to local residents in Pond Inlet about the number of bowhead whales seen in 2019, they mentioned that it was more than they had seen in recent years, but they had seen high numbers about eight years ago. This was also the first year that bowhead whales were observed during the Ship-based Observer (SBO) Program (Golder 2020). Twenty-two sightings totalling 24 bowhead whales where recorded during Leg 1 of the 2019 SBO Program (Golder 2020).

Bowhead whales were observed in every strata in the Eclipse Sound grid except the Fjord stratum during the early shoulder season (Leg 1; see Appendix B, Figures B-1 to B-5). Bowhead whales were most commonly observed in Eclipse Sound West, Milne Inlet, and at the mouth of Tremblay Sound. Bowhead whale group sizes ranged from single animals to one group eight whales, with mean group size of 1.5. Two mother/calf pairs were observed during Leg 1.

Leg 2: Bowhead whale observations declined substantially prior to the start of the open-water season (Leg 2), suggesting that most bowheads seen during Leg 1 had migrated out of the area prior to 17 August (start of Leg 2). This is consistent with local IQ information (JPCS 2017/TSD 03) which includes observations of bowhead migrating through the RSA in Aujaq (end of July to September). Four bowhead whales were observed in the RSA on 17 August 2019. Three of the bowheads were observed opportunistically by MMOs during a photographic survey in Tremblay Sound and one was observed on-transect near the entrance to Tremblay Sound. Bowhead whales were not seen again by the aerial survey program in the Eclipse Sound grid after 17 August 2019. During previous aerial surveys flown in August within the RSA, six sightings of individual bowheads were observed in 2014 (Thomas et al 2015) and none were observed during 2013 or 2015 surveys (Elliott et al. 2015; Thomas et al. 2016). Based on this, the decline in abundance of bowhead during Leg 2 is consistent with baseline conditions, and therefore does not suggest that Project shipping activities resulted in displacement of bowhead from their summering ground.

In Admiralty Inlet, bowhead whales were observed during every Leg 2 survey flown in August. All bowhead sightings (with the exception of one) were located in the southern portion of Admiralty Inlet, south of Yeoman Island (see Appendix B, Figures B-11 to B-15). 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 much higher than previous estimates in Admiralty Inlet. Bowhead whale abundance estimates were calculated for three of the surveys flown during Leg 2 in 2019. 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; see Table 23). 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; see Table 23). Bowhead group sizes ranged from single animals to a group size of ten, with mean and median group sizes of 1.5 and 1.0, respectively. Three mother/calf pairs were recorded during the 2019 MMSASP surveys in Admiralty Inlet. An aerial survey flown in August 2013 reported bowhead group sizes of one to four individuals with most consisting of single animals (Doniol-Valcroze et al. 2015).

Killer Whale

Leg 1: During the 2019 MMASP, killer whales were first observed (three sightings) in the RSA on 22 July, in the Baffin Bay stratum (see Figure 15). The three sightings consisted of one, two, and seven individuals. They were likely all from the same pod based on the close proximity to each other. These were the only killer whale sightings during Leg 1.

Leg 2: On 18 August 2019, observers stationed at Bruce Head as part of the shore-based monitoring program observed killer whales in south Milne Inlet. The killer whales entered the Bruce Head study area from the north at 08:04 and remained in the area for several hours before exiting through the north end at 14:05 (Mitch Firman, Golder, Pers. Comm. 2020). A photographic aerial survey was flown in Milne Inlet South on the same day (18 August) from 12:31 to 14:09. During the photographic survey, MMOs on the aircraft noted that narwhals were bunched up on the southern shore of Koluktoo Bay and western shore of Assomption Harbour. The killer whales were not sighted by MMOs during the photographic survey. Killer whales were next observed during the 2019 MMASP on 21, 26, and 29 August. On 21 and 29 August, killer whales were observed in Milne Inlet North strata (Figure 24 and Figure 26). On 26 August, killer whales were observed at the north end of Navy Board Inlet (Figure 25). While it is unclear whether the same killer whales were observed repeatedly, and where they travelled between surveys, these observations demonstrate that killer whales were likely in the Eclipse Sound grid from 17–30 August during Leg 2 of the 2019 MMASP. The presence of killer whales in the Eclipse Sound grid during aerials surveys may have influenced survey results as discussed in section 4.1 (narwhal abundance estimates). Killer whales were not observed in the Admiralty Inlet grid during Leg 2 of the 2019 MMASP.

Beluga Whale

A total of four beluga whales were observed in the RSA during the 2019 MMASP. Three were sighted during Leg 1 and one was sighted during Leg 2. The sightings were always of a lone individual and it is possible that it was the same individual that stayed in the RSA for the duration of the 2019 MMASP. Beluga whales were not observed in previous Baffinland surveys from 2013 to 2015 (Elliott et al. 2015; Thomas et al. 2015; Thomas et al. 2016), suggesting their numbers have always been low in the RSA. In 2007 and 2008, beluga whales were observed in the RSA in small numbers (three individuals in 2007 and 59 individuals in 2008; Baffinland 2012). Beluga whales were not observed in the Admiralty Inlet grid during Leg 2 of the 2019 MMASP.

Pinnipeds

Pinniped data collected in 2019 should be interpreted with caution due to the relative difficulty in observing seals at survey altitudes of 305 m (1,000 ft) above seal level (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: In 2013, 2014 and 2015, aerial surveys conducted by Baffinland found ringed seals distributed throughout the study area (Elliott et al. 2015; Thomas et al. 2015; Thomas et al. 2016). Similarly, ringed seals were sporadically distributed throughout the survey area during the 2019 MMASP. During Leg 1, 43 sightings totalling 79 ringed seals were recorded during visual surveys in the Eclipse Sound grid (Table 4). During Leg 2, there was a total of 17 sightings totalling 23 individual ringed seals recorded in Eclipse Sound grid (Table 12), and a total of 19 sightings of individual ringed seals recorded in the Admiralty Inlet grid during visual surveys (Table

13). More ringed seals were observed during Leg 1 surveys which may be related to the presence of ice in the study area. Ringed seals are generally observed as single animals which makes them difficult to see due to their small size. When surveying in ice conditions MMOs focused their attention on open-water areas where narwhal would be sighted, which would result in less effort focused on ice where ringed seals could have also been observed. Ringed seal observations provide relative distribution information, but cannot be used to assess effects of Project shipping or reliable abundance estimates.

Harp Seal: In 2013, 2014 and 2015, aerial surveys conducted by Baffinland found harp seals distributed primarily in northern Navy Board Inlet and Pond Inlet strata (Elliott et al. 2015; Thomas et al. 2015; Thomas et al. 2016). Similarly, harp seals were distributed primarily in northern Navy Board Inlet and Pond Inlet strata in the Eclipse Sound grid during Leg 1 and 2 the 2019 MMASP. In Admiralty Inlet, harp seals were only observed on surveys flown in Admiralty Inlet North stratum (see Appendix B, Figures B-11, B-13, B-14, B-15). Ten sightings totalling 117 harp seals were recorded during Leg 1 visual surveys (Table 4). Harp seals were seen in high numbers during the open-water season (August) in the Eclipse Sound grid. A total of 45 sightings and 669 individual harp seals were recorded during Leg 2 visual surveys in Eclipse Sound grid (Table 12). In Admiralty Inlet grid, a total of 18 sightings and 216 individual harp seals were recorded during Leg 2 visual surveys (Table 13). Harp seal observations provide relative distribution information, but cannot be used to assess effects of Project shipping or reliable abundance estimates.

Bearded Seal: A few bearded seals (two sightings during Leg 1 and two sightings during Leg 2 were observed during aerial surveys in Eclipse Sound in 2019. No bearded seals were observed during aerial surveys in Admiralty Inlet in 2019.

Polar Bear

Leg 1: Four polar bear sightings were made during the early shoulder season (see Table 4). The first sightings was of an individual swimming in the Milne Inlet South/ stratum during Survey 4 (see Appendix B, Figure B-4). The polar bear appeared to react to the aircraft by looking up at the plane and changing its direction of swimming. The last three sightings were observed during Survey 5 in the Eclipse Sound West stratum. One was of an individual bear walking on the shore and the other two sightings were of animals in the water swimming.

Leg 2: Seven polar bear sightings were made during the open-water season in Eclipse Sound Grid (Table 12). During Survey 1, a sighting of an individual polar bear swimming in the water was observed in Navy Board Inlet and a sighting of a mother with two cubs walking on the shore was observed in Pond Inlet stratum (see Appendix B, Figure B-6). During Survey 3, a single polar bear was observed running on the shore in the Eclipse Sound East stratum (see Appendix B, Figure B-8). Two sightings of a mother with cubs were observed during Survey 4 within a minute of each other (see Appendix B, Figure B-9). Both sightings were recorded in Navy Board Inlet. One observer indicated that the bears was walking on shore. The other sighting was also observed on shore but no behaviour was identified for it. During Survey 5, two sightings of individual polar bears were observed (see Appendix B, Figure B-10). The first sighting was of a polar bear looking back and running in a direction away from the aircraft. The second sighting was of a polar bear walking on one of the small island in Navy Board Inlet. The second bear did not appear to react to the aircraft.

Six polar bear sightings were made during the open-water season in Admiralty Inlet (see Table 13). During Survey 1, an individual polar bear was observed swimming in the Admiralty Inlet North stratum (see Appendix B, Figure B-11). During Survey 4, three polar bear sightings were observed. The first sighting was of an individual polar bear swimming at the south end of Admiralty Inlet South stratum (see Appendix B, Figure B-14). The second sighting was of a mother with a cub on the shore in close. The second sighting was in close proximity to the third sighting which was of an individual bear, also on the shore (see Appendix B, Figure B-14). During Survey 5, two polar bear sightings were observed (see Appendix B, Figure B-15). The first sighting was of an individual polar bear on the west shore in the southern portion of the Admiralty Inlet North stratum. The second sighting was of a mother and cub on the west shore in the northern portion Admiralty Inlet North stratum.

5.0 SUMMARY

The 2019 MMASP addressed Project Certificate Terms and Conditions # 99, #101, #109, #111, and #126. Table 25 demonstrates how Project Certificate Terms and Conditions were met through the 2019 MMASP.

Table 25: NIRB Project Certificate No. 005 Terms and Conditions relevant to the 2019 MMASP

Project Certificate Terms and Conditions No.	Condition / Evidence of Conditions Met
# 99	Collection of additional baseline data
# 101	Efforts to involve Inuit in monitoring studies at all levels ▪ Involved Inuit researcher in the field data collection and analysis of photographic aerial survey data Monitoring protocols that are responsive to Inuit concerns ▪ Aerial surveys allow for evaluation of large-scale displacement effects, abandonment of the RSA, moderate to large changes in stock size Schedule for periodic aerial surveys as recommended by the MEWG ▪ Aerial surveys conducted in 2019
# 109	Conducted a monitoring program to confirm the prediction in the FEIS ▪ Aerial survey can measure effects at the 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 a power analysis to determine if the aerial surveys had sufficient power to determine if negative impacts as a result of vessel noise are occurring
# 126	Design monitoring program to ensure that local users can assist with monitoring and evaluating potential impacts ▪ Aerial surveys use local Inuit to assist in data collection and in 2019 an Inuit researcher from Pond Inlet assisted in the photographic data analysis

The revised aerial survey approach applied in 2019 with the combined visual and photographic surveys offered an improved platform for obtaining narwhal abundance estimates compared to previous aerial survey programs conducted in the RSA. The 2019 abundance estimate for the Eclipse Sound narwhal summer stock based on data from Surveys 3 and 4 (9,931 animals; CV = 0.05; CI of 9,009 – 10,946) falls within the 95% CI of all previous DFO abundance estimates for the Eclipse Sound summer stock. The 2019 narwhal abundance estimate for the combined Eclipse Sound and Admiralty Inlet stocks based on data from Surveys 3 and 4 (38,771 animals;

CV=0.12; 95% CI of 30,667–49,016) falls within the 95% CI of the 2013 DFO abundance estimate of the combined stock (45,532 narwhals, CV=0.33, 95% CI of 22,440–92,384; Doniol-Valcroze et al. 2015).

These findings are consistent with impact predictions made in the FEIS Addendum for the Early Revenue Phase (ERP) 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). Based on the results of the 2019 MMASP, it appears that mitigation measures implemented to minimize effects of Project shipping on marine mammals in the RSA (e.g., speed restrictions, limited icebreaker transits during shoulder season, establishment of a 40km buffer zone, etc.) are functioning as intended and that no additional adaptive management measures to Project shipping operations are required at this time. Continuation of the MMASP in future years will be discussed with the Marine Environmental Working Group (MEWG) in accordance with Project Certificate Terms and Conditions.

6.0 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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APPENDIX A

MMO Training Manual

REPORT

2019 Marine Mammal Aerial Survey Program

Training Manual

Submitted by:

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1.0 INTRODUCTION

The Marine Mammal Aerial Survey Program (MMASP) represents one of several programs that were developed to support the Mary River Project (the Project). The MMASP is part of the Marine Environmental Effects Monitoring Program (MEEMP) 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 and non-biologists who may or may not have appropriate experience to support the objectives of the MEEMP.

A marine mammal observer (MMO) is a person with training in marine mammal survey techniques, including from an aerial platform. These survey techniques include spotting and identifying marine mammals, determining location of sightings and their movement with respect to the aircraft, 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 OBJECTIVES

The objectives of the marine mammal aerial survey program are as follows:

- Determine relative numbers of narwhal (*Monodon Monoceros*) during the staging period in late July at the floe edge
- Obtain a reliable abundance estimate of the Eclipse Sound and Admiralty Inlet summering herds during the open-water season

The main role of the MMO onboard the aircraft is to scan the water along the transect line and actively look and document all marine mammal observations and environmental conditions.

3.0 HEALTH AND SAFETY

3.1 Aircraft

Surveys will be flown in a de Havilland Canada DHC-6 Twin Otter aircraft operated by Kenn Borek Air Ltd. (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 has a cruise speed of 265 km/h (165 mph).

Kenn Borek Air Ltd'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, what safety equipment is on board the aircraft, and where it is located. 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

While flying there is the potential to become motion sick. This can affect your ability to continue to observer for marine mammals.

4.0 FIELD PROGRAM

4.1 Overview

Golder will implement the 2019 MMASP with support from Inuit participants from the communities of Pond Inlet and Arctic Bay. Survey design and data collection methodology previously developed by Fisheries and Oceans Canada (Asselin and Richard 2011; DFO 2017; Doniol-Valcroze et al. 2015) will be adopted to allow for reliable inter-annual comparisons of survey data. The 2019 aerial survey program will be staged in two separate steps.

Step 1 will target a 15-day window in late July to capture narwhal abundance and distribution near Pond Inlet with an emphasis on the area near the floe edge. The focus will be to capture narwhal presence in the Regional Study Area (RSA) prior to the start of the shipping season and to determine their relative number during this staging period (as narwhal await ice break-out prior to their entry into Eclipse Sound and Milne Inlet). Step 1 surveys will be conducted by a five-person survey team based in Pond Inlet using a single survey aircraft chartered from Kenn Borek Air.

Step 2 will target a 15-day window in mid-August corresponding with the peak open-water period. Step 2 surveys will be conducted by two coordinating five-person survey teams, one based in Pond Inlet and one in Arctic Bay. The objective of these surveys is to obtain a reliable abundance estimate of the combined Eclipse Sound and Admiralty Inlet narwhal summering herd during the open-water season. To capture the full summer range of this sub-population, survey coverage will include Milne Inlet, Eclipse Sound, Tremblay Sound, Navy Board Inlet and Admiralty Inlet. This will require conducting simultaneous aerial surveys using two aircraft and survey crews, with each team covering their respective half of the full survey grid. Attempts will be made to fly the full survey grid within a two-day period that corresponds with optimal survey conditions (with as many replicates of the survey grid allowable within the 15-day period).

4.2 Survey Area

The boundaries for Step 1 will initially focus in the open water area around the floe edge where narwhal are known to stage prior to entering Eclipse Sound (blue lines in Figure 2). Reconnaissance flights will be flown periodically in Tremblay Sound and Milne Inlet to verify narwhal presence/absence (Figure 3). If narwhal are observed in Tremblay Sound or Milne Inlet, the entire survey grid will be flown including all strata (switch from blue lines to yellow lines in Figure 2). Systematic random visual line-transect surveys will be flown for the Pond Inlet, Eclipse Sound East, Eclipse Sound West, Milne Inlet North, Baffin Bay and Navy Board Inlet strata with the location of the first line chosen at random. A photographic survey with complete coverage will be flown for the Tremblay Sound and Milne Inlet South strata.

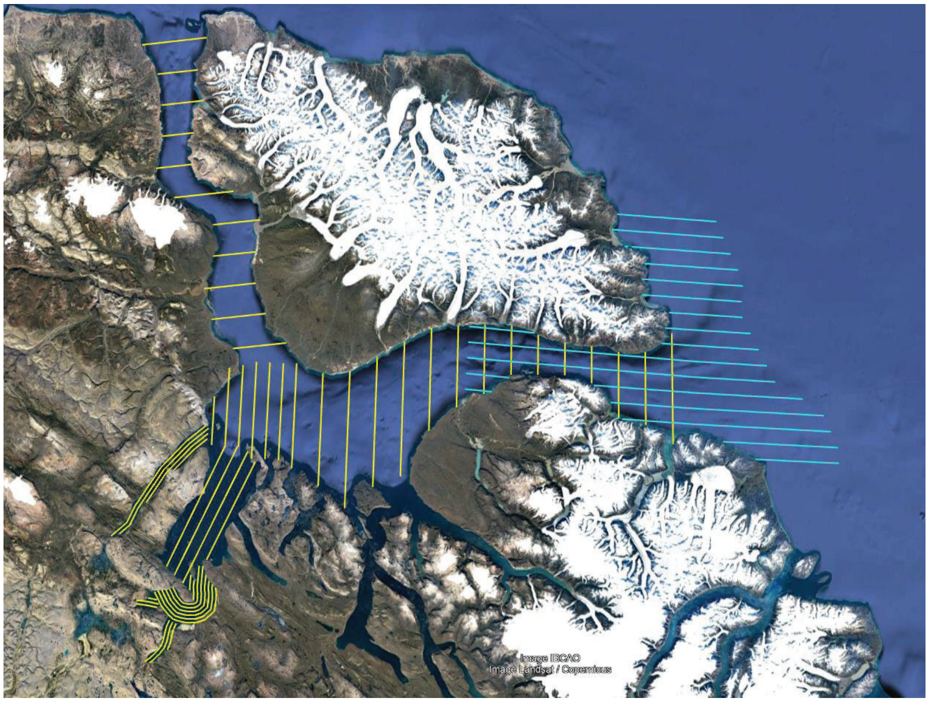


Figure 2: Eclipse Sound visual aerial survey transect lines. Blue lines flown during Step 1 when floe edge is intact. Yellow lines flown during Step 2 in open water conditions.

Figure 3: Eclipse Sound study area and geographic strata

Step 2 will survey Eclipse Sound and Admiralty Inlet within a two-day period to obtain an estimate of narwhal abundance in the combined areas. The boundaries and transect lines for Eclipse Sound and Admiralty Inlet will follow that flown in previous DFO surveys (yellow lines in Figure 2 and red lines in Figure 4). Systematic random visual line-transect surveys will be flown, except for Tremblay Sound and Milne Inlet South (Koluktoo Bay) where a photographic survey will be flown. Reconnaissance flights will be flown in the northern fjords in Admiralty Inlet study area and in Eskimo Inlet and White Bay in Eclipse Sound study area if time permits.

Figure 4: Admiralty Inlet visual aerial survey transect lines for Step 2 in open water conditions.

4.3 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 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. Four observers, consisting of two certified MMOs and two trained Inuit observers, will be stationed at the front and rear bubble windows that provide a view of the track line directly below the aircraft. The 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 setting up the camera system and overseeing navigation along the survey grid.

Observers will continuously scan below the aircraft while actively on a transect line. The observer will record every marine mammal sighting by speaking into a hand-held audio recorder. Each sighting record will include information on species type, time at which the animal passed abeam of the window, perpendicular declination angle of each sighting relative to the horizontal plane using an inclinometer or geometer, 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 or 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 perpendicular distance and other variables (direction of movement, presence of young, number of tusks) if time permits. Position and altitude of the plane will be recorded every two seconds using a GPS connected to a laptop running electronic mapping software.

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).

4.4 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. The aircraft will be fitted with a camera belly port hatch to accommodate a camera frame and two Digital Single Lens Reflex (DSLR) still cameras. The camera system will consist of two Canon EOS 5DS R DSLR cameras mounted on a custom camera frame.

A dedicated Bluetooth GPS unit and iPad will be used to track the aircraft location using specialized navigational mapping software (pre-programmed with the survey transect grid). 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 and flight track logs will be transferred to an external hard drive.

4.4.1 Photographic Survey

In addition to the visual surveys, photographic surveys will be conducted on large aggregations (>50 narwhals) identified during the visual surveys to allow for complete counts of animals. To identify these aggregations, all personnel on board the aircraft (pilots, observers and crew chief) are instructed to look out for herds of narwhals and alert everyone when one was sighted. The lead MMO will make the final decision as to what constituted an aggregation of >50 narwhals. When such an aggregation is located, a photographic survey of the herd using a systematic grid with complete coverage will be used. Photographic surveys will be flown at an altitude of 610 m (2,000 ft) flying at 185 km/h.

5.0 DAILY ROUTINES

Non-flight days — Typical workdays range in length from 6-10 hours depending upon the number of trained staff members available, the weather, and how much data needs processing from the previous day. Every day is a potential flight day with weather being the major limiting factor. As such, the aviation and marine forecasts are checked early each morning by the lead MMO and, if conditions look promising for an early morning flight, the lead will notify the crew and pilots. Weather requirements for surveying include a ceiling of greater than 333 m (1,000 ft) and sea states of less than beaufort level five.

If an MMO has not heard from the lead by 09:00 they should call or stop by the office to hear the weather report and plans for the day. Weather is highly variable and often the lead will set-up another check-in time, a few hours later, or ask the MMO to come in for data entry and validation while waiting for the weather to improve. The lead MMO continues to coordinate with the pilots about weather conditions and if by late afternoon the conditions still have not improved enough to allow for a flight, it will be canceled.

Flight days — If the weather permits a flight, the lead MMO will set up a meeting time and place. *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. 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.

6.0 EQUIPMENT

Clinometer

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). See Appendix A 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 electronically record sighting time and declination angles to sighting in an electronic database, that will be uploaded to the Mysticetus database at the end of a flight. This devise 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.

Garmin GPS

A Garmin GPS device will be used to track the aircraft during marine mammal surveys at 2 second intervals.

Each GPS device should be turned on at the start of the flight by pressing the "ON" button located on the top of the device. It may take a few minutes for the device to acquire satellites. The GPSs will be connected to external antennae for them to be able to acquire a signal.

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 lens. The cameras will be connected to GPS units to geo-reference photographs, and to a laptop computer to control exposure settings and photo interval. The cameras will be installed within the optical glass covered camera hatch on a custom-made mount. Geo-referenced 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 noise cancelling headset prior to each flight.

7.0 DATA COLLECTION

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

7.1 Data/ Photo Manager

The data/photo manager is responsible for setting up the cameras and computer system for surveying. A portable GPS unit is plugged into the computer to record GPS positions and waypoints during each flight. The date, time, and GPS coordinates are automatically recorded with each two-second point on the track line.

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 data manager the start and stop point of the transects. To make data entry easier after each flight, sightings and transect start and stop times will be saved using the waypoint feature in the Mysticetus program. A drop-down menu is available to facilitate recording data collected during the survey, but most data will be transcribed from the audio recorders into the database after the flight.

