FINAL REPORT

REPORT

Mary River Project

2021 Ringed Seal Aerial Survey

Submitted to:

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Executive Summary

The ringed seal aerial survey program (RSASP) was conducted by Golder in the North Baffin area during June 2021. The first objective of the survey was to document ringed seal density and distribution along the Northern Shipping Route in the Regional Study Area (RSA) and to allow for a comparison with previous results obtained in 2016 and 2017 (Young et al. 2019). The second objective of the survey was to identify ringed seal hotspots throughout the RSA and identify overlaps with hotspots identified in 2016 and 2017 (Yurkowski et al. 2018).

Two types of analyses were performed on the 2021 dataset. Strip-transect analysis of infrared imagery combined with digital photographs was used to calculate densities of ringed seals in the RSA, and density surface modelling was used to identify ringed seal hotspots in the RSA.

Results from the 2021 forward-looking infrared (FLIR) survey indicated that ringed seal densities are stable in Eclipse Sound (ES) and Navy Board Inlet (NB) strata and increased in Milne Inlet (MI) stratum compared to surveys flown in 2016. A comparison in the ES stratum of the highest estimate in 2021 (1.04 seals/km^2, CV = 0.08) with the highest estimate in 2016 (0.92 seals/km^2, CV = 0.09) indicated no statistically significant difference in density estimates in ES stratum (z-score = 1.02, $p = 0.31$). Similarly, a comparison in the NB stratum of the highest estimate in 2021 (0.83 seals/km^2, CV = 0.12) with the highest estimate in 2016 (0.74 seals/km^2, CV = 0.43) indicated no statistically significant difference in density estimates in NB stratum (t-test = 0.27, $p = 0.79$). In the Milne Inlet (MI) stratum ringed seal densities were higher in 2021 compared to previous surveys in 2016 and 2017. A comparison of the highest estimate in 2021 (2.84 seals/km^2, CV = 0.15) with the highest estimate in 2016 (1.40 seals/km^2, CV = 0.12) indicated a statistically significantly higher ringed seal density observed in 2021 in the MI stratum (t-test = 3.14, $p = 0.003$). However, surveys flown prior to 2016 indicated MI stratum varies in ringed seal densities annually.

Ringed seal hotspots were identified in similar geographic areas in 2021 as in 2016–2017, with hotspots in western Eclipse Sound, southern Milne Inlet and Tremblay Sound. The eastern Eclipse Sound hotspot identified in 2016 and 2017 was not present in 2021. The northern half of Navy Board Inlet had low sightings of ringed seals in all years (2016, 2017, and 2021).

Ringed seal aerial surveys for the Project were also conducted in the North Baffin area during June 2014. The objective of the survey was to update baseline data on ringed seal density and distribution along the Northern Shipping Route in the RSA. Using data from these surveys, ringed seal density estimates were calculated by Golder for this report using two different methods (strip-transect and line-transect analysis) to allow for comparison with subsequent surveys flown in 2016 and 2017 (Young et al. 2019), and in 2021.

Results from the visual strip-transect analysis found similar ringed seal density estimates in ES stratum between 2014 and 2016. A comparison of the highest estimate in 2014 (0.60 seals/km^2, CV = 0.07) with the highest estimate in 2016 (0.52 seals/km^2, CV = 0.10) indicated no statistically significant difference in ringed seal densities (z-score = 1.25, $p = 0.21$). In the MI stratum ringed seal densities appeared higher in 2014 compared to subsequent surveys in 2016. A comparison of the highest estimate in 2014 (1.45 seals/km^2, CV = 0.14) with the highest estimate in 2016 (0.31 seals/km^2, CV = 0.17) indicated a statistically significantly higher density observed in 2014 in the MI stratum (t-test = 5.49, $p < 0.001$).

The MI stratum appeared to fluctuate in ring seal density annually. Ringed seal surveys flown in 2008 and 2014 saw high densities of ringed seal in MI (1.44 seals/km^2 and 1.45 seals/km^2, respectively; Baffinland 2012)

whereas ringed seal surveys flown in 2007 and 2016 observed lower densities of ringed seal in MI (0.27 seals/km^2 and 0.31 seals/km^2, respectively; Baffinland 2012; Young et al. 2019). Based on visual strip-transect surveys flown in 2007, 2008, 2014, and 2016, ringed seal densities appeared to be stable in ES and variable in MI strata.

Results from the line-transect analysis found in the ES stratum ringed seal densities were higher in 2014 (ranged from 1.07 to 1.27 seals/km^2) compared to 2016 (ranged from 0.57 to 0.79 seals/km^2) surveys. A comparison of the highest estimate in 2014 (1.27 seals/km^2, CV = 0.09) with the highest estimate in 2016 (0.79 seals/km^2, CV = 0.11) indicated a statistically significantly higher ringed seal density observed in 2014 in the ES stratum (t-test = 3.36, p = 0.004). Similarly, in the MI stratum, ringed seal densities were higher in 2014 (ranged from 1.14 to 2.13 seals/km^2) compared to 2016 (ranged from 0.93 to 1.27 seals/km^2) surveys. A comparison of the highest estimate in 2014 (2.13 seals/km^2, CV = 0.12) with the highest estimate in 2016 (1.27 seals/km^2, CV = 0.16) indicated a statistically significantly higher ringed seal density observed in 2014 in the MI stratum (t-test = 2.66, p = 0.013).

Comparing 2021 infrared strip-transect densities (1.04 seals/km^2 in ES and 2.84 seals/km^2 in MI) to 2014 line-transect distance analysis densities (1.27 seals/km^2 in ES and 2.13 seals/km^2 in MI), no statistical difference was observed between the two years (t-test = 1.63, p = 0.013 and t-test = 1.44, p = 0.017, respectively). These results indicated ring seal densities have not changed in the RSA since the onset of shipping operations in 2015, and since Project icebreaking activities began in the shoulder seasons in 2018.

Mitigation measures in place for ringed seal have been carefully developed to completely avoid shipping impacts on ringed seal during periods when they are “grouped up” (i.e., the winter and spring) when group behaviour is critical to reproductive activities such as mating. The timing of the shipping season protects seals during the basking period and aims to avoid impacts on seals at the time when they start maintaining breathing holes during initial ice freeze-up.

The results of the 2021 RSASP showed ringed seal densities have overall remained stable since the onset of shipping operations in 2015, and since Project icebreaking activities began in the shoulder seasons in 2018. These results confirmed that mitigation measures were functioning as intended and that Project activities are being managed in a way that has not adversely affected ringed seals. Given that no changes to icebreaking operations are proposed within Baffinland’s Phase 2 Proposal, these results also lend confidence to predictions made in Phase 2 impact assessment, which states that effects on ringed seal as a result of the Project would not result in population level effects (Golder, 2018).

ᐊᐅᓚᑦᑎᔨᓂᙶᕐᑐᑦ ᓇᐃᓈᕐᓯᔪᑦ

ᓇᑦᑎᕐᓂᒃ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᐅᓲᖅ (RSASP) ᐱᓕᕆᐊᕆᔭᐅᓚᐅᖅᐳᖅ ᒎᑐᒃᑯᓐᓂ ᕿᑭᖅᑖᓘᑉ ᐅᐊᖕᓇᖓᓂ ᔫᓂ 2021–ᖑᑎᓪᓗᒍ. ᓱᕝᓕᓕᖅ ᐱᔾᔪᑕᐅᔪᖅ ᖃᐅᔨᓴᕐᓂᕐᒥᒃ ᑎᑎᕋᖅᑕᐅᕙᓪᓕᐊᕐᑯᓪᓗᒋᑦ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ ᓇᓃᓐᓂᖏᓪᓗ ᐅᑭᐅᖅᑕᖅᑐᒥ ᐅᒥᐊᕐᔪᐊᒃᑯᑦ ᐃᖏᕐᕋᕙᐅᕙᒃᑐᒃᑯᑦ ᓄᓇᓂ ᐊᕙᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕙᐅᕙᒃᑐᒥᒃ (RSA) ᐊᒻᒪᓗ ᖃᓄᐃᓕᓐᓂᖅᓴᐅᖕᒪᖔᑕ ᑕᑯᓇᕐᑯᓪᓗᒋᑦ ᑕᑯᓗᒋᑦ ᐊᓯᖏᑦ ᖃᐅᔨᓴᐅᓯᒪᔪᑦ ᐊᕐᕌᒍᓂᒃ ᐊᓂᒍᖅᓯᒪᓕᖅᑐᓂᒃ 2016-ᒥ 2017–ᒥᓪᓗ (ᔭᖕ ᐊᑕᖏᖅᓱᑎᒃ 2019). ᐊᐃᑉᐸᖓᓂᒃ ᐱᔾᔪᑎᖃᖅᓱᑎᒃ ᖃᐅᔨᓴᕐᓂᐅᔪᒥᒃ ᓇᓗᓇᐃᕐᓗᒍ ᓇᑦᑏᑦ ᓇᓃᒐᔪᒪᖔᑕ ᓄᓇᓂ ᐊᕙᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕙᐅᕙᒃᑐᒥᒃ ᐊᒻᒪᓗ ᓇᓗᓇᐃᕐᓗᒋᑦ ᖃᓕᕐᑯᒥᒃᑯᑦ ᐅᐸᒃᑕᐅᓯᒪᓚᔪᒃᑐᑦ ᓇᓗᓇᐃᖅᑕᐅᓂᒃᑯᑦ 2016–ᒥ 2017–ᒥᓪᓗ (ᔪᑕᐅᔅᓯ ᐊᑕᖏᖅᓱᑎᒃ 2018).

ᒪᕐᕈᐃᓕᖓᔪᓂᒃ ᖃᐅᔨᓴᕐᓂᖅᑕᖃᓚᐅᖅᐳᖅ 2021–ᒥ ᑎᑎᕋᖅᓯᒪᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᑯᐃᑦ. ᐊᕙᒃᑐᖅᓯᒪᔪᓂ-ᑐᑭᓕᐊᖅᑐᓂᒃ ᐊᑐᖅᓱᑎᒃ ᖃᐅᔨᓴᕐᓃᑦ ᐆᓇᖅᑐᒥᒃ ᓇᓗᓇᐃᖅᓯᓯᒥᑦ ᑲᑎᙵᓪᓗᑎᒃ ᐊᔾᔨᓕᐅᖅᑕᐅᕙᓪᓕᐊᕙᒃᑐᑦ ᐊᑐᖅᑕᐅᓚᐅᖅᐳᖅ ᓈᓴᖅᑕᐅᕐᑯᓪᓗᒋᑦ ᐅᓄᕐᓂᖏᑦ ᓇᑦᑏᑦ ᓄᓇᓂ ᐊᕙᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕙᐅᓯᒥᒃ, ᐊᒻᒪᓗ ᓇᓃᓐᓂᖏᑦ ᓴᖅᑮᔭᖅᑐᑦ ᐋᖅᑭᙳᐊᖅᑕᐅᓯᒪᔪᑦ ᐊᑐᖅᑕᐅᓚᐅᖅᑐᑦ ᓇᓗᓇᐃᔭᐃᑎᓪᓗᒋᑦ ᓇᑦᑏᑦ ᑕᐅᔭᓂ ᐅᐸᒃᓯᒪᓚᔪᒃᑕᖏᑦ ᓄᓇᓂ ᐊᕙᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕙᐅᕙᒃᑐᒥᒃ.

ᖃᐅᔨᔭᐅᔪᑦ 2021–ᒥ ᐅᖓᒻᒍᑦ-ᑎᒃᑯᐊᖓᓪᓗᓂ (FLIR) ᖃᐅᔨᓴᖅᑕᐅᔪᖅ ᓇᓗᓇᐃᖅᓯᓚᐅᖅᐳᖅ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ ᓱᕋᙱᑦᑐᑦ ᑕᓯᐅᔭᕐᒥ (ES) ᐊᒻᒪᓗ ᐃᒡᓗᐊᑕ ᓱᓪᓗᐊᓂ (NB) ᐊᕙᒃᑐᖅᓯᒪᔪᓂᒃ ᐊᒻᒪᓗ ᐅᓄᕐᓂᖅᓴᐅᓪᓗᑎᒃ ᕿᙳᐊᓂ (MI) ᐃᓛᒃᑰᖓᔪᒃᑯᑦ ᖃᓄᐃᓐᓂᖅᓴᐅᖕᒪᖔᑕ ᖃᐅᔨᓴᕈᑎᕙᓂᕐᓂ ᖃᖓᑕᖃᑦᑕᖅᑎᓪᓗᒋᑦ 2016–ᒥ. ᖃᓄᐃᓐᓂᖅᓴᐅᓂᖏᑦ ᑕᓯᐅᔭᕐᒥ (ES) ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᐅᓄᓛᖑᓚᐅᖅᐳᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᔪᑦ 2021–ᒥ (1.04 ᓇᑦᑏᑦ/ᑭᓛᒥᑕ ᑭᑉᐹᓇᒃᑐᑦ, CV = 0.9) ᓇᓗᓇᐃᖅᓯᓚᐅᙱᓚᑦ ᓇᐃᓴᐅᑎᑎᒍᑦ ᐊᓯᔾᔨᕐᔪᐊᖅᓯᒪᔪᖃᙱᓐᓂᖓᓂᒃ ᐅᓄᕐᓂᖏᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᑕᓯᐅᔭᕐᒥ (ES) ᖃᐅᔨᓴᖅᑕᐅᔪᓂ (z-score = 1.02, p = 0.31). ᐊᔾᔨᐸᓗᖏᓪᓗᓂᐅᒃ, ᖃᓄᐃᓐᓂᖅᓴᐅᓂᖏᑦ ᑕᐅᕙᓂ ᐃᒡᓗᐊᑕ ᓱᓪᓗᐊᓂ (NB) ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᑎᒍᑦ (t-ᖃᐅᔨᓴᕐᓂᖅ = 0.27, p = 0.79). ᕿᙳᐊᓂ (MI) ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ ᕐᑯᕚᓯᖕᓂᖅᓴᐅᓚᐅᖅᑐᑦ 2021-ᒥ ᖃᓄᐃᓐᓂᖅᓴᐅᓂᖏᑦ ᑕᑯᓪᓗᒋᑦ ᖄᖏᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᓂᐅᓚᐅᖅᑐᓂ 2016-ᒥ ᐊᒻᒪᓗ 2017-ᒥ. ᖃᓄᐃᓐᓂᖅᓴᐅᓂᖏᓐᓄᑦ ᕐᑯᕚᓯᓛᖑᔪᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 2021-ᒥ (2.84 ᓇᑦᑏᑦ/ᑭᓛᒥᑕ ᑭᑉᐹᓇᒃᑐᑦ, CV = 0.15) ᓇᓗᓇᐃᖅᓯᓪᓗᑎᒃ ᓇᐃᓴᐅᑎᑎᒍᑦ ᐅᓄᕐᓂᖅᓵᔪᐃᑦ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ ᑕᑯᔭᐅᓚᐅᖅᑐᑦ 2021-ᒥ ᑕᐅᕙᓂ ᕿᙳᐊᓂ (MI) ᖃᐅᔨᓴᖅᑕᐅᔪᓂ (t-ᖃᐅᔨᓴᕐᓂᖅ= 3.14, p = 0.003). ᑭᓯᐊᓂᓕ, ᖃᐅᔨᓴᖅᓱᑎᒃ ᖃᖓᑕᖃᑦᑕᓚᐅᖅᑐᑦ 2016-ᒥ ᓇᓗᓇᐃᖅᓯᓯᒪᔪᑦ ᕿᙳᐊᓂ (MI) ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᐊᔾᔩᙱᖏᓐᓂᖏᓐᓂᒃ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ ᐊᕐᕌᒍᑕᒫᑦ.

ᓇᑦᑏᑦ ᓇᓃᓪᓗᐊᑕᖃᑦᑕᕐᓂᖏᑦ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᖅᐳᑦ ᐊᔾᔨᐸᓗᖏᓐᓂ ᐃᓂᒋᔭᐅᕙᒃᑐᓂᒃ 2021–ᒥ ᐊᔾᔨᒋᓪᓗᓂᐅᒃ 2016–2017–ᒥ, ᐅᐸᒃᑕᐅᓯᒪᓛᖑᔫᖑᓪᓗᓂ ᐱᓇᖕᓇᖓᓂ ᑕᓯᐅᔭᕐᒥ, ᓂᕆᐊᓂ ᕿᙳᐊᑕ ᐊᒻᒪᓗ ᑲᖏᖅᓱᑭᓗᖕᒥ. ᑲᓇᖕᓇᖓᓂ ᑕᓯᐅᔭᕐᒥ ᐅᐸᒃᑕᐅᓯᒪᓛᖑᔫᑦ ᖃᐅᔨᔭᐅᓚᐅᖅᐳᑦ 2016–ᒥ 2017–ᒥᓪᓗ ᐱᑕᖃᓚᐅᙱᓚᑦ 2021–ᒥ. ᐅᐊᖕᓇᖅᐸᓯᐊᒍᑦ ᐃᒡᓗᐊᑕ ᓱᓪᓗᐊᓂ ᑕᑯᓇᓗᐊᓚᐅᖏᑦᑐᖅ ᓇᑦᑎᕐᓂᒃ ᐊᑕᖏᖅᓱᑎᑦ ᐊᕐᕌᒍᐃᑦ ᑕᑯᓗᒋᑦ (2016, 2017, 2021–ᓗ).

ᓇᑦᑏᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᐱᓕᕆᐊᒧᑦ ᐱᓕᕆᐊᖑᒃᑲᓂᓚᐅᖅᐳᑦ ᕿᑭᖅᑖᓘᑉ ᐅᐊᖕᓇᖓᓂ ᔫᓂ 2014–ᒥ. ᑐᕋᖓᕆᔭᐅᔪᖅ ᖃᐅᔨᓴᕐᓂᐅᔪᒧᑦ ᓄᑖᙳᕆᐊᖅᑕᐅᕙᓪᓗᑎᒃ ᖃᐅᔨᓴᖕᒐᐅᑕᐅᓯᒪᔪᑦ ᑎᑎᖅᑲᕐᑯᑎᖏᑦ ᓇᑦᑎᕐᓄᑦ ᐅᓄᕐᓂᖏᓐᓄᑦ ᓇᓃᒻᒪᖔᑕᓗ ᑕᐅᓐᓇ ᐅᑭᐅᖅᑕᖅᑐᒥ ᐅᒥᐊᕐᔪᐊᑦ ᐊᖅᑯᑎᖏᑦᑎᒍᑦ ᓄᓇᓂ ᐊᕙᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᔪᐅᔪᓂ. ᑎᑎᖅᑲᕐᑯᑎᓂᒃ ᐊᖅᑐᖑᑎᒃ ᑕᒪᒃᑯᓄᖓ ᖃᐅᔨᓴᕈᑎᓄᑦ, ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᐳᑦ ᒎᑐᒃᑯᓐᓂ ᑖᔅᓯᒧᖓ ᐅᓂᒃᑲᒧᑦ ᒪᕐᕈᐃᓕᖓᔪᓂᒃ ᐊᑐᖅᓱᑎᒃ ᐱᓕᕆᔾᔪᓯᕐᓂᒃ (ᑐᑭᓕᐅᑦ-ᖃᖓᑕᕝᕙᐅᔪᑦ ᐊᒻᒪᓗ ᐊᕙᒃᑐᖅᓯᒪᔪᑦ ᐊᔾᔨᒌᖏᑦᑐᑦ ᖃᐅᔨᓴᕐᓃᑦ) ᖃᓄᐃᓐᓂᖅᓴᐅᖕᒪᖔᑕ ᑭᖑᓂᖓᒍᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᕙᓃᑦ ᖃᖓᑕᓲᒃᑯᑦ 2016–ᒥ 2017–ᒥᓪᓗ (ᔭᖕ ᐊᑕᖏᖅᓱᑎᒃ 2019), 2021–ᒥᓪᓗ.