The data manager will be responsible for keeping a flight log in the Mysticetus database. 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 clinometer (or 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 cover**: Tenths of the viewing area covered in ice.
- **Beaufort wind force**: Visual conditions of the wave height and froth.
- **Glare**: Angle of searching area affected by sun reflection and intensity.
- **Fog**: Percentage of the viewing area obscured due to fog and what 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	Tenths 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	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.
Glare Angle	0-90 degrees	Angle of viewing area affected by sun reflection
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 can’t 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 are recorded every time a marine mammal is sighted (Table 2). For examples with descriptions of each sighting data see Appendix B. Inform the data recorder when a marine mammal that is spotted is **perpendicular** to the aircraft so that they can enter species, number and location information. Record the following additional information about the sighting on your digital voice recorder in order of importance:

- **Species**: name of species observed
- **Group size**: number of individuals in group
- **Clinometer angle:** depression angle from the horizon to the sighting as determined using a clinometer, when the marine mammal is perpendicular to the aircraft.
- **Included/excluded from density analyses:** does the sighting meet density analysis criteria so it can be included in analyses?
- **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 to a few body lengths 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.
Include/Exclude	Include	A sighting seen within the field of view, and at the surface or clearly visible just below surface, and at survey altitude.

Sighting Type	Code	Description
	Exclude	If the sighting is seen 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 above 333 m (1,000 ft).
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.
	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.
	# juvenilles	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	If no tusk visible 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.
	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).
	Traveling	Moving in a distinct direction with a moderate to fast pace.
	Unknown	Nothing recorded.

Sighting Type	Code	Description
Behaviour	Hauled out	Hauled out on ice or land (pinnipeds).
	Diving	Animal descends below the surface.
	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).
	Walking	Polar bear walking on ice or land.
	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.
	Fluking	When a whale raises its fluke as it dives beneath the water.
	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.
	Surfacing	When a marine mammal is observed coming to the surface of the water.
	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 as soon as possible so that people may be able to accurately fill in any data not recorded during the survey. Direct entry into the database is preferred. 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 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 (Pond Inlet or Arctic Bay)
- 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 angle 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 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 data recorder during flight)
- Species (filled in by data recorder during flight if time permits)
- Group size (filled in by primary observer audio recordings after flight)
- Clinometer angle (filled in from text fill generated by geometer)
- Include/exclude (filled in by primary observer audio recordings after flight)
- Direction of movement (filled in by primary observer audio recordings after flight)
- Speed (filled in by primary observer audio recordings after flight)
- Age (filled in by primary observer audio recordings after flight)
- Sex (filled in by primary observer audio recordings after flight)
- Activity (filled in by primary observer audio recordings after flight)
- Behaviour (filled in by primary observer audio recordings after flight)
- Sighting cue (filled in by primary observer audio recordings after flight)

Marine mammal sightings data recorded by the secondary observers will be entered in an excel spreadsheet manually from the audio recordings after the flight (see Appendix C for sample spreadsheet). 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 or 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 and lead MMO's laptop.
- The spreadsheet should be backed up regularly. The electronic spreadsheet will be backed up in several places: external hard drive, lead MMO's laptop and on the field computer, as coordinated by the lead MMO. In addition, the most recent copy of the spreadsheet should be saved in each survey folder on the MMO laptop. 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.

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, turn auto rotation off, and 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. Also note PSO watch or recorder times so that they can accurately be matched with the photos.
- 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.

Glass in camera port

- clean glass inside and outside
- leave it open to main passenger area for heat, glass will ice up or fog up otherwise
- in low temperatures avoid using wetting agents on the window, ice will form immediately and be difficult to remove

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 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
- battery backup must be secured under seat or to floor, use Velcro straps and/or duct tape

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 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

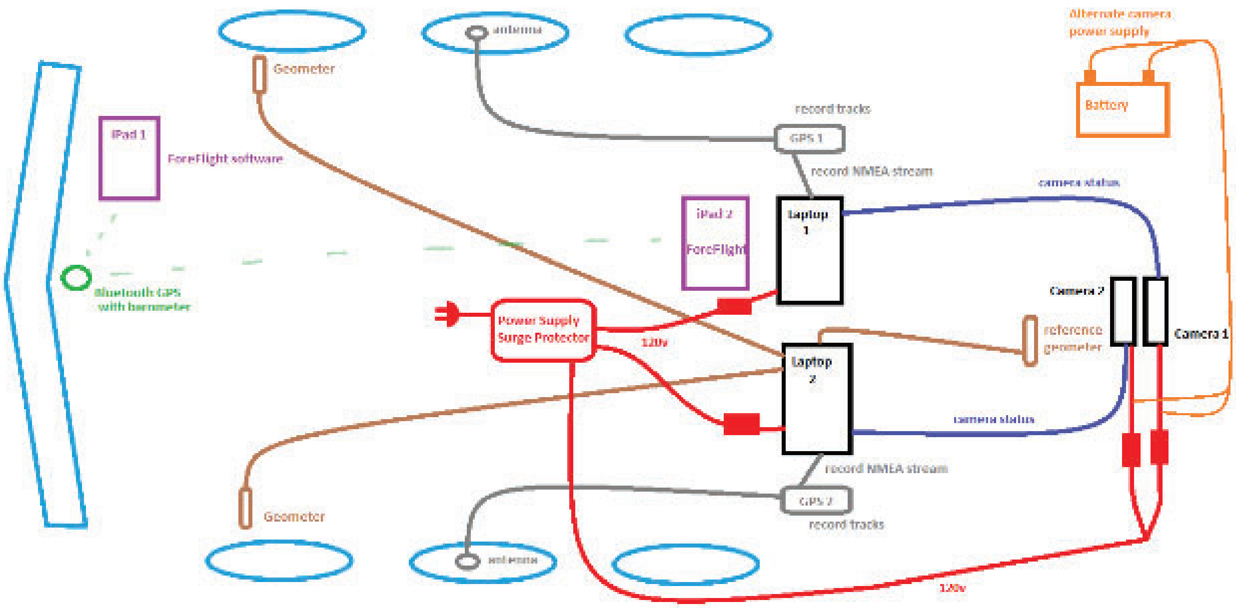
Setup power

- prefer a battery backup for cameras, ensures that power to the cameras will not go off, with AC/DC power to cameras, ensures not interruption if the inverter is accidentally switched manually and will not fry the camera electronics if you get a spike from the inverter

Setup interval timers

- keep cords untangled, timer has several settings make sure no delays are set

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


antenna
Geometer
Alternate camera power supply
Battery
record tracks
GPS 1
record NMEA stream
iPad 1
ForeFlight software
camera status
iPad 2
ForeFlight
Laptop 1
Bluetooth GPS with barometer
Camera 2
Camera 1
Power Supply Surge Protector
120v
reference geometer
Laptop 2
camera status
record NMEA stream
GPS 2
record tracks
Geometer
antenna
120v

APPENDIX B

Examples of Environmental and Sighting Data

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

Environmental data includes:

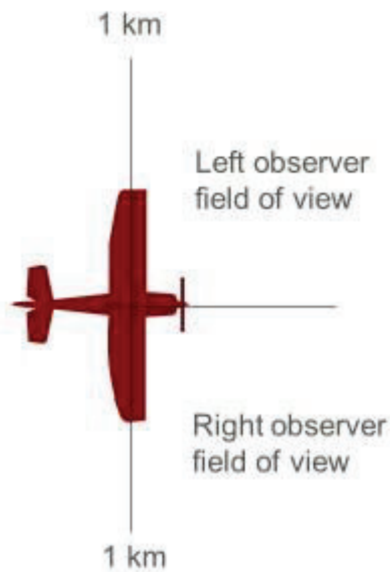
- Ice cover
- Wind force
- Glare
- Fog

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

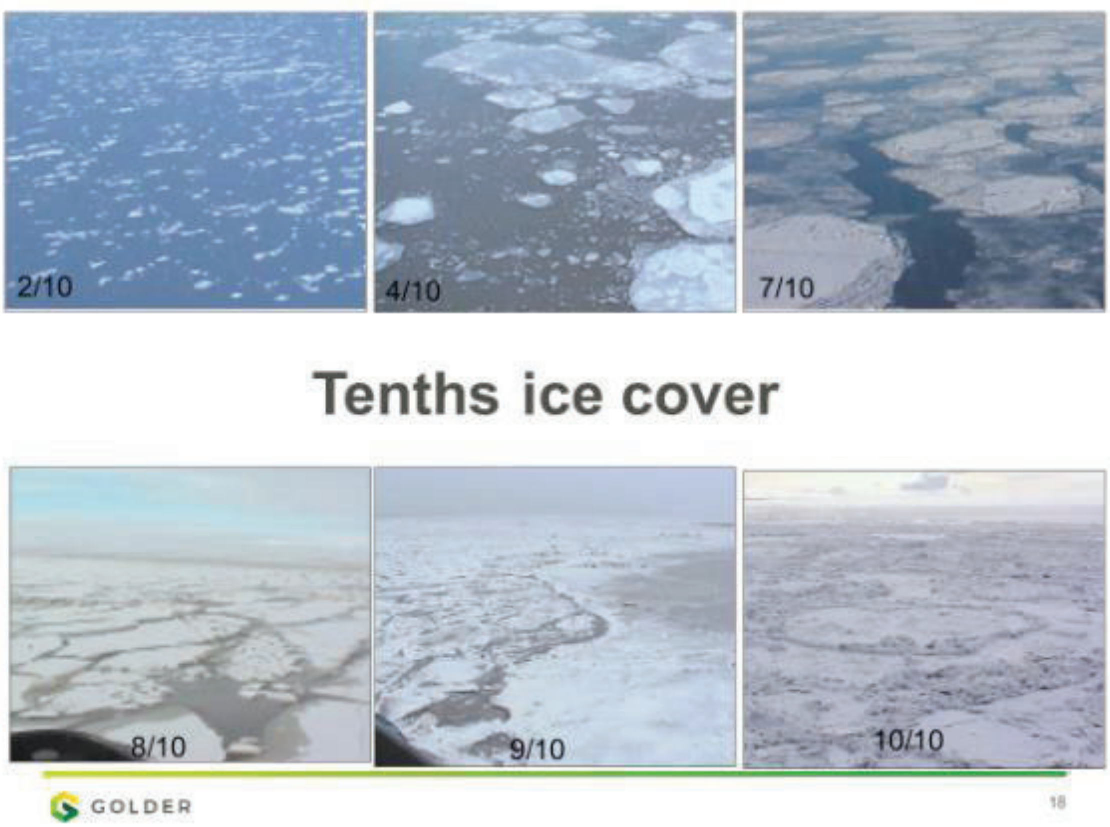


Environmental Data

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

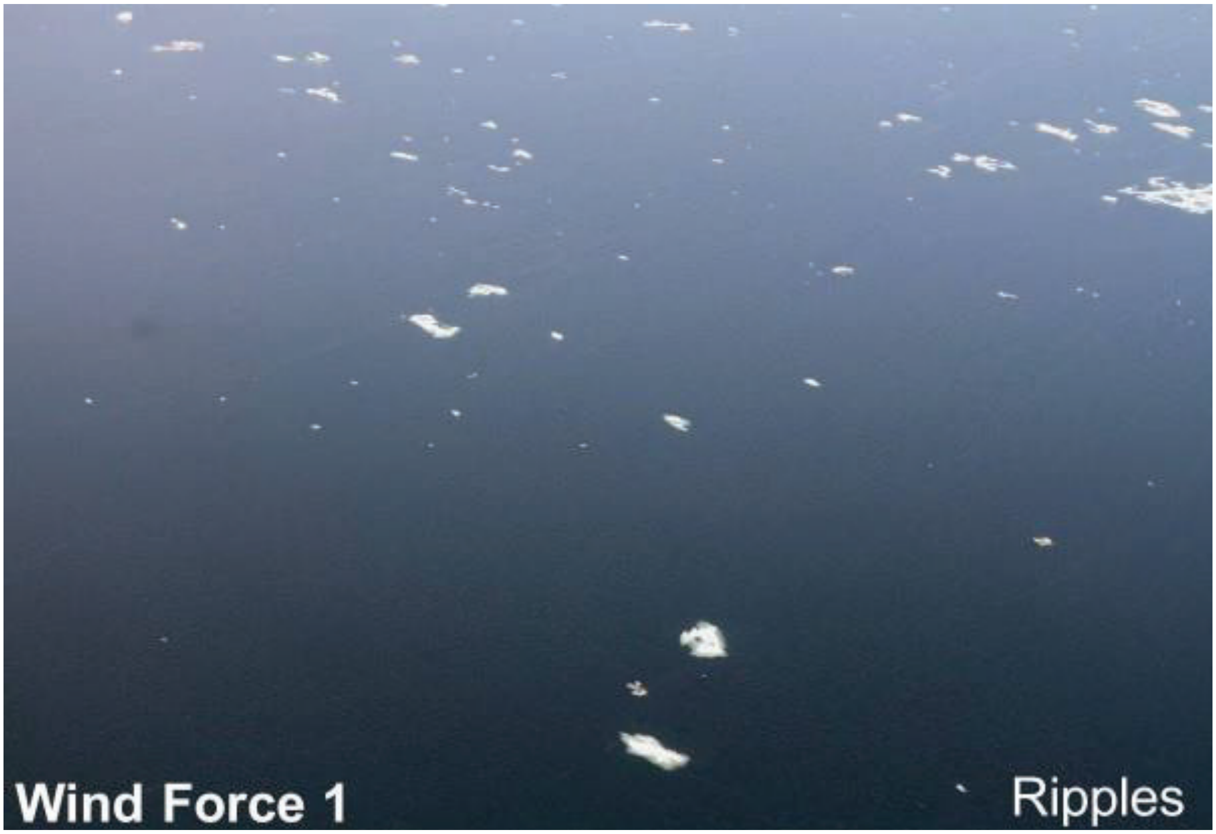
Subjective

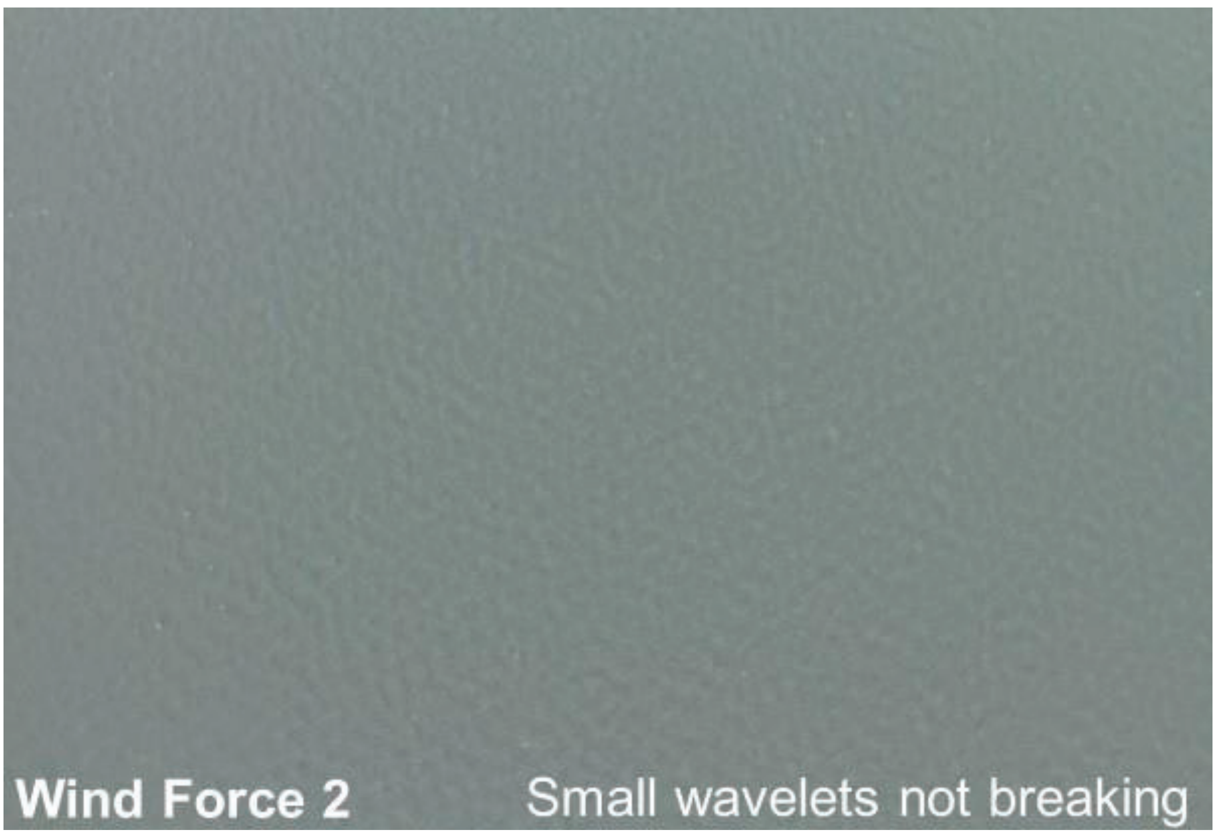
Based on average of conditions


2/10
4/10
7/10
Tenths ice cover
8/10
9/10
10/10
GOLDER
18

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 1
Ripples


Wind Force 2
Small wavelets not breaking

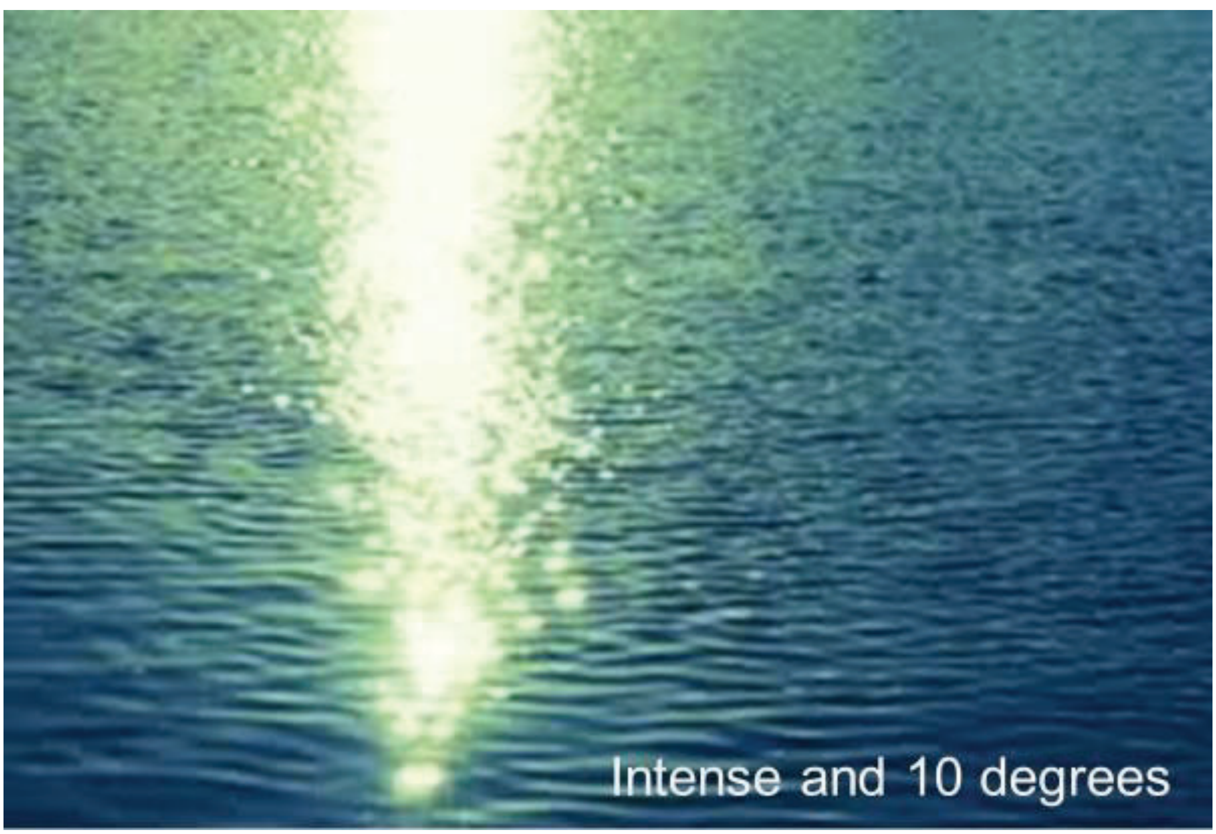

Wind Force 3
Scattered white-caps

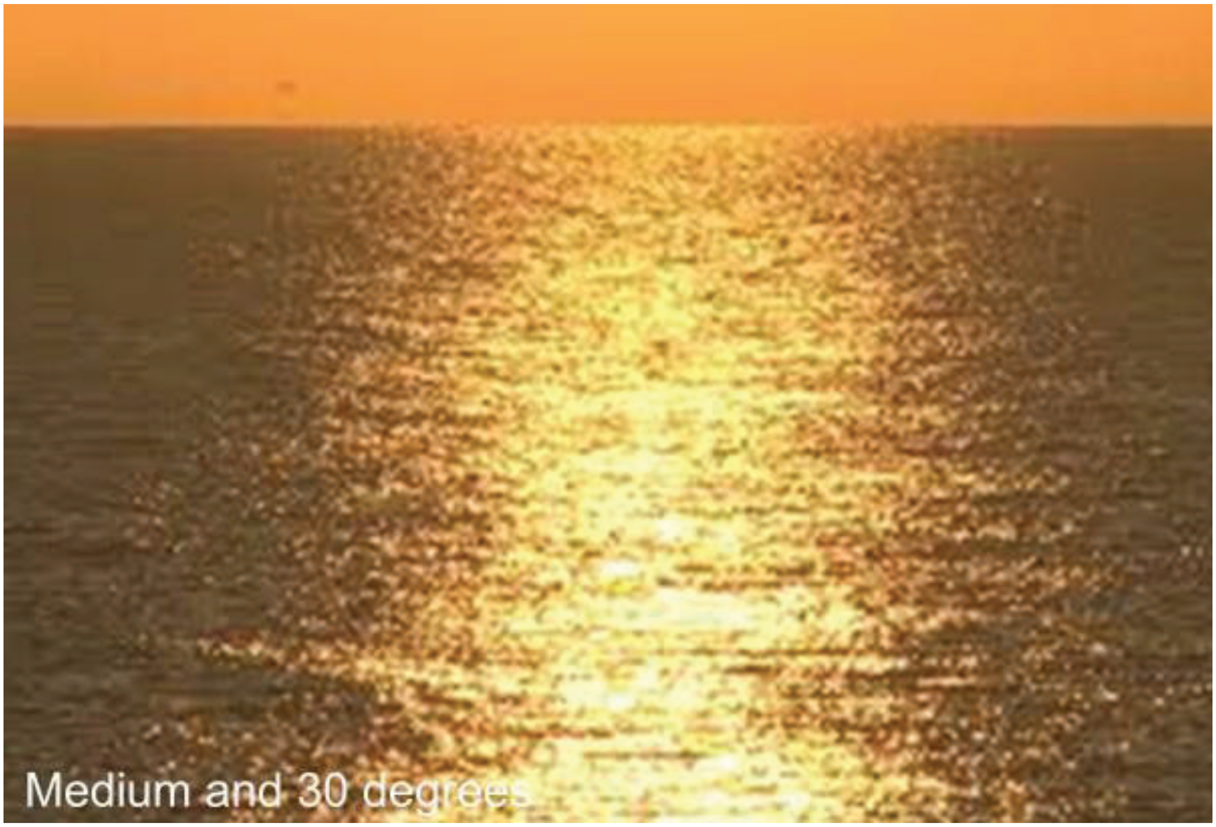

Wind Force 3-4
Frequent white-caps

Glare

Two measurements:

- Degree - angle of viewing area affected by sun reflection (0-90 degrees)
- Intensity – intense, medium, low, or none




Medium and 30 degrees

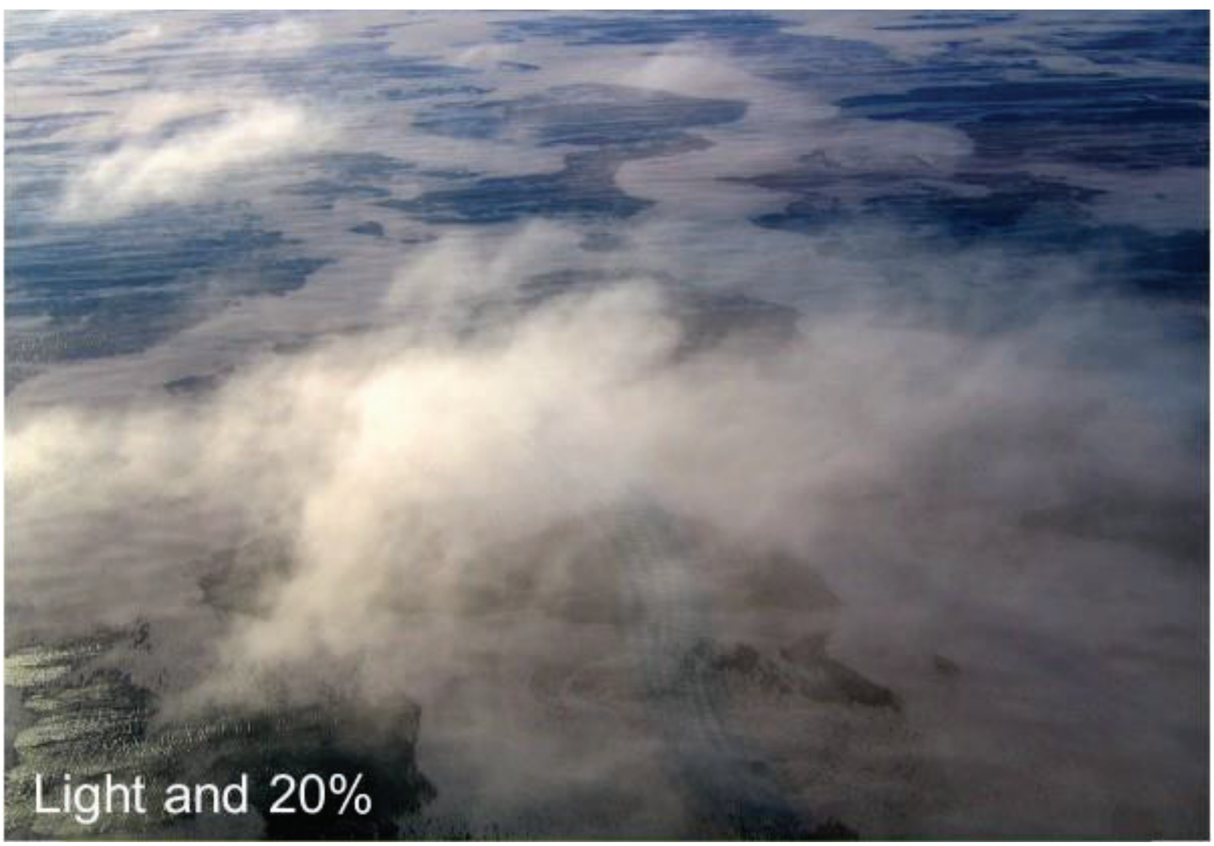

Low and 20 degrees

Fog

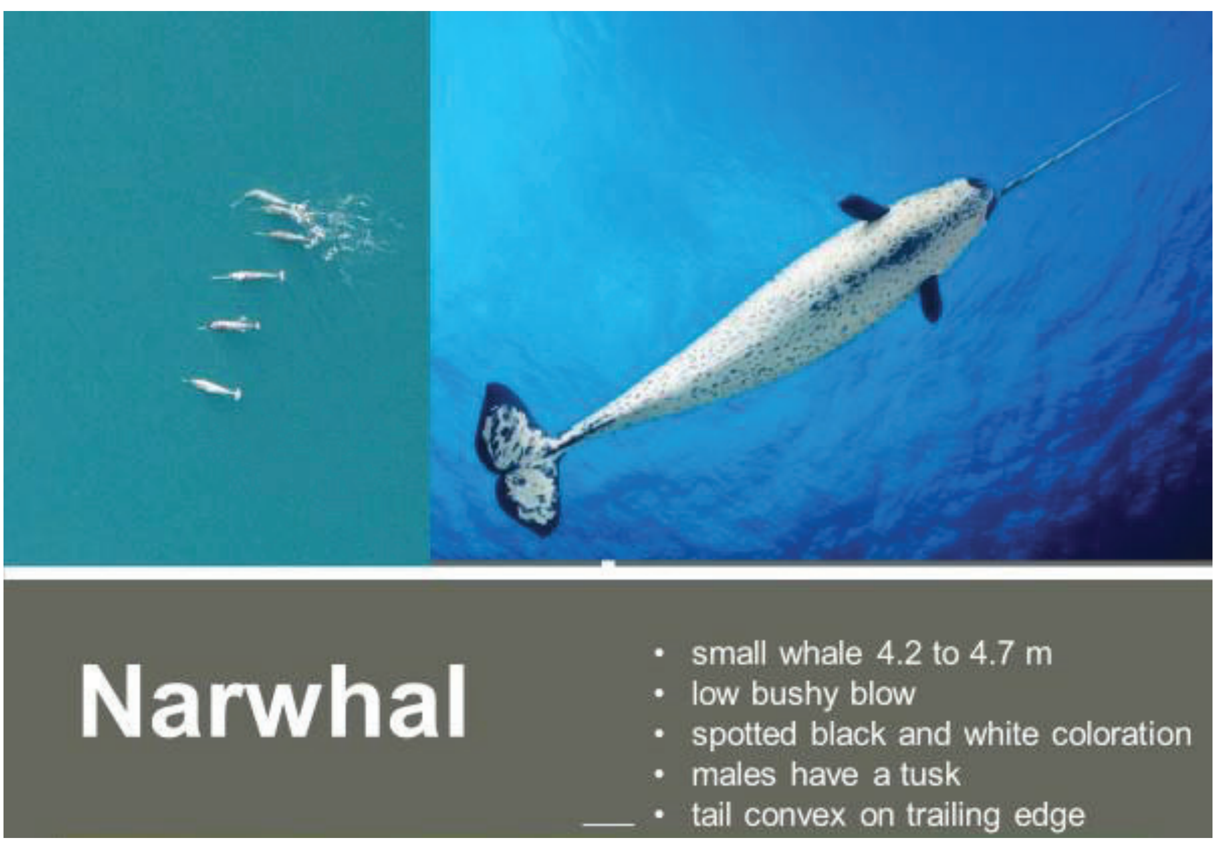
Two measurements:

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


Moderate and 100%


Light and 20%


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


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

Beluga

- small whale 2.7 to 4.2 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

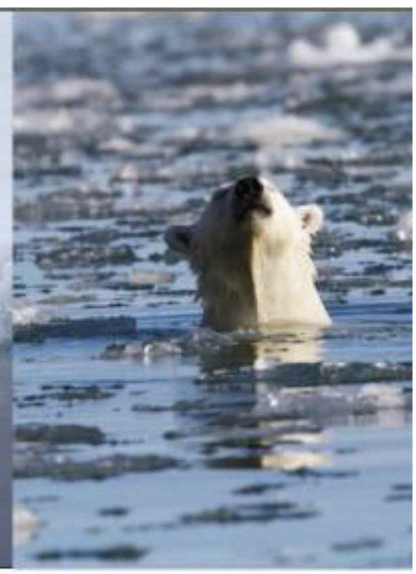
- mid-sized whale 9 m
- dorsal fin
- black with white patches

Seals

- Ringed Seal
- Harp Seal
- Bearded Seal

Walrus

- large pinniped
- light to dark brown
- white tusks



Polar Bear

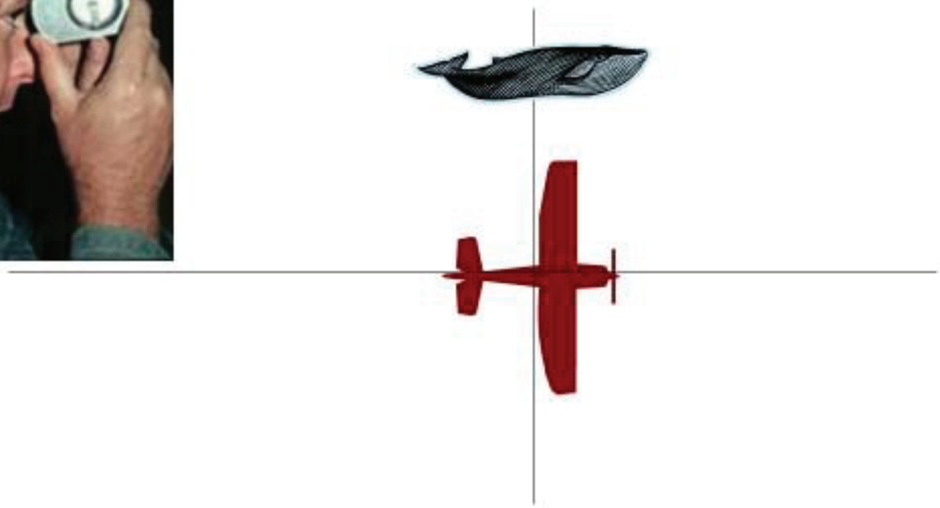
Group Size

- 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)

52

Using Clinometers

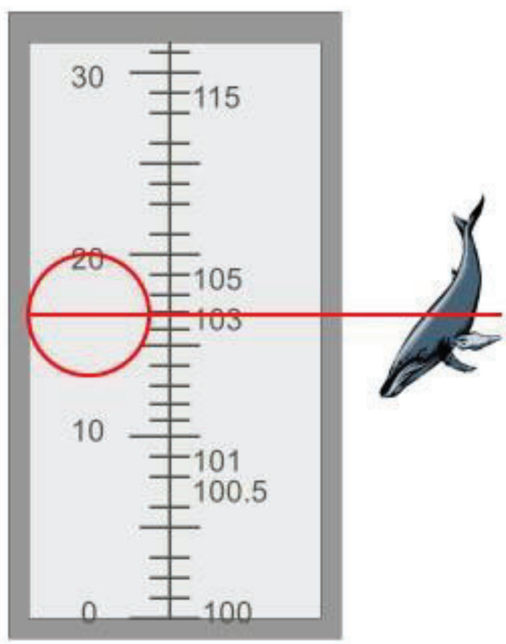
- Wait until the plane is perpendicular to the sighting. Then keep both eyes open and, looking though the inclinometer, line up the horizontal line with the center portion of the animal.
- Record the number on the **left** that the horizontal line passes through.
- If a group of several animals is sighted,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



•**Keep both eyes open!**

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

•Use scale on left = **17**



Include / Exclude

Include

- Sighting is within the field of view, at the surface or clearly visible just below surface, and at survey altitude

Exclude

- Sighting is outside of the field of view (i.e. behind the aircraft or well beyond 1 km distance), 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

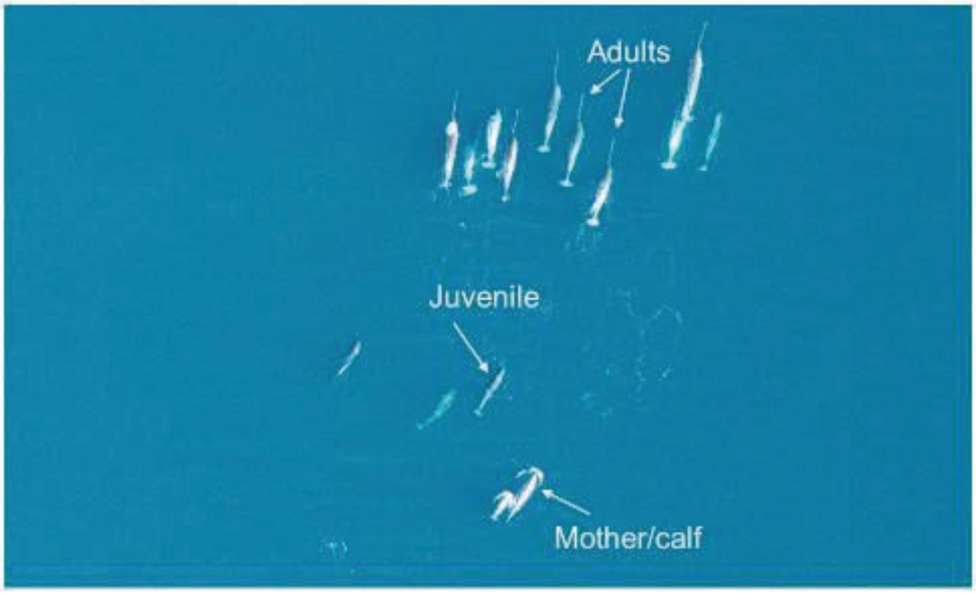
Slow

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

Not Moving

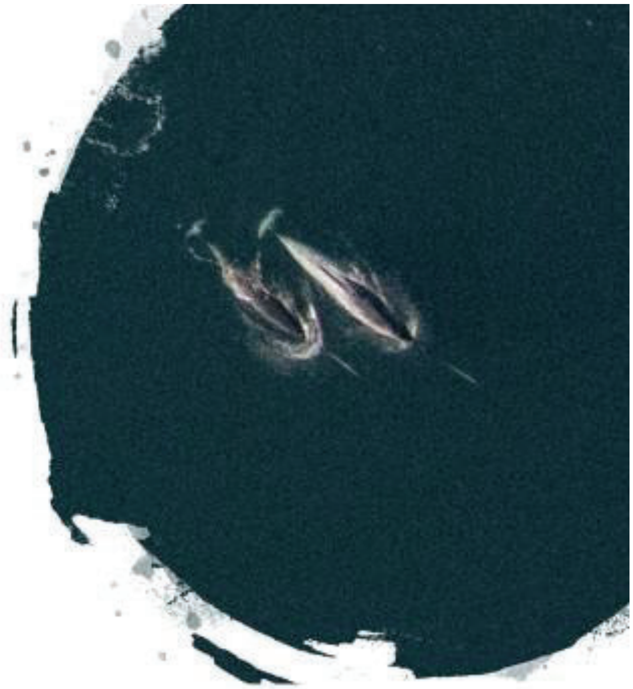
- Marine mammal is stationary, no movement

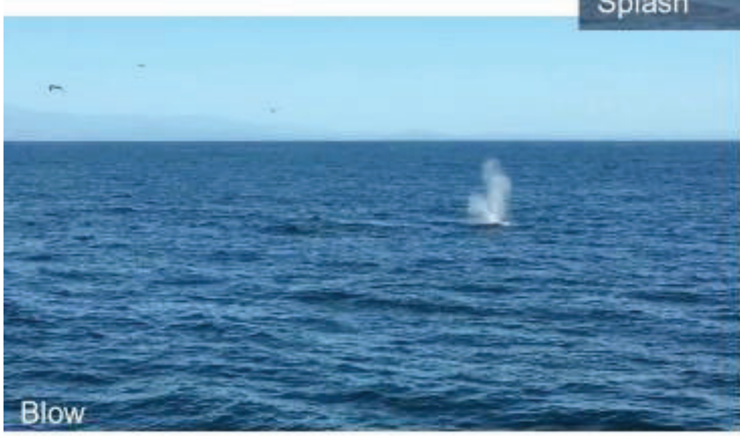
Narwhal age classes



Sighting Cue

- Body
- Blow
- Footprint
- Splash
- Birds



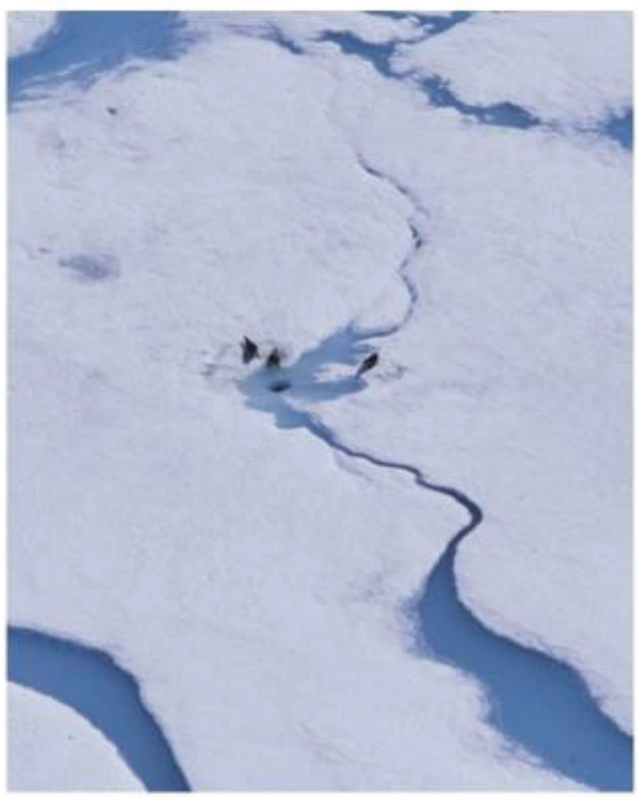


Behaviour

- Hauled Out
- Diving
- Fluke
- Surfacing
- Swimming
- Surface Activity
- Looking
- Blow
- Breaching/spyhopping
- Walking

Hauled Out

Hauled out on ice or land (pinnipeds)



Diving

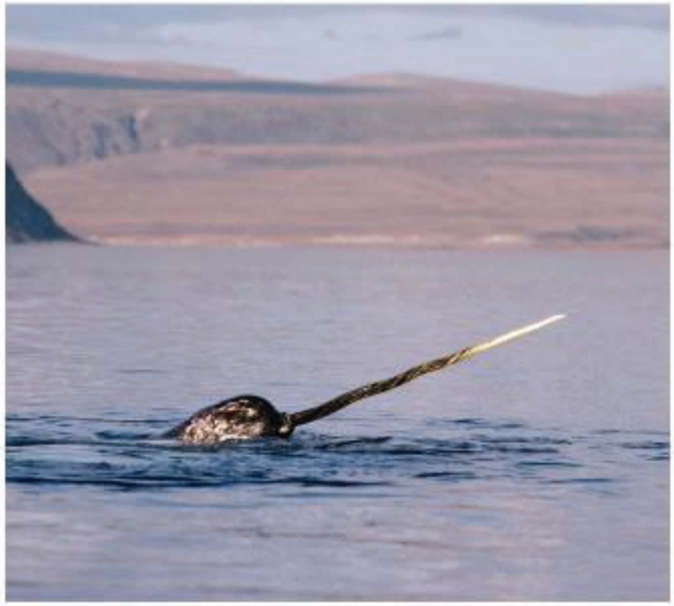
Marine mammal descends below the surface.

Fluke

Whale shows its fluke as it dives beneath the water.

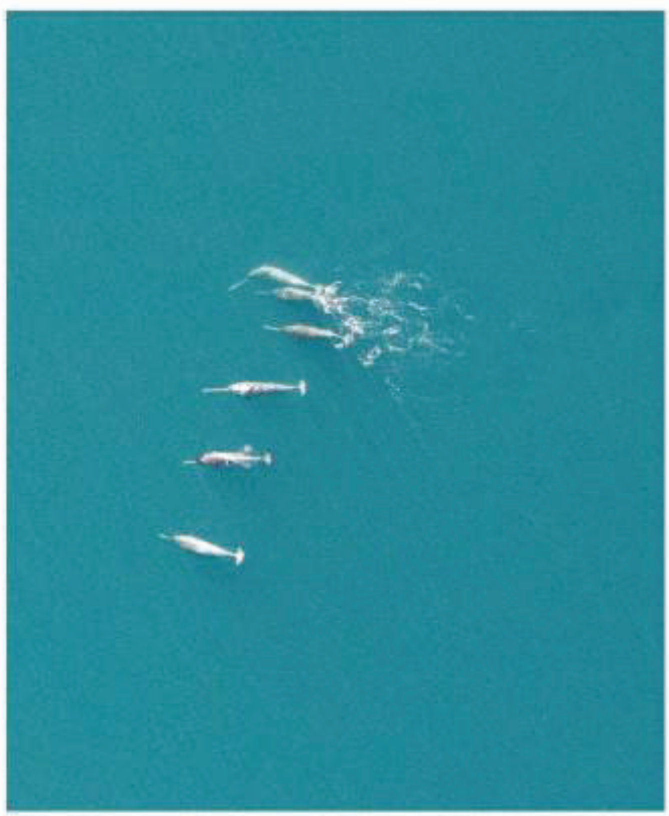
Surfacing

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

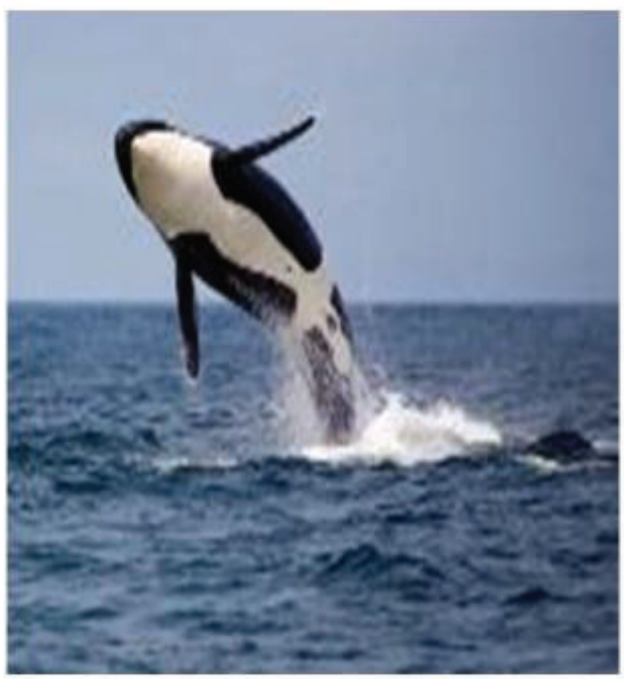
When animal is in an upright position with its head out of the water and is actively looking at something (pinniped or polar bear)

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.

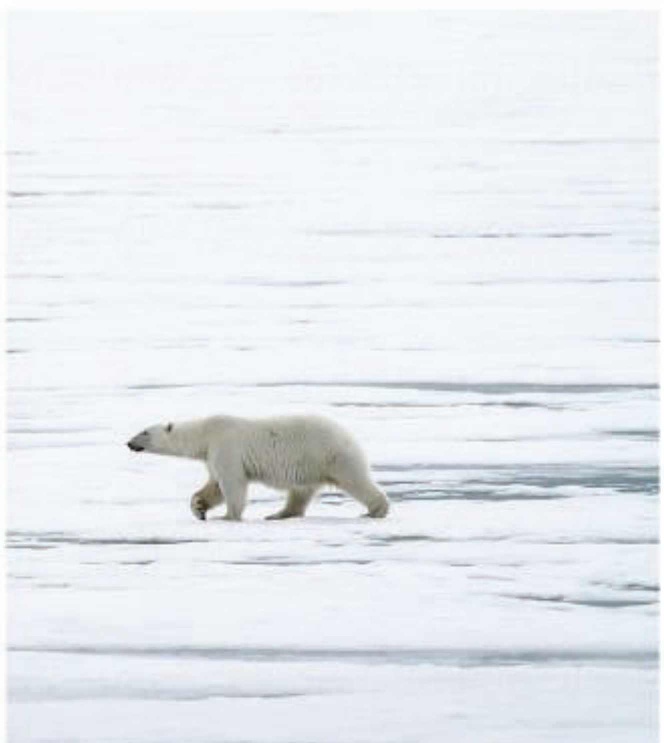


Spyhop

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

Walk

Polar bear walking on ice or land.