ᓇᑦᑏᑦ ᑖᒃᑯᓇᙵᓕᑦ ᑕᑯᔭᐅᓯᒪᔪᑦ ᑐᑭᓕᐅᓂ-ᖃᖓᑕᕝᕙᐅᔪᓂᑦ ᖃᐅᔨᓴᕐᓃᑦ ᐊᔾᔨᐸᓗᓚᐅᕐᓂᖏᓐᓂᒃ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᑕᓯᐅᔭᕐᒥ (ES) ᐊᑯᓐᓂᖓᓂ 2014 ᐊᒻᒪᓗ 2016. ᖃᓄᐃᓐᓂᖅᓴᐅᖕᒪᖔᑕ ᕐᑯᕚᓯᖕᓂᖅᓴᐃᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 2014–ᒥ (0.60 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᑉᐹᓇᒃᑐᑦ, CV = 0.07) ᐅᓄᓛᓇᓪᓗᓂᒋᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᔪᑦ 2016–ᒥ (0.52 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᑉᐹᓇᒃᑐᑦ, CV = 0.10) ᓇᓗᓇᐃᖅᓯᓚᐅᖅᑐᑦ ᓇᐃᓴᐅᑎᑎᒍᑦ ᐊᓯᔾᔨᓗᐊᖅᓯᒪᙱᓐᓂᖏᓐᓂᒃ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ (z–ᐃᒪᐃᓕᖓᔪᑦ = 1.25, p = 0.21). ᑖᔅᓯᒥᖓ ᕿᙳᐊᓂ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖅᓴᐅᖅᑰᔨᓚᐅᖅᐳᑦ 2014–ᒥ ᑕᑯᓗᒋᑦ ᐊᓯᖏᑦ ᖃᐅᔨᓴᕐᓂᐅᓯᒪᔪᑦ 2016–ᒥ. ᖃᓄᐃᓐᓂᖅᓴᐅᖕᒪᖔᑕ ᐅᓄᕐᓂᖅᐸᖑᓇᓯᕆᔭᐅᓯᒪᔪᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 2014–ᒥ (1.45 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᑉᐹᓇᒃᑐᑦ, CV = 0.14) ᐅᓄᕐᓂᖅᐹᖑᔪᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 2016–ᒥ (0.31 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᑉᐹᓇᒃᑐᑦ, CV = 0.17) ᓇᓗᓇᐃᖅᓯᓚᐅᖅᐳᖅ ᓇᐃᓴᐅᑎᑎᒍᑦ ᐅᓄᕐᓂᖅᓴᐅᓪᓗᑎᒃ ᐅᔾᔨᕆᔭᐅᔪᑦ 2014–ᒥ ᕿᙳᐊᓂ (MI) ᖃᐅᔨᓴᕐᓂᒥ (t–ᖃᐅᔨᓴᕐᓂᖅ = 5.49, p ᐅᓄᖏᓐᓂᖅᓴᐅᓪᓗᑎᒃ 0.001–ᒥ).

ᕿᙵᒍᐊᓂ (MI) ᖃᐅᔨᓴᖅᑕᐅᑎᓪᓗᒍ ᐃᒪᓐᓇᐅᖅᑰᔮᓚᐅᖅᐳᖅ ᐅᓄᕐᓂᖏᑦ ᓇᑦᑏᑦ ᐋᔾᔨᒌᖃᑦᑕᖏᓐᓂᖏᓐᓂ ᐊᕐᕌᒍᑕᒫᑦ. ᓇᑦᑏᑦ ᖃᐅᔨᓴᖅᑕᐅᓂᖏᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᖓᑕᔭᕋᕐᓂᐅᓚᐅᖅᑐᑦ 2008–ᒥ 2014–ᒥᓪᓗ ᐅᓄᕐᓂᖅᐸᓇᓚᐅᖅᐸᖏᑦ ᓇᑦᑏᑦ ᕿᙵᒍᐊᓂ (MI) (1.44 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐ, ᐊᒻᒪᓗ 1.45 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐ, ᐱᔾᔪᑎᒋᓪᓗᒋᑦ; ᐹᕙᓛᓐᑯᑦ 2012–ᒥ) ᐃᒪᐃᒃᑲᓗᐊᖅᑎᓪᓗᒍ ᓇᑦᑏᑦ ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᑦ ᖃᖓᑕᒃᑕᖅᑎᓪᓗᒋᑦ 2007–ᒥ ᐊᒻᒪᓗ 2016–ᒥ ᐅᔾᔨᕆᔭᐅᓚᐅᖅᐳᑦ ᐅᓄᙱᓐᓂᖅᓴᐅᓂᖏᓐᓂᒃ ᓇᑦᑏᑦ ᕿᙵᒍᐊᓂ (MI) (0.27 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐ, ᐊᒻᒪᓗ 0.31 ᓇᑦᑏᑦ/ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐ, ᐱᔾᔪᑎᒋᓪᓗᒋᑦ; ᐹᕙᓛᓐ 2012; ᔭᖕ ᐊᑕᖏᖅᓘᑎᒃ 2019). ᑕᑯᔭᐅᑐᐃᓐᓇᖅᑐᒃᑯᓪᓕ ᐊᕕᒃᑐᖅᓯᒪᔪᑎᒍᑦ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᖅᑕᐅᓃᑦ 2007, 2008, 2014, 2016–ᒥᓪᓗ, ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ ᑕᐃᒪᓐᓇᐅᖏᓐᓇᐸᓗᓚᐅᖅᐳᑦ ᑕᓯᐅᔭᕐᒥ (ES) ᐊᒻᒪᓗ ᐋᔾᔨᒌᖏᑦᑕᖅᓘᑎᒃ ᕿᙵᒍᐊᓂ (MI) ᖃᐅᔨᓴᕐᓂᕐᓂ.

ᖃᐅᔨᔭᐅᔪᑦ ᑐᑭᓕᓃᒃᑐᑦ-ᖃᖓᑕᕝᕕᐅᓯᒪᔪᑦ ᖃᐅᔨᓴᕐᓂᕐᓂ ᖃᐅᔨᓯᒪᔪᑦ ᑕᓯᐅᔭᕐᒥ (ES) ᖃᐅᔨᓴᕐᓂᕐᓂ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ ᐅᓄᕐᓂᖅᐹᖑᓚᐅᖅᐳᑦ 2014–ᒥ (ᐋᔾᔨᒌᖏᒃᑑᔪᑦ 1.07–ᒥ 1.27–ᒨᖓᓪᓗᑎᒃ ᓇᑦᑏᑦ/ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐᑦ) ᑕᑯᓗᒍ ᖃᓄᐃᓕᖓᓚᐅᖅᑐᑦ 2016–ᒥ (ᐋᔾᔨᒌᖏᒃᑑᔪᑦ 0.57–ᒥ 0.79–ᒧᑦ ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐᑦ) ᖃᐅᔨᓴᖅᑕᐅᓂᑯᑦ. ᑲᓄᐃᓐᓂᖅᓴᐅᓂᖏᓐᓄᑦ ᐅᓄᓛᓇᓯᒪᔭᖏᓐᓄᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 2014–ᒥ (2.13 ᓇᑦᑏᑦ/ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐᑦ, CV = 0.12) ᓇᓗᓇᐃᖅᓯᓯᒪᔪᑦ ᓇᐃᓴᐅᑎᑎᒍᑦ ᐅᓄᕐᓂᖅᓴᐅᓂᖏᓐᓄᑦ ᓇᑦᑏᑦ ᑕᑯᔭᐅᖃᑦᑕᖅᓯᒪᔪᑦ 2014–ᒥ ᑕᓯᐅᔭᒥ (ES) ᖃᐅᔨᓴᖅᑕᐅᔪᓂ (t-ᖃᐅᔨᓴᕐᓂᖅ = 3.36, p = 0.004). ᐋᔾᔨᐸᓗᒋᓪᓗᓂᐅᒃ, ᑕᐅᕙᓂ ᕿᙵᒍᐊᓂ (MI) ᖃᐅᔨᓴᖅᑕᐅᔪᖅ, ᓇᑦᑏᑦ ᐅᓄᕐᓂᖅᓴᐅᓚᐅᖅᑐᑦ 2014-ᒥ (ᐋᔾᔨᒌᖏᒃᑑᔪᑦ 1.14-ᒥ 2.13-ᒧ ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐᑦ) ᖃᐅᔨᓴᕈᑎᓂ. ᖃᓄᐃᓐᓂᖅᓴᐅᓂᖏᑦ ᕐᑯᕝᕙᓯᓛᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 2014-ᒥ (2.13 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐᑦ, CV = 0.12) ᐅᓄᓛᖑᓪᓗᑎᒃ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ 2016-ᒥ (1.27 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐᑦ, CV = 0.16) ᓇᓗᓇᐃᖅᓯᓚᐅᖅᐳᖅ ᓇᐃᓴᐅᑎᑎᒍᑦ ᐅᓄᕐᓂᖅᓴᐅᓂᖏᓐᓂᒃ ᓇᑦᑏᑦ ᐅᔾᔨᕆᔭᐅᔪᑦ 2014–ᒥ ᕿᙵᒍᐊᓂ (MI) ᖃᐅᔨᓴᖅᑕᐅᔪᓂᒃ (t–ᖃᐅᔨᓴᖅᑕᐅᔪᑦ = 2.66, p = 0.013).

ᖃᓄᐃᓐᓂᖅᓴᐅᖕᒪᖖᑕ 2021–ᒥ ᐆᓇᖅᑐᒥᒃ ᕿᓂᓲᖅ ᑐᑭᓕᓃᒃᑐᓂ-ᖃᐅᔨᓴᕐᓃᑦ ᐅᓄᕐᓂᖏᓐᓄᑦ (1.04 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐᑦ ᑕᓯᐅᔭᕐᒥ (ES) ᐊᒻᒪᓗ 2.13 ᓇᑦᑏᑦ/ ᑭᓛᒥᑕ ᑭᐸᓃᒃᑐᑦ ᕿᙵᒍᐊᓂ(MI)), ᓇᐃᓴᐅᑎᑎᒍᑦ ᐋᔾᔨᙱᓐᓂᖃᓗᐊᓚᐅᙱᑦᑐᑦ ᐅᔾᔨᕆᔭᐅᔪᓂ ᑖᒃᑯᓇᓂ ᒪᕐᕉᒃ ᐅᑭᐅᑦ ᐊᑯᓐᓂᖏᓐᓂ (t–ᖃᐅᔨᓴᖅᑕᐅᔪᖅ = 1.63, p = 0.013 ᐊᒻᒪᓗ t–ᖃᐅᔨᓴᖅᑕᐅᔪᖅ = 1.44, p = 0.017, ᐊᑐᓂ). ᑖᒃᑯᐊ ᖃᐅᔨᔭᐅᔪᑦ ᓇᓗᓇᐃᖅᓯᓚᐅᖅᐳᑦ ᓇᑦᑏᑦ ᐅᓄᕐᓂᖏᑦ ᐊᓯᔾᔨᖅᓯᒪᖏᓐᓂᖏᓐᓂᒃ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᖅᑕᐅᕕᐅᕙᒃᑐᒥ ᑕᐃᒪᙵᓂ ᐱᒋᐊᓚᐅᖅᑎᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᖃᑦᑕᓕᖅᑎᓪᓗᒋᑦ 2015–ᒥ, ᐊᒻᒪᓗ ᐱᓕᕆᐊᒥ ᓯᑯᓂ ᐊᔭᐅᖅᑐᐃᖃᑦᑕᕐᓃᑦ ᐅᒥᐊᕐᔪᐊᓂᑦ ᐃᖏᕐᕋᓯᑕᐃᓐᓇᖃᑦᑕᖅᑎᓪᓗᒋᑦ ᓯᑯᐃᓕᓵᖅᑎᓪᓗᒍ ᓯᑯᓕᖅᑎᓪᓗᒍᓗ 2018–ᒥ.

ᐊᒃᑐᐃᓗᐊᖅᑕᐅᓕᒪᔾᔪᑏᑦ ᐱᓕᕆᔾᔪᓰᑦ ᓇᑦᑎᕐᓄᑦ ᐋᖅᑭᒃᑕᐅᑦᑎᐊᕋᓱᒃᓯᒪᕗᑦ ᐅᒥᐊᕐᔪᐊᑦ ᐊᒃᑐᐃᓂᖃᖅᑎᑦᑕᐃᓕᒪᓪᓗᒋᑦ ᓇᑦᑎᕐᓂᒃ “ᑲᑎᙵᕙᒃᑎᓪᓗᒋᑦ” (ᓲᕐᓗ ᐅᑭᐅᒃᑯᑦ ᐅᐱᕐᖓᒃᓵᒃᑯᓪᓗ) ᑲᑎᙵᓪᓗᑎᒃ ᐃᓕᖅᑯᓯᖏᑦ ᐱᒻᒪᕆᐅᓂᖏᓐᓄᑦ ᓄᓕᐊᕐᓇᐅᑎᓪᓗᒍ. ᐅᒥᐊᕐᔪᐊᖃᕐᕕᒋᔪᓐᓇᖅᑕᖓ ᓴᐳᒻᒥᓲᖑᔮᖅ ᓇᑦᑎᕐᓂᒃ ᐆᑦᑑᕙᓕᖅᑎᓪᓗᒋᑦ ᐊᒃᑐᐃᑦᑕᐃᓕᒪᓪᓗᑎᒡᓗ ᓇᑦᑎᕐᓂᒃ ᐊᒡᓗᖃᖅᐸᓕᖅᑎᓪᓗᒋᑦ ᓯᑯᕙᓪᓕᐊᓕᓵᖅᑎᓪᓗᒍ.ᖃᐅᔨᔭᐅᔪᑦ 2021–ᒥ ᓇᑦᑎᕐᓂᒃ ᖃᖓᑕᓲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᐅᓲᒥᑦ (RSASP) ᓴᖅᑮᔭᖅᑎᑦᑎᔪᖅ ᑕᒪᒃᑯᐊ ᓇᑦᑏᑦ ᓱᕐᑯᓯᐊᓗᐊᖅᓯᒪᙱᑦᑐᑦ ᑕᐃᒪᙵᓂ ᐅᒥᐊᕐᔪᐊᖃᑦᑕᓕᖅᑎᓪᓗᒍ ᐊᐅᓚᓂᖓ 2015–ᒥᓂ, ᑕᐃᒪᙵᓂᓪᓗ ᐱᒋᐊᓚᐅᖅᑎᓪᓗᒋᑦ ᐱᓕᕆᐊᒥ ᓯᑯᓯᐅᕐᓂᖃᑦᑕᓕᓚᐅᖅᑐᖅ ᐅᒥᐊᕐᔪᐊᖃᕐᓇᐅᔨᓐᓇᖅᓯᑎᓪᓗᒍ 2018–ᒥ. ᑖᒃᑯᐊ ᖃᐅᔨᔭᐅᔪᑦ ᓇᓗᓇᐃᖅᓯᔪᑦ ᑕᒪᒃᑯᐊ ᐊᒃᑐᐃᓗᐊᖅᑕᐃᓕᔾᔪᑏᑦ ᐱᓕᕆᔾᔪᓰᑦ ᐊᐅᓚᓂᖃᖅᑐᑦ ᐋᖅᑭᒃᑕᐅᓯᒪᓪᓗᑎᒃ ᑕᐃᒪᐃᑎᑕᐅᓇᓱᒃᑲᒥᒃ ᐱᓕᕆᐊᒥᓪᓗ ᐱᓕᕆᓃᑦ ᐊᒃᑐᐃᓂᕐᓗᑎᒃᓯᒪᓇᑎᒃ ᓇᑦᑎᕐᓂᒃ. ᐊᓯᔾᔩᓯᒪᙵᖏᓐᓂᖏᓐᓄᑦ ᓯᑯᓯᐅᕐᓂᕐᒧᑦ ᐊᐅᓚᓂᐅᔪᑦ ᑐᒃᓯᕋᖅᑕᐅᓯᒪᔪᑦ ᐹᕙᓛᓐᑯᑦ ᐱᓕᕆᐊᑉ ᒪᕈᕆᓕᖅᑕᖓᓄᑦ ᑐᒃᓯᕋᐅᒥ, ᑖᒃᑯᐊ ᖃᐅᔨᔭᐅᓯᒪᔪᑦ ᐅᒃᐱᕐᓇᖅᓯᑎᑦᑎᓯᒪᖏᒥᔪᑦ ᓂᕆᐅᕆᔭᐅᓯᒪᔪᓂᒃ ᐱᓕᕆᐊᑉ ᒪᕈᕆᓕᖅᑕᖓᓄᑦ ᐊᒃᑐᐃᓂᕐᓄᑦ ᖃᐅᔨᓴᖅᑎᓪᓗᒋᑦ, ᐅᖃᖅᓯᒪᔪᑦ ᐊᒃᑐᐃᓃᑦ ᓇᑦᑎᕐᓄᑦ ᓴᖅᑭᑦᑐᑦ ᐱᓕᕆᐊᒥᑦ ᐊᓯᔾᔩᓇᔭᖏᓐᓂᖏᓐᓂ ᐅᓄᕐᓂᖏᓐᓄᑦ (ᒌᑐ, 2018).

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Table of Contents

TABLES

FIGURES

APPENDICES

Abbreviation and Acronym list

AIC	Akaike's Information Criterion
ASL	Above sea level
Baffinland	Baffinland Iron Mines Corporation
BF	Beaufort Sea State
CV	Coefficient of Variation
DFO	Fisheries and Oceans Canada
DS	Distance Sampling
ERP	Early Revenue Phase
ES	Eclipse Sound stratum
FEIS	Final Environmental Impact Statement
FLIR	Forward-looking Infrared Camera
ft	Feet
Golder	Golder Associates Ltd.
GPS	Global Positioning System
IQ	Inuit Qaujimajatuqangit
km	Kilometres
km^2	square kilometres
km/h	Kilometers per hour
kn	Knots
m	Metre
MCDS	Multiple covariate distance sampling
MEWG	Marine Environmental Working Group
MHTO	Mittimatalik Hunters and Trappers Organization
Milne Port	port at Milne Inlet
MI	Milne Inlet stratum
MMASP	Marine Mammal Aerial Survey Program
MMP	Marine Monitoring Program

Mtpa	million tonnes per annum
MMOs	Marine Mammal Observers
MR	Mark-recapture
MRDS	Mark-recapture distance sampling
MSV	Multipurpose support/supply vessel
NB	Navy Board Inlet stratum
NIRB	Nunavut Impact Review Board
Project	Mary River Project
PC	Project Certificate No. 005
RSA	Regional Study Area
RSASP	Ringed Seal Aerial Survey Program
SBO	Ship-based Observer Program
SE	Standard Error
Steenbsy Port	port at Steensby Inlet
TS	Tremblay Sound stratum

1.0 INTRODUCTION

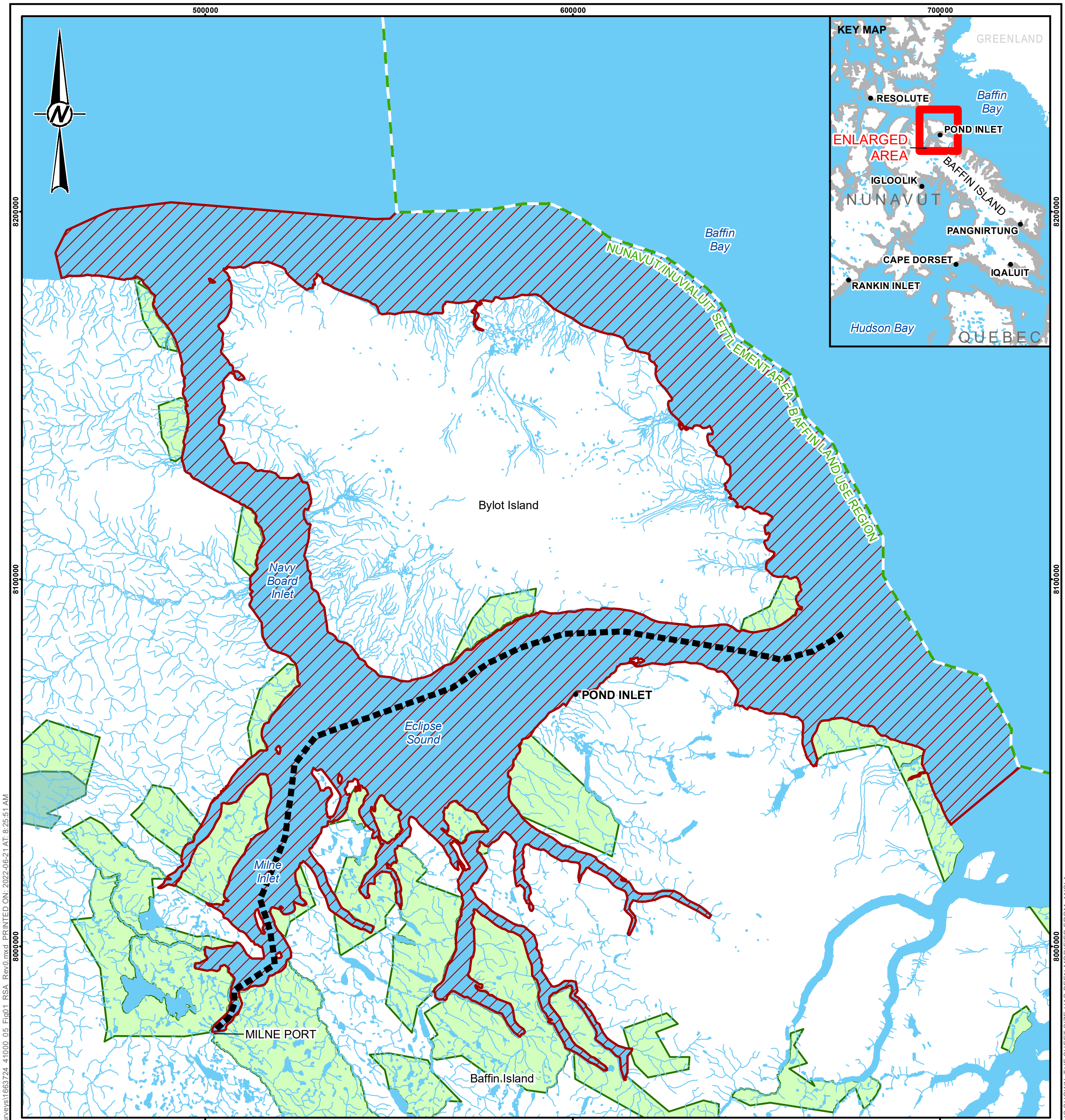
This report presents the results of the 2021 Ringed Seal Aerial Survey Program (RSASP) conducted on North Baffin Island during June 2021. Ringed seal aerial surveys were conducted by Golder Associates Ltd. (Golder) using a strip-transect analysis of infrared imagery combined with high-resolution photography. The primary objective of the survey was to document ringed seal density and distribution along the Northern Shipping Route in the Regional Study Area (RSA) and to compare them with 2016 and 2017 results (Young et al. 2019). The secondary objective of the survey was to identify ringed seal hotspots throughout the RSA and identify overlaps with hotspots identified in 2016 and 2017.