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

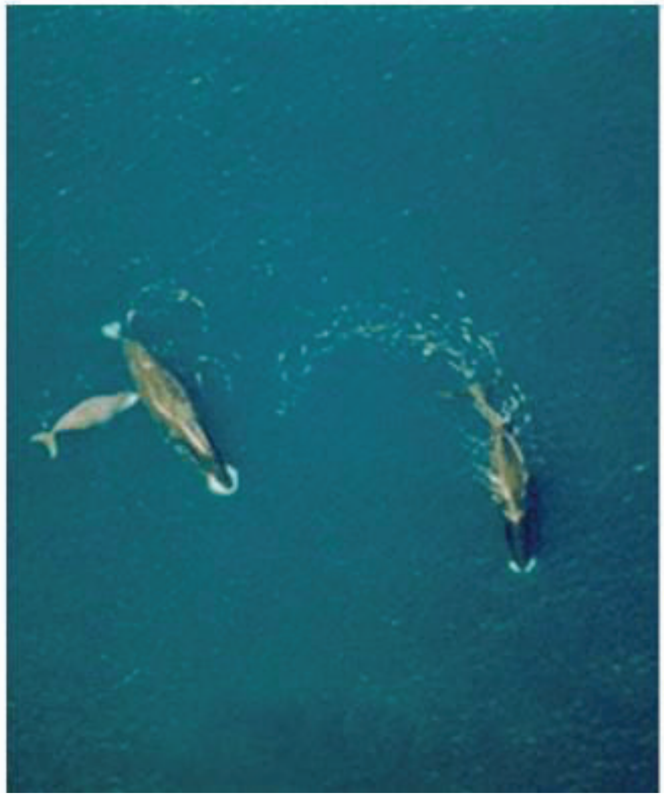
Moving in a distinct direction with a moderate to fast pace

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.	Sigh. cue

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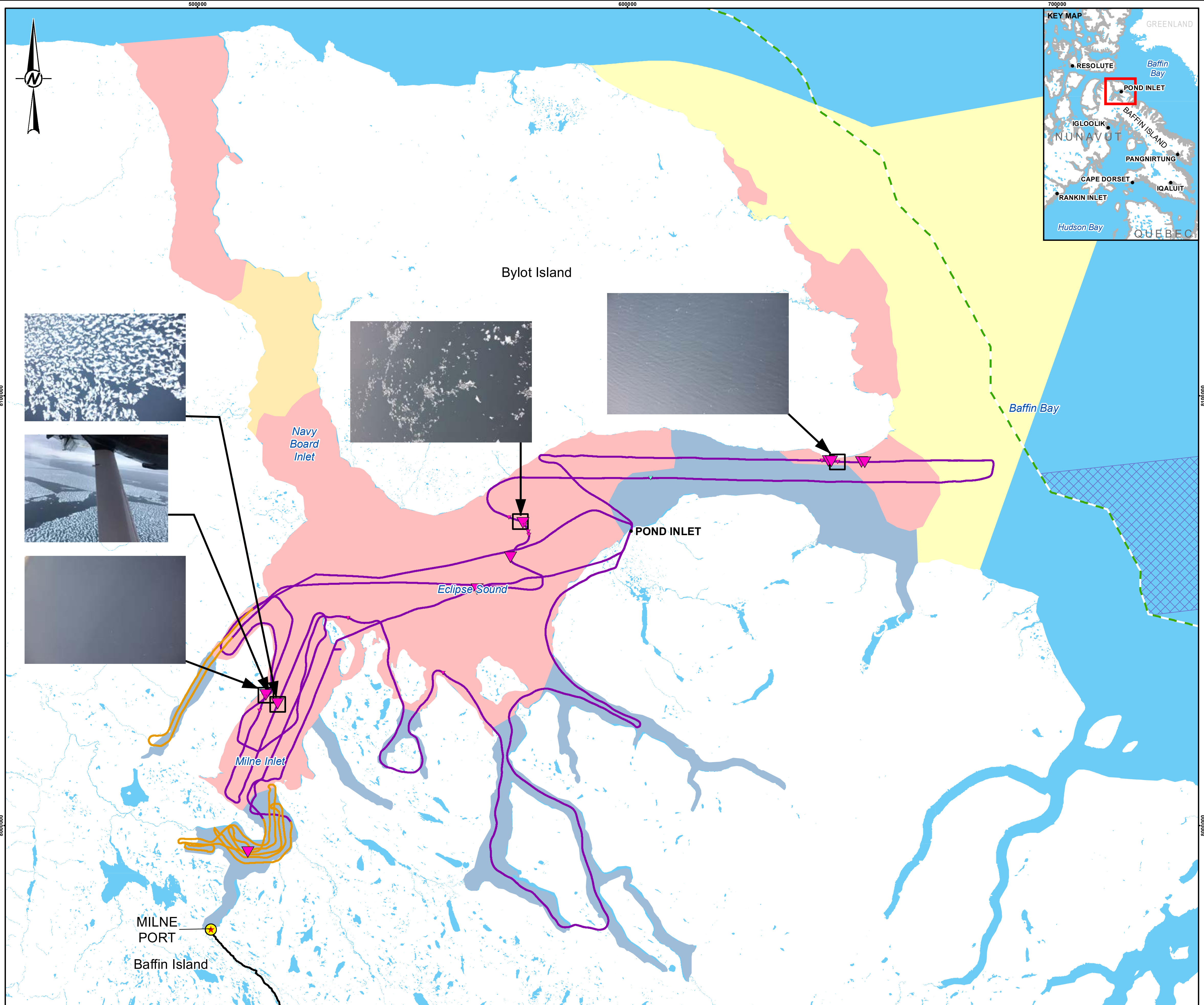
APPENDIX B

Mapbook



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA

- 1

NARWHAL

- 1
- 2 - 10

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

ICE CONCENTRATION

- < 1/10
- 4-6/10
- 7-8/10
- 9-10/10

0 25 50

1:900,000 KILOMETRES

NOTE(S)

PRIOR TO SHIPPING ACTIVITIES. FLOE EDGE HAD DEGRADED AND MUCH OF EASTERN ECLIPSE SOUND WAS OPEN WATER. CONDITIONS MODERATE WITH BEAUFORT SEA STATE (BF) 0-6 AND FOG ON PORTIONS OF NORTH MILNE INLET, THE FJORDS, AND BAFFIN BAY. RECONNAISSANCE FLIGHT USED TO IDENTIFY LOCATIONS OF NARWHAL PRESENCE. NO NARWHALS SEEN IN TREMBLAY SOUND OR SOUTH MILNE INLET/KOLUKTOO BAY.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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

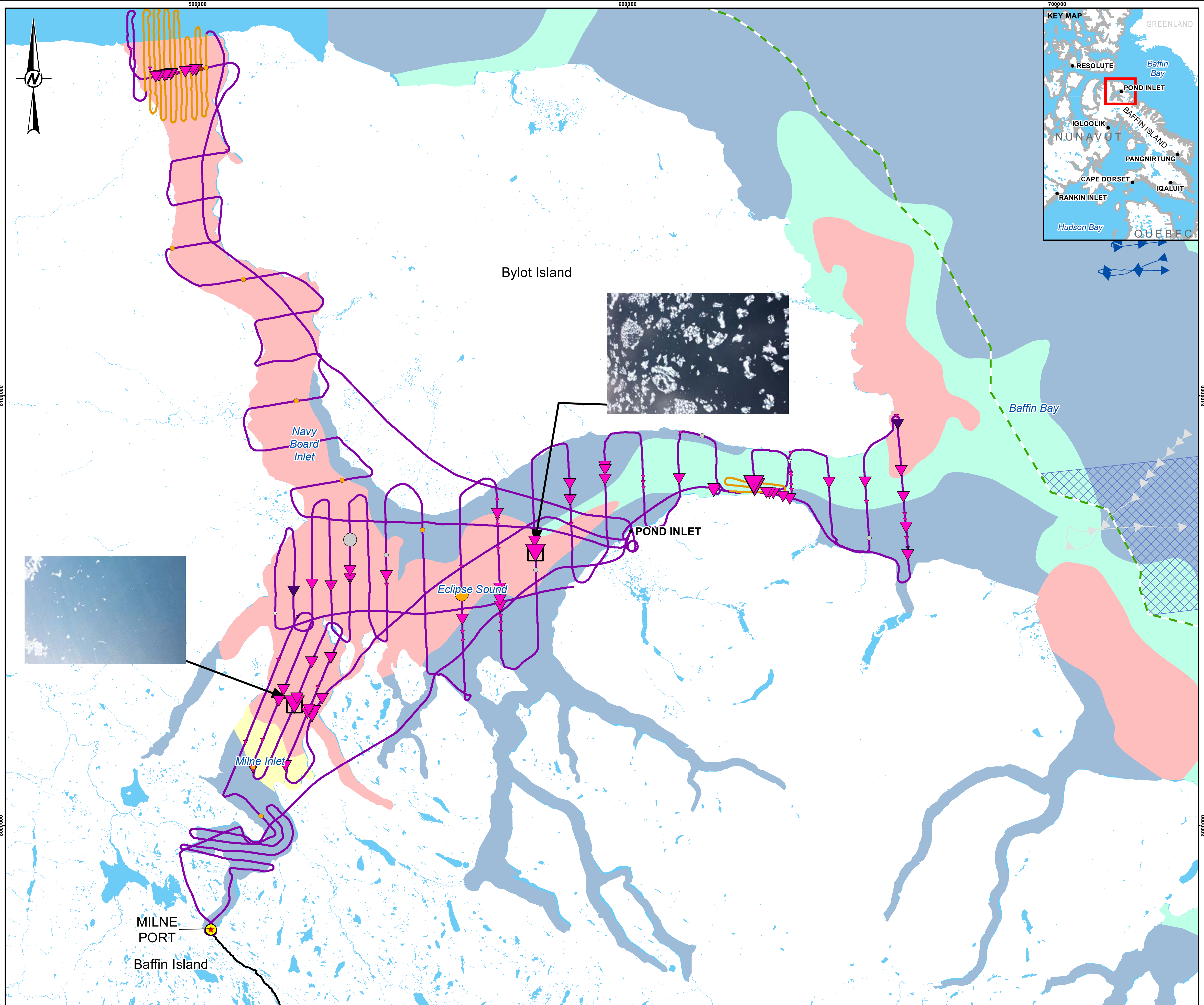
PROJECT
MARY RIVER PROJECT
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE
POND INLET LEG 1 SURVEY 1 - JULY 12-13, 2019

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-1



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BOWHEAD WHALE
- 1
- 2 - 10

NARWHAL
- 1
- 2 - 10
- 10+

RINGED SEAL
- 1
- 2 - 10

UNIDENTIFIED SEAL/PINNIPED
- 1
- 2 - 10

UNIDENTIFIED WHALE/CETACEAN
- 1

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

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
- 9-10/10

0 25 50

1:900,000 KILOMETRES

NOTE(S)

PRIOR TO SHIPPING ACTIVITIES. CONDITIONS GOOD WITH BF 0-4 AND SOME FOG IN NAVY BOARD INLET AND TREMBLAY SOUND. NARWHALS ABSENT IN SOUTH MILNE INLET/KOLUKTOO BAY. LARGE CONCENTRATION OF NARWHAL OBSERVED IN NORTH NAVY BOARD INLET IN HIGH ICE CONDITIONS (PHOTOGRAPHIC SURVEY FLOWN).

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

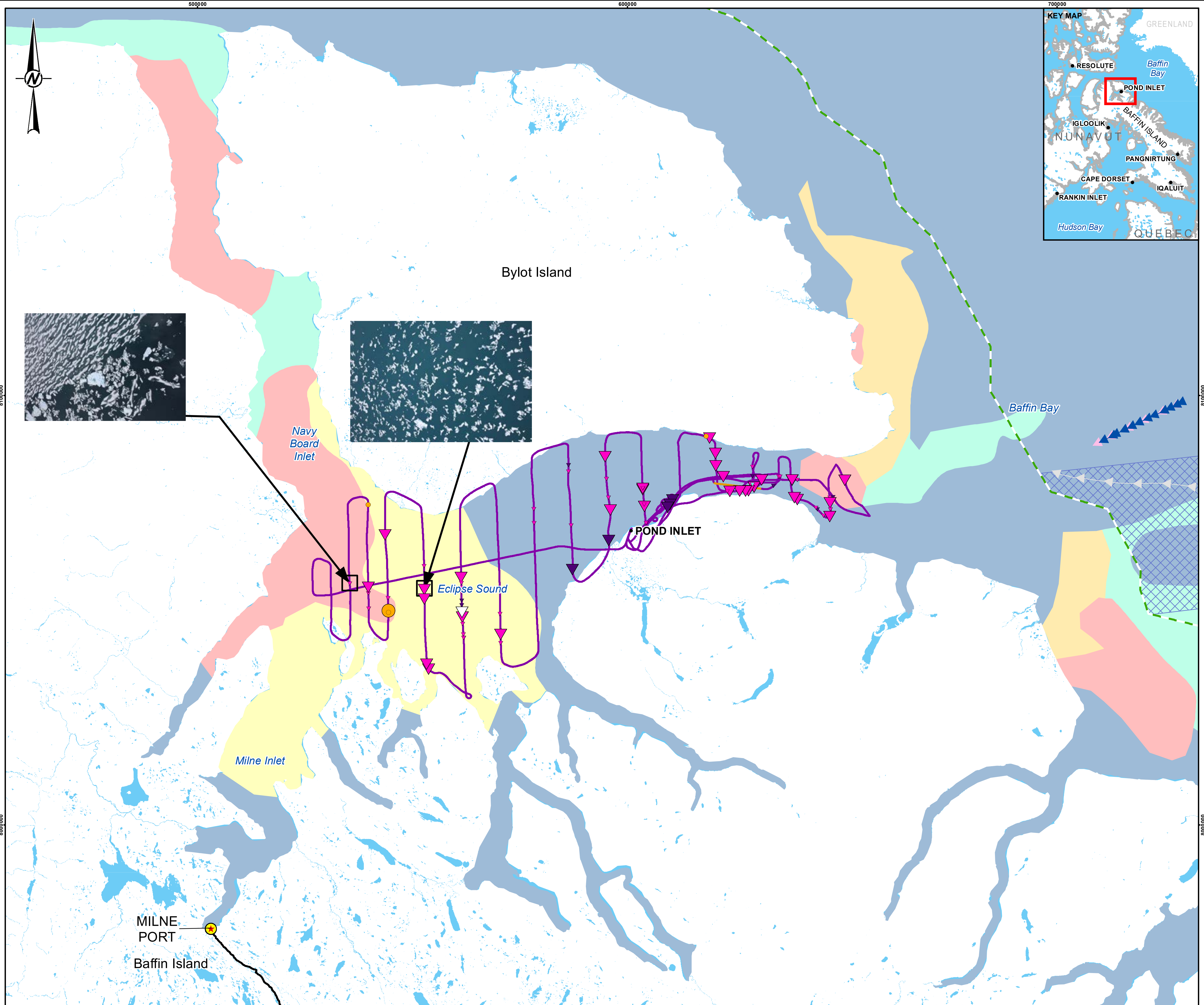
TITLE
POND INLET LEG 1 SURVEY 2 - JULY 15-16, 2019

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-2



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1

BOWHEAD WHALE
- 1
- 2 - 10

NARWHAL
- 1
- 2 - 10

RINGED SEAL
- 1
- 2 - 10

UNIDENTIFIED WHALE/CETACEAN
- 2 - 10

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

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

1:900,000 KILOMETRES

NOTE(S)

PRIOR TO SHIPPING ACTIVITIES. CONDITIONS MODERATE WITH BF 0-5 AND FOG ON PORTIONS OF ECLIPSE SOUND.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

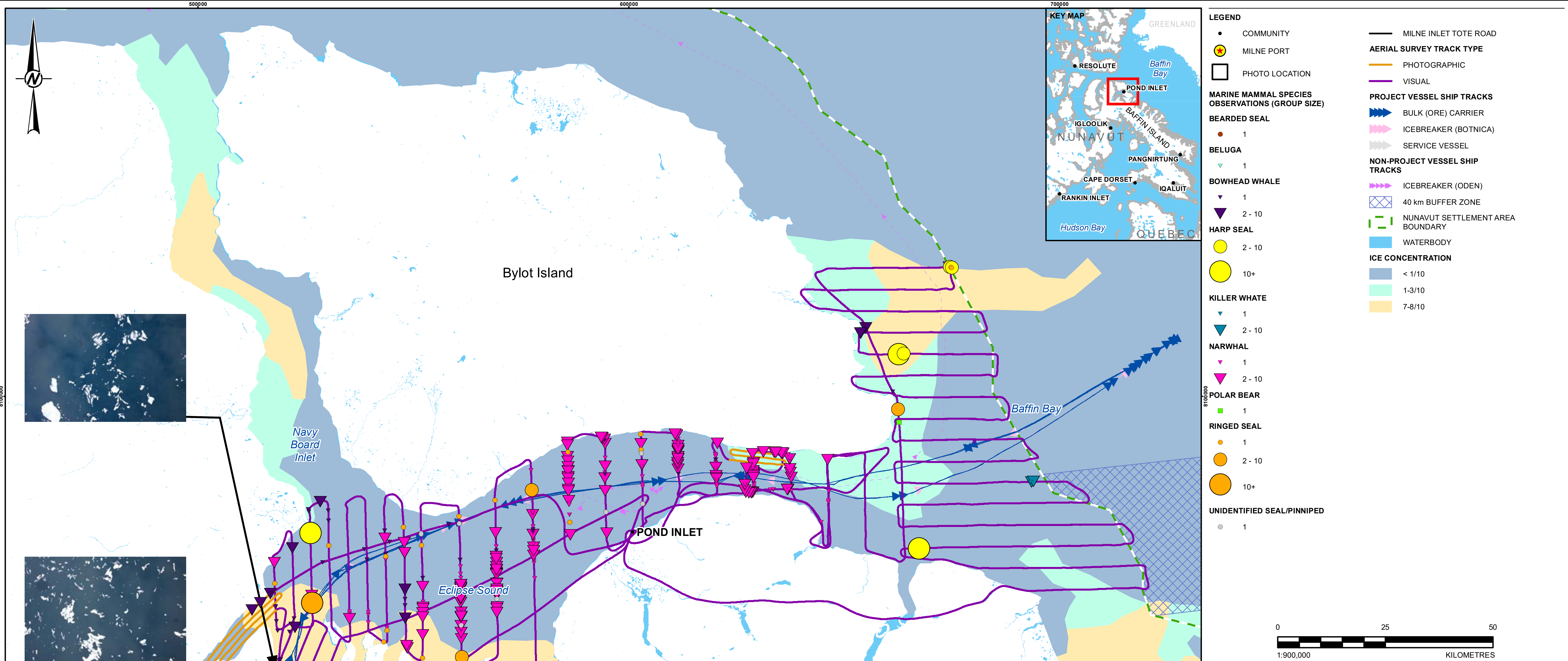
TITLE
POND INLET LEG 1 SURVEY 3 - JULY 17, 2019

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-3



NOTE(S)

DURING SHIPPING ACTIVITIES. CONDITIONS GOOD WITH BF 0-3 FOR MUCH OF SURVEY AREA. FOG PRESENT ON ONE TRANSECT IN EASTERN ECLIPSE SOUND. BF 4-5 ON PORTIONS OF THE BAFFIN BAY TRANSECTS. NO NARWHALS SEEN IN TREMBLAY SOUND OR SOUTH MILNE INLET/KOLUKTOO BAY.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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

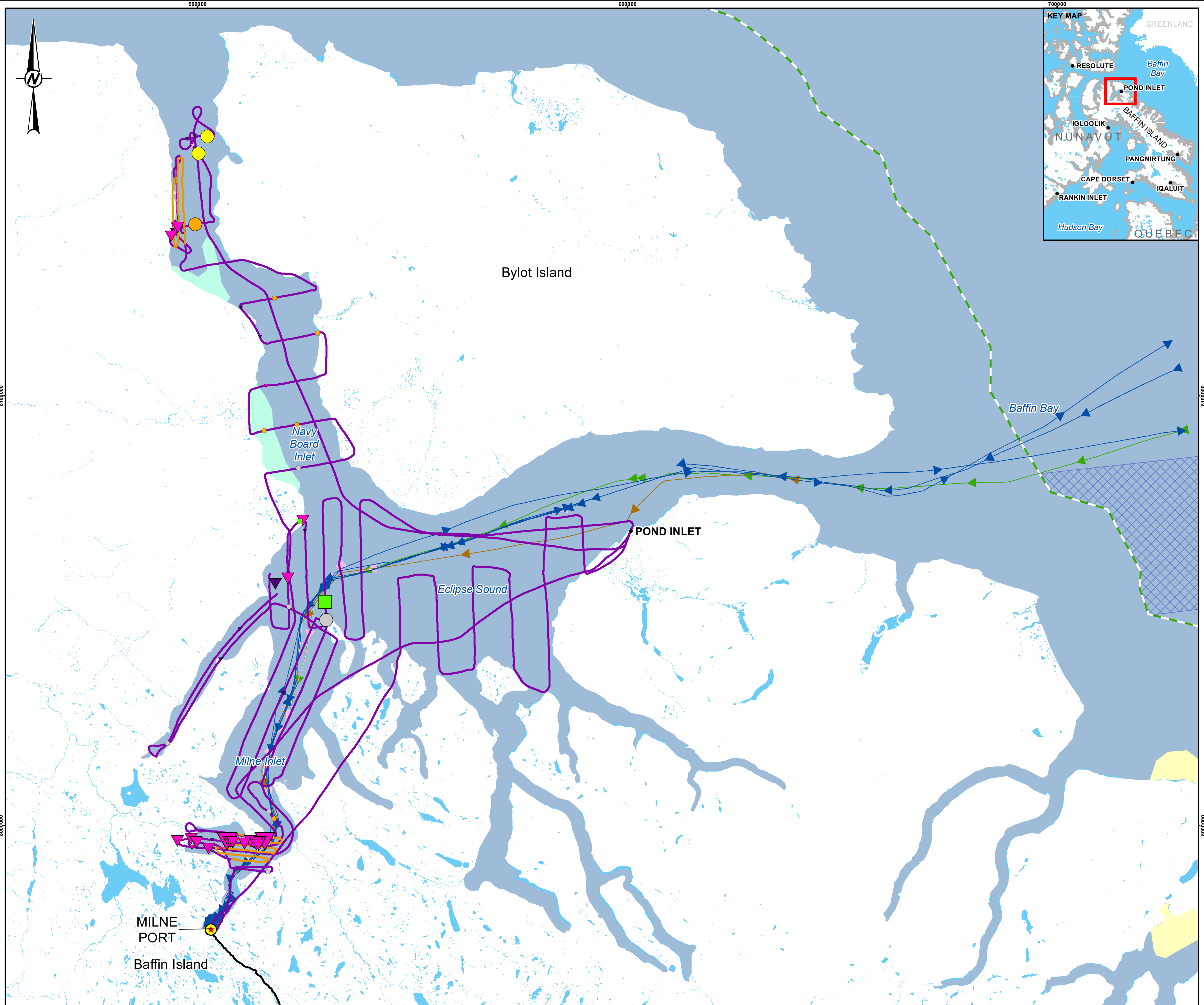
PROJECT
MARY RIVER PROJECT
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE
POND INLET LEG 1 SURVEY 4 - JULY 21-23, 2019

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-4



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1
- 2 - 10

DOLPHIN
- 1

HARP SEAL
- 2 - 10

NARWHAL
- 1
- 2 - 10
- 10+

POLAR BEAR
- 1
- 2 - 10

RINGED SEAL
- 1
- 2 - 10

UNIDENTIFIED SEAL/PINNIPED
- 1
- 2 - 10

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

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

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

0 25 50

1:900,000 KILOMETRES

NOTE(S)

DURING SHIPPING ACTIVITIES. CONDITIONS MODERATE WITH BF 1-6 AND FOG ON PORTIONS OF NAVY BOARD INLET, ECLIPSE SOUND, AND KOLUKTOO BAY. LARGE CONCENTRATIONS OF NARWHAL OBSERVED IN NAVY BOARD INLET AND SOUTH MILNE INLET/KOLUKTOO BAY (PHOTOGRAPHIC SURVEY FLOWN).

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

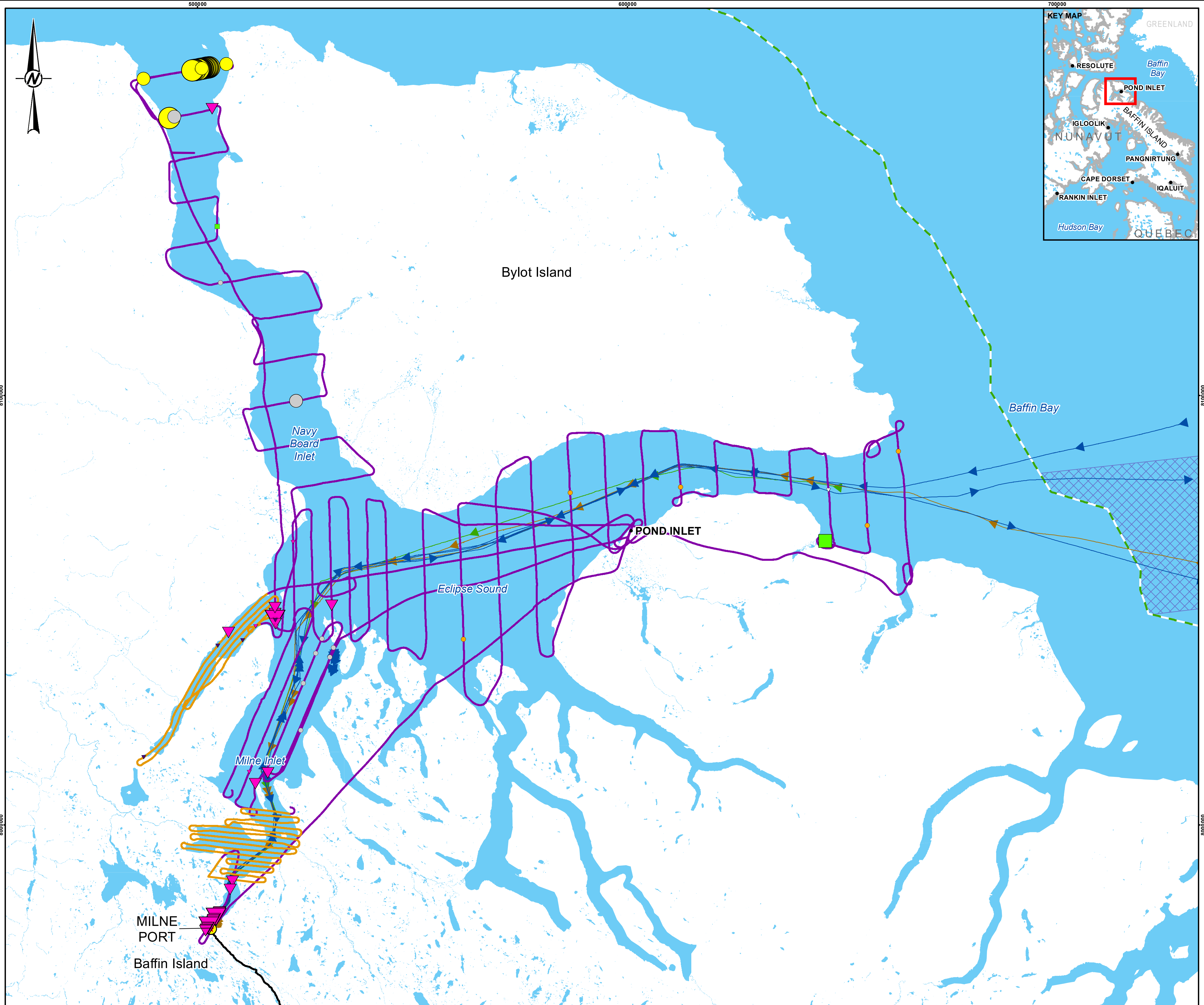
TITLE
POND INLET LEG 1 SURVEY 5 - JULY 25-26, 2019

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-5



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1

BOWHEAD WHALE
- 1

HARP SEAL
- 1
- 2 - 10
- 10+

NARWHAL
- 1
- 2 - 10
- 10+

POLAR BEAR
- 1
- 2 - 10

RINGED SEAL
- 1

UNIDENTIFIED SEAL/PINNIPED
- 1
- 2 - 10

UNIDENTIFIED WHALE/CETACEAN
- 1

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

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

0 25 50

1:900,000 KILOMETRES

NOTE(S)

CONDITIONS GOOD WITH BF 0-3 FOR MUCH OF THE SURVEY AREA AND NO FOG. BF 4-5 ENCOUNTERED ON THREE TRANSECTS IN WESTERN ECLIPSE SOUND. NARWHALS CONCENTRATED AT THE ENTRANCE OF TREMBLAY SOUND. NARWHALS HIGHLY CLUMPED AND CLOSE INSHORE IN SOUTH KOLUKTOO BAY ON TWO TRANSECTS. KILLER WHALES OBSERVED BY THE BRUCE HEAD CREW EARLIER IN THE DAY.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE
POND INLET LEG 2 SURVEY 1 - AUGUST 17-18, 2019

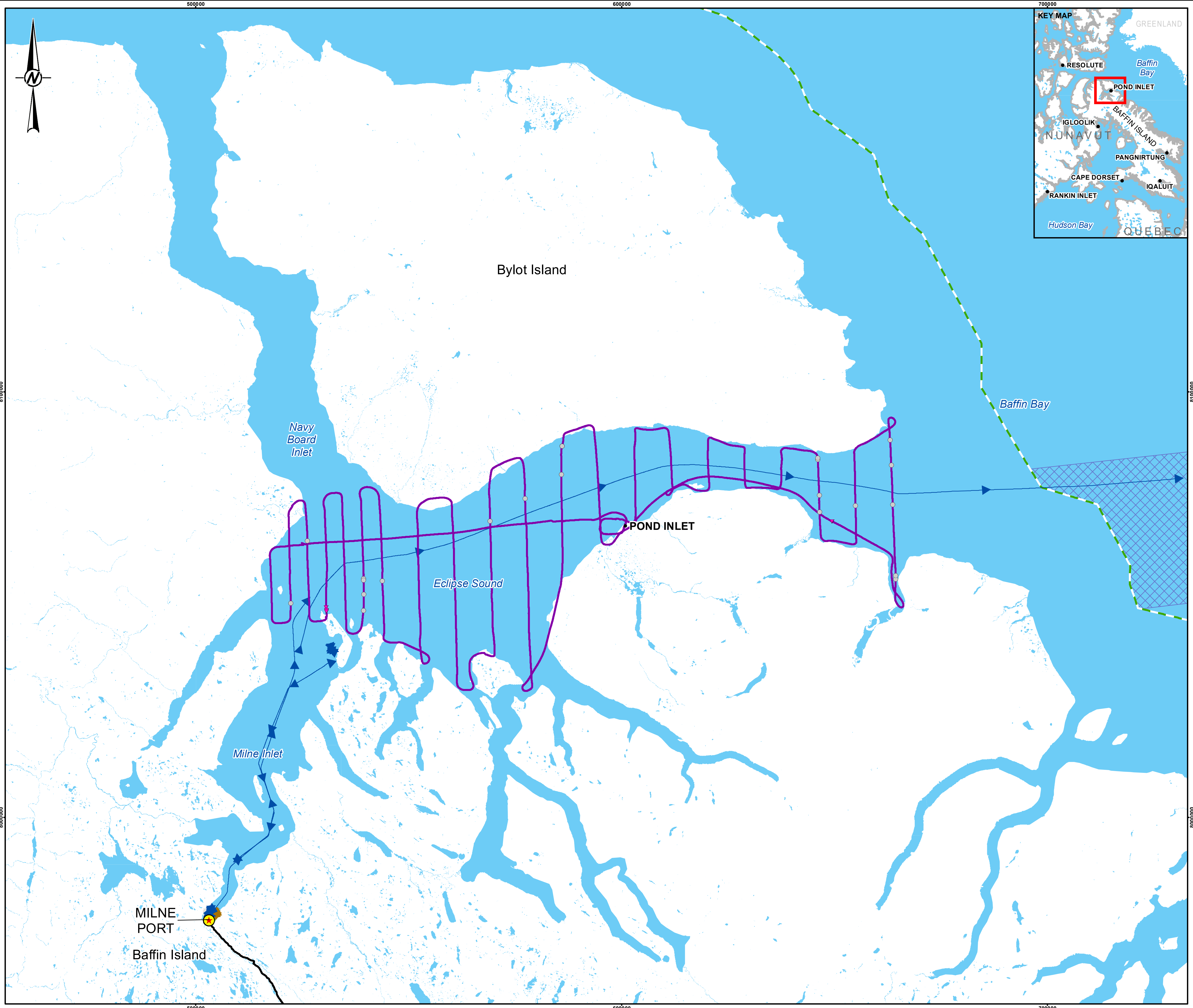
CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-6

25mm



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

NARWHAL

- 1

UNIDENTIFIED SEAL/PINNIPED

- 1

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE

- VISUAL

PROJECT VESSEL SHIP TRACKS

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

0 25 50

1:900,000 KILOMETRES

NOTE(S)

CONDITIONS GOOD WITH BF 0-3 AND NO FOG IN THE AREA. INCOMPLETE SURVEY DUE TO POOR CONDITIONS THE FOLLOWING DAYS.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE
POND INLET LEG 2 SURVEY 2 - AUGUST 19, 2019

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
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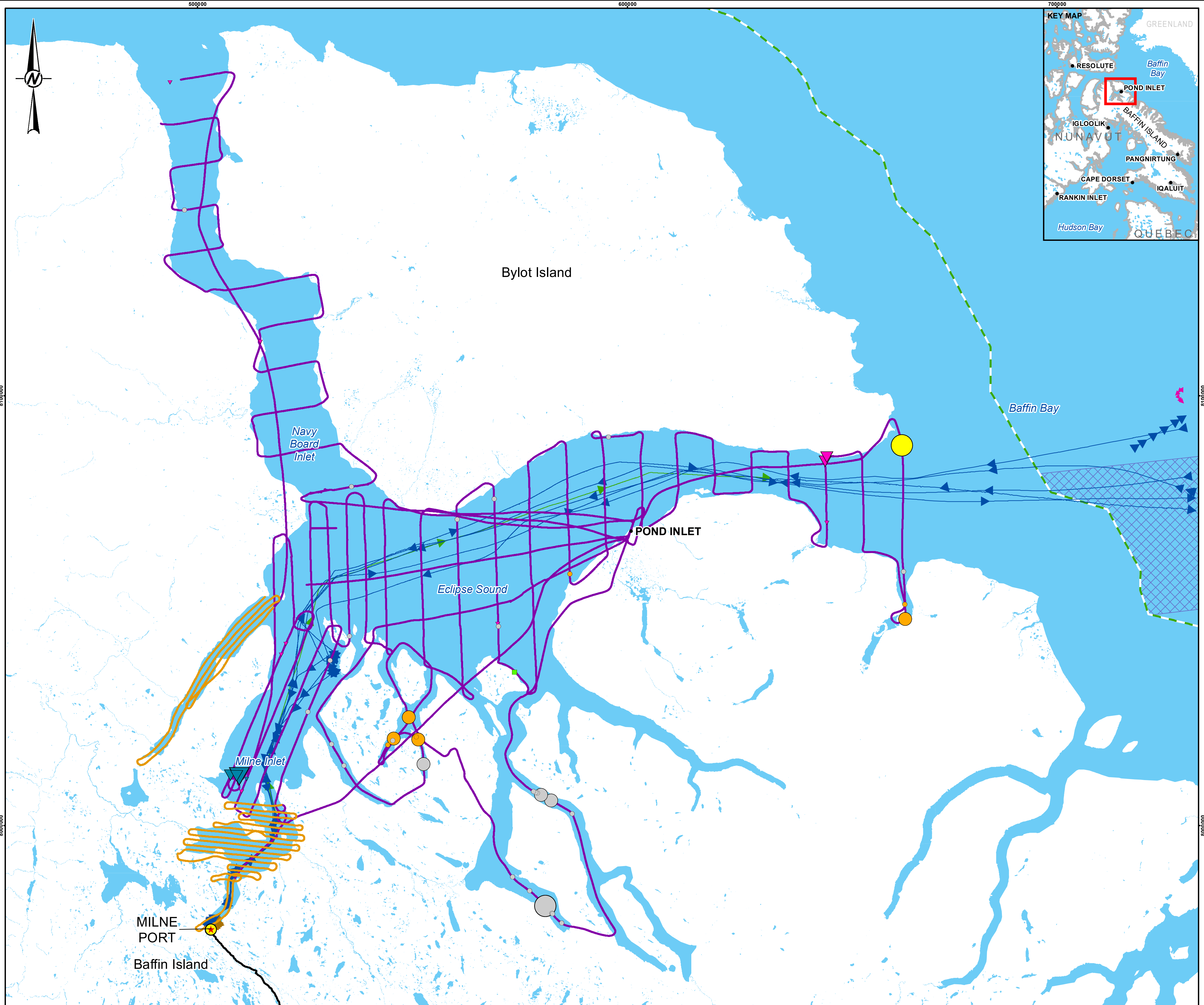


LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL
- 10+

KILLER WHATE
- 1
- 2 - 10
- 10+

NARWHAL
- 1
- 2 - 10

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2 - 10

UNIDENTIFIED SEAL/PINNIPED
- 1
- 2 - 10
- 10+

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

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

NON-PROJECT VESSEL SHIP TRACKS
- ICEBREAKER (LOUIS S ST LAURENT)
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 25 50

1:900,000 KILOMETRES

NOTE(S)

CONDITIONS GOOD WITH BF 0-3 FOR MUCH OF THE SURVEY AREA AND NO FOG. BF 4-5 ENCOUNTERED ON EASTERN THREE TRANSECTS IN ECLIPSE SOUND. NARWHALS CONCENTRATED IN SOUTHERN END OF TREMBLAY SOUND AND DISPERSED THROUGHOUT SOUTH MILNE INLET/KOLUKTOO BAY AREA.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE
POND INLET LEG 2 SURVEY 3 - AUGUST 21-22, 2019

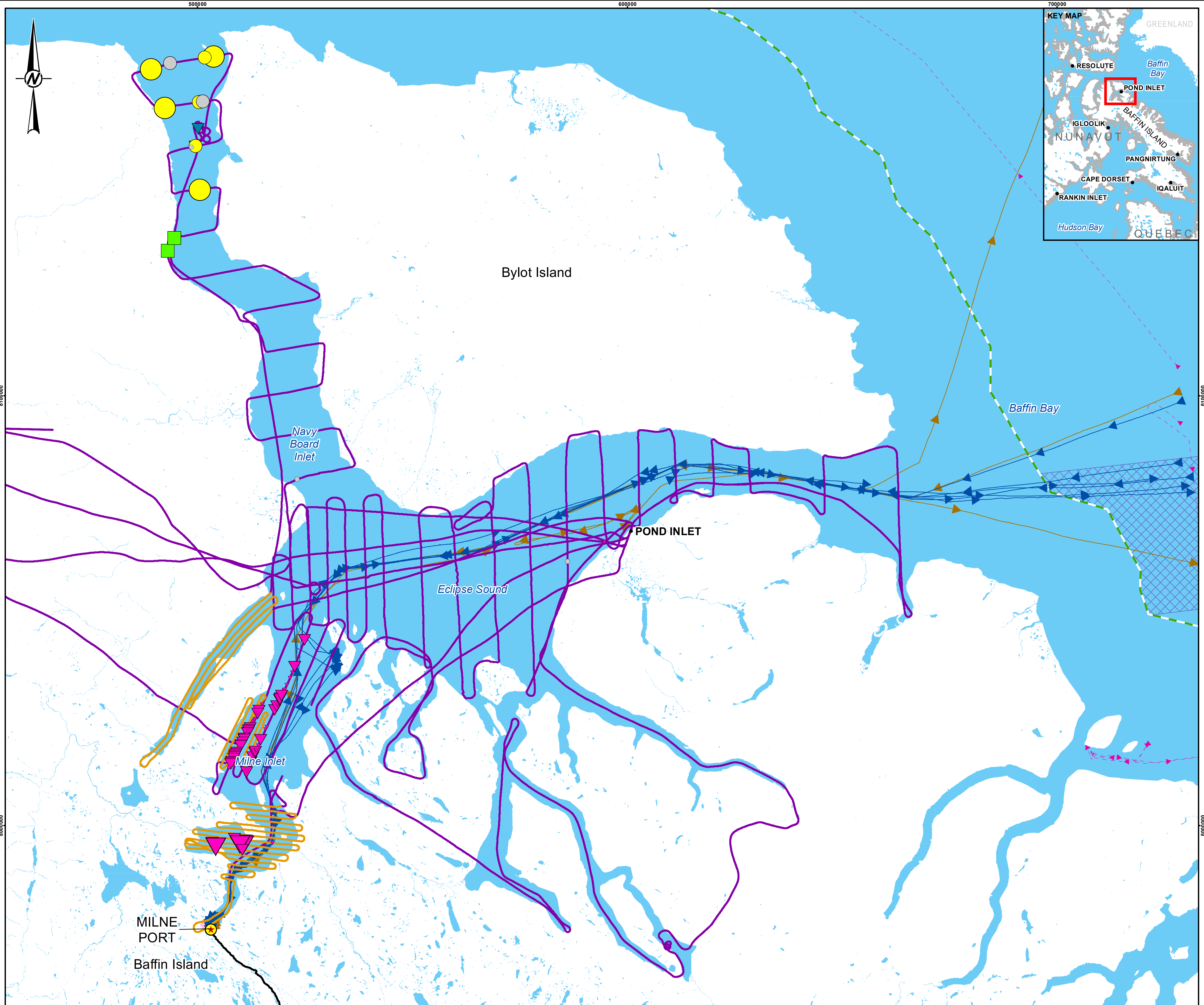
CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-8

25mm

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



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL
- 2 - 10
- 10+

KILLER WHATE
- 2 - 10

NARWHAL
- 1
- 2 - 10
- 10+

POLAR BEAR
- 2 - 10

UNIDENTIFIED SEAL/PINNIPED
- 1
- 2 - 10

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

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

NON-PROJECT VESSEL SHIP TRACKS
- ICEBREAKER (LOUIS S ST LAURENT)
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 25 50
1:900,000 KILOMETRES

NOTE(S)

CONDITIONS GOOD WITH BF 0-3 FOR MUCH OF THE SURVEY AREA AND NO FOG. BF 4-5 ENCOUNTERED ON EASTERN PORTION OF ECLIPSE SOUND AND PORTIONS OF NAVY BOARD INLET. NARWHALS CONCENTRATED IN THE CENTRAL PORTION OF TREMBLAY SOUND AND DISPERSED THROUGHOUT SOUTH MILNE INLET/KOLUKTOO BAY AREA. KILLER WHALES OBSERVED IN NORTHERN NAVY BOARD INLET.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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

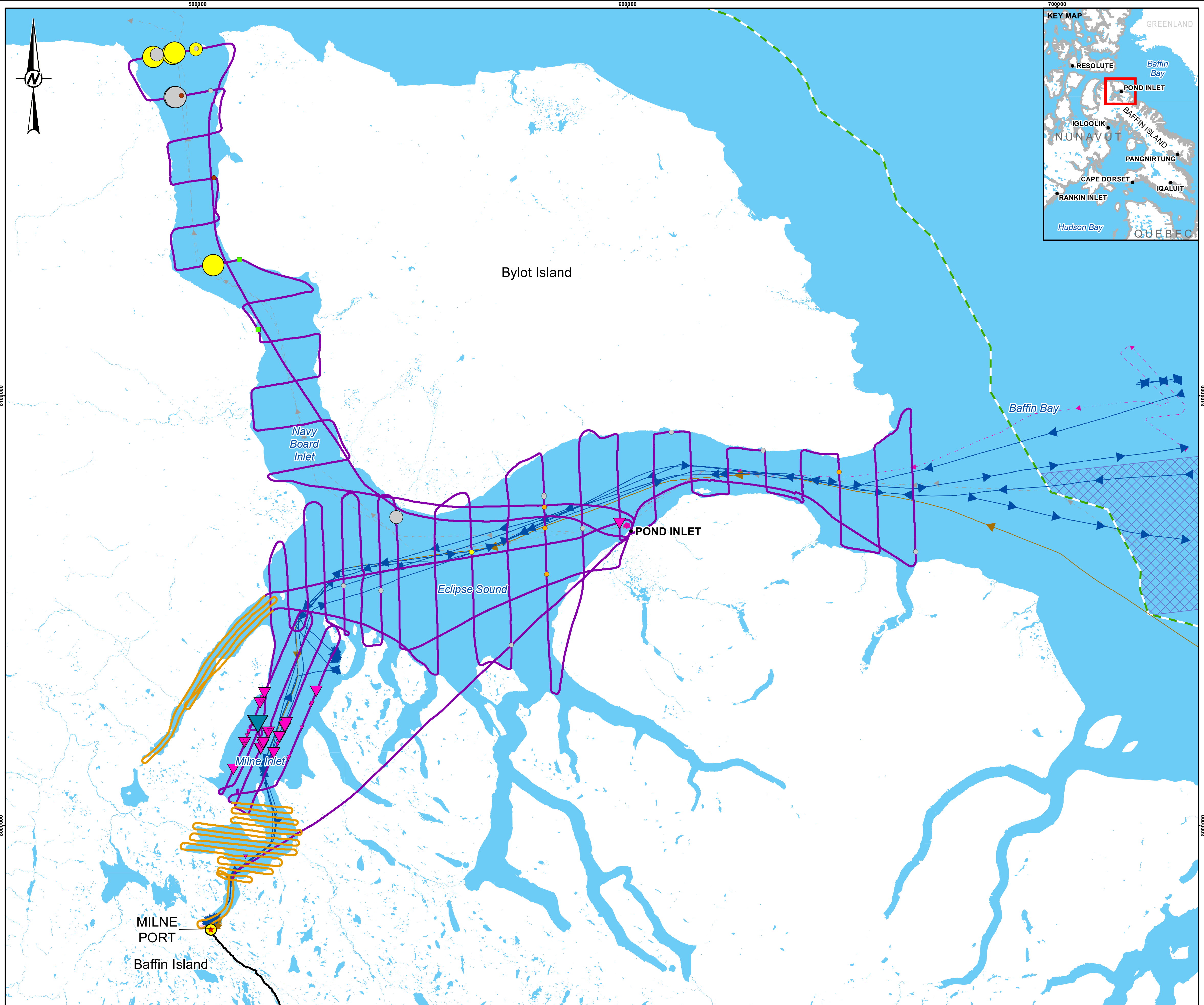
PROJECT
MARY RIVER PROJECT
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE
POND INLET LEG 2 SURVEY 4 - AUGUST 25-27, 2019