Section 3 of this report presents the results of a 2014 ringed seal aerial survey conducted on North Baffin Island during June 2014 by LGL Limited. Raw data were analyzed by Golder using strip-transect and line-transect analysis methods. The objective of analyzing data from the 2014 survey was to update baseline ringed seal density and distribution along the Northern Shipping Route in the RSA.

1.1 Project Background

The Mary River Project (the Project) is an operating open-pit iron ore mine located in the Qikiqtani Region of North Baffin Island, Nunavut (Figure 1). Baffinland Iron Mines Corporation (Baffinland) is the owner and operator of the Project. The operating mine site is connected to a port at Milne Inlet (Milne Port) via the 100 km long Milne Inlet Tote Road. Approved, but undeveloped components of the Project include a South Railway connecting the mine site to a future port at Steensby Inlet (Steensby Port).

To date, Baffinland has been operating in the Early Revenue Phase (ERP) of the Project and is authorized to transport 4.2 Mtpa of ore by truck to Milne Port for shipping through the Northern Shipping Route using chartered ore carrier vessels. A production increase to ship 6.0 Mtpa from Milne Port was approved from 2018 to 2021 and shipping is expected to continue for the life of the Project (20+ years). During the first year of ERP Operations in 2015, Baffinland shipped ~900,000 tonnes of iron ore from Milne Port involving 13 return ore carrier voyages. The amount of ore shipped increased in 2016 with 38 return ore carrier voyages shipping ~2.7 million tonnes. In 2017, the total volume of ore shipped out of Milne Port reached ~4.2 million tonnes involving 56 return ore carrier voyages. Following approval to increase production to 6.0 Mtpa, a total of 5.44 million tonnes of ore were shipped via 71 return voyages in 2018, 5.86 million tonnes of ore were shipped via 81 return voyages in 2019, and 5.5 million tonnes of ore were shipped involving 72 return ore carrier voyages in 2020. The total volume of ore shipped out of Milne Port in 2021 reached 5.6 million tonnes involving 74 return ore carrier voyages. The Northern Shipping Route is inhabited by a variety of marine mammals, predominantly narwhal (*Monodon monoceros*), ringed seal (*Pusa hispida*), harp seal (*Pagophilus groenlandicus*), bowhead whale (*Balaena mysticetus*), polar bear (*Ursus maritimus*), bearded seal (*Erignathus barbatus*), beluga (*Delphinapterus leucas*), and walrus (*Odobenus rosmarus*).



LEGEND

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

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
2021 RINGED SEAL AERIAL SURVEYS

TITLE

MARINE MAMMAL REGIONAL STUDY AREA

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-21
DESIGNED	TT
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	1

PATH: I:\2016\1663724\Mapping\MXD\41000_2021SealAerialSurveyReport_RingedSealAerialSurveys\1663724_41000_05_Fig01_RSA_Rev0.mxd PRINTED ON: 2022-06-21 AT: 8:25:51 AM

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25mm

1.2 Regulatory Drivers and Community Engagement

In accordance with existing Terms and Conditions of Nunavut Impact Review Board (NIRB) Project Certificate (PC) No. 005, Baffinland is responsible for the establishment and implementation of the Marine Monitoring Plan (MMP) which comprises environmental effects monitoring studies that are conducted over a sufficient time 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 RSASP is one of several monitoring programs that collectively make up the MMP for marine mammals. The RSASP was designed to address PC conditions related to evaluating potential disturbance to ringed seals from shipping activities that may result in changes in animal distribution, abundance, and migratory movements in the RSA. Specifically, this included the following conditions:

- Condition No. 101 — "*The Proponent shall incorporate into the appropriate monitoring plans the following items:*
  - *b. Efforts to involve Inuit in monitoring studies at all levels.*
  - *c. Monitoring protocols that are responsive to Inuit concerns.*
  - *e. Schedule for periodic aerial surveys as recommended by the Marine Environment Working Group (MEWG).*"
- Condition No. 109 — "*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. 119* — "In conjunction with the MEWG, monitor ringed seal birth lair abundance and distribution for at least two years prior to the start of ice-breaking to develop a baseline, with continue monitoring over the life-time of the project."
- 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 and ringed seal habitat due to port construction and shipping.
- Injuries or mortality of marine mammals due to ship strikes.
- Acoustic disturbance effects on marine mammals from port construction and shipping that may lead to changes in animal distribution, abundance, migration patterns, and subsequent availability of these animals for harvesting.

Baffinland was provided feedback from Inuit hunters that indicated they have observed localized changes in seal abundance and distribution in the RSA, which was resulting in carry-over effects on seal harvesting. In response to this feedback, Baffinland committed to undertaking targeted ringed seal monitoring along the Northern Shipping Route in 2021. The 2021 RSASP was also undertaken to address residual uncertainty regarding the impact predictions related to the potential effects of shipping and icebreaking on ringed seal associated with Baffinland's Phase 2 Proposal.

1.3 Ringed Seal Background

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

Based on best available science (McLaren 1958; Smith and Stirling 1975; Smith and Hammill 1981; Smith 1987; Hammill et al. 1991; Lyderson 1995; Kelly et al. 2010; Chambellant et al. 2012a), the breeding season for ringed seal, which includes pupping, nursing and mating, occurs in the Eastern High Arctic between the months of March and May, with mating occurring towards the end of the nursing period and preceding the annual molt in June, when ringed seals haul out on ice to bask in the sun (McLaren 1958; Smith 1973a). Furgal et al. (2002) further indicated pupping occurred from late March until early April, when females inhabit haul-out lairs and birth white-coated pups (McLaren 1958; Smith & Stirling 1975; Kingsley 1990; Smith & Hammill 1981).

Inuit Qaujimajatuqangit (IQ) reported in JPCS (2017) and ERM (2019) indicated that the seal pupping season runs from February to March, and as late as the middle of April and May, throughout the RSA. Additionally, IQ recorded in QIA (2019) provided additional knowledge regarding the areas in which seal pupping takes place. Following is a summary of IQ from these resources:

> "*…seal hunting also continues in Ukiuq and seal pupping will last into March. Ringed seal pups are preferred by local Inuit and are harvested throughout Eclipse Sound*." - p. 32, JPCS 2017.

> *"Starting in March the seal pups are born. March and June are the most important months. In the past, it didn't used to be until April that the seals were born. Just to the west of us now, they are catching pups. March and June are the months I'm worried about. Most able men go out still, even if it's just occasionally."* – Workshop #2 Participant, 27-29 April 2015, p. 48, JCPS 2017.
>
> *"There are seal pups in the area until the middle of April."* – Elijah, 27-29 April 2015, p.165, JCPS 2017.
>
> *"There are no certain areas for seal pups; they are born everywhere. Even along the routes we travel. That is something that needs to be monitored."* - Paniloo, 27-29 April 2015, p. 171, JPCS 2017.
>
> *"We have to give consideration to seals when they start giving birth in April and May. In May, they are quite large and some seal pups…"* – Elijah, 27-29 April 2015, p. 178, JPCS 2017.
>
> *"The baby seals breed in March..."* Sakiasee, 27-29 April 2015, p. 217, JPCS 2017.
>
> *"In the spring (March to May), seal pups are very small and vulnerable…"* – Workshop #3 Participant, p. 17, ERM 2019).
>
> *"…So the seals come in to the Eclipse Sound to feed and mate. So, they come in from offshore, and he says in March they start coming in to this area, March, April, May and they'll just keep going in to the sounds."* – Participant 11, 05 February 2019, p. 43, QIA 2019.
>
> *"…Also, regular movement of the seals around here all the time, and moving up there, especially in Eclipse Sound Area they, which is part of the, those inlets, Milne and Tremblay Sound at almost every inlet these are seal calving areas. When the ice break up in the middle of the summertime, the young ones are starting to go out through the inlets, some stay there all year round…"* – Participant 10, 06 February 2019, p. 45, QIA 2019.

Pups are weaned after a six-week lactation period (Hammill et al. 1991). Mating occurs in the water underneath the ice around the time pups are weaned, during periods when females temporarily leave their den and enter the water (Lydersen1995; Smith 1987). If mating is successful, this is time when the egg becomes fertilized. Ringed seals have a gestation of 10–11 months, which includes the 2–3 months of suspended development (Hammill and Smith 1989; McLaren 1958; Smith 1987).

The timing of ringed seal aerial surveys was selected to overlap with the peak basking period in late May to early June (Smith and Hammill 1981), when more ringed seals are available for detection on the ice, and before an influx of ringed seals from the pack ice which generally occurs in the later part of June (Smith and Hammill 1981). In June, during the peak basking period, ringed seals spend over 60% of the time on the ice (Kelly et al. 2010). By July, the time out of the water drops to 30% as basking is completed and the foraging period begins (Kelly et al. 2010). Hunters in Arctic Bay use hunting methods to stalk basking and moulting seals in late spring, when ringed seals are hauled-out at breathing holes, leads and ice edges (McLaren 1958; Smith 1973b; Finley 1979 *in* Furgal et al. 2002).

IQ reported in JCPS (2017), and QIA (2019) indicated springtime as the peak basking period for ringed seals:

> *"Seal harvesting occurs throughout Eclipse Sound at breathing holes, while seals are basking on the ice, and in leads, although not regularly during Upirngaaq* (Arctic spring, roughly June)*"* – General Summary of workshop responses, p.29, JSPC 2017.
>
> *"I would catch enough to cache* [hunted seal or narwhal] *for the winter. It would mainly be in the spring as this area is teeming with seals basking in the sun during springtime. There would be enough seal here to cache for the winter."* – Ipeelie Koonoo of Arctic Bay, as reported in Baffinland Iron Ore Corporation (2012, p. 25), p.29, QIA 2019.

1.3.1 Previous Ringed Seal Surveys

Aerial surveys of ringed seal in the RSA have been undertaken during the basking/molting period (spring) when ringed seal were mainly on the sea ice and easy to count (Baffinland 2012, Yurkowski et al. 2018, Young et al. 2019). Ringed seal aerial surveys were first flown in the RSA in June 2006, 2007 and 2008 to characterize marine mammal baseline conditions (density and distribution) in support of the Final Environmental Impact Statement (FEIS; Baffinland 2012). Visual observer data using strip-transect methodology was analyzed for these surveys. The 2006 survey was exploratory in nature covering Milne Inlet, Eclipse Sound and Navy Board Inlet with low survey coverage. Surveys flown in 2007 and 2008 focused on Milne Inlet. Subsequent aerial surveys were flown in 2014 to update baseline data on ringed seal density and distribution. Survey effort in 2014 focused on Eclipse Sound and Milne Inlet, where observer-based sightings data was collected. Aerial surveys were conducted in June 2016 and 2017 by DFO to assess the spring distribution and density of ringed seal in the Eclipse Sound and Milne Inlet areas (Young et al. 2019). Young et al. (2019) used three different survey methods (visual observer with strip-transect methodology, overlayed infrared and photographic data with strip-transect methodology, and visual observer combined with overlayed infrared and photographic data with distance methodology) to determine ringed seal densities in the RSA. The three methods resulted in different density estimates with the distance methodology and infrared/photographic strip-transect methods providing similar results that were approximately 2–3 times greater than the visual observer strip-transect analyses. Young et al. (2019) concluded that strip-transect analysis of infrared imagery combined with photographs was the preferred method because it did not require collection of observer-based sightings data from the aircraft (i.e., fewer personnel required), it allowed for a high probability of animal detection, it was associated with a lower visibility bias, and it allowed for simplified data processing and density calculations. Their results provided density estimates ranging from 0.57 to 0.79 seals/km^2 for Eclipse Sound, 0.93 to 1.27 seals/km^2 for Milne Inlet, and 0.27 to 0.77 seals/km^2 for Navy Board Inlet.

2.0 2021 RINGED SEAL FORWARD-LOOKING INFRARED SURVEY

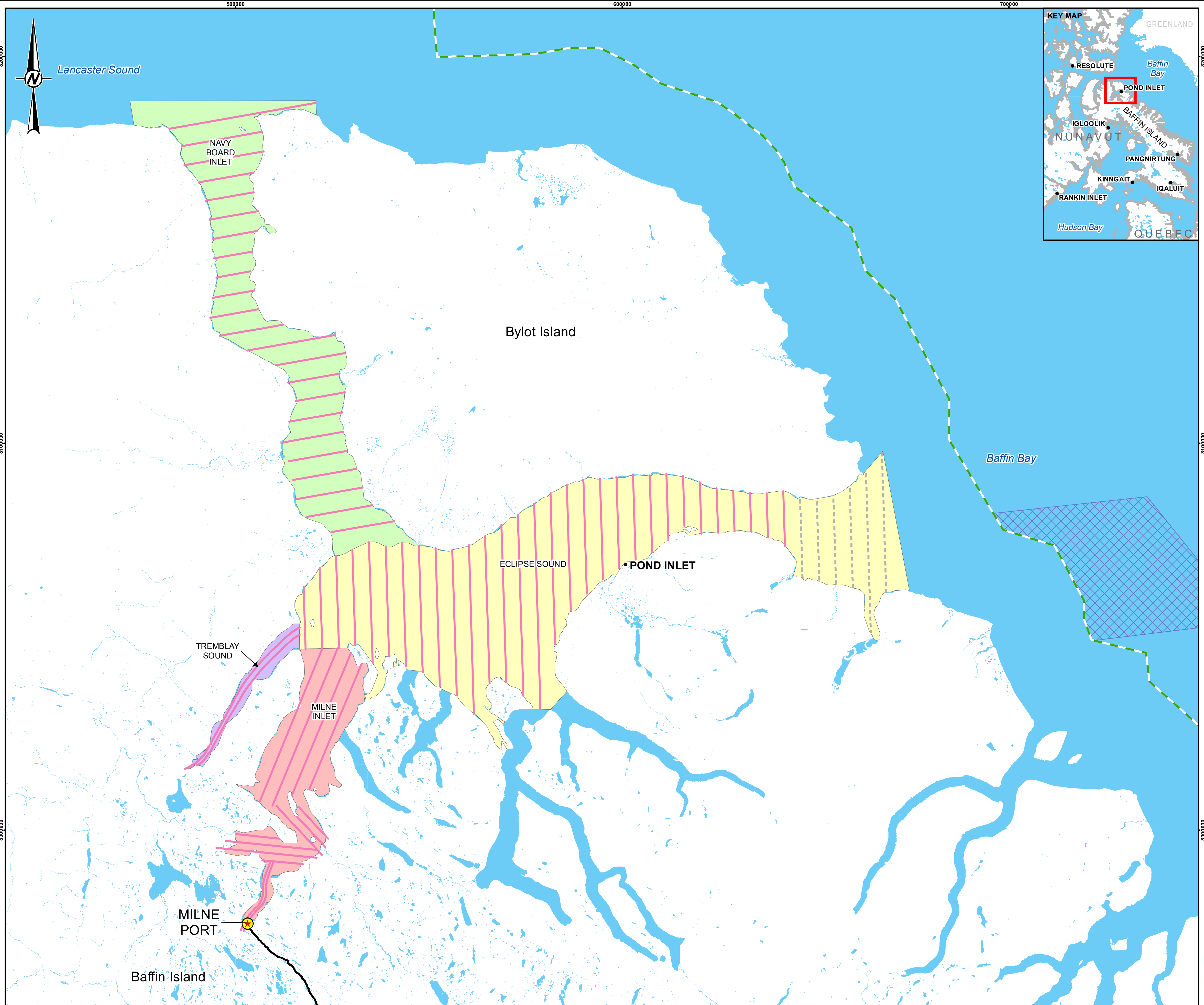
2.1 Objectives

The RSASP was conducted by Golder in the North Baffin area during June 2021. The primary objective of the survey was to document ringed seal density and distribution along the Northern Shipping Route in the Regional Study Area (RSA) and to compare them with 2016 and 2017 results (Young et al. 2019). Yurkowski et al. (2018) noted several ringed seal hotspots throughout the RSA during the June spring molt. A secondary objective of the survey was to identify ringed seal hotspots throughout the RSA and identify overlaps with hotspots identified in 2016 and 2017.

2.2 Study Area and Design

The 2021 aerial surveys took place over a two-week period with flights occurring between 8–14 June 2021. The survey team consisted of one Golder biologist and one contracted marine biologist with previous marine mammal survey experience, two pilots, and one mechanic. Due to COVID-19 restrictions in Nunavut, no Inuit researchers from local communities were able to participate in the 2021 survey.

The study area for the RSASP was based on the boundaries used Young et al.'s (2019) 2016 and 2017 surveys. The aerial surveys were designed to characterize ringed seal distribution and density in the RSA during the period when ringed seals were hauled out on the ice during the peak moulting period and to allow for comparison with past surveys. Aerial surveys were conducted in four strata within the RSA: Eclipse Sound (ES), Milne Inlet (MI), Tremblay Sound (TS), and Navy Board Inlet (NB; Figure 2).



LEGEND

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

GEOGRPHIC STRATA

- ECLIPSE SOUND
- MILNE INLET
- NAVY BOARD INLET
- TREMBLAY SOUND

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 RINGED SEAL AERIAL SURVEYS

TITLE
GEOGRAPHIC STRATA AND TRANSECTS FOR 2021 RINGED SEAL AERIAL SURVEYS

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-21
DESIGNED	TT
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	2

Survey design and data collection methodology followed the preferred method identified by Young et al. (2019), using the strip-transect analysis of infrared imagery, coupled with digital photographs. Surveys were flown during June 2021 using a de Havilland Twin Otter (DHC-6) fixed-wing aircraft equipped with a ventral camera port. Surveys planned for ES, MI, TS, and NB consisted of 36, 13, 2, and 23 transects, respectively (Figure 2).

2.2.1 Survey Adaptations

Transects in the southern portion of MI strata were adapted from 22 zigzag transects flown by DFO in 2016 and 2017 to nine parallel transects. This adaptation was made because zigzag transects are difficult for pilots to maintain in high terrain, and can result in a significant amount of aircraft banking (i.e., turning) which then has to be removed from the survey effort calculations. The sharp turns required for zigzag transects in a high terrain area also increases the noise produced by the aircraft in an area not yet surveyed, increasing the potential for seals to react to the aircraft and dive into holes prior to being counted.

Four to six transects on the eastern end of the ES stratum (Figure 2) were not flown at the request of the Mittimatalik Hunters & Trappers Organization (MHTO) to avoid potential interference with the community harvesters along the Pond Inlet floe edge.

2.3 Material and Methods

2.3.1 Field Methodology

Field methodology followed data collection for strip-transect analysis of infrared imagery combined with digital photographs identified as the preferred method for ringed seal surveys by Young et al. (2019). Transects were flown at a target ground speed of 204 km/hour (110 knots) and a target altitude of 305 m (1,000 ft). A Bluetooth GPS unit and iPad was used to track the aircraft location and record its position, altitude, speed, and heading every second during the survey using specialized navigational mapping software (Foreflight) pre-programmed with the survey transect grid.