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-9



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

HARP SEAL
- 1
- 2 - 10
- 10+

KILLER WHATE
- 10+

NARWHAL
- 1
- 2 - 10

POLAR BEAR
- 1

RINGED SEAL
- 1

UNIDENTIFIED SEAL/PINNIPED
- 1
- 2 - 10
- 10+

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

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

NON-PROJECT VESSEL SHIP TRACKS
- ICEBREAKER (LOUIS S ST LAURENT)
- OTHER
- 40 km BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 25 50

1:900,000 KILOMETRES

NOTE(S)

CONDITIONS GOOD WITH BF 0-3 FOR MUCH OF THE SURVEY AREA AND NO FOG. BF 4 ENCOUNTERED ON PORTIONS OF EASTERN ECLIPSE SOUND. NARWHALS CONCENTRATED IN THE CENTRAL PORTION OF TREMBLAY SOUND AND DISPERSED THROUGHOUT SOUTH MILNE INLET/KOLUKTOO BAY AREA. KILLER WHALES OBSERVED IN NORTH MILNE INLET.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

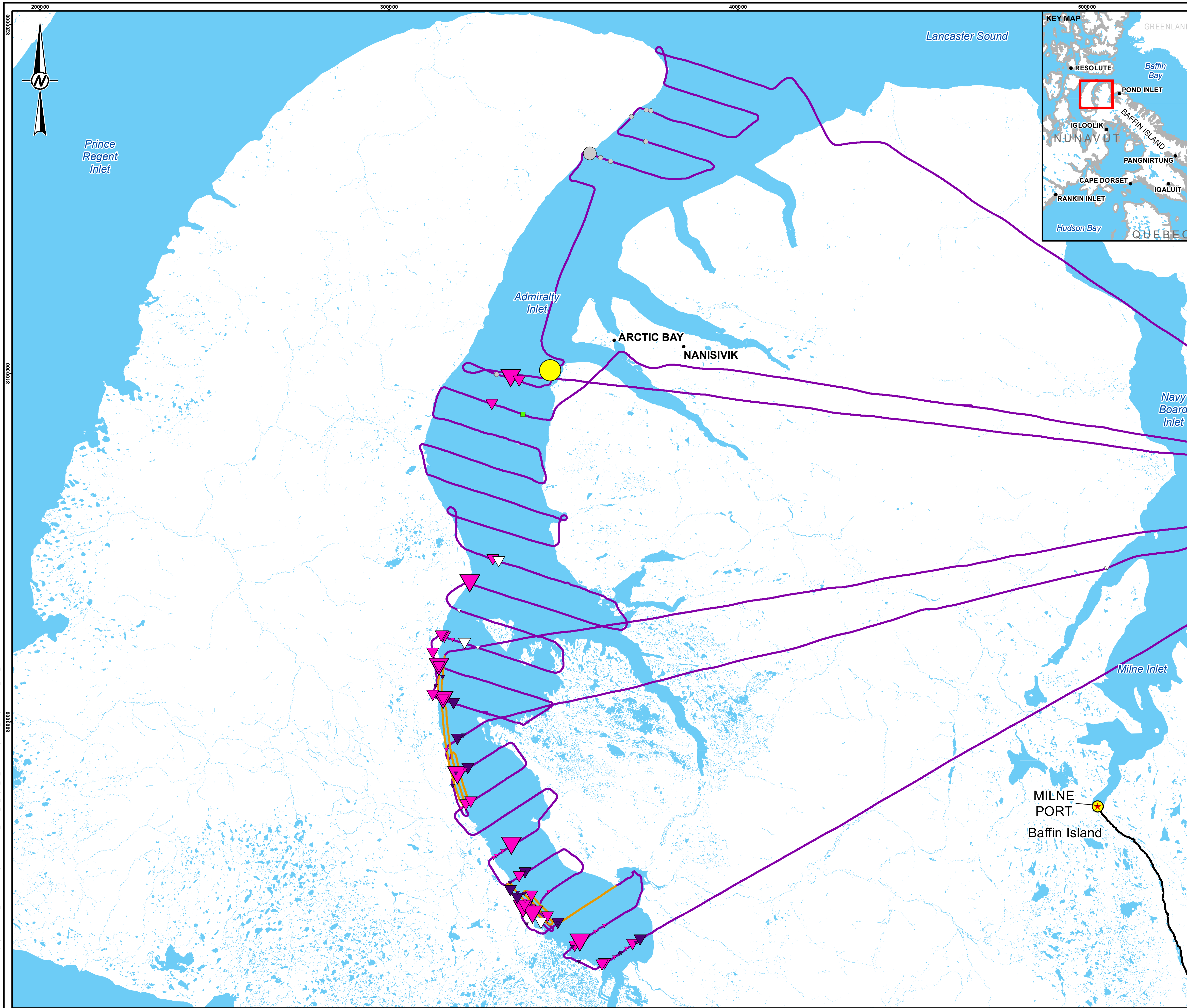
TITLE
POND INLET LEG 2 SURVEY 5 - AUGUST 29-30, 2019

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-10



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1
- 2 - 10

HARP SEAL
- 10+

NARWHAL
- 1
- 2 - 10
- 10+

POLAR BEAR
- 1

UNIDENTIFIED SEAL/PINNIPED
- 1
- 2 - 10

UNIDENTIFIED WHALE/CETACEAN
- 1
- 2 - 10

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 30 60

1:1,100,000 KILOMETRES

NOTE(S)

CONDITIONS GOOD WITH BF 1-3 AND NO FOG IN SOUTHERN PORTION OF THE SURVEY AREA. MODERATE CONDITIONS FOR CENTRAL AND NORTHERN PORTION OF THE SURVEY AREA WITH BF 1-5 AND FOG ON NORTHERN TRANSECTS. NARWHALS CONCENTRATED IN SOUTHERN PORTION OF ADMIRALTY INLET ALONG THE WESTERN SHORE. THREE PHOTOGRAPHIC SURVEYS WERE FLOWN.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE
ARCTIC BAY LEG 2 SURVEY 1 - AUGUST 17-18, 2019

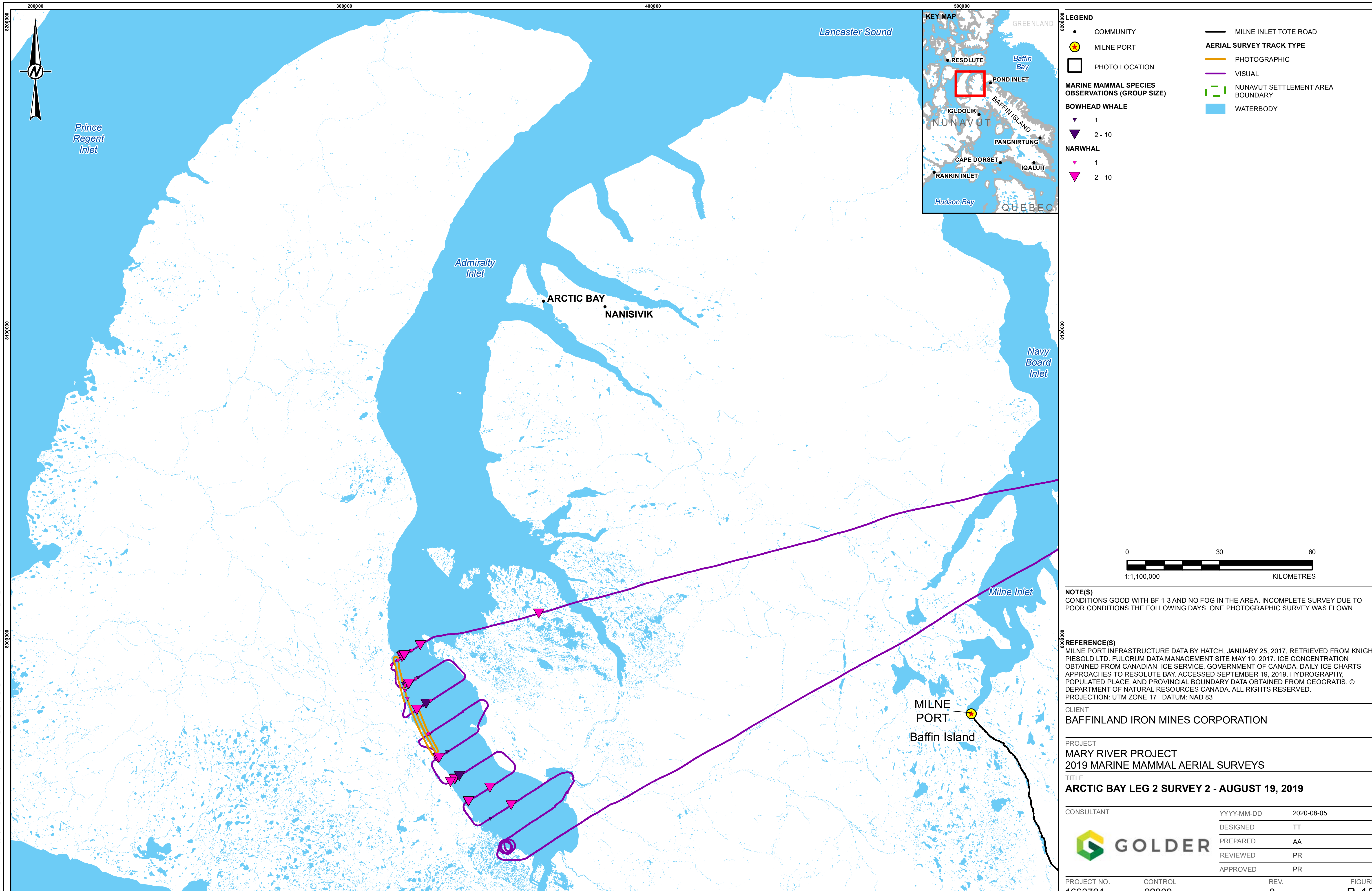
CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-11

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



NOTE(S)

CONDITIONS GOOD WITH BF 1-3 AND NO FOG IN THE AREA. INCOMPLETE SURVEY DUE TO POOR CONDITIONS THE FOLLOWING DAYS. ONE PHOTOGRAPHIC SURVEY WAS FLOWN.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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

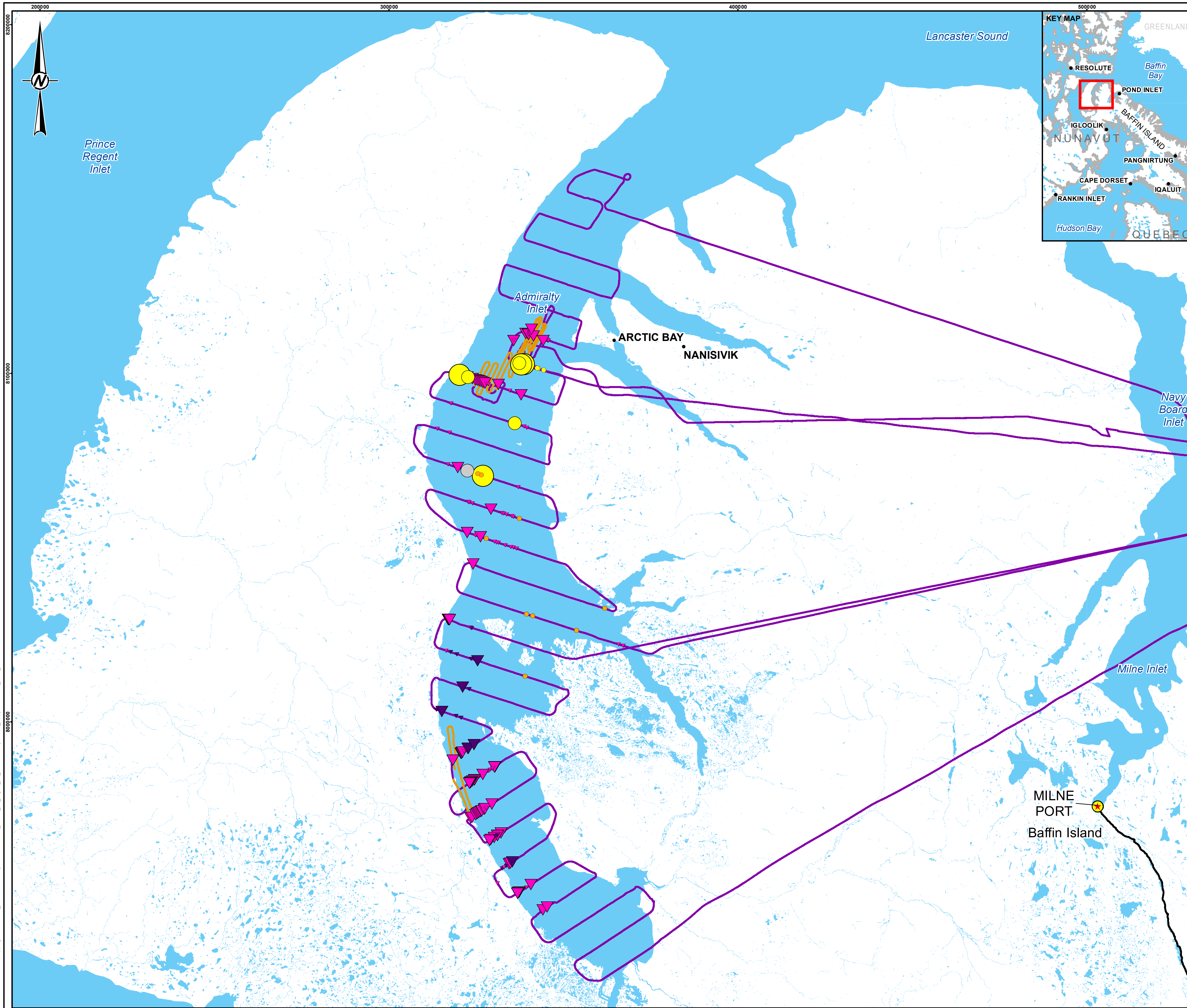
PROJECT
MARY RIVER PROJECT
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE
ARCTIC BAY LEG 2 SURVEY 2 - AUGUST 19, 2019

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-12



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1
- 2 - 10

HARP SEAL
- 1
- 2 - 10
- 10+

NARWHAL
- 1
- 2 - 10

RINGED SEAL
- 1

UNIDENTIFIED SEAL/PINNIPED
- 2 - 10

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 30 60

1:1,100,000 KILOMETRES

NOTE(S)

CONDITIONS GOOD WITH BF 0-3 AND FOG ON THREE OF THE NORTHERN TRANSECTS. NARWHALS CONCENTRATED IN THE SOUTHERN PORTION OF ADMIRALTY INLET ALONG THE WESTERN SHORE AND IN THE CENTRAL PORTION OF THE INLET CLOSE TO ARCTIC BAY. FOUR PHOTOGRAPHIC SURVEYS WERE FLOWN.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

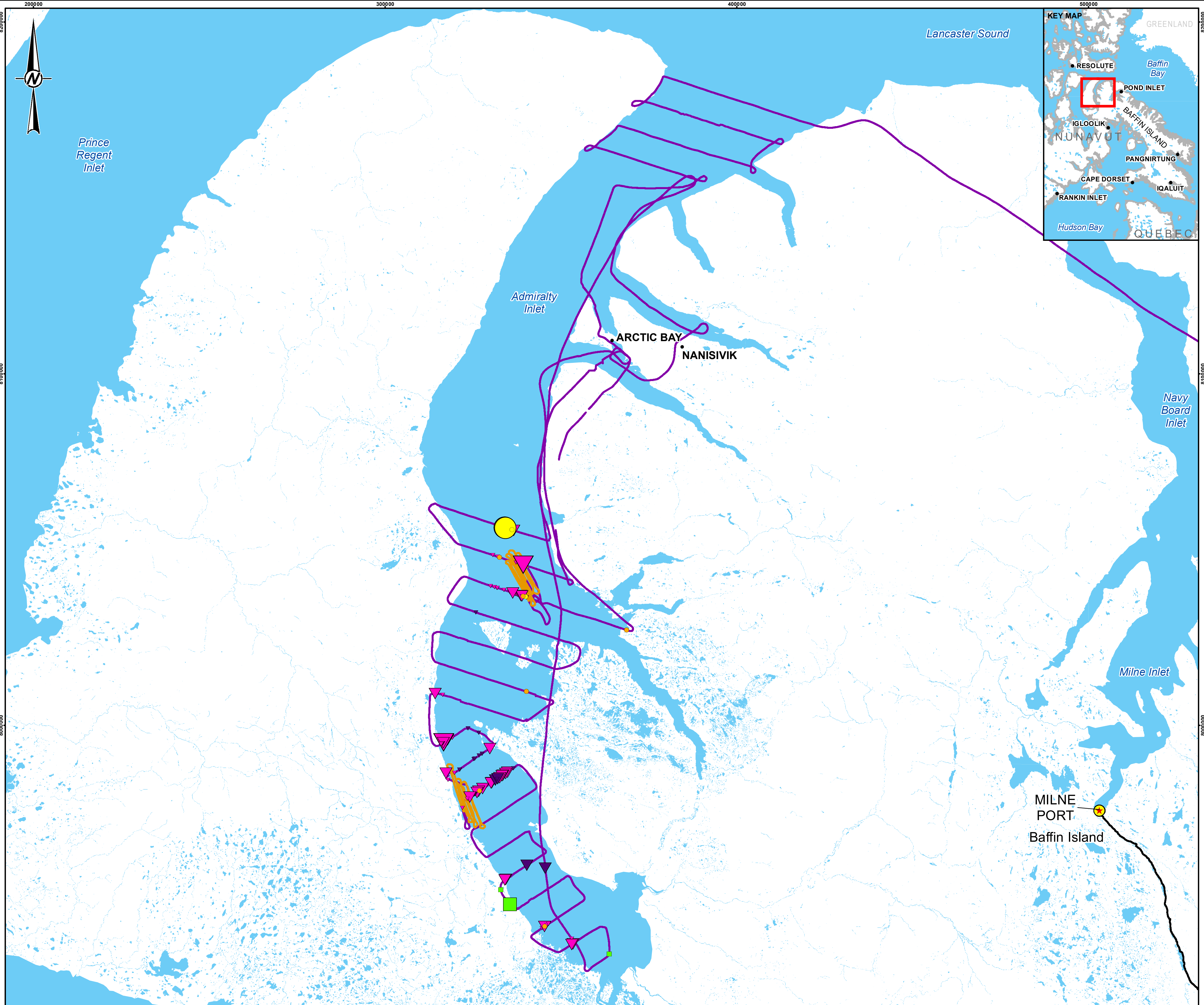
TITLE
ARCTIC BAY LEG 2 SURVEY 3 - AUGUST 21-22, 2019

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-13



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1
- 2 - 10

HARP SEAL
- 1
- 10+

NARWHAL
- 1
- 2 - 10
- 10+

POLAR BEAR
- 1
- 2 - 10

RINGED SEAL
- 1

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 30 60

1:1,100,000 KILOMETRES

NOTE(S)

CONDITIONS MODERATE WITH BF 0-5 AND NO FOG. NARWHALS CONCENTRATED IN THE SOUTHERN PORTION OF ADMIRALTY INLET ALONG THE WESTERN SHORE AND IN THE CENTRAL PORTION OF THE INLET NORTH OF YEOMAN ISLAND. TWO PHOTOGRAPHIC SURVEYS WERE FLOWN.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE

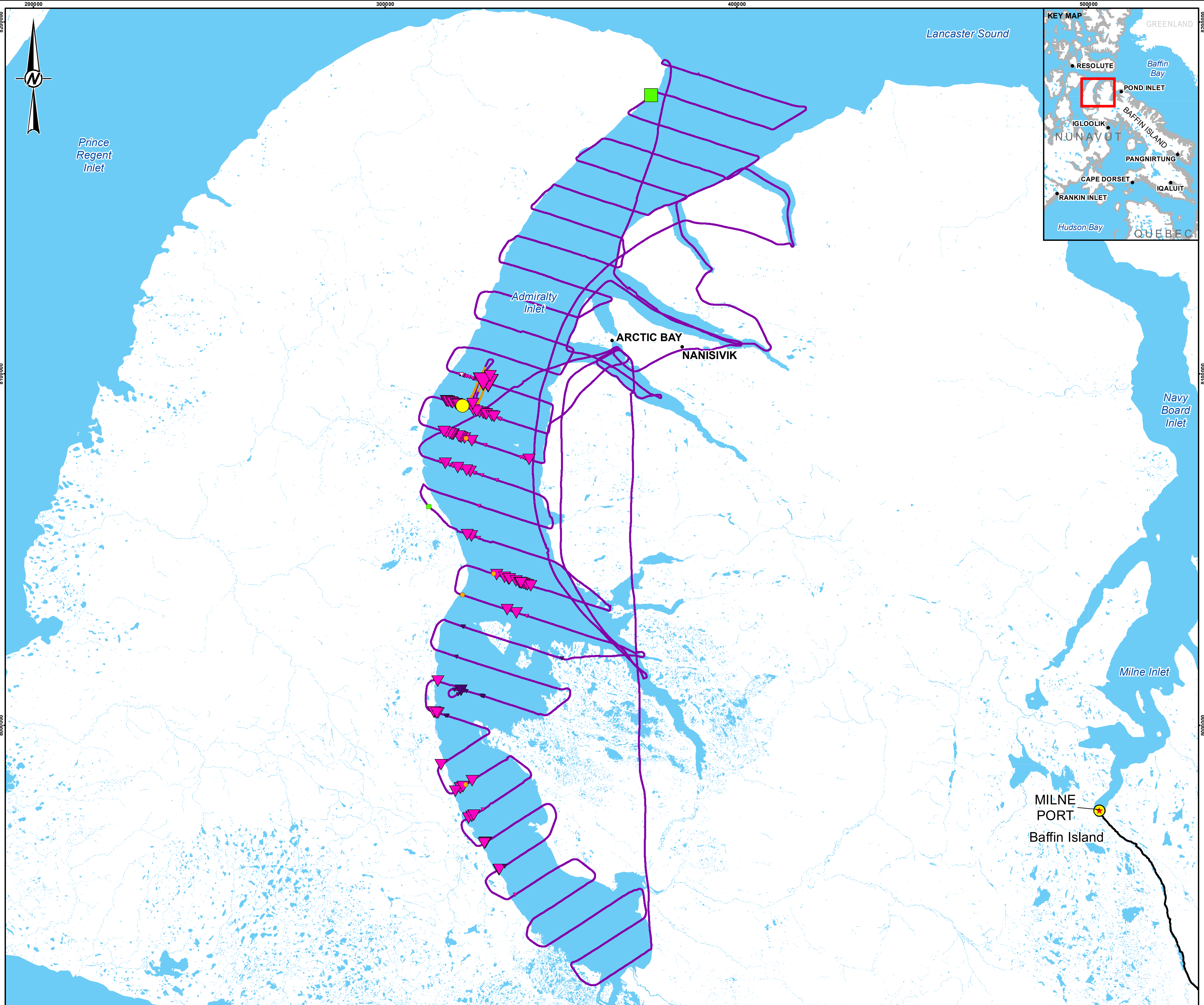
ARCTIC BAY LEG 2 SURVEY 4 - AUGUST 25-27, 2019

CONSULTANT

GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-14



LEGEND

- COMMUNITY
- MILNE PORT
- PHOTO LOCATION

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE
- 1
- 2 - 10

HARP SEAL
- 1
- 2 - 10

NARWHAL
- 1
- 2 - 10
- 10+

POLAR BEAR
- 1
- 2 - 10

RINGED SEAL
- 1

UNIDENTIFIED WHALE/CETACEAN
- 1

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE
- PHOTOGRAPHIC
- VISUAL

- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 30 60

1:1,100,000 KILOMETRES

NOTE(S)

CONDITIONS MODERATE WITH BF 0-5 AND FOG ON PORTIONS OF THE NORTHERN FOUR TRANSECTS. NARWHALS CONCENTRATED IN THE CENTRAL PORTION OF ADMIRALTY INLET. ONE PHOTOGRAPHIC SURVEY WAS FLOWN.