A data recorder entered environmental conditions into Mysticetus software at the beginning and end of each transect, and when changes in conditions occurred along an active transect. Environmental conditions included cloud cover (percent), surface air temperature (°C), surface wind speed (km/h), surface wind direction (N, S, E, W), ice cover (in tenths), ice type, snow/ice roughness (percent), fog cover (in tenths), and fog intensity. Air temperature and wind variables were obtained from Windy.com ECMWF (European Centre for Medium-Range Weather Forecasts) model of the surface conditions either during (depending on cellular coverage) or after the flight. Snow/ice roughness was subjectively estimated based on the percent of snow drift or ice ridges that covered the surface of the ice (i.e., 0% snow/ice roughness represents a smooth ice surface with no snow drifts or ice ridges, whereas a 50% roughness represents an ice surface with 50% of it covered in snow drifts and/or ice ridges).

Thermal infrared imagery was obtained using a forward-looking infrared camera (FLIR T1020) with a 45° lens. At the target altitude of 305 m, the strip width covered by the FLIR imagery was approximately 250 m wide strip directly below the aircraft. The FLIR T1020 used an uncooled microbolometer type sensor with a resolution of 1,024 x 768 pixels and detected infrared radiation in the range of 7.5–14 μm. The FLIR camera was connected to a laptop and controlled remotely by a camera operator using FLIR ResearchIR Max software version 4.40.11.35 (FLIR Systems, Inc., Wilsonville, OR, USA).

Visible light (visual) photographs were obtained using a Canon EOS 5DS R DSLR (digital single-lens reflex) camera fitted with a 35 mm lens (Sigma 35 mm f/1.4 DG HSM). Visual photographs were taken at an interval of two seconds, providing approximately 30% overlap between consecutive photos. At the target altitude of 305 m, the strip width covered by the DSLR camera was 313 m wide strip directly below the aircraft. Visual photographs taken with the Canon EOS 5DS R were captured in .jpg format at the maximum camera resolution setting of 8,688 x 5,792 pixels. The DSLR camera was connected to a laptop and controlled remotely by a camera operator using Breeze Multi-Camera Array software version v2.1.2 (Breeze Systems limited., Camberley, Surrey, UK).

2.3.2 Data Analysis

2.3.2.1 Strip-Transect Analysis for Densities

A single analyst from a third party (Whale Seeker Inc.) analyzed the infrared video files using FLIR ResearchIR Max software version 4.40.11.35 (FLIR Systems, Inc., Wilsonville, OR, USA). This software allowed the user to view FLIR infrared video files and provided tools to visually identify temperature spikes indicative of potential seals.

All potential seals observed in the infrared imagery were verified by viewing the corresponding visual images obtained from the Canon DSLR camera. Through this verification process, only visual photographs that corresponded to potential seals in the infrared imagery were included in the analysis. A random set of transect was extracted from the database and reanalyzed by a secondary analyst as quality control (QC). During this QC process, resighting and sightings outside the FLIR field of view were identified which should have been removed or flagged by the primary analyst. A second review of the FLIR video and digital images flagged these sightings and removed them from the analysis.

To assess the success rate of the infrared camera, an experienced observer analyzed a random set of 1,172 visual photographs from the 2021 dataset. Seals identified in the visual photographs were compared with the results of the infrared imagery analysis to determine whether the infrared method was missing seals that could be seen in the visual photographs.

Strip-transect analysis was performed on “infrared” data obtained from infrared imagery within a 250 m wide strip following the methods of Young et al. (2015) and Chambellant et al. (2012b). The density of ringed seals per km^2 was estimated following Buckland et al. (2001) by computing the number of detected seals over the surveyed strip area:

$$\widehat{D} = \sum_{i=1}^{k} n_i / \omega \sum_{i=1}^{k} l_i$$

Where k is the number of transects flown, n_i is the number of ringed seals counted on the i^{th} transect, ω is the width of the strip, and l_i is the length of the i^{th} transect.

Following Kingsley and Smith (1981), the variance of density, was determined by:

$$\sigma^2(\widehat{D}) = k \times \frac{\sum_{i=1}^{k-1}(d_i - d_{i+1})^2}{2(k-1) \times (\omega \sum_{i=1}^{k} l_i)^2}$$

where

$$d_i = n_i - \widehat{D} \times \omega l_i$$

The coefficient of variation (CV) of the estimated density was calculated by dividing the square root of the variance by the estimated density.

2.3.2.2 Density Surface Modelling for Hotspots

A density surface modelling (DSM) framework was used to model spatially-referenced count data with the additional environmental data and distances collected to account for imperfect detection. Modelling proceeded in two steps. First, a multiple covariate distance sampling (MCDS) detection function was fitted to the perpendicular distance data to obtain detection probabilities for individuals. Second, counts were then summarised per segment (contiguous transect sections), and a generalised additive model (GAM, Wood 2006) was then constructed with the per-segment counts as the response. GAMs provided a flexible class of models that included generalized linear models but extend them with the possible addition of splines to create smooth functions of covariates. DSM modelling was performed within the R software environment using the dsm, mgcv and Distance packages (Miller et al. 2021; Wood 2021; Miller 2021).

Ideally, the maximum segment length is such that neither the density of objects nor covariate values varied appreciably within segments. Bathymetry data, that informed the majority of model covariates, did not have uniform precision across the study area. The resolution of bathymetry grids varied between study area regions: Assomption Harbour, 5 m; Milne Inlet and western Eclipse Sound, 20 m; and Eastern Eclipse Sound and Navy Board Inlet, 500 m. A segment length of 1 km was selected to minimize potential bias associated with the varying precision of bathymetry data, that would be magnified by smaller segments. For each segment, the following multiple static environmental covariates were extracted: latitude, longitude, distance from the nearest shore, mean depth, mean slope, distance from Pond Inlet floe edge and distance from Navy Board Sound floe edge. Additional segment covariates of maximum and minimum depth were also extracted from the bathymetry. The segment centroid was used for determining latitude, longitude and distance calculations, while bathymetry data was extracted from a 500 m buffer on the transect segment to capture sufficient bathymetry data points (larger than the model truncation distance). The manipulation and measurement of spatial data was performed with ESRI ArcMap 10.7.1 ArcInfo license with the Spatial Analyst toolbox (ESRI 2019). A Lambert conformal conic projection, with origin centered on the project area, was used to ensure that distance measurements were uniform across the study area. Floe edge locations were estimated using satellite imagery (Zoom Earth 2021) and digitized for inclusion in the spatial data. The Pond Inlet and Navy Board Inlet floe edges did not noticeably change during the survey period. Count per segment was then modelled as a sum of smooth functions of covariates (e.g., location, depth, distance to shore, measured at the segment level) using a GAM. Smooth functions were modelled as splines, providing flexible curves and surfaces to describe the relationship between the covariates and the response.

To predict across the study area with the fitted model, a 1 km square prediction grid was created in ArcMap and the cells were clipped to the coastline and floe edges. Grid cell areas were calculated to be used as the offset value during prediction. Environmental covariates were extracted using the same methodology as completed for the segments.

Detection Function

The DSM methodology involved two separate statistical models. The first statistical model was a fitted detection function to the perpendicular sighting distances, as in a conventional distance-sampling analysis, to estimate the detection probability. Normally this model compensates for observer bias but this isn't expected to be an issue with imagery data. Alternatively, this model is used to compensate for availability bias, whereby the species of interest changes its surface availability depending on environmental covariates. The expectation is that ringed seals will dive depending on the proximity of the aircraft and will vary the distance at which they dive depending on covariates that could alter their ability to detect the aircraft. Environmental variables that may affect the seal's ability to detect the aircraft (wind speed, aircraft travel direction and travel direction relative to wind direction) were incorporated as covariates (Marques et al. 2007). The best detection function model was selected based on Akaike's Information Criterion (AIC) values.

Spatial Model Fitting

The second statistical model was a spatial density component. The abundance of ringed seals seen in each segment was described by a GAM via a Horvitz-Thompson estimator with segment effort indicated by the area of each segment (length by a width twice that of the detection function truncation distance). Problems can occur when smoothing over areas with complicated geography (e.g., peninsulas or islands) where the proximity of counts on one side of a feature would unrealistically influence the model's interpretation of counts on the other side of the feature. Therefore, a "soap film" smoother (Wood et al. 2008) was fitted to the spatial data, which usually performs better for complex study regions by reducing smoothing of density contours across land boundaries and minimizing edge effects. The soap film is a bivariate smooth of spatial coordinates that require a grid of "soap knots" within the study area. Various densities of "soap knots" are trialed to assess performance of the smoother and assess overfitting of the data. Over fitting the soap film smoother can result in unrealistic hotspots and account for more of the variance in the data that could otherwise have been accounted for by environmental covariates.

Global models were initially run with all possible covariates treated as penalized thin plate regression spline smoothers. Three global models were run for each distribution family, each using only one of the depth variables (mean, maximum or minimum values) to avoid issues of covariation between these depth variables. This "shrinkage" approach (Marra and Wood 2011) minimized stepwise model term selection, reducing the problem of path dependence when dropping covariates for model selection. Covariates with smooth significances with $p \leq 0.05$ were retained for modelling and evaluation. Plots of the GAM smooth functions and their associated standard error bounds were also examined, as these also contained information that could support the decision to either drop or retain a covariate term. The relative magnitudes of each smoother's basis size (k) and its resulting effective degrees of freed (edf) value were examined for the presence of unrealistically high values that could indicate over-fitting and to also ensure that smooth functions were given sufficient freedom to describe the underlying covariate relationship (k was then adjusted accordingly as necessary). Smoothing parameter estimates were optimized using restricted maximum likelihood (REML). To address zero-inflation, which is a common cause of overdispersion in count data, candidate models were fit with negative binomial or Tweedie response distributions in addition to the quasi-Poisson distribution.

Model Selection and Validation

For each response distribution family, AIC values were used to select the best fit models from the candidates. The top candidate models from the different response distributions were then assessed using quantile-quantile (QQ) plots that included reference bands produced by repeated simulations of new response data from the fitted model. Departure of the residuals from the bounds of the reference bands indicate a misspecification of the model (see Augustin et al. 2012) and thus can be used to assess fit and eliminate a model from the candidate set (i.e. incorrect distribution family used).

It was assumed that the modelled detection function was independent of the GAM, with the total variance of the abundance estimated using the delta method (Seber 1982) to combine the detection model and spatial component variances (Hedley & Buckland 2004).

2.4 Results

2.4.1 Survey Coverage

Three surveys were completed between 8–14 June 2021 (Table 1). Over the course of the three surveys, a total of 4,351.6 km of survey effort was conducted. All survey effort was flown over 10/10 landfast ice coverage. Surveys were flown between 08:00 and 18:00 whenever weather conditions allowed. Four transects (during Surveys 1 and 2) and six transects (during Survey 3) on the eastern end of the ES strata were removed at the request of the MHTO to avoid potential interference with the community harvesters along the Pond Inlet floe edge. This allowed a buffer of 4 km (with 4 transects removed) to 13 km (with 6 transects removed) from the Pond Inlet floe edge. During Survey 2, poor weather conditions prevented six of the planned transects from being completed in the NB stratum (Table 1).

Table 1: Summary of surveys, dates, transects completed, and effort for aerial surveys of ringed seals in the RSA in June 2021.

Date	Survey #	Strata[a]	Transects (completed/planned)	Effort (km)
8 June 2021	1	ES	32/36	810.0
8 June 2021	1	TS	2/2	86.6
8/9 June 2021	1	MI	13/13	284.4
9 June 2021	1	NB	23/23	322.8
Subtotal	***1***	**—**	***70/74***	***1,503.8***
10 June 2021	2	ES	32/36	799.1
10 June 2021	2	TS	2/2	88.0
10/11 June 2021	2	MI	13/13	287.4
11 June 2021	2	NB	17/23	200.4
Subtotal	**2**	**—**	**64/74**	**1,374.9**
12 June 2021	3	ES	30/36	762.5
12/14 June 2021	3	MI	13/13	283.5
14 June 2021	3	TS	2/2	88.0
14 June 2021	3	NB	23/23	338.8
Subtotal	**3**	**—**	**68/74**	**1,472.8**

[a] ES=Eclipse Sound, MI=Milne Inlet, TS=Tremblay Sound, NB=Navy Board Inlet

2.4.2 Sighting Conditions

Environmental sighting conditions were recorded during the surveys at the beginning and end of each transect and when conditions changed along the track. All sighting conditions were recorded within the 250 m strip below the aircraft. Sighting conditions were evaluated based on survey effort when each condition was observed. For calculating hotspots, density surface modelling analyses used the sighting conditions as covariates in the model.

Cloud Cover

Cloud cover during the 2021 RSASP ranged from 0 to 100%. During Survey 1 conditions ranged from 0 to 10% with the majority (93%) of the survey effort flown in 0% cloud cover (Figure 3). Cloud cover conditions during Survey 2 ranged from 0 to 50% with the majority (99%) of the survey effort flown in 0% cloud cover (Figure 3). During Survey 3 conditions ranged from 0 to 100% with the majority (67%) of the survey effort flown in 0% cloud cover (Figure 3).

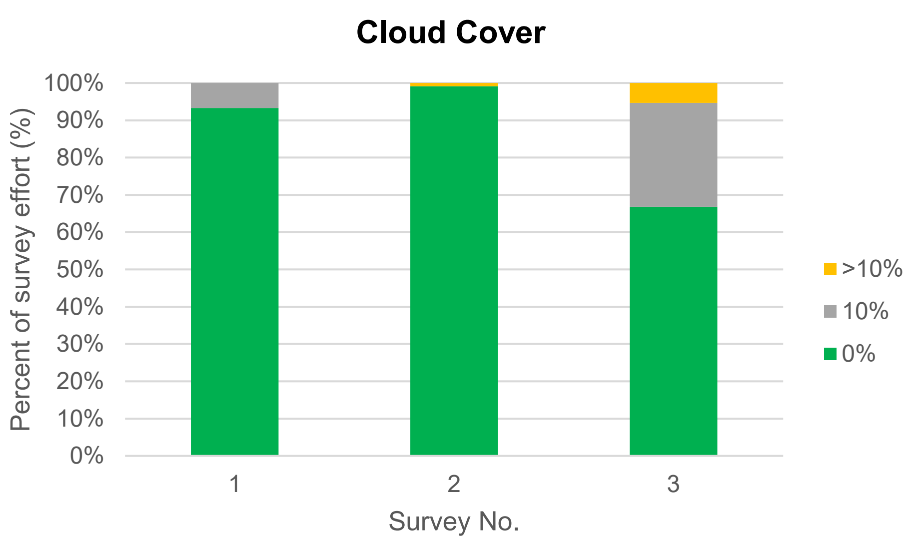


Figure 3: Cloud cover during 2021 RSASP.

Air Temperature

Ground air temperatures during the 2021 RSASP ranged from 0 to 7°C (Figure 4). During Survey 1 conditions ranged from 0 to 5°C with a mean air temperature of 2.6°C. Air temperature conditions during Survey 2 ranged from 0 to 7°C with a mean air temperature of 3.3°C. During Survey 3 conditions ranged from 1 to 7°C with a mean air temperature of 4.1°C.

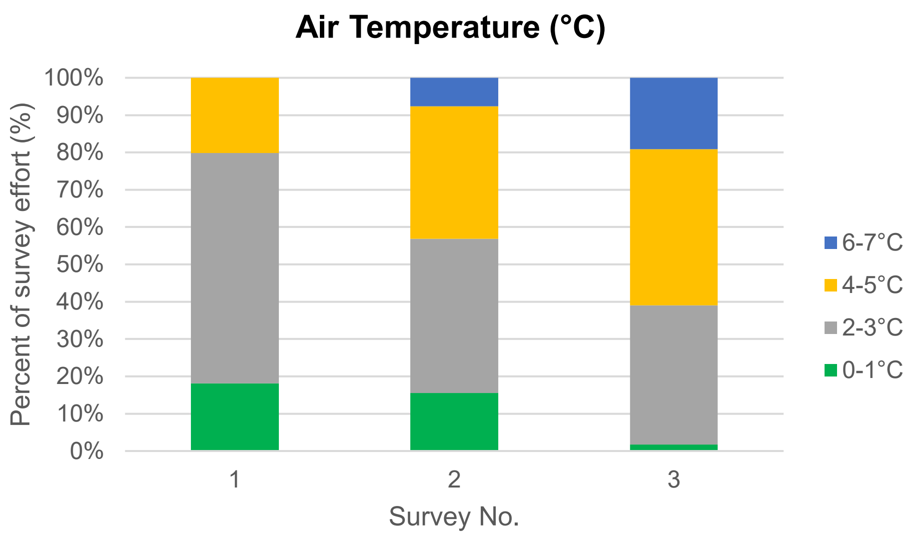


Figure 4: Air temperature during the 2021 RSASP.

Wind Speed

Ground wind speeds ranged from 0 to 28 km/h during the 2021 RSASP. During Survey 1 conditions ranged from 0 to 28 km/h with a mean wind speed of 4.7 km/h. The majority (91%) of the survey effort flown in Survey 1 was in 0 to 10 km/h conditions (Figure 5). Wind speed conditions during Survey 2 ranged from 0 to 22 km/h with a mean wind speed of 7.1 km/h. The majority (81%) of the survey effort flown during Survey 2 was in 0 to 10 km/h conditions (Figure 5). During Survey 3 conditions ranged from 0 to 23 km/h with a mean wind speed of 7.0 km/h. The majority (74%) of the survey effort flown in 0 to 10 km/h conditions (Figure 5).

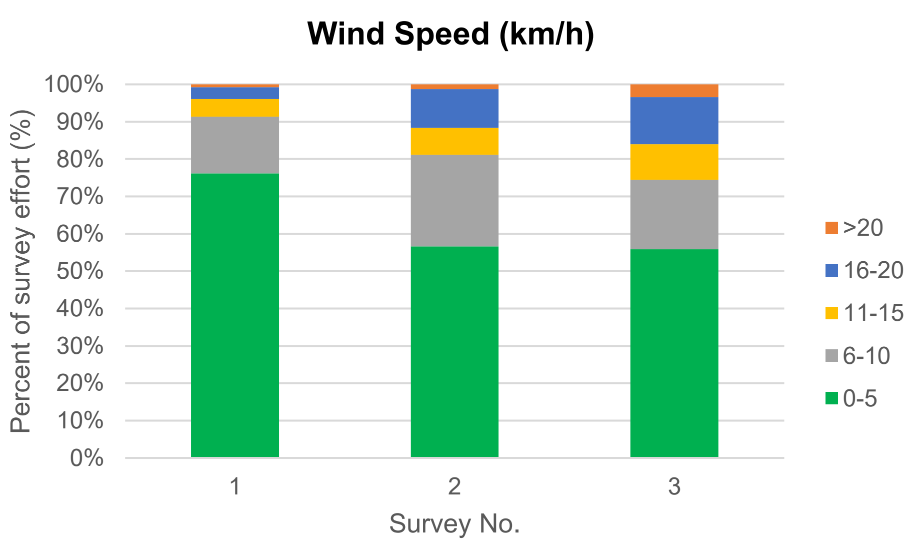


Figure 5: Wind speed during the 2021 RSASP.

Wind Direction

Wind direction varied considerable during the 2021 RSASP due to the high terrain and the large study area. During Surveys 1 and 2 the majority (68% and 72%, respectively) of the survey effort was flown in areas with westerly wind directions (SW, W, and NW; Figure 6). During Survey 3 the majority (55%) of the survey effort was flown in areas with northerly wind directions (NW, N, and NE; Figure 6).

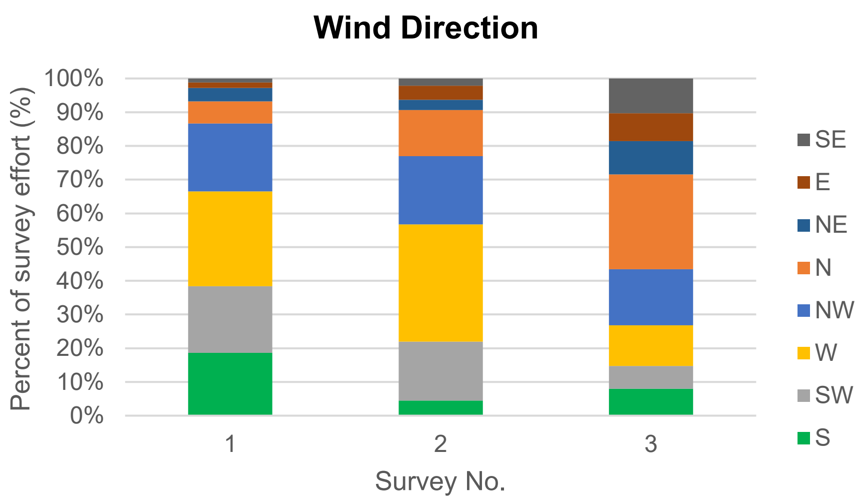


Figure 6: Wind direction during the 2021 RSASP.