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 – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019. 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
2019 MARINE MAMMAL AERIAL SURVEYS

TITLE
ARCTIC BAY LEG 2 SURVEY 5 - AUGUST 29-30, 2019

CONSULTANT
GOLDER

YYYY-MM-DD	2020-08-05
DESIGNED	TT
PREPARED	AA
REVIEWED	PR
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	22000	0	B-15

APPENDIX C

Power Analysis

1.0 POWER ANALYSIS - METHODS

In statistics two types of outcome errors are possible and can mislead conclusions about the presence of detectable effects. A Type I error is concluding there is a significant effect when none exists (i.e., a false positive). Alpha (α) is the probability of committing a Type I error (Zar 1999). A Type II error is the probability of concluding there is no significant effect when there is a real effect of some specified magnitude (i.e., a false negative) (Zar 1999). Beta (β) is the probability of committing a Type II error. Effect sizes are the magnitude of the change or difference in the response variables, which in this report were the estimates of narwhal abundance. The power of a statistical test (1 - β) is the probability of detecting a valid statistical effect. The power of a statistical test depends on the alpha level, the effect size, the sample size, and the variability in the data. In this analysis, the Type I error-rate (α), also referred to as the significance level, was set to 0.05. The desired minimum statistical power was 80%, which corresponds to a Type II error-rate of 0.2.

The starting point for the power analysis were the narwhal abundance estimates from the 2019 aerial survey data (hereafter reference). Specifically, the two 2019 estimates used were the averages of the survey 3 and 4 (leg 2) estimates for the Eclipse Sound region and the combined Eclipse Sound and Admiralty Inlet regions (Table 1). Two power analyses were completed to evaluate the ability of the aerial survey program to track changes in narwhal abundance for Eclipse Sound and for combined surveys of Eclipse Sound and Admiralty Inlet completed in the same year.

Table 1: Reference narwhal survey abundance estimates for power analysis.

Average estimate for Leg 2, Surveys 3 and 4	Abundance	% coefficient of variation (CV)	Degrees of freedom
Eclipse Sound	9,931	4.97	6.45
combined Eclipse Sound and Admiralty Inlet	38,771	12.01	19.18

The power to detect statistically significant effects was estimated using the formula for comparing two abundance values in R v. 3.6.2 (R 2019), following the approach of Buckland et al. (2001). If two abundance estimates are independent, the difference in abundance by $\widehat{N}_1 - \widehat{N}_2$ can be estimated with variance

$$\widehat{var}\left(\widehat{N}_1 - N_2\right) = \widehat{var}(N_1) + \widehat{var}(N)$$

Distance provides the approximate degrees of freedom df_1 for $\widehat{N}_1$ and df_2 for $\widehat{N}_2$, based on Satterthwaite's approximation. The degrees of freedom are used to obtain an approximate *t*-statistic:

$$T = \frac{\left(\widehat{N}_1 - \widehat{N}_2\right) - (N_1 - N_2)}{\sqrt{\widehat{var}\left(\widehat{N}_1 - \widehat{N}_2\right)}} \sim t_{\mathrm{df}}$$

where

$$df \simeq \frac{\{\widehat{var}(\widehat{N}_1) + \widehat{var}(\widehat{N}_2)\}^2}{\{\widehat{var}(\widehat{N}_1)\}^2/df_1 + \{\widehat{var}(\widehat{N}_2)\}^2/df_2}$$

The null hypothesis H0 : *N1* = *N2* can be tested by substituting *N1* - *N2* = *0* in the t-statistic equation and looking at the resulting value in a t-table. Approximate 100·(1-2α)% confidence limits for (*N1* = *N2*) are given by:

$$(\widehat{N}_1 - \widehat{N}_2) \pm t_{\mathrm{df}}(\alpha) \cdot \sqrt{\widehat{var}(\widehat{N}_1 - \widehat{N}_2)}$$

Since the interest in the detection of a change in narwhal abundance is a decrease, the analysis was limited to negative effect sizes (one-tailed *t*-statistic).

Effect Size Application and Data Simulation

For each of the narwhal abundance estimates in Table 1 (N_1), a range of negative effect sizes (decreases) were applied to the abundance estimates ranging from 1 to 60 %, and assumed that resulting abundance values (N_2) have the same CV and df, as the original estimates (N_1).

For each N_1 estimate and effect size test, the resulting $\widehat{N}_1 - \widehat{N}_2$ values were simulated based on the probabilities log-normal distribution. Ten-thousand simulated values were produced for every effect size tested and the proportion of the simulated values with a lower confidence limit that was greater than zero (one-tailed; $P<0.05$), was interpreted as the statistical power of the test (i.e. the ability to detect a decrease in narwhal abundance).

2.0 POWER ANALYSIS – RESULTS

For the Eclipse Sound estimate, the power analysis indicated that there was sufficient power (>0.8) to detect a reduction in narwhal abundance at an effect size of -17% and high power (>0.9) was attained at effect size of -19% (**Figure 1**).

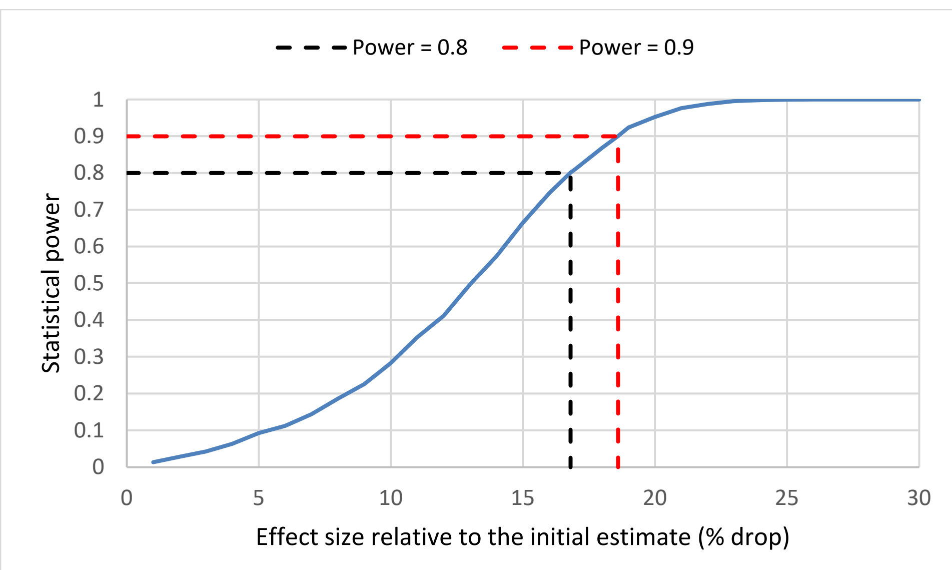


Figure 1: Statistical power to detect an effect size when using the Eclipse Sound estimate as a reference value.

For the combined Eclipse Sound and Admiralty Inlet abundance estimate, the power analysis indicated that there was sufficient power (>0.8) to detect a reduction in narwhal abundance at effect size of -36% and high power (>0.9) was attained at effect size of -39% (Figure 2).

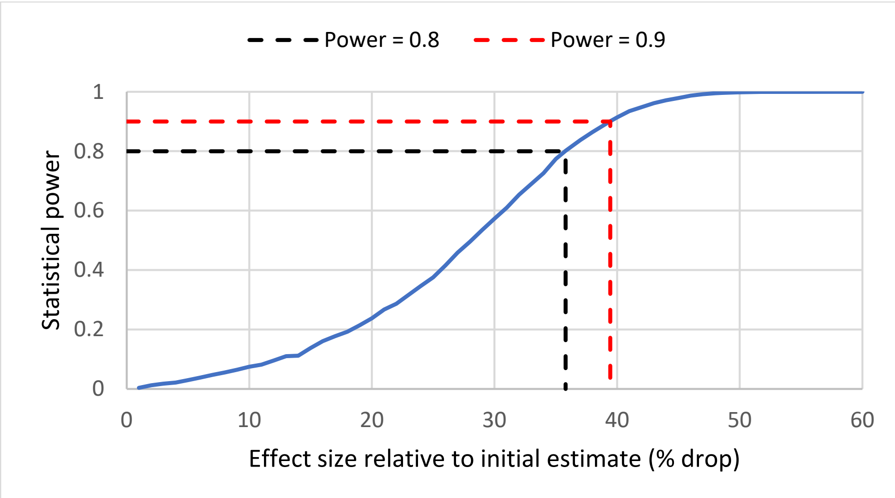


Figure 2: Statistical power to detect an effect size when using the combined Eclipse Sound and Admiralty Inlet estimate as a reference value.

Comparisons for abundance estimates more than one year apart

The statistical power calculated for these comparisons does not have a specific time scale and can be extrapolated to provide comparisons between surveys that occur more than one year apart. Assuming a constant rate of decrease, the reduction (effect size) necessary to achieve a power of 0.8 can be shared over a number of years, to provide an annual rate of decrease that achieves the same total effect size between the first and last years of the comparison. A comparison of the number of years between abundance estimates and the minimum annual rate of change that would be required to achieve a power of 0.8 is presented in Figure 3.

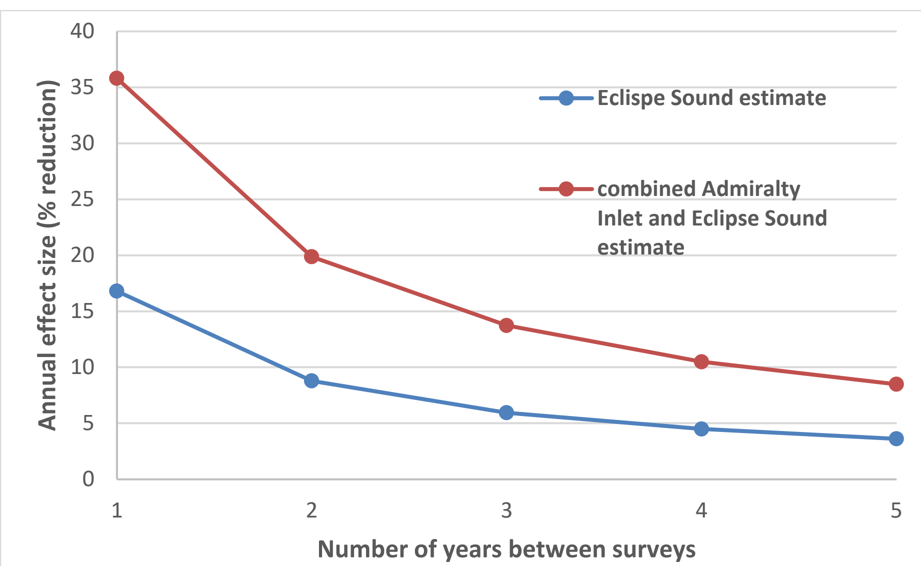


Figure 3: The annual effect size necessary to achieve a power of 0.8 (one tailed; α =0.05) based on increasing the number of years between survey estimates, using the two 2019 survey estimates as reference values.

3.0 POWER ANALYSIS USING THE LOG-LINEAR REGRESSION FRAMEWORK

Although this document's power analysis focused on the statistical comparison between two estimates, it is also possible to assess the statistical power for 3 or more estimates. When using the log-linear regression framework we can estimate the number of years of data required to achieve a desired power level, given a CV and alpha level. Although this method assumes a continuous time series of data at regular intervals (consecutive years of data in our example), it is still useful to asses the number of years of data required to achieve a power level in comparison to the two-sample test elaborated upon above. As described in Buckland et al. (2004), a model can be used to asses the number of years of data required to detect a log-linear population trend for a range of rates of change and CVs. Assuming the test is one-tailed (i.e. we are only interested in significant declines), the power $(1 - \tau)$ of the *t-test* is given by

$$1 - \tau \;=\; 1 \;- F_t(t_{1-\alpha,\upsilon}, \upsilon, \eta)$$

Where $F_t(x, \upsilon, \eta)$ is the cumulative distribution function of the non-central *t*-distribution with υ degrees of freedom and non-centrality parameter η, evaluated at x and $t_{\gamma,\upsilon}$ is the $100\gamma\%$ quantile from a central *t* distribution with υ degrees of freedom. A contour map of the number of years of monitoring required to achieve a power of 0.8 at α = 0.05 at varying CV values, is presented in Figure 4. Based on the observed CVs for Eclipse Sound and combined Eclipse Sound and Admiralty Inlet (Table 1), approximately 5 years of monitoring with a 5% CV would be required for the power to detect a 10% annual decrease in abundance while approximately 7 years of data with a 12% CV would be required for the power to also detect the same decrease in abundance. Likewise, fewer years are required for 0.8 power to detect larger annual rates of decline and more years are required for 0.8 power to detect smaller annual rates of decline. This method is not suited to short temporal time-series datasets since the degrees of freedom for the regression are calculated as the number of samples (years) minus 2 (i.e. this is why 3 years of data will not detect a decline on Figure 4, regardless of the precision of the CV or the annual rate of decrease.

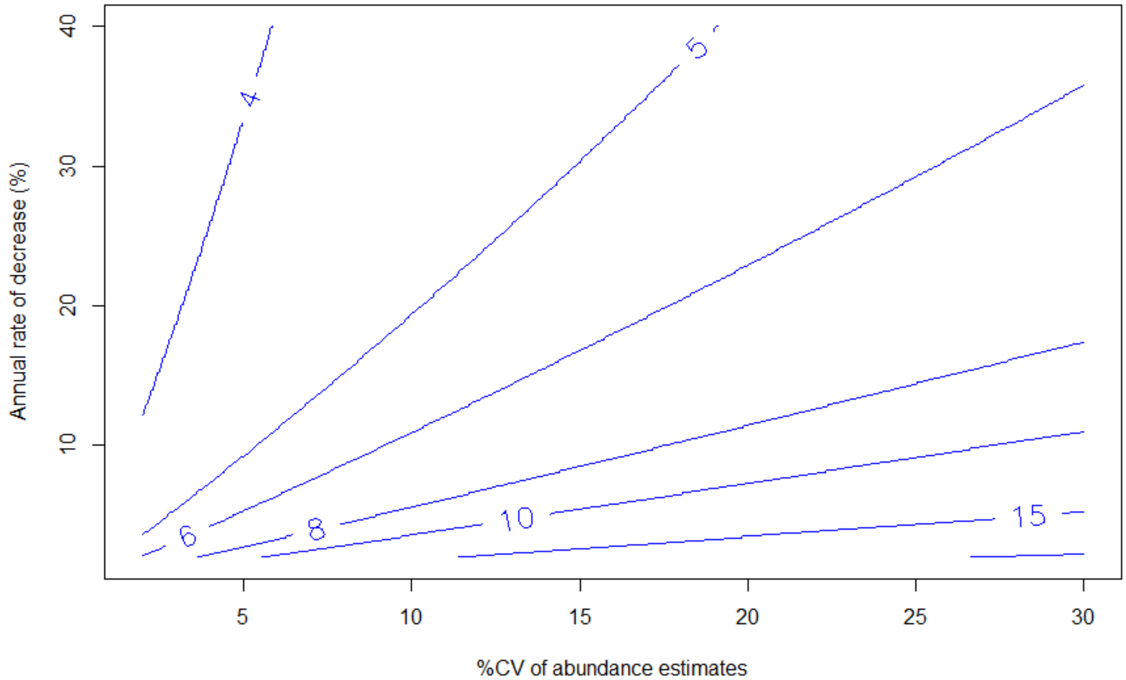


Figure 4: The number of years of monitoring required (blue values) across a variety of log-linear effect sizes and CVs at a power of 0.8 (one-tailed t-test assuming α = 0.05).

4.0 CONCLUSION

The magnitude of effect size required to achieve a power level is dependent on the CV of the refence estimate and the assumption that CV is constant through time. Since the CV of the reference estimates was directly influenced by the percentage of sightings that occurred within the estimate's photographic surveys, the Eclipse Sound estimate had a lower CV and in turn, indicated that smaller effect sizes could be used to achieve the desired power levels when compared to the combined Admiralty and Eclipse estimate. The test statistic used in the power analysis can also be used to compare current and future abundance estimates to identify whether a decrease in abundance is statistically significant.

If future aerial surveys use the same survey methods and capture a similar percentage of narwhal by photographic surveys, then the future surveys will likely achieve a similar precision (CV) of their estimates. Thus, the results of the power analysis indicate that declines of 17% in the Eclipse Sound regional abundance estimate and 36% in the combined Eclipse Sound and Admiralty Inlet regional abundance estimate can be detected. Increasing the number of years between estimates assumes a constant rate of decline that is cumulatively equal to these effect sizes and detectable at the same power level.

Although it is possible to use a log-linear regression model to estimate the power required to detect an effect size or to detect a significant decrease in abundance, this method requires a long temporal time-series dataset to outperform the two-sample comparison, which currently precludes this analysis method for this dataset.

5.0 REFERENCES

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

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L., and Thomas, L. 2004. Advanced distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, 416 p. The companion R code used to create some the figures in this reference document, and the code which Figure 4 is based on, is available at: http://lenthomas.org/software/rtrend.zip.

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Zar, Jerrold H. 1999. Biostatistical Analysis. Prentice Hall, 663p.

APPENDIX D

MMO Questionnaire

2019 Aerial Survey Program Participant Survey

Date: ____
Name: ____
Phone Number: ____
Email Address: ____
Address: ____

Anything else to add?

Program Design

1. **What was your personal experience with the aerial survey program? Explain what you did or did not like about it?**

2. **Is there anything you would suggest changing or modifying in the future? Is there anything you think should not change in the future?**

3. **Do you think that running aerial survey programs helps understand how shipping might be affecting marine mammals?**

4. **Do you think the transects are at a good distance from one another? Do you think that the number of transects accurately covered the area that marine mammals use? Should more transects be added? Or should some be removed?**

5. **When is the best time to do these aerial surveys to count narwhal?**

6. **What do you think of the elevations the plane flies at? Could you see marine mammals well enough to count them? Did you notice if the plane disturbed the marine mammals?**

7. **What did you learn working with the biologists on the aerial survey?**

8. **What do you think the biologists learned from you working on the aerial surveys this summer?**

9. **What areas do you think are most important for narwhal? For other marine mammals? Why?**

GOLDER

Data Analysis

1. **When do narwhals gather at the floe edge?**

2. **Do you notice marine mammals in or around the ice breakup? Where?**

3. **Do you think that the number of narwhal that you saw from the plane is a good indicator of the number of narwhal that hunters are seeing on the water?**

4. **What do you consider to be one group of narwhals?**

5. **Have you seen any vessels during the aerial surveys? Were there any marine mammals in the area? If so, how were they behaving?**

6. **Did you see anything during the program that you did not expect to see?**

Reporting

1. **What do you think is the best way to describe the studies that were undertaken for the aerial survey program this year?**

2. **What is the best way to communicate results to the residents of Pond Inlet?**

3. **What do you think people will be most interested in hearing about?**

Adaptive Management

1. **Has your opinion of the impact of shipping activities on marine mammals changed since you participated in the program?**

2. **Do you have any suggestions to improve how we are monitoring for shipping effects on narwhal, or marine mammals in general?**

APPENDIX E

Distance Sampling and Mark-Recapture Detection Models

Table 1: Eclipse Sound Narwhal Distance Sampling and Mark-Recapture Detection Models

Distance Sampling		Mark Recapture	
AIC	**Model[1,2]**	**AIC**	**Model[1]**
5585.15	~GlrRank+Side+Bft	837.44	~distance+Side:Obs+30SecRoll
5585.26	~GlrRank+Side	838.05	~distance+observer:Side+GlrRank
5586.27	~Side:Bft+Side+GlrRank	839.36	~distance+Side+Side:Obs +30Sec
5587.13	~30Sec+Side+Bft+GlrRank	839.37	~distance+Side:Obs
5587.24	~30Sec+Side+GlrRank	839.51	~distance+Obs+GlrRank+30Sec+Side
5587.94	~Side+Bft+Glare	840.76	~distance+Side+Obs+30Sec
5588.01	~Glare+Side	840.77	~distance+Glare+Obs+Side+30Sec
5588.74	~Side+Bft+GlrAngle	841.37	~distance+Side+Side:Obs
5588.89	~Side:Bft+Side+Glare	841.74	~distance+Side+Obs+Glare
5589.85	~30Sec+Side+Bft+Glare	842.35	~distance+Side+Obs
5589.87	~Side+Bft	844.98	~distance+Obs+30Sec:Side
5589.91	~30Sec+Side+Glare	845.18	~distance+Obs+30Sec+Glare
5590.02	~Side	845.28	~distance+Obs+GlrRank
5590.46	~Side:Bft+Side	848.14	~distance+Obs+Glare
5591.82	~30Sec+Side+Bft	848.18	~distance+Obs+30Sec
5591.94	~30Sec+Side	848.68	~distance+Obs+30Sec+Bft
5598.06	~Side:Bft+GlrRank	850.61	~distance+Obs:Glare
5599.81	~Side:Bft+Glare	852.55	~distance+Obs+GlrAngle
5601.95	~Bft+Glare	852.70	~distance+Obs
5602.04	~Bft+GlrRank	853.09	~distance+Obs+Bft

1) distance = horizontal distance, Bft = Beaufort sea state, Side = aircraft side, Glare = glare intensity, GlrRank = glare intensity ranking, Obs = primary/secondary observer, GlrAngle = area of visual field covered by glare, 30Sec = number of observer sightings in the previous 30 seconds.

2) The top twenty distance sampling models all used the gamma key function.