Snow/Ice Roughness

Snow/ice roughness during the 2021 RSASP ranged from 0 to 50%. A 0% roughness represents a smooth ice surface with no snow drifts or ice ridges, whereas a 50% roughness represents an ice surface with 50% of it covered in snow drifts and/or ice ridges. During Survey 1 conditions ranged from 20% to 50% roughness with the majority (81%) of the survey effort flown over 30% snow/ice roughness (Figure 7). During Survey 2 conditions ranged from 10% to 50% roughness with the majority (79%) of the survey effort flown over 20% and 30% snow/ice roughness (Figure 7). During Survey 3 conditions ranged from 0% to 30% roughness with the majority (65%) of the survey effort flown over 10% snow/ice roughness (Figure 7).

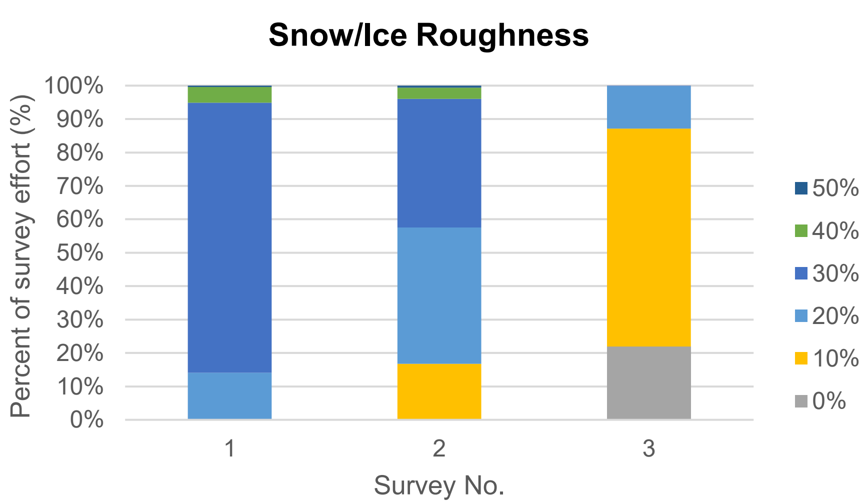


Figure 7: Snow/Ice roughness during the 2021 RSASP.

2.4.3 Survey Sightings

A total of 1,029 potential animal observations were identified during analysis of the infrared imagery. Of these potential observations, 987 (96%) were confirmed to be animals while 42 (4%) could not be confirmed. Figure 8 shows how infrared imagery matches up with the digital photographs for confirming observations. The 987 confirmed observations consisted of 1,229 ringed seals (986 observations) and one polar bear. The 42 potential animal observations that could not be confirmed as animals were likely warmer areas on the ice created by a combination of melt ponds, rocks, dirt, debris, or garbage.

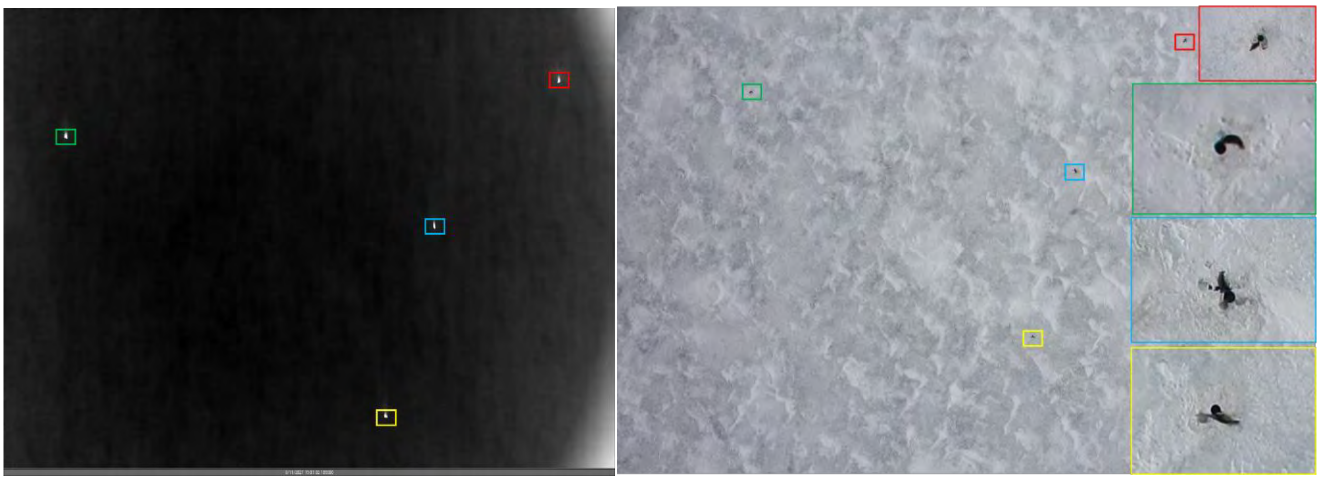
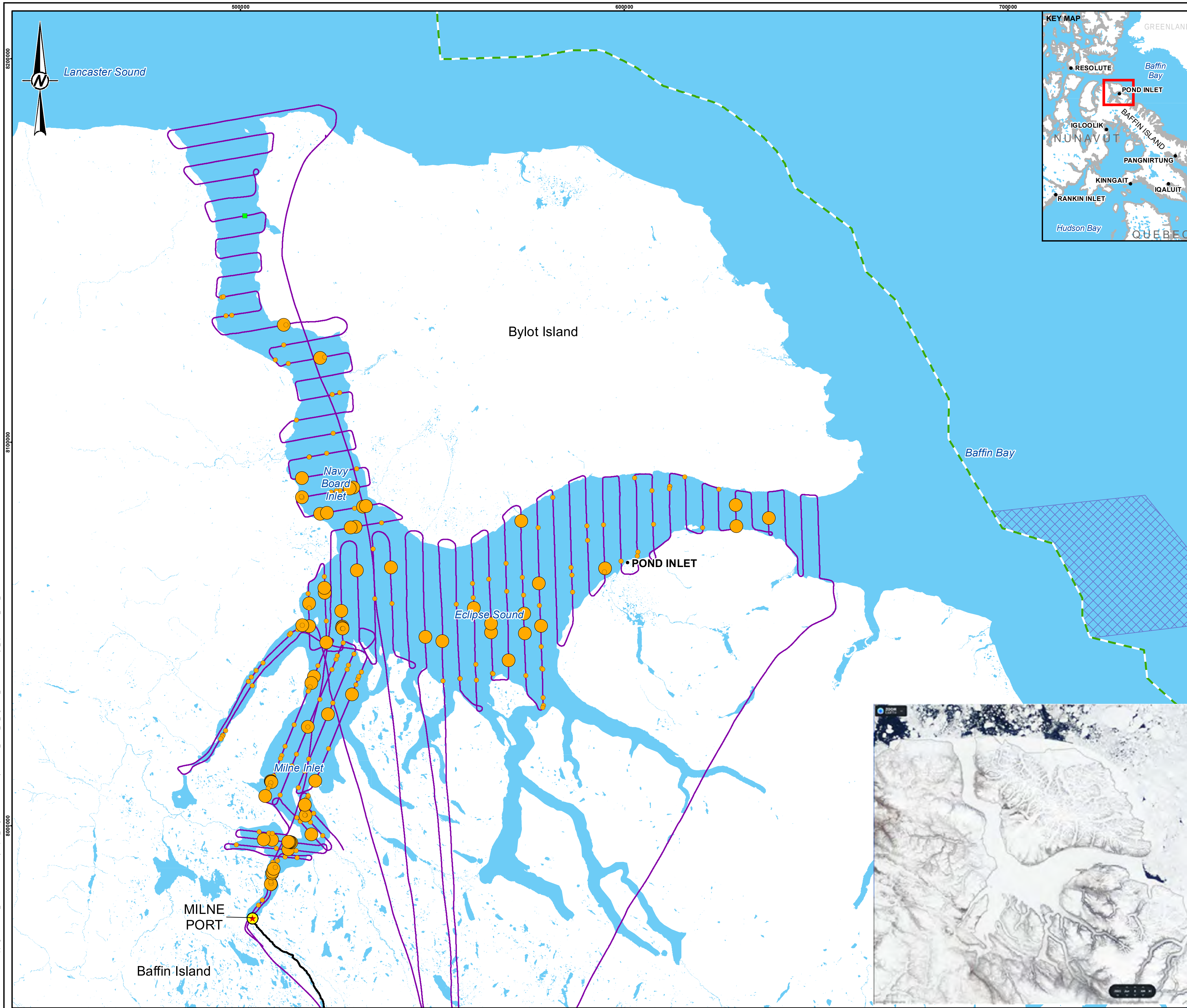


Figure 8: Example of paired aerial images from infrared camera (left) and digital single-lens reflex camera (right) during the 2021 RSASP demonstrating infrared imagery with visual photographs. Inset images show close-up views of the seals in the visual photographs.

Ringed seals were observed throughout the survey area during the three surveys (Figures 9–11). Ringed seal group sizes ranged from single animals to a group size of five, with mean and median group sizes of 1.2 and 1.0, respectively. Forty-one ringed seal pups were observed during the surveys. During Survey 1, 19 ringed seal pups were observed in ES, MI, and NB strata. Fourteen ringed seal pups were observed during Survey 2 in ES and MI strata. Eight ringed seal pups were observed during Survey 3 in ES, MI, and TS strata.

In the analysis of a random set of 1,172 visual photographs to assess the success rate of the infrared camera data, 21 ringed seal observations were detected in both the infrared method and the independent analysis of the visual photographs, five seal observations were detected in the infrared method but missed in the independent analysis of the visual photographs, and five seal observations were detected in the independent analysis of the visual photographs but missed in the infrared method. The five seal observations that were missed in the infrared method were outside of the field of view (250 m) of the FLIR and thus expected to be missed and would not have been captured in the data analysis. Of the 26 seal observations within the FLIR field of view, the infrared method was 100% (26 out of 26 available sightings) effective in detecting seal observations, and the independent analysis of the visual photographs was 81% (21 out of 26 available sightings) effective in detecting seal observations.



LEGEND

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

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

POLAR BEAR

- 1

RINGED SEAL

- 1
- 2-5

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 RINGED SEAL AERIAL SURVEYS

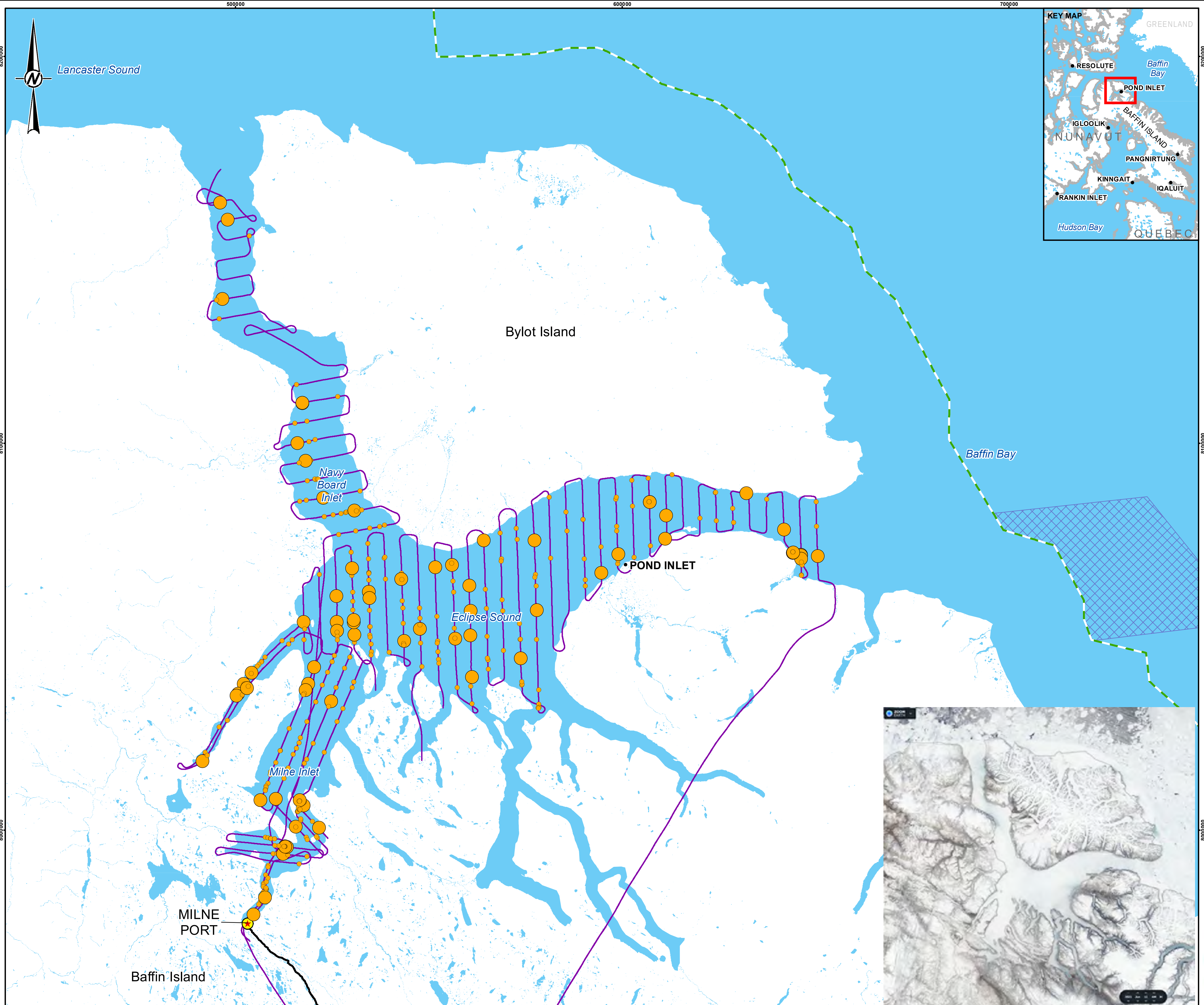
TITLE
DISTRIBUTION OF RINGED SEALS AND POLAR BEARS RECORDED DURING SURVEY 1 ON 8-9 JUNE 2021

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-21
DESIGNED	TT
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	9



LEGEND

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

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

RINGED SEAL

- 1
- 2-5

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

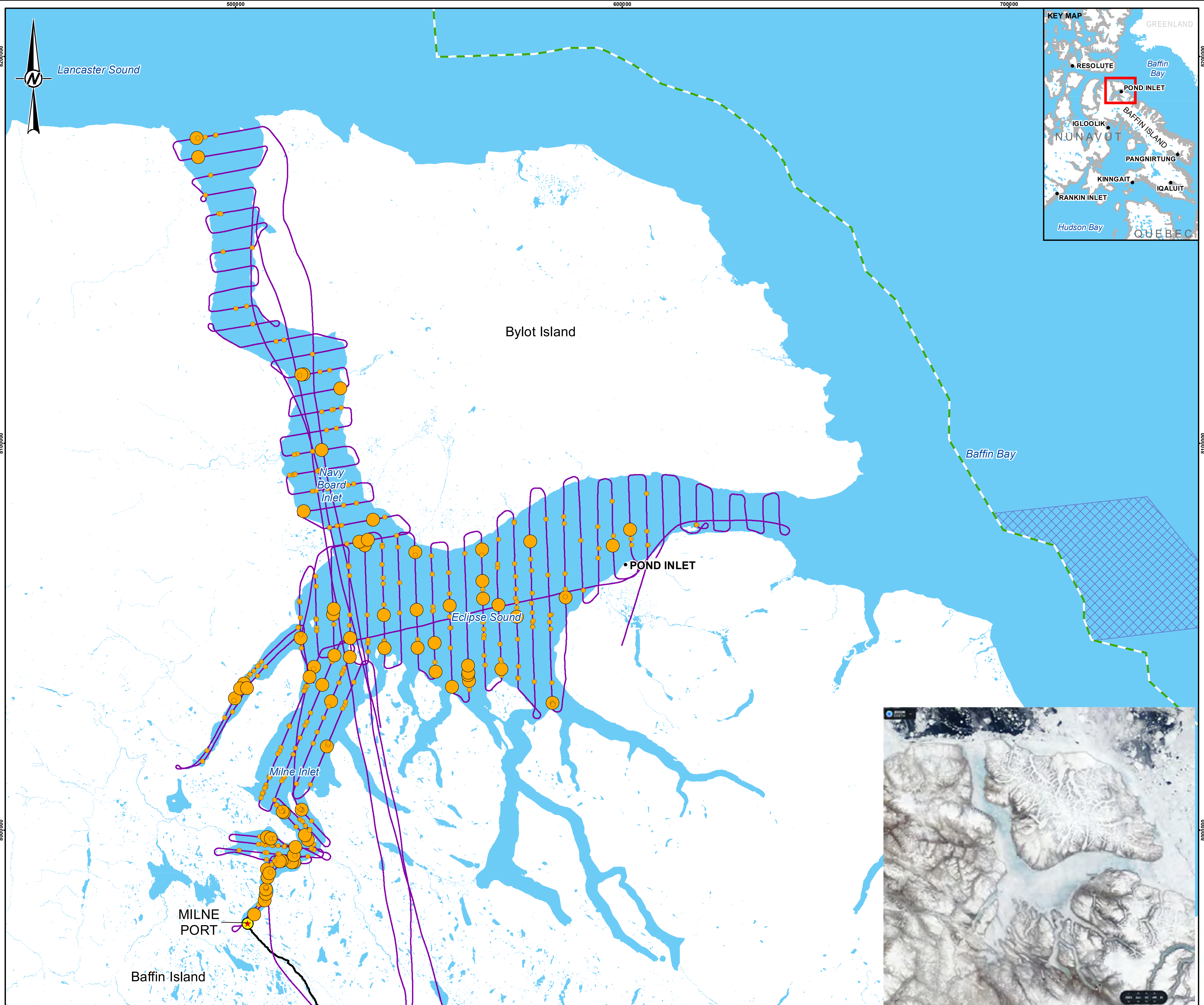
PROJECT
MARY RIVER PROJECT
2021 RINGED SEAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF RINGED SEALS RECORDED DURING SURVEY 2 ON 10-11 JUNE 2021

CONSULTANT

YYYY-MM-DD	2022-06-21
DESIGNED	TT
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	10



LEGEND

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

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

RINGED SEAL

- 1
- 2-5

0 25 50

1:1,000,000 KILOMETRES

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 RINGED SEAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF RINGED SEALS RECORDED DURING SURVEY 3 ON 12-14 JUNE 2021

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-21
DESIGNED	TT
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	11

2.4.4 Strip-Transect Density Estimates

A summary of ringed seal densities for each survey and strata is presented in (Table 2). Ringed seals had the highest density in the Milne Inlet stratum during Survey 3 (2.84 seals/km^2) and the lowest density in the Eclipse Sound stratum during Survey 1 (0.55 seals/km^2). Densities also varied within strata, with Survey 1 generally having the lower densities compared to Surveys 2 and 3 (Table 2). During Survey 2, poor sighting conditions in Navy Board Inlet prevented approximately 40% of the transect effort from being surveyed in that stratum. The transects that were flown were in areas that had higher numbers of seals on previous surveys. Therefore, the density of 1.36 seals/km^2 in the Navy Board Inlet stratum during Survey 2 is likely an overestimate and was not considered in the subsequent analyses. Survey 3 represented the survey with the highest ringed seal densities (1.04 seals/km^2 in ES, 2.84 seals/km^2 in MI, 1.27 seals/km^2 in TS, and 0.83 seals/km^2 in NB).

Table 2: Ringed seal density, SE (standard error), and CV (coefficient of variation) from the three surveys flown in 2021.

Survey #	Stratum[a]	Ringed Seal Observations	Ringed Seal # Animals	Density (seals/km^2)	SE	CV	Coverage %
1	ES	79	111	0.55	0.09	0.16	5.5
2	ES	156	195	0.98	0.10	0.10	5.4
3	ES	160	199	1.04	0.08	0.08	5.4
1	MI	105	138	1.94	0.35	0.18	7.5
2	MI	108	125	1.74	0.21	0.12	7.5
3	MI	171	201	2.84	0.42	0.15	7.4
1	TS	17	18	0.83	0.22	0.26	14.1
2	TS	22	28	1.27	0.32	0.25	14.3
3	TS	24	28	1.27	0.58	0.46	14.3
1	NB	36	48	0.59	0.10	0.17	4.4
2[b]	NB	48	68	1.36	0.33	0.24	3.5
3	NB	60	70	0.83	0.10	0.12	4.6

[a] ES=Eclipse Sound, MI=Milne Inlet, TS=Tremblay Sound, NB=Navy Board Inlet
[b] possible overestimate

Comparison of 2021 survey results with previous surveys (2016 and 2017) flown in ES stratum showed similar density estimates, with current density estimates ranging from 0.55 to 1.04 seals/km^2 and past estimates ranging from 0.45 to 0.92 seals/km^2. A comparison of the highest estimate in 2021 (1.04 seals/km^2, CV = 0.08) with the highest estimate in 2016 (0.92 seals/km^2, CV = 0.09) indicated no statistically significant difference in the estimates (z-score = 1.02, $p = 0.31$). In the MI stratum, ringed seal densities appeared higher in 2021 (ranged from 1.74 to 2.84 seals/km^2) compared to previous surveys in 2016 and 2017 (ranged from 0.77 to 1.40 seals/km^2). A comparison of the highest estimate in 2021 (2.84 seals/km^2, CV = 0.15) with the highest estimate in 2016 (1.40 seals/km^2, CV = 0.12) indicated a statistically significantly higher density in 2021 in the MI stratum
(t-test = 3.14, $p = 0.003$). Ringed seal densities in NB ranged from 0.59 to 0.83 seals/km^2 in 2021 and from 0.24 to 0.74 seals/km^2 in 2016 and 2017. A comparison of the highest estimate in 2021 (0.83 seals/km^2, CV = 0.12) with the highest estimate in 2016 (0.74 seals/km^2, CV = 0.43) indicates no statistically significant difference in the estimates (t-test = 0.27, $p = 0.79$).

Table 3: Comparison of ringed seal density estimates from FLIR strip-transect analyses for strata within the RSA.

Year	Date	Stratum[a]/Survey#	Density (seals/km^2)	SE	CV	Source
2016	17 June	ES1	0.48	0.06	0.12	Young et al. 2019
2016	19/22 June	ES2	0.92	0.08	0.09	Young et al. 2019
2017	6/8 June	ES3	0.45	0.07	0.15	Young et al. 2019
2021	8 June	ES1	0.55	0.09	0.16	Current Study
2021	10 June	ES2	0.98	0.10	0.10	Current Study
2021	12 June	ES3	1.04	0.08	0.08	Current Study
2016	17 June	MI1	0.77	0.09	0.12	Young et al. 2019
2016	21 June	MI2	0.98	0.21	0.22	Young et al. 2019
2016	22 June	MI3	1.40	0.17	0.12	Young et al. 2019
2021	8/9 June	MI1	1.94	0.35	0.18	Current Study
2021	10/11 June	MI2	1.74	0.21	0.12	Current Study
2021	12/14 June	MI3	2.84	0.42	0.15	Current Study
2016	21 June	NB1	0.74	0.32	0.43	Young et al. 2019
2016	22 June	NB2	0.26	0.12	0.47	Young et al. 2019
2017	8 June	NB3	0.24	0.07	0.28	Young et al. 2019
2021	9 June	NB1	0.59	0.10	0.17	Current Study
2021	14 June	NB3	0.83	0.10	0.12	Current Study

[a] ES=Eclipse Sound, MI=Milne Inlet, TS=Tremblay Sound, NB=Navy Board Inlet

2.4.5 Ringed Seal Hotspots

Survey 3 was selected as the survey to run the density surface modelling on because it had the highest density of ringed seals Yurkowski et al. (2018) used the same criteria (i.e. survey with the highest densities) in selecting the data to calculate hotspots.

<u>Detection Function Model</u>

A total of 498 unique ringed seal observations were made during Survey 3. Of these, four were clipped as outliers because they were beyond the 125 m track width. This data at the outer edge of the photo was due to potential issues with photo / IFR alignment and crabbing of the aircraft (necessary to maintain heading in crosswinds). This left 494 observations for detection function fitting.

Since seal sighting counts were expected to dip beneath the aircraft, this would cause a dip in detection at the trackline. Since detection functions are primarily used is to model decreasing detections with distance from the trackline, the distances from the trackline were reversed so that what is now zero distance was at the outside side edges of the photos and 125 m at the photo center. A histogram of ring seal counts did indicate a dip in detections in the middle of the photos under the aircraft (Figure 12).

Tested models used Uniform, Half-Normal and Hazard Rate detection functions. In this case, testing for an animal availability bias rather than observer detection bias. MCDS models were fitted to the data with different key functions, with and without covariates. The model that best fitted the data was a half-normal key function with one covariate (wind speed). A single global detection function was used with p(x) estimated at 0.907 (CV = 0.04; Figure 12).

The only covariate that proved useful was wind speed, with higher winds resulting in a flatter detection function and lower wind speeds resulting in a greater dip in detections. Essentially, the noise from the wind appeared to mask the aircraft approach. For lower wind speeds it appeared that seals were more likely to dive when the aircraft is directly overhead (combination of visual and audio cues from the aircraft).

The same availability bias for seals in relation to the vertical photo axis (in front of / behind aircraft) could also be expected. No pattern of availability bias was seen in the vertical photo axis but this was not unexpected since the distance covered by the vertical axis is a third less than the horizontal axis. The seal availability-bias correction factor derived by this method (diving due to aircraft proximity) should be considered a minimum value, and not necessarily an absolute value, since detection at “distance zero” is not certain (i.e., seals may be disturbed at distances greater than 125 m from the photo midline).

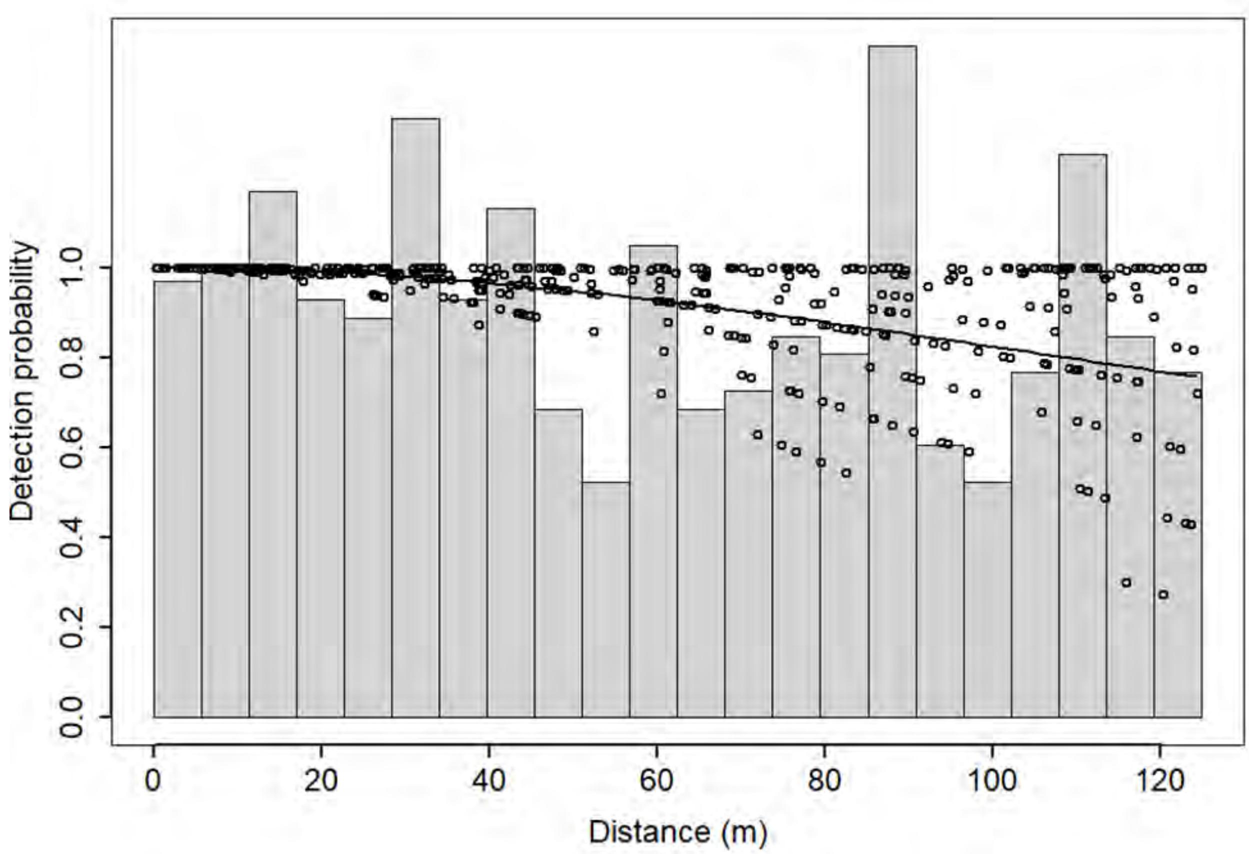


Figure 12: Histogram showing perpendicular distances of ringed seal observations during Survey 3. Note: Fitted Half-normal key function is shown with right truncation at 125 m. O = probability of detection for each sighting based on the perpendicular distances and wind speed as the covariate. Distances are reversed, with 0 indicating photo edge and 125 m at photo center.

Density Surface Models

A soap-film smoother with a grid of 93 soap knots was selected, which performed the most precise geographic smooths without overfitting the data. This soap knot density in the survey area corresponded to an approximately 8.5 km grid spacing between knots. Regardless of model covariates, the only distribution family that had acceptable quantile–quantile (QQ) plots was the negative binomial, and only those models were evaluated further. A table providing listing the top candidate DSMs, their associated diagnostic parameters and abundance estimates are presented in Table 4.

The model from the minimum depth covariate group had the lowest AIC and was selected as the best model. A visual assessment of the resulting DSM plots also indicated that prediction resulting from the maximum depth variable best represented the sighting distributions. The mean depth model had the bivariate “soap film” smooth of the xy coordinates dropped since its contribution to the model was not significant ($p \leq 0.05$). If this model was “forced” to keep the bivariate smooths of location coordinates, the resulting models’ geographic predictions were highly flawed, ignoring the high density of sightings in south Milne Inlet. Together in the same model, the floe edge variables and soap film smooth competed to explain the same pattern of geographic distribution leading to poor results.

The density prediction values for the selected model are presented in Figure 13 while a geographic representation of the model variance is presented in Figure A-13 (Appendix A). Model variance is highest near the Pond Inlet floe edge where survey flights were restricted from surveying that area.

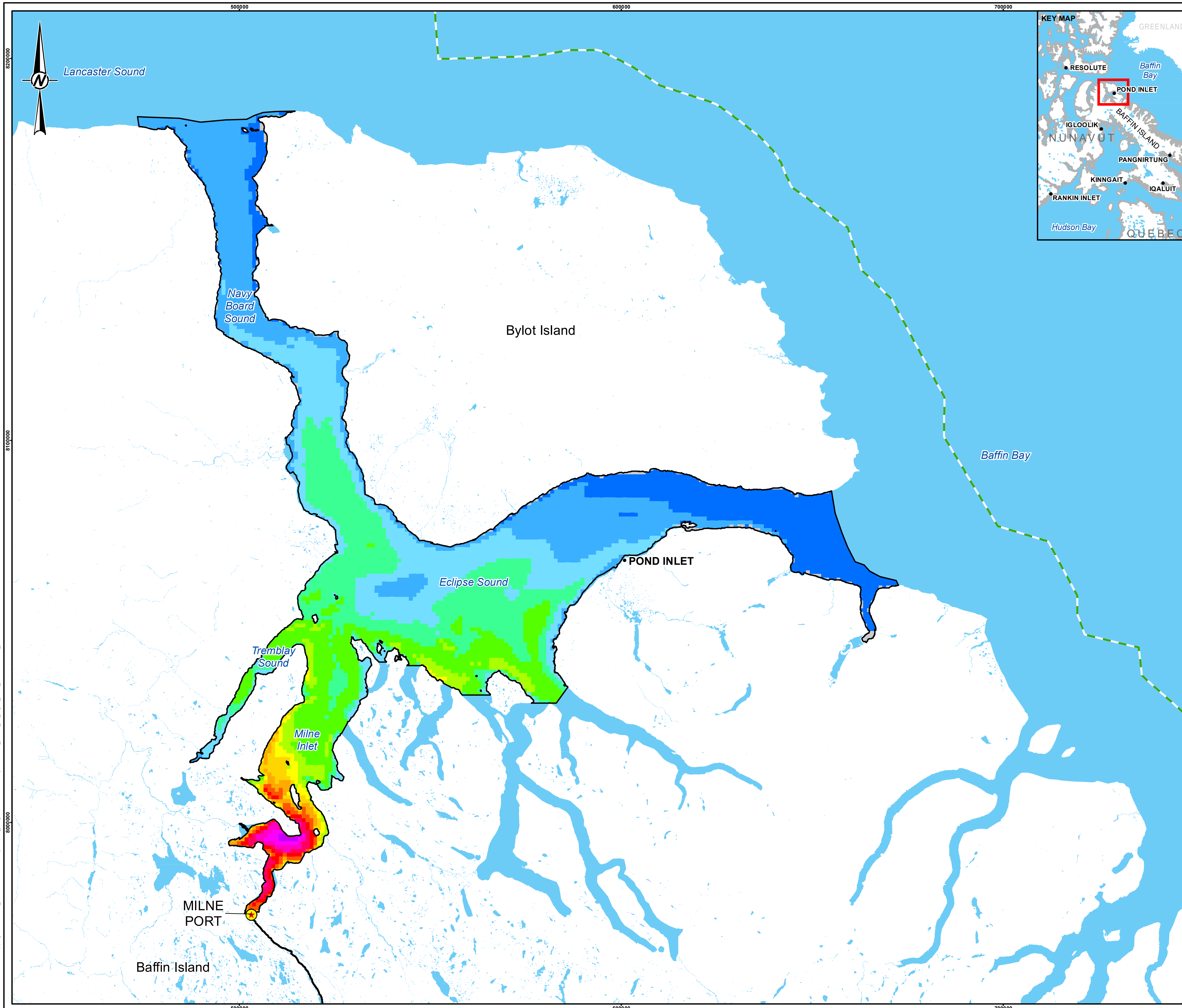
The low deviance explained value and issues with the diagnostic plots indicate that important covariates are likely missing from the models. Ice type/thickness and tidal currents/heights are likely to be import covariates that could help to explain the distribution of seal sighting but are not available in detail for the study area. Reducing the segment length and width when correlating bathymetry data may improve the model fit but this would require removing the 500 m bathymetry grid area from the model. The resulting model could be extrapolated to the area of poor bathymetry coverage, but this technique is generally discouraged, even more so since important covariates are likely missing.

Table 4: Spatial density models for the negative binomial distribution.

GAM Model[a]	AIC	Spatial model		Deviance explained	Average Density[b] dsm (#/km2)	CV		
		xy soap film smoother (edf)	covariates (edf)			ddf	GAM	total
s(MeanDepth) + s(DistPIFE) + s(DistNBFE) + ti(MeanDepth, DistShore)	2168	-	0.9, 1.1, 1.1, 5.4	14.0%	0.302	3.9%	6.2%	7.3%
soap(x,y) + ti(MaxDepth, DistShore)	2165	15.01	2.7	16.6%	0.295			
soap(x,y) + s(MinDepth) + ti(MinDepth, DistShore)	2179	11.6	1.0, 2.0, 2.8	15.6%	0.305			

a) “s”=univariate smooth; “ti” = bivariate tensor smooth (does not include primary affect of variables unless stated separately); “soap” = bivariate soap film smoother.

b) based on 6,695 km^2 study area



LEGEND

- COMMUNITY
- MILNE PORT
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA BOUNDARY
- STUDY AREA

RING SEAL DENISTY (INDIVIDUALS PER km^2)

- ≤ 0.1
- > 0.1 AND ≤ 0.2
- > 0.2 AND ≤ 0.3
- > 0.3 AND ≤ 0.4
- > 0.4 AND ≤ 0.5
- > 0.5 AND ≤ 0.6
- > 0.6 AND ≤ 0.7
- > 0.7 AND ≤ 0.8
- > 0.8 AND ≤ 0.9
- > 0.9 AND ≤ 1.0
- > 1.0 AND ≤ 1.1
- > 1.1 AND ≤ 1.2
- > 1.2 AND ≤ 1.3
- > 1.3 AND ≤ 1.4
- > 1.4
- INSUFFICIENT DATA

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 RINGED SEAL AERIAL SURVEYS

TITLE
RING SEAL PREDICTION GRID

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-21
DESIGNED	MF
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	13

2.5 Discussion

2.5.1 Ringed Seal Densities

High-level Summary: *Results from the 2021 FLIR survey indicated that ringed seal densities were stable in ES and NB strata, and increased in MI stratum compared to surveys flown in 2016–2017.*

Ringed seal densities were calculated using the preferred method identified by Young et al. (2019) using strip-transect analysis on “infrared” data obtained from infrared imagery. This allowed a direct comparison of the 2021 ringed seal densities with the 2016 and 2017 densities and would show if ringed seal numbers are increasing, decreasing or remaining stable in the RSA since Project icebreaking activities began in the shoulder seasons in 2018. Three complete aerial surveys were flown in the RSA in 2021. Survey 3 represented the survey with the highest ringed seal densities of
1.04 seals/km^2 in ES, 2.84 seals/km^2 in MI, 1.27 seals/km^2 in TS, and 0.83 seals/km^2 in NB.

Surveys flown in 2021 showed similar density estimates in ES and NB strata with previous surveys flown in 2016 and 2017 (see Table 3). A comparison in the ES stratum of the highest estimate in 2021 (1.04 seals/km^2, CV = 0.08) with the highest estimate in 2016 (0.92 seals/km^2, CV = 0.09) indicated no statistically significant difference in density estimates in ES stratum (z-score = 1.02, $p = 0.31$). Similarly, a comparison in the NB stratum of the highest estimate in 2021 (0.83 seals/km^2, CV = 0.12) with the highest estimate in 2016 (0.74 seals/km^2, CV = 0.43) indicated no statistically significant difference in density estimates in NB stratum (t-test = 0.27, $p = 0.79$). In the MI stratum ringed seal densities appeared higher in 2021 compared to previous surveys in 2016 and 2017. A comparison of the highest estimate in 2021 (2.84 seals/km^2, CV = 0.15) with the highest estimate in 2016 (1.40 seals/km^2, CV = 0.12) indicated a statistically significantly higher ringed seal density observed in 2021 in the MI stratum (t-test = 3.14, $p = 0.003$). Based on the current study, ringed seal densities were stable in ES and NB, and potentially increasing in MI since 2016.

2.5.2 Ringed Seal Hotspots

High-level Summary: *Results from the 2021 FLIR survey indicated that ringed seal hotspots were located in geographically similar areas to hotspots identified in 2016 and 2017, with hotspots in western Eclipse Sound, southern Milne Inlet and Tremblay Sound. The eastern Eclipse Sound hotspot identified in 2016 and 2017 was not present 2021.*

Yurkowski et al. (2018) noted several ringed seal hotspots throughout the RSA during the June spring molt. One hotspot was identified as a large area in western Eclipse Sound extending southward from Bylot Island, and other hotspots were identified in Milne Inlet, eastern Eclipse Sound, and Tremblay Sound (Yurkowski et al. 2018). The amount of spatial overlap of ringed seal hotspots in Eclipse Sound and Navy Board Inlet between 2016 and 2017 was low (75 km^2 and 12%), however the general locations of ringed seal hotspots in western and eastern Eclipse Sound were geographically similar interannually (Yurkowski et al. 2018).

Using surface density models, ringed seal hotspots were identified in the RSA in 2021 (see Figure 13). Hotspots were identified in similar geographic areas in 2021 as in 2016–2017, with hotspots in western Eclipse Sound, southern Milne Inlet and Tremblay Sound. The eastern Eclipse Sound hotspot identified in 2016 and 2017 was not present in 2021. A possible explanation for the lack of a hotspot in eastern Eclipse Sound in 2021 may be a result of some transects being removed from the eastern portion of ES stratum. The northern half of Navy Board Inlet had low sightings of ringed seals in all years (2016, 2017, and 2021).