Table 2: Admiralty Inlet Narwhal Distance Sampling and Mark Recapture Detection Models

Distance Sampling		Mark Recapture	
AIC	**Model[1,2]**	**AIC**	**Model[1]**
6042.36	Obs:Bft+GlrRank+30Sec	621.437	~distance+Obs+30Sec+Side
6042.92	Obs+Bft+GlrRank+30Sec	622.141	~distance+Obs:Side+30Sec
6043.25	Obs:Bft+GlrRank	622.332	~distance+Obs+GlrRank+x30Sec+Side
6044.02	Obs:Bft+Obs+GlrRank+30Sec	622.803	~distance+Obs:Side+GlrRank+30Sec
6044.19	Obs:GlrAngle+Bft+30Sec	623.274	~distance+Glare+Obs+Side+30Sec
6044.67	Obs:Bft+Glare	623.427	~distance+Side+Side:Obs+30Sec
6045.28	Obs:GlrRank+Bft	628.594	~distance+Obs+30Sec+Bft
6045.33	Obs:Bft	628.614	~distance+Obs+30Sec
6045.37	Bft+Obs+GlrInt	628.781	~distance+Obs+30Sec+Glare
6045.51	Bft+Obs	629.772	~distance+Obs+30Sec:Side
6045.7	Obs:GlrAngle+Bft	648.514	~distance+Obs+Side
6046.84	GlrRank:Bft+Obs	649.135	~distance+Side+Obs+Glare
6047.11	Obs:Bft+GlrAngle	649.51	~distance+Obs:Side
6047.23	Bft+Obs+GlrAngle	650.286	~distance+Obs:Side+GlrRank
6047.33	Obs:Bft+GlareRank:30Sec	650.513	~distance+Side+Side:Obs
6047.57	Obs:Bft:GlrRank	652.815	~distance+Obs+GlrAngle
6048.56	GlareInt+GlrAngle+Obs	652.951	~distance+Obs:Glare
6048.77	GlrRank+30Sec+Bft	653.186	~distance+Obs+GlrRank
6049.2	Obs+Bft:Glare	654.863	~distance+Obs+GlrInt
6049.26	GlrRank+30Sec	656.251	~distance+Obs

1) distance = horizontal distance, Bft = Beaufort sea state, Side = aircraft side, Glare = glare intensity, GlrRank = glare intensity ranking, Obs = primary/secondary observer, GlrAngle = area of visual field covered by glare, 30Sec = number of observer sightings in the previous 30 seconds.

2) The top twenty distance sampling models all used the gamma key function.

Table 3: Eclipse Sound Bowhead Distance Sampling and Mark Recapture Detection Models

Distance Sampling			Mark Recapture	
AIC	Model[1]	Key Function	AIC	Model[1]
716.93	~GlrAngle:GlrRank	hazard rate	93.27	~distance+Obs:Side
717.05	~30Sec:Bft+Glare	half normal	93.81	~distance+Obs
717.10	~GlrAngle+GlrRank	hazard rate	94.31	~distance+Obs:Side+GlrRank
717.14	~Glare+Bft	half normal	94.50	~distance+Obs+Side
717.27	~GlrAngle:GlrRank	half normal	95.26	~distance+30Sec+Side:Obs
717.35	~GlrAngle+GlrInt	half normal	95.28	~distance+Obs+GlrRank
717.53	~GlrRank	half normal	95.49	~distance+Obs:Glare
717.60	~GlrAngle:Bft:GlrRank	gamma	95.65	~distance+Obs+30Sec
717.64	~GlrAngle:Bft:GlrRank	half normal	95.67	~distance+Obs+Bft
717.81	~Glare	gamma	95.71	~distance+Obs+GlrAngle
717.99	~GlrRank+30Sec	half normal	96.30	~distance+Obs:Side+GlrRank+30Sec
718.01	~30Sec:Bft+GlrRank	half normal	96.47	~distance+ Obs+30Sec+Side
718.21	~FogRank	half normal	97.25	~distance+Obs+Glare
718.21	~Fog	half normal	97.61	~distance+Obs+30Sec:Side
718.30	~GlrInt+30Sec+Bft	half normal	97.66	~distance+Obs+GlrRank+30Sec+Side
718.36	~GlrAngle+GlrRank+Bft	gamma	108.06	~distance+GlrRank:Side
718.46	~GlrAngle:Bft+GlrRank	gamma	110.04	~distance+Obs:Bft
718.48	~GlrAngle:Bft:GlrRank	Hazard	110.54	~distance+Obs:30Sec
718.56	~Glare	hazard rate	111.09	~distance+Obs:GlrRank
718.56	~Glare+GlrAngle	Gamma	111.24	~distance+Side

1) distance = horizontal distance, Bft = Beaufort sea state, Side = aircraft side, Glare = glare intensity, GlrRank = glare intensity ranking, Obs = primary/secondary observer, GlrAngle = area of visual field covered by glare, Fog = fog intensity, FogRank = fog intensity ranking, 30Sec = number of observer sightings in the previous 30 seconds.

Table 4: Admiralty Inlet Bowhead Distance Sampling and Mark Recapture Detection Models

Distance Sampling		Mark Recapture	
AIC	**Model[1,2]**	**AIC**	**Model[1]**
776.82	~Bft	110.60	~distance+Obs+GlrRank
777.50	~Bft+Obs	111.68	~distance+Obs
777.81	~Glare	111.76	~distance+Obs+30Sec
778.17	~30Sec+Bft	111.87	~distance+Obs+Bft
778.17	~30Sec+Bft	112.03	~distance+Obs+GlrAngle
778.51	~30Sec+Bft	112.14	~distance+Obs:Side+30Sec
778.51	~GlrRank+Bft	112.14	~distance+Side:Obs
778.58	~Bft:Side	112.25	~distance+Obs:Side+GlrRank
778.62	~Bft+Side	112.29	~distance+Obs:Side+GlrRank+30Sec
778.77	~Glare+Bft	112.65	~distance+Obs+GlrRank+30Sec+Side
778.83	~GlrRank+Bft	113.41	~distance+Obs+Side
778.87	~30Sec:Bft	113.50	~distance+Obs+30Sec+Side
778.94	~Bft+Side	113.71	~distance+Obs+30Sec:Side
779.00	~Obs	113.71	~distance+30Sec:Side+Obs
779.04	~30Sec:Bft:GlrRank	114.34	~distance+Obs:GlrRank
779.04	~x30Sec	114.57	~distance+Obs+Glare
779.14	~Glare+Bft	115.25	~distance+Obs:Glare
779.16	~30Sec:Bft	116.94	~distance+Obs:GlrRank+30Sec+Side
779.19	~Side	118.24	~distance+Obs:30Sec:Side
779.20	~GlrRank	118.31	~distance+Obs:30Sec

1) distance = horizontal distance, Bft = Beaufort sea state, Side = aircraft side, Glare = glare intensity, GlrRank = glare intensity ranking, Obs = primary/secondary observer, GlrAngle = area of visual field covered by glare, 30Sec = number of observer sightings in the previous 30 seconds.

2) The top twenty distance sampling models all used the gamma key function.

APPENDIX F

Response to MEWG Comments

Baffinland

Name: Jeff W. Higdon

Agency / Organization: Qikiqtani Inuit Association

Date of Comment Submission: 15 June 2020

#	Document Name	Section Reference	Comment	Baffinland Response
1	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	Executive Summary	The bowhead abundance estimates should be added to the Executive Summary.	The Executive Summary summarized the main objectives of the aerial survey program. Estimating bowhead abundance during Leg 1 of the aerial survey program was not a primary objective of the program (as outlined in Section 1.4). Calculated bowhead estimates during Leg 1 are provided in Section 3.1.5.3.
2	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	1.3 Existing Environment, p. 4 (Narwhal)	"... the Baffin Bay narwhal population is currently managed as four summering stocks... (Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island; DFO 2015a)." What about Smith Sound and Jones Sound, which were surveyed in 2013 and have population estimates and associated TALC recommendations? All six Baffin Bay stocks are included in DFO 2015a.	The following statement was added to the report in Section 1.3: *"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 narwhals are recognized by DFO as the Jones Sound the Smith Sound stocks (DFO 2015a). Their relationship with the four recognized Baffin Bay stocks and the Inglefield Bredning stock in Greenland is unclear."*

Baffinland

#	Document Name	Section Reference	Comment	Baffinland Response
3	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	1.3 Existing Environment, p. 5 (Harp seal)	Has Baffinland collected and compiled any IQ or observations on harp seal occurrence at the floe edge?	The survey altitude is designed to detect/record cetaceans. Nonetheless, pinnipeds observed are recorded and reported, including during Leg 1. The reported sightings are available in Table 4. However, as noted in Section 3.1.1, by the time surveys began on 12 July 2019, the floe edge had broken up and most of the ice was situated west of Pond Inlet and into North Milne Inlet, therefore marine mammal sightings at this time occurred in open-water or on drifting ice floes.
4	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	3.1.3 Visual Survey Sightings, p. 31 (Ringed seal)	"Ringed seals on the ice [n = 10 groups] were observed with group sizes ranging from one to 15 seals, with mean and median group sizes of 4.1 and 2.5, respectively." Did any of the aerial surveys and associated counts of hauled out ringed seal groups overlap in space and time with the SBO program data from the MSV *Botnica*? This is an area where results from different programs could potentially be integrated.	The aerial survey transects did not overlap with the path of the MSV *Botnica* during Leg 1 in 2019.
5	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	3.1.5.3 Bowhead Abundance, p. 37	"Total bowhead abundance for the visually surveyed area of Survey 2 was 1,279 (CV=0.30; Table 10)." Should say Survey 4, not 2?	Yes, this has been corrected in the report.

#	Document Name	Section Reference	Comment	Baffinland Response
6	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	3.2.5.2 Photographic Survey Data Characteristics, p. 66, Figure 39	This is a useful figure (Figure 39) and could be made full-page.	Formatting has been adjusted to increase the sizing of Figure 39 to fill the entire page.
7	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	3.2.5.3 Narwhal Abundance, p. 71; 3.2.5.3.3 Combined Eclipse Sound and Admiralty Inlet Stocks, p.74 (and elsewhere as relevant, e.g. Discussion)	Re: impacts of killer whales on narwhal movements, behaviour, etc., and as a further example of opportunities to integrate data from different programs, PAM data on killer whale detections (AMARs) could provide additional information on occurrence at the times surveys were conducted. Local observations could also be contributed via Community-Based Monitoring, etc.	Leg 2 of the 2019 Marine Mammal Aerial Survey Program ended on 30 August 2019. Killer whales were only detected on AMARs between 31 August and 16 September 2019.
8	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	3.3 Inuit Researcher Questionnaires, p. 77	"They also noticed that the narwhals were not going close to JASCO AMAR near the Bruce Head Behavioural Study Area." Are there any data from the Bruce Head program on sightings in relation to the AMAR location?	This report is limited to results of the 2019 Marine Mammal Aerial Survey Program.

#	Document Name	Section Reference	Comment	Baffinland Response
9	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	4.1 Narwhal Abundance, p. 80	"The Canadian High Arctic Cetacean Survey conducted by DFO in August 2013 was the first complete survey of the four major narwhal summer stock areas belonging to the Baffin Bay population (Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island; DFO 2015a)." The ranges of all four summer stocks (or parts thereof, at least) were surveyed between 2002 and 2004 (Richard et al. 2010). The surveys in 2002 did not cover the entire range of the Somerset Island stock but they included Prince Regent Inlet and the Gulf of Boothia, which allowed a population estimate for the stock.	The text has been modified to: "The Canadian High Arctic Cetacean Survey conducted by DFO in August 2013 was the first complete survey flown in a single season of the four major narwhal summer stock areas belonging to the Baffin Bay population (Somerset Island, Admiralty Inlet, Eclipse Sound, and East Baffin Island; DFO 2015a)."
10	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	4.1 Narwhal Abundance (Leg 2 – Open-water Season), p. 83	"Comparing the Marcoux et al. (2019) estimate of 12,039 (CV = 0.23, 95% CI of 7,768−18,660) to the current estimate of 9,931 (CV = 0.05, 95% CI of 9,009−10,946) found the current estimate was not significantly less (T-test = 0.749, p = 0.237)." A Z-test might be more appropriate for comparing the two population estimates (but the 2019 estimate is likely not significantly less than the 2016 estimate either way).	The T-test results were replaced with Z-test results in the report. This did not change the significance of the results. It should be noted that the sample sizes for the abundance estimates in the Marcoux et al. (2019) or Doniol-Valcroze et al. (2015) were not provided. The use of the Z-statistic may represent a higher precision than is warranted by the comparison of the DFO and Baffinland data.

#	Document Name	Section Reference	Comment	Baffinland Response
11	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	4.2 Narwhal Distribution (Leg 2 – Open-water Season), p. 84	"Killer whales had not been observed in southern Milne Inlet area by the Bruce Head study team during 2013 to 2017 (Thomas et al. 2014; Smith et al. 2015, 2016, 2017; Golder 2018a)…" While not observed from the Bruce Head site, Elijah P. saw killer whales from the helicopter while departing the field camp one year.	The text has been modified to: "Killer whales had not been observed in southern Milne Inlet area during the Bruce Head study from 2013 to 2017 (Thomas et al. 2014; Smith et al. 2015, 2016, 2017; Golder 2018a)…".
12	2019 Marine Mammal Aerial Survey Mary River Project (file: 2019 Marine Mammal Aerial Survey Program Report_DRAFT FOR MEWG.pdf)	5.0 SUMMARY, p. 90	"… it appears that mitigation measures implemented to minimize effects of Project shipping on marine mammals in the RSA (e.g. speed restrictions… are functioning as intended and that no additional adaptive management measures to Project shipping operations are required at this time." Based on the vessel speeds shown in the tagging study draft for vessel Closest Point of Approach, some targeted intervention may be required for specific companies and/or vessels (cargo and fuel tankers) with respect to compliance.	No response required with regards to the 2019 Marine Mammal Aerial Survey Program.

Baffinland

Name: Marianne Marcoux, Jacquie Bastick, Cory Matthews

Agency / Organization: DFO, PCA

Date of Comment Submission: June 18th, 2020

#	Document Name	Section Reference	Comment	Baffinland Response
1	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	General comment	It would be useful that the results from the different monitoring programs related to marine mammals get interpreted and integrated together. The different monitoring programs were designed to complement each other and their results should feed into each other. In addition, they are all part of the same adaptive management and mitigation plan.	A Technical Memorandum entitled "Summary of Results for the 2019 Marine Mammal Monitoring Programs" was submitted to the MEWG in May 2020 and incorporated an integrated summary of the results of all the marine mammal monitoring programs. Baffinland's Annual Report to the NIRB also provides for an integrated summary of results from all marine monitoring programs. All monitoring programs are captured in the Marine Monitoring Plan.
2	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	General comment	The report provided enough information and detail to be able to assess the data and results. The design, analysis and results seemed appropriate and are in line with previous DFO surveys to estimate abundance of whales.	No response required, although it is noted that this comments somewhat contradicts reviewer comment number 13 and feedback provided by DFO during the June/July 2020 MEWG Meeting. See also response to comment number 13.
3	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	General comments	Would it be possible to add tables with the Mark-recapture distance sampling model considered with their respective AIC values?	These have been included in the report in Appendix E.

#	Document Name	Section Reference	Comment	Baffinland Response
4	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	3.2.5.3 Narwhal Abundance 3.2.5.3.1 Eclipse Sound Stock	The coefficient of variation (CV) of the Eclipse Sound part of the survey is very low (0.05). This is unusual for an aerial count of whales. The way the CV was calculated seemed correct and the low CV is a result of having most of the narwhals counted in the strata that were fully covered by photos.	No response required.
5	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	4.1 Narwhal Abundance Leg 2 – Open-water Season	"Because narwhal were distributed in a relatively small area (mostly in Milne Inlet and Tremblay Sound where most sightings were captured by photographic surveys), low CVs were achieved in the August surveys which provided the best abundance estimate. Narwhals concentrated in areas where shipping activities were high (Milne Inlet South) rather than moving to areas with low shipping activities. This is a sign that the level of shipping activity is not causing displacement. This is consistent with impact predictions made in the FEIS Addendum for the ERP that the Project was 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)." Your results do show that narwhals were present in Milne Inlet/Koluktoo Bay while shipping is occurring. However, in order to investigate large scale displacement, the densities of narwhals need to be compared to the densities of narwhals before shipping started. It would be informative to compare the current estimates with estimates from	A comparison between the 2019 abundance estimate of 9,931 (CV = 0.05) and the 2013 DFO abundance estimate of 10,489 (CV = 0.24) is now included in Section 4.1. A Technical Memorandum entitled "Summary of Results for the 2019 Marine Mammal Monitoring Programs" was submitted to the MEWG in May 2020 and incorporated an integrated summary of the results of all the marine mammal monitoring programs.

Baffinland

#	Document Name	Section Reference	Comment	Baffinland Response
			before project-related shipping started. In addition, it would be interesting to link these comments to the results of the Integrated Narwhals Tagging Study where small scale displacements were documented.	
6	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	4.2 Narwhal Distribution Leg 2 – Open-water Season	Golder states that killer whales had not been observed in southern Milne Inlet area by the Bruce Head study team during 2013 to 2017 and that killer whales had not been observed by Baffinland aerial survey study teams in 2013–2015. DFO notes that there were reports of killer whales in the area during those years, with prolonged period in 2017.	Additional studies documenting recent killer whale activity in the RSA have been identified in Section 4.2 and included in the reference list.
7	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	2.5.1 Visual Survey	For the survey of Milne Inlet South during the surveys 2 and 4 of Leg 1, the design of this strata does not meet the standard for distance sampling analysis. It seems like the intent for this strata design was to use surface density modelling. How was this strata analysed?	Narwhal were not observed in Milne Inlet South during either survey 2 or survey 4 of Leg 1 in 2019, therefore the strata was not analyzed using these track lines. Leg 1 survey analysis focuses on encounter rate and has not been used for generating animal abundance estimates using distance sampling methods.
8	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	2.5.1.1 Distance Analysis Table 2	Golder used published data for the availability bias correction factors. Did you consider using the data from the 2017-2018 tagging program? Given environmental changes that occurred since 2012, it is recommended to use the most recent data possible. Another approach would be to update the published correction factor with the more recent tag data.	A number of environmental and biological factors could affect the diving behaviour of whales in any given year thus affecting the availability bias correction factors. Since the 2017-2018 tagging data was not from the same year as the 2019 aerial survey, Golder decided to use the same availability bias correction factors that DFO used for their 2016 abundance estimate. This also allowed for a more accurate comparison between the 2016 and 2019 population estimates.

#	Document Name	Section Reference	Comment	Baffinland Response
9	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	2.5.2.1 Narwhal	How was the 2 m depth determined? How did the photo trainer determine that some narwhals were below 2 m depth?	Only narwhal that could be positively identified were included in the photo analysis. As noted in Richard et al. (1994), experiments with narwhal-shaped models showed that narwhals could be seen and identified by observers at depths of about 2 m but not deeper.
10	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	2.5.2.1 Narwhal	The availability correction factor usually takes into account water clarity (or murkiness) and the correction factor can be adjusted according to the depth at which narwhals can be seen. How was the information about the murkiness integrated into the abundance estimates?	No narwhal were observed in murky water during the 2019 photographic surveys. Had there been narwhal observed in murky water, the appropriate correction would have been applied to that photograph.
11	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	3.2.5.1 Visual Survey Data Characteristics - Narwhal	Golder combined sightings from early shoulder season survey (Leg 1) and the open-water season survey (Leg 2) were used for estimating the detection function and mark-recapture detection probabilities for narwhal in Eclipse Sound. Golder's justification for combining the two was because of low sample size for the open-water period. Were the same observers present during the two sets of surveys? Do you have evidence to suggest that the detection function should be the same during the two legs of the survey? Could you use color coding on figure 27 to illustrate the sightings from the different legs? In Buckland et al 2001, p.14 section 1.5.1, it is suggested that a sample size of 60-80 should be sufficient to determine the detection function. Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L.,	When the covariates of the selected model for the combined data are applied to the Leg 1 and Leg 2 data separately, the detection function probabilities are within two percent of each other (0.416 and 0.402, respectively). The Eclipse Sound secondary observers were the same for both legs, while one of the three primary observers for Leg 2 was also on Leg 1. Golder is not aware of a method that would allow for the differentiation of data sources in Figure 27. The inclusion of covariates and mark-recapture analysis increases the need for larger sample sizes. Buckland et al. 2001, p.15 end of the same paragraph, also states that "sample sizes of several hundred are often required for effective management".

#	Document Name	Section Reference	Comment	Baffinland Response
			Borchers, D.L., and Thomas, L. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, USA, Oxford	
12	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	3.2.5.2 Photographic Survey Data Characteristics Figure 40-41	Have you tried to fit linear detection function to the photographic data? The default function in distance sampling assume a shoulder at the track line but it might not be the case for oblique photos.	Since there was no logical reason for detections to diminish close to the trackline of the photographic data, it was assumed that any apparent reduction in detections near the trackline was an artifact of the clumped distribution of the narwhal. Fitting a linear regression was not attempted since the reduction in detections at increasing distances was not uniform (i.e. drop was most pronounced in the farthest third/half of the data). Fitting a linear function to this data would push the fitted detection function above the data at the trackline, where it is most sensitive to adjustments (i.e. the correction factor would be higher than logically warranted by the data).
13	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	4.1 Narwhal Abundance	For their stock assessment, DFO aims at conducting the aerial survey between Aug 1 and 24 (Watt et al. 2015). Narwhals tend to start migrating around August 25 when they tend to make more extensive movement and change their dive behaviour (Dietz et al. 2001, Heide-Jørgensen et al. 2002, Heide-Jørgensen et al. 2003, Dietz et al. 2008,). It should be noted that it is possible that the abundance estimate from Aug 25-27 include narwhals from other stocks that have started their fall migration.	The impact of survey timing on diving behaviour was accounted for in the analysis using the appropriate availability bias correction factor from Watt et al. (2015) for the time at which the survey was conducted (see Section 2.5.1.1. The tagging data from the references used to support the statement that narwhal tend to start migrating around August 25 actually indicate that narwhal start their fall migration in mid to late September (Dietz et al. 2001, Heide-Jørgensen et al. 2002, Heide-

#	Document Name	Section Reference	Comment	Baffinland Response
			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. Canadian Science Advisory Secretariat Res. Doc. 2015/044.	Jørgensen et al. 2003, and Dietz et al. 2008). Dietz et al. 2001, Heide-Jørgensen et al. 2003, and Dietz et al. 2008 did not observe any movement of narwhal out of their summer stock area in August. Dietz et al. 2001: Ten narwhal were tagged in Tremblay Sound in 1997–1998. Five were tagged in 1997 between 8–24 August and five were tagged in 1998 between 14–25 August. In both years, the whales left the Bylot Island area between 20 and 29 September. Heide-Jørgensen et al. 2003: Sixteen narwhal were tagged at Somerset Island in 2000–2001. Nine were tagged in 2000 between 14–24 August and seven were tagged in 2001 between 7–12 August. In mid to late September, most whales began to migrate into western Lancaster Sound. The eastward migration out of Lancaster Sound started in early October with most whales moving close to the southern shore of Devon Island. Dietz et al. 2008: Twenty-one narwhal were tagged In Admiralty Inlet in 2003–2004. Thirteen were tagged in 2003 between 16–21 August and eight were tagged in 2004 between 11–22 August. Outmigration from Admiralty Inlet took place between 14 September and 11 October (mean: 28 September).

#	Document Name	Section Reference	Comment	Baffinland Response
				Evidence of narwhal movements between stocks in August from these four papers is limited to one tagged narwhal in Tremblay Sound in August 1999 that exited the RSA on 26 August through Navy Board Inlet and moved into Admiralty Inlet (Heide-Jørgensen et al. 2002). Three of the other tagged narwhal from this 1999 tagging program stayed in the deep northern parts of Eclipse Sound until 13–30 September. The two other tagged narwhal that year moved into Navy Board Inlet in late August and both remained there until 11 September before heading into Lancaster Sound. From these four papers, only one out of 53 tagged whales started their fall migration on 26 August. The other 52 whales all began their fall migration on 11 September or later.
14	REPORT 2019 Marine Mammal Aerial Survey Mary River Project	Appendix C. Power analysis 1.0 POWER ANALYSIS - METHODS	This analysis assumes that the coefficient of variation (CV) of future surveys will be similar to the CV of this current survey. As noted above, the 0.05 CV for Eclipse Sound in this current survey is very low and future surveys will likely have a higher CV. It would be helpful to run the power analysis with different values for CV.	If a higher CV (>0.05) is identified for the 2020 aerial survey, or any future survey, we can revise the power analysis accordingly.

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