Hotspots identified in 2016–2017 (Yurkowski et al. 2018) and in the current study in 2021 represented hotspots during the month of June when ringed seal were in their basking/moulting phase. These hotspots are possibly a good representation of ringed seal density during the period from the formation of the landfast ice in November to the start of the break-up of the land fast ice in late June, an important period in ringed seals' seasonal life-history because of their establishment of territories and subsequent parturition, nursing, breeding, and basking activities (McLaren 1958; Smith 1987). By July ringed seals are transitioning into their foraging phase and are moving around more as the ice begins to break-up and melt. Generally, the area in southern Milne Inlet begins to break-up first with open water extending from Assomption Harbour to Stevens Island within the first week of July. Ring seal hotspots identified in June were unlikely to be present in the same locations in mid-July when icebreaking begins.

2.5.3 Advantages of FLIR Surveys

During the process of analyzing infrared imagery and then verifying observations using the visual photographs, several advantages of using infrared technology for detecting seals on ice were identified:

- In the case where the presence of melt ponds makes detection of seals in photographs or by visual observation challenging, the infrared imagery makes detection of seals easy and lessens the chance of the observations being missed (Figure 14). As identified in the analysis of a random set of visual photographs to assess the success rate of the infrared camera data (see Section 2.4.3), five seal observations were missed in the independent analysis of the visual photographs but detected in the infrared method.

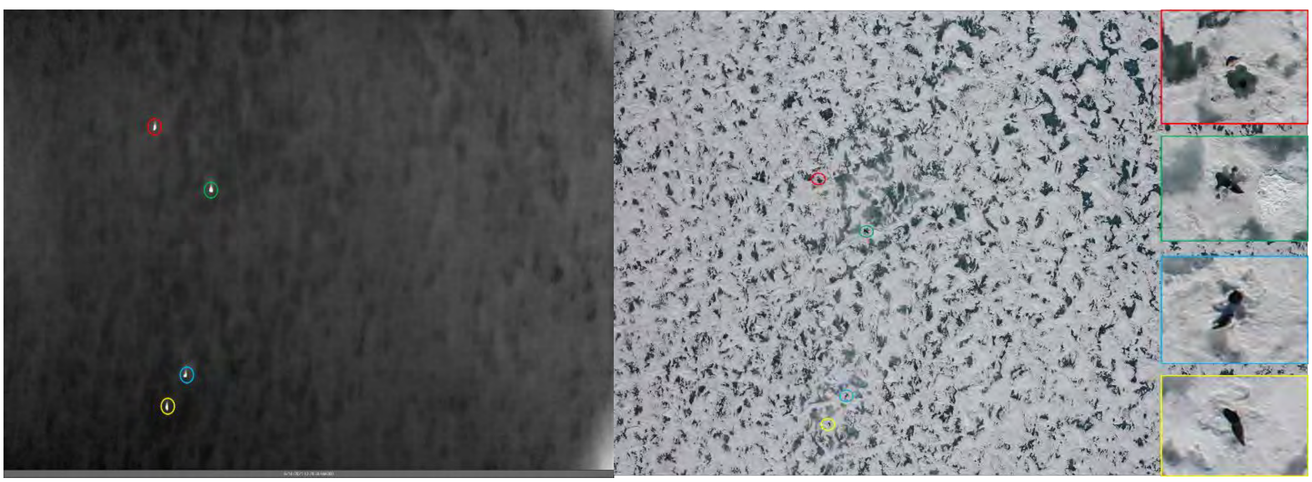


Figure 14: Example of paired aerial images obtained from infrared camera (left) and digital single-lens reflex camera (right) during the 2021 RSASP on 14 June demonstrating the efficiency of infrared imagery with visual photographs in poor visual sighting conditions.

As identified in the Young et al. (2019) paper, the presence of dirty or decaying ice, rocks, and melt ponds can create warm spots on the ice that can also make analysis of infrared imagery challenging (Figure 15). However, with tools available in the FLIR ResearchIR Max software, analysts can disregard a number of these erroneous hotspots based on their size, shape, and relative temperature.

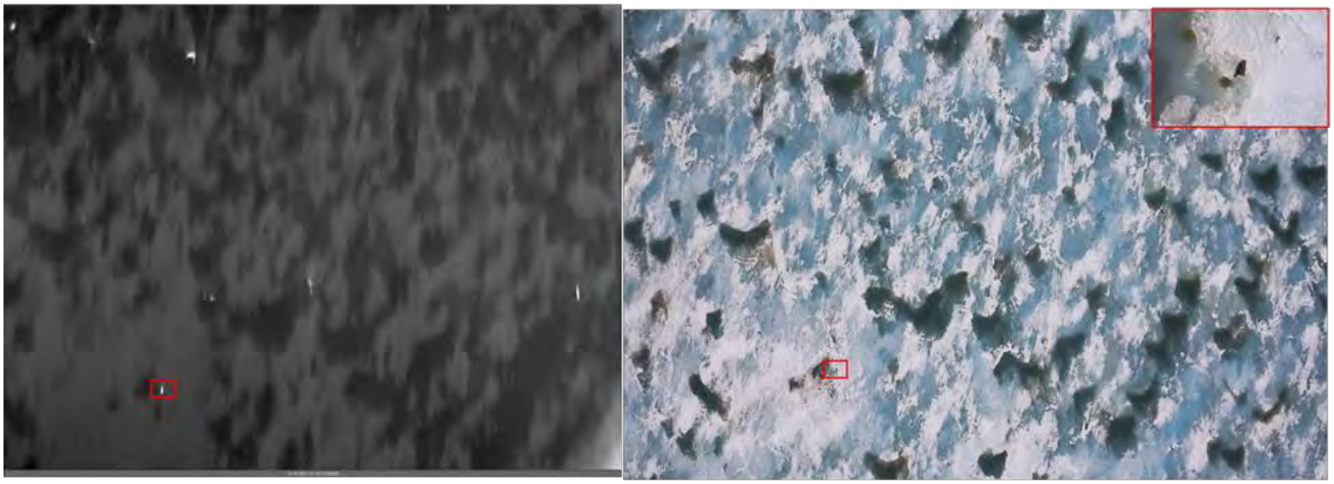


Figure 15: Example of paired aerial images obtained from infrared camera (left) and digital single-lens reflex camera (right) during the 2021 RSASP on 14 June demonstrating the efficiency of infrared imagery with visual photographs in poor sighting conditions.

- With the exception of TS, all CV values from the infrared method were <0.25 and comparable to CV values from visual observer methods (distance analysis and strip-transect analysis), despite these methods having more than double the survey coverage because of their wider strip widths. The larger CV values for the TS surveys were consistent across all three surveys and likely due to improper orientation of transects due to the shape and surrounding terrain of the stratum. Young et al. (2019) found the CV of the infrared strip-transect method to be similar to (or better than) the observer methods when survey coverage exceeded 5%. In the current study CV values in NB ranged between 0.12 and 0.24 with the lower CV of 0.12 obtained from 4.6% coverage. Based on CV values in the current study, survey coverage exceeding 4.5% in the infrared strip method may be adequate for obtaining lower CV values with FLIR surveys.
- As stated earlier and identified in the Young et al. (2019) paper, the main advantages of using infrared imagery coupled with visual photographs is it does not require the collection of observer data from the aircraft (i.e., fewer personnel), it allows for high probability of detection, reduces visibility bias, and allows for simplified data processing and density calculations.

3.0 2014 RINGED SEAL VISUAL SURVEY

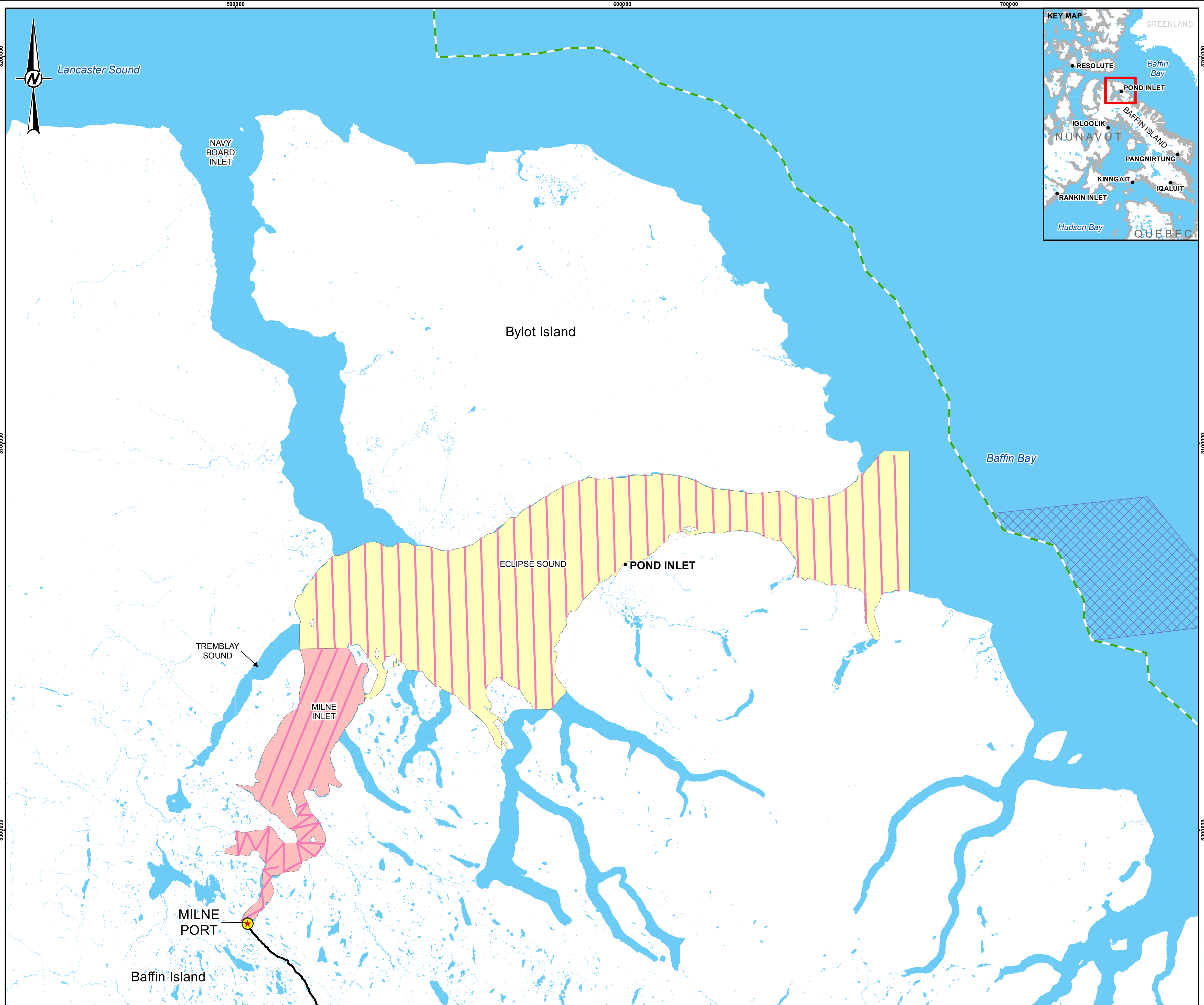
3.1 Objectives

Ringed seal aerial surveys were conducted in the North Baffin area during June 2014 by LGL Limited on behalf of Baffinland. The objective of the survey was to update baseline data on ringed seal density and distribution along the Northern Shipping Route in the RSA.

3.2 Study Area and Design

During spring 2014 (6–10 June), two aerial surveys were flown between longitudes 75.05ºW and 81.08ºW. Each survey consisted of 35 north-south transects in Eclipse Sound spaced 4 km apart, four northeast-southwest transects in Milne Inlet spaced 4 km apart, and 23 “zigzag” transects in the southern part of Milne Inlet and Koluktoo Bay (Figure 16).

The timing of the survey was selected to overlap with the peak moulting period in late May to early June (Smith and Hammill 1981) when more ringed seals would be available for detection on the ice and before an influx of ringed seals from the pack ice which generally occurs in the later part of June (Smith and Hammill 1981). Local ice conditions near Pond Inlet were also used to determine when to conduct the aerial surveys.



LEGEND

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

GEOGRAPHIC STRATA

- ECLIPSE SOUND
- MILNE INLET

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 RINGED SEAL AERIAL SURVEYS

TITLE
GEOGRAPHIC STRATA AND TRANSECTS FOR 2014 RINGED SEAL AERIAL SURVEYS

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-06-21
DESIGNED	TT
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	16

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3.3 Material and Methods

3.3.1 Field Methodology

Surveys were flown in a de Havilland Twin Otter (DH-6) equipped with four bubble windows. Visual line transect surveys were conducted at an altitude of 91 m (300 ft) and a ground speed of 222 km/h (120 kts) with four marine mammal observers (MMOs). The MMOs were stationed at the front and rear bubble windows that provide a view of the track line directly below the aircraft. The MMOs focused their scanning effort on a ~1,000-m strip on each side of the aircraft while on transect. For each seal sighting, the MMO dictated onto a digital voice recorder the species, number of animals, activity, behaviour, structure associated with sighting (i.e., hole or crack) and angle of inclination (using a clinometer) to the sighting location. The visual surveys were conducted as a double-platform experiment with independent observation platforms at the front (primary observers) and rear (secondary observers) 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 overseeing navigation along the survey grid and entering additional sighting data obtained from the primary observers into the database.

At the end of each 1-min time period along a transect (and whenever noticeable changes occurred), the two primary observers dictated onto a digital voice recorder the time, ice cover (intervals of 10%), ice type, ice roughness (intervals of 10%), sun glare (none, moderate, severe), and overall sightability conditions (subjectively classified as excellent, good, moderately impaired, severely impaired, or impossible).

A computer was connected to a Garmin GPS receiver with an external antenna, independent of the aircraft GPS. Latitude, longitude and flight altitude from the GPS were transmitted to the computer every second. The navigator viewed the aircraft's location and path in real time using Garmin NRoute 2.7.6 software and communicated the transect start/end times to the primary observers.

3.3.2 Data Analysis

Ringed seal density estimates were calculated using two different methods (strip-transect and line-transect analysis) to allow for comparison with subsequent surveys flown in 2016 and 2017 (Young et al. 2019).

3.3.2.1 Strip-Transect Analysis

Based on poor detection of seals close to the transect centerline and the possibility of seals diving along the centerline, observations used for the strip-transect analyses of visual observer data were left-truncated at a distance of 100 m. The strip-transect analysis was performed on a 600 m wide strip and consisted of observations made between distances of 100 and 400 m on each side of the aircraft, following the methods of Young et al. (2015) and Chambellant et al. (2012b). Only sightings made by primary observers were used in this analysis to enable a comparison with the numbers presented in the Young et al. (2019). The density of ringed seals per km^2 was estimated following Buckland et al. (2001) by computing the number of detected seals over the surveyed strip area:

$$\widehat{D} = \sum_{i=1}^{k} n_i / \omega \sum_{i=1}^{k} l_i$$

Where k is the number of transects flown, n_i is the number of ringed seals counted on the i^{th} transect, ω is the width of the strip, and l_i is the length of the i^{th} transect.

Following Kingsley and Smith (1981), the variance of density, was determined by:

$$\sigma^2(\widehat{D}) = k \times \frac{\sum_{i=1}^{k-1}(d_i - d_{i+1})^2}{2(k-1) \times (\omega \sum_{i=1}^{k} l_i)^2}$$

where

$$d_i = n_i - \widehat{D} \times \omega l_i$$

The coefficient of variation (CV) of the estimated density was calculated by dividing the square root of the variance by the estimated density.

3.3.2.2 Line-Transect Analysis

Line-transect distance analysis was also used to analyse the 2014 dataset. 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 ringed seals, the average density of ringed seals was considered to be the same irrespective of distance from the transect line. Subsequently, any observed change in ringed seal 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 ringed seals 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.

Encounter rate [$\frac{n}{L}$ from the equation above] was calculated as the number of ringed seal sighting per transect kilometre and was specific to each survey area. Even though the 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.

An implicit assumption of this method was that the probability of detection depended solely on an animal's perpendicular distance from the transect line. Line transect theory assumes that all animals on the transect line were detected with certainty ($g(0) = 1$). However, aerial survey observers miss some ringed seal visible on the ice (Richard et al. 2010), referred to as perception bias. 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 Mark-Recapture Distance Sampling (MRDS) methods can be used to estimate density 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 or "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 the average perpendicular declination angle as measured by the two observers
- Used the largest group size as measured by the two observers
- Used group differentiation as measured by the primary observer

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

Line-transect analyses to estimate density 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.

It is an unrealistic assumption that all animals on the transect line are detected with certainty ($g\ (0) = 1$) for animals that spend considerable time underwater where observers fail to detect animals due to availability bias (animal was not detected because it was diving under the ice) (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). Availability bias was not accounted for in the DFO paper (Young et al. 2019) and therefore was not accounted for in this report to allow for comparisons between the data.

3.4 Results

3.4.1 Survey Coverage

Two surveys were flown between 6–10 June 2014 (Table 5). Over the course of the two surveys, a total of 2,180.5 km of survey effort was conducted and 100% of the planned survey effort was completed. Surveys were flown between 08:00 and 18:00 whenever weather conditions allowed. Survey coverage and associated seal sightings in areas of open water and pack ice habitat east of the landfast ice edge at the entrance to Pond Inlet are excluded from the values presented in this report.

Table 5: Summary of surveys, dates, transects completed, and effort for aerial surveys of ringed seals in the RSA in June 2014.

Date	Survey #	Strata[a]	Transects (completed/planned)	Effort (km)
6-7 June 2014	1	ES	35/35	825.2
6 June 2014	1	MI	27/27	262.7
Subtotal	**1**		**62/62**	**1,087.9**
8-10 June 2014	2	ES	35/35	829.6
8 June 2014	2	MI	27/27	263.0
Subtotal	**2**		**62/62**	**1,092.6**

[a] ES=Eclipse Sound, MI=Milne Inlet

3.4.2 Sighting Conditions

Environmental sighting conditions were recorded during the surveys at the beginning and end of each transect and anytime conditions changed along the track. All sighting conditions were recorded within the 1,000 m strip on each side of the aircraft. Sightings conditions were evaluated based on survey effort when each condition was observed.

Cloud Cover

Cloud cover during the 2014 ringed seal aerial survey ranged from 0 to 100%. During Survey 1 conditions were variable ranging from 0 to 100% (Figure 17). Cloud cover conditions during Survey 2 ranged from 50 to 100% with the majority (80%) of the survey effort flown in 90–100% cloud cover (Figure 17).

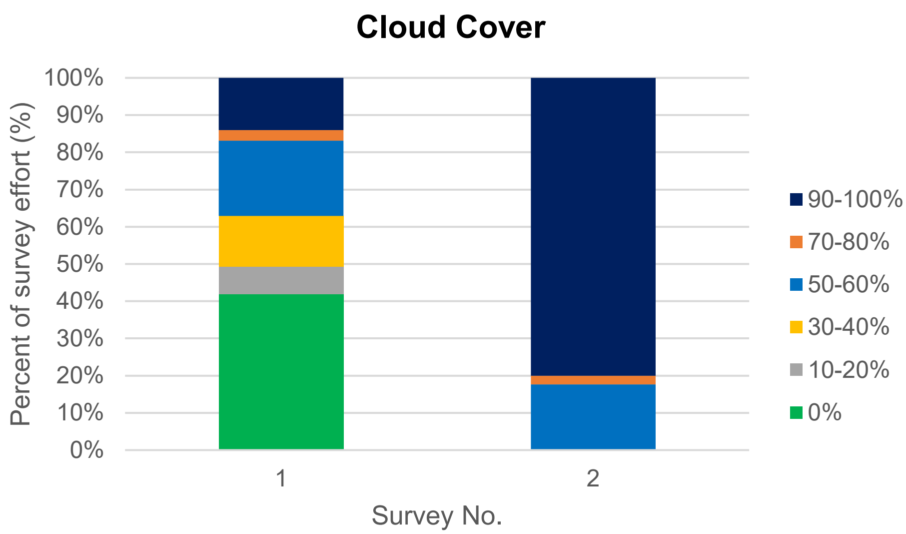


Figure 17: Cloud cover during 2014 ringed seal aerial survey.

Air Temperature

Air temperatures during the 2014 ringed seal aerial survey ranged from -1 to 4°C (Figure 18). During Survey 1, conditions were variable and temperatures ranged from -1 to 4°C with a mean air temperature of 2°C. Air temperature conditions during Survey 2 ranged from -1 to 0°C with a mean air temperature of 0°C.

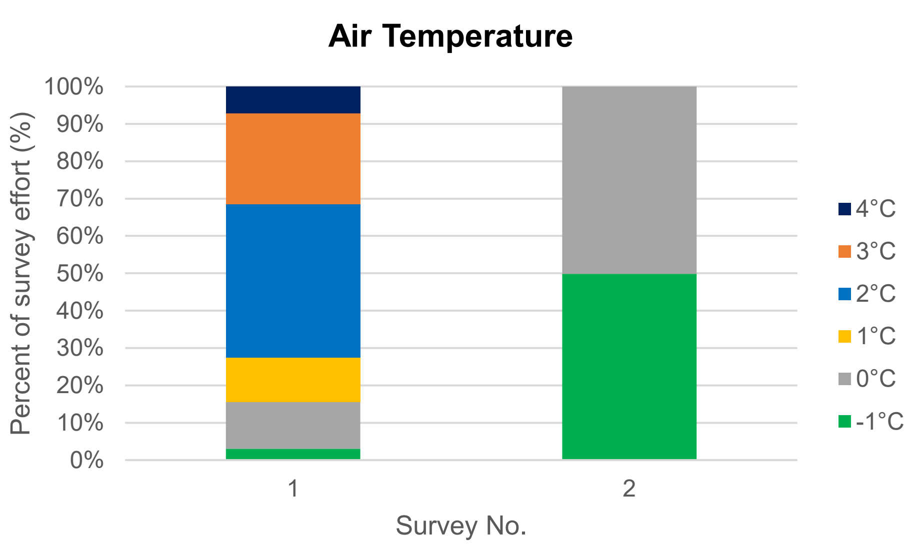


Figure 18: Air temperature during 2014 ringed seal aerial survey.

Melt Water

Melt water on the ice surface during the 2014 ringed seal aerial survey ranged from 0 to 10%. During Survey 1, conditions ranged from 0% to 10% melt water with the majority (98%) of the survey effort flown over 0% melt water (Figure 19). During Survey 2, conditions ranged from 0% to 10% melt water with the majority (94%) of the survey effort flown over 0% melt water (Figure 19).

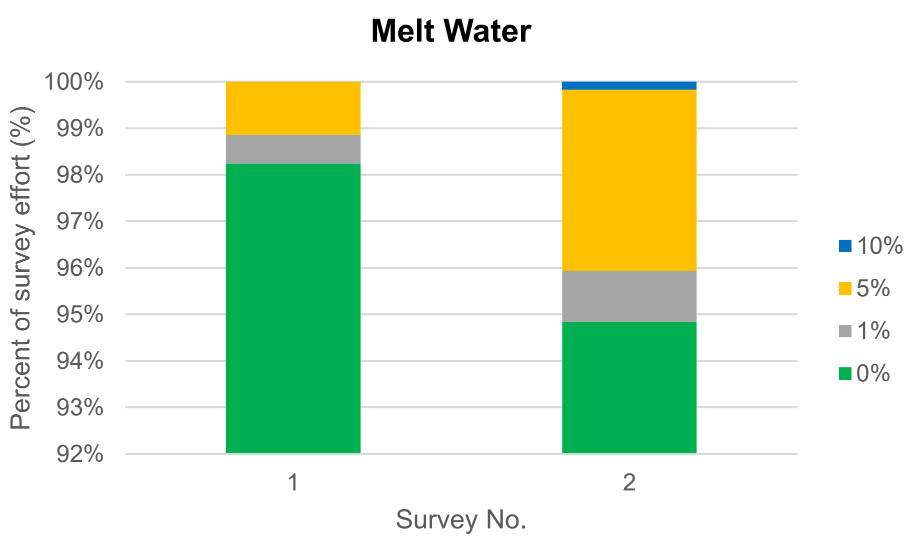


Figure 19: Melt water presence on ice surface during 2014 ringed seal aerial survey.

Snow/Ice Roughness

Snow/ice roughness during the 2014 ringed seal aerial survey ranged from 0 to 40%. Zero percent roughness represents a smooth ice surface with no snow drifts or ice ridges, whereas a 40% roughness represents an ice surface with 40% of it covered in snow drifts and/or ice ridges. During Survey 1, conditions ranged from 0% to 40% roughness with the majority (68%) of the survey effort flown over 0% snow/ice roughness (Figure 20). During Survey 2, conditions ranged from 0% to 40% roughness with the majority (78%) of the survey effort flown over 0% snow/ice roughness (Figure 20).

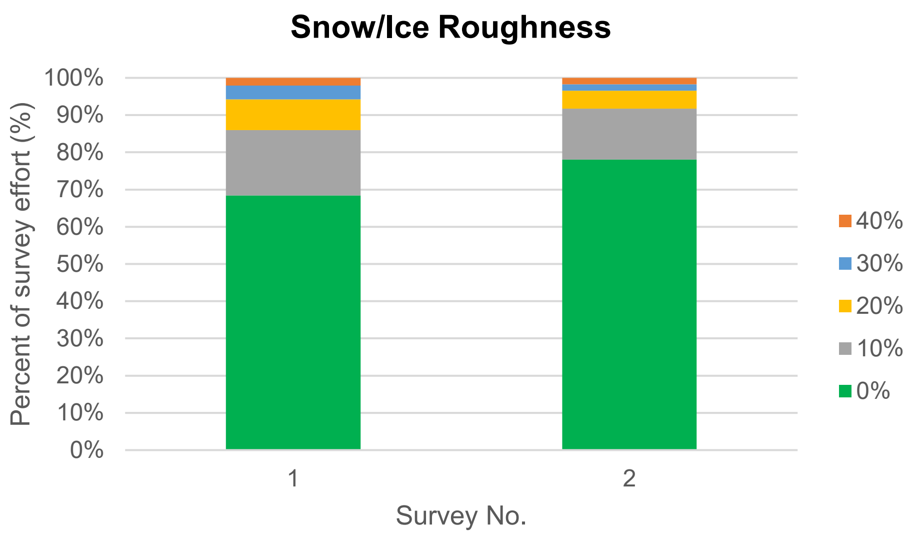


Figure 20: Snow/Ice roughness during 2014 ringed seal aerial survey.

Sightability

Sightability ranged from excellent to impossible during the 2014 ringed seal aerial survey. During Survey 1, conditions ranged from excellent to impossible with the majority (99%) of the survey effort flown in excellent or good sighting conditions (Figure 21). Sighting conditions during Survey 2 were either excellent or good for the duration of the survey (Figure 21).

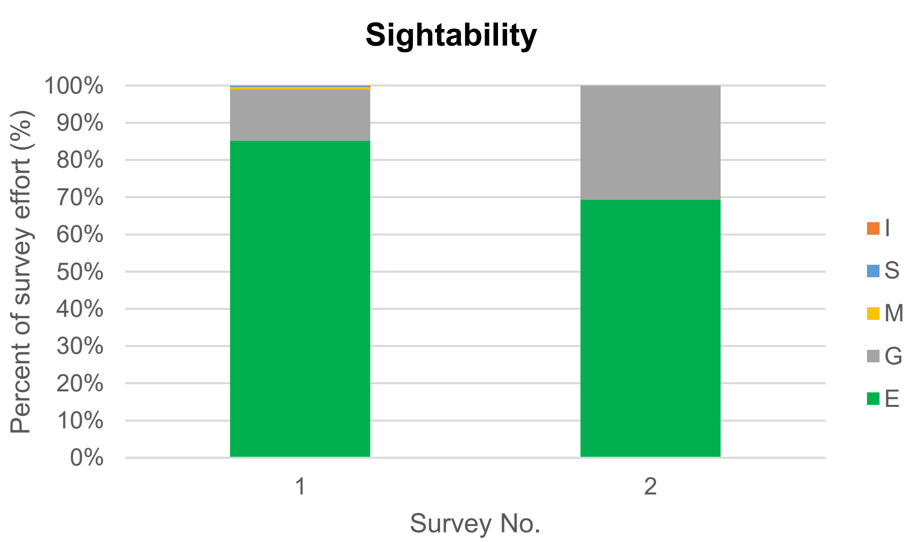


Figure 21: Sightability during 2014 ringed seal aerial survey.

3.4.3 Survey Sightings

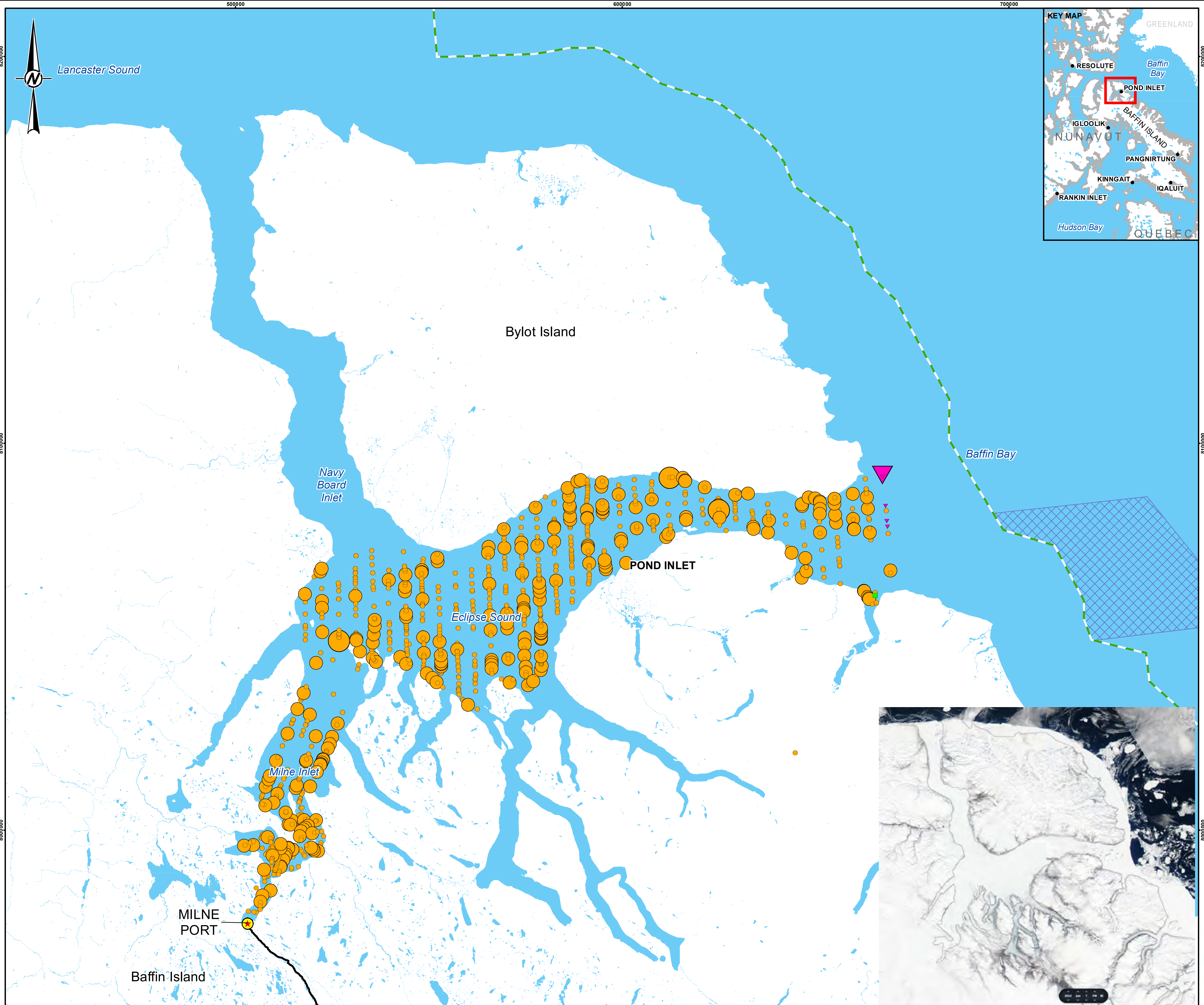
The numbers of observed ringed seals varied between the two surveys even though they were surveyed within 72 hours of each other. A total of 2,530 ringed seals (2,023 sightings) were seen on-effort by the primary observers and a total of 3,207 ringed seals (2,433 sightings) were seen on-effort by the combined primary and secondary observers in landfast ice habitat during the two surveys (Table 6).

Table 6: Ringed seal sightings and number of individuals recorded during aerial surveys in late spring 2014. Includes all on-effort sightings.

Date	Survey #	Strata[a]	Sightings (Primary)	Number of Individuals (Primary)	Sightings (Primary & Secondary)	Number of Individuals (Primary & Secondary)
6-7 June 2014	1	ES	581	697	745	968
6 June 2014	1	MI	186	216	261	333
Subtotal	**1**		**767**	**913**	**1,006**	**1,301**
8-10 June 2014	2	ES	816	1,057	930	1,262
8 June 2014	2	MI	440	560	497	644
Subtotal	**2**		**1,256**	**1,617**	**1,427**	**1,906**

[a] ES=Eclipse Sound, MI=Milne Inlet

Ringed seals were widely distributed throughout the study area during aerial surveys in the spring of 2014 (Figures 22 and 23).



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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 RINGED SEAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF RINGED SEALS, POLAR BEARS AND NARWHALS RECORDED DURING SURVEY 1 ON 6-7 JUNE 2014

CONSULTANT
GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-21
DESIGNED	TT
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	22

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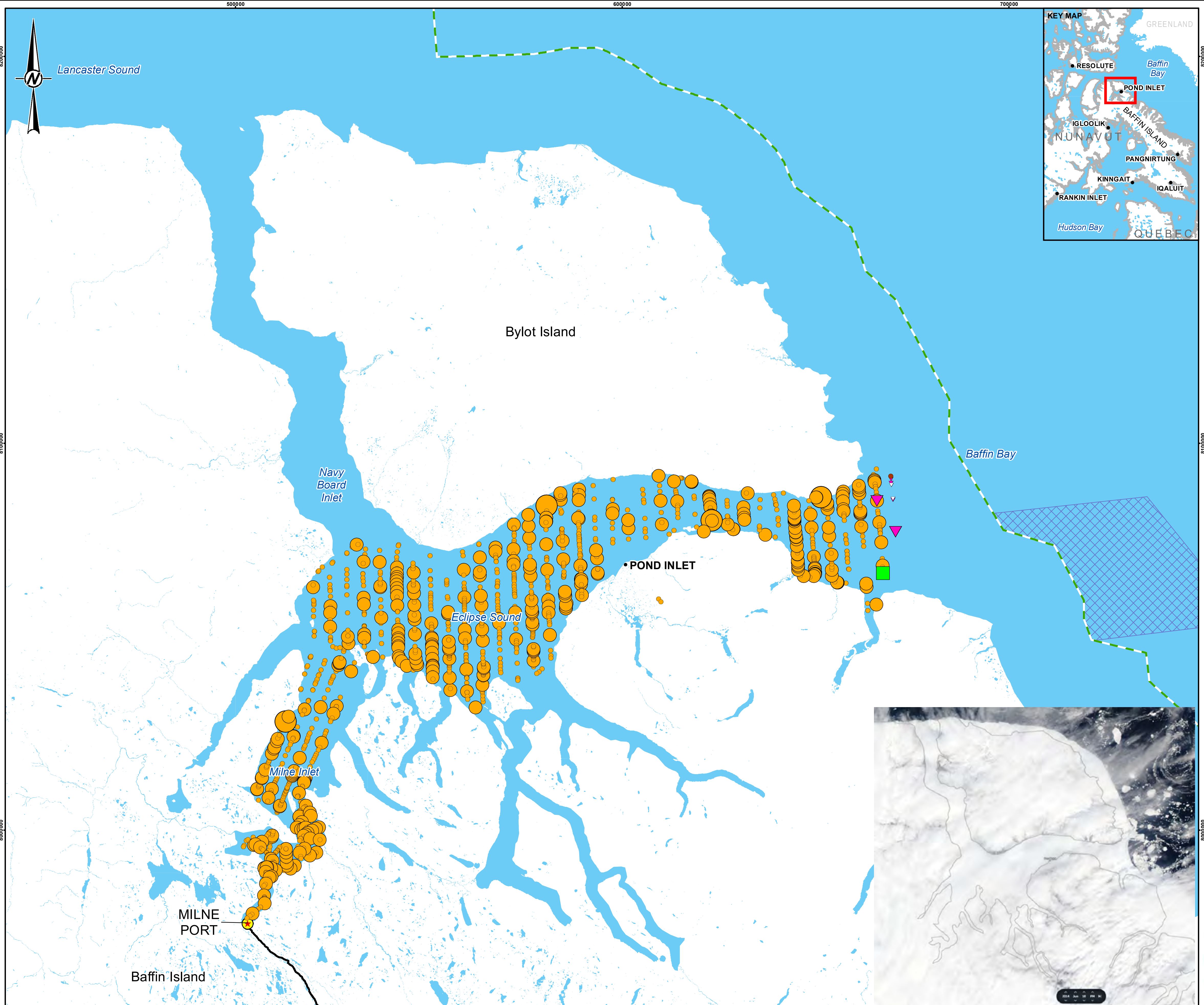

LEGEND

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

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

NARWHAL
- 1
- 2-10

POLAR BEAR
- 2-10

RINGED SEAL
- 1
- 2-10
- 10+

UNIDENTIFIED WHALE
- 1

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

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

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BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 RINGED SEAL AERIAL SURVEYS

TITLE
DISTRIBUTION OF RINGED SEALS, POLAR BEARS AND NARWHALS RECORDED DURING SURVEY 2 ON 8-10 JUNE 2014

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2022-06-21
DESIGNED	TT
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	23

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3.4.4 Density Estimates

3.4.4.1 Strip-Transect Densities

A summary of ringed seal densities for each survey and stratum is presented in Table 7. Ringed seal had the highest density in the Milne Inlet stratum (1.45 seals/km^2) and the lowest density in the Eclipse Sound stratum (0.53 seals/km^2). Densities also varied within strata, with Survey 1 having lower densities than Survey 2 (Table 7). The highest ringed seal densities (0.60 seals/km^2 in ES, 1.45 seals/km^2 in MI) were recorded during Survey 2.

Table 7: Ringed seal density (seals/km^2), SE (standard error), and CV (coefficient of variation) from two aerial surveys flown in the study area of 2014.

Survey	Strata[a]	# Sighting	# Individuals	Density (seals/km^2)	SE	CV
1	ES	233	263	0.53	0.05	0.10
1	MI	92	107	0.68	0.10	0.15
2	ES	253	301	0.60	0.04	0.07
2	MI	193	226	1.45	0.20	0.14

[a] ES=Eclipse Sound, MI=Milne Inlet

A comparison of 2014 surveys with subsequent 2016 surveys flown in ES stratum showed similar density estimates, with 2014 density estimates ranging from 0.53 to 0.60 seals/km^2 and 2016 estimates ranging from 0.37 to 0.52 seals/km^2. A comparison of the highest estimate in 2014 (0.60 seals/km^2, CV = 0.07) with the highest estimate in 2016 (0.52 seals/km^2, CV = 0.10) indicated no statistically significant difference in ringed seal densities (z-score = 1.25, $p = 0.21$). In the MI stratum, ringed seal densities appeared higher in 2014 (ranged from 0.68 to 1.45 seals/km^2) compared to 2016 surveys (ranged from 0.19 to 0.31 seals/km^2). A comparison of the highest estimate in 2014 (1.45 seals/km^2, CV = 0.14) with the highest estimate in 2016 (0.31 seals/km^2, CV = 0.17) indicated statistically significant higher density observed in 2014 in the MI stratum (t-test = 5.49, $p < 0.001$).

Table 8: Comparison of ringed seal densities from observer strip-transect analyses for strata in the RSA.

Year	Date	Strata[a]/Survey#	Density (seals/km^2)	SE	CV	Source
2014	6–7 June	ES1	0.53	0.05	0.10	Current Study
2014	8–10 June	ES2	0.60	0.04	0.07	Current Study
2016	17 June	ES1	0.37	0.06	0.17	Young et al. 2019
2016	19–22 June	ES2	0.52	0.05	0.10	Young et al. 2019
2014	6 June	MI1	0.68	0.10	0.15	Current Study
2014	8 June	MI2	1.45	0.20	0.14	Current Study
2016	17 June	MI1	0.19	0.04	0.19	Young et al. 2019
2016	21 June	MI2	0.19	0.04	0.19	Young et al. 2019
2016	22 June	MI3	0.31	0.05	0.17	Young et al. 2019

[a] ES=Eclipse Sound, MI=Milne Inlet

3.4.4.2 Line-Transect Analysis

3.4.4.2.1 Data Characteristics

Sightings data from both surveys in the survey grid supplemented one another to provide a more robust model of probability detection function. The same MMOs flew both surveys and were incorporated into the model as a covariate. Re-sightings were not used for the estimation of any variables.

One detection function was created for ringed seal for the combined surveys. 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 densities.

Analysis of sightings data was performed using the MRDS analysis package within R version 3.6.2 (R Core Team 2019; Laake et al. 2018). The shape of the histogram suggested that some animals were missed close to the trackline despite the bubble windows. There was a risk that hazard-rate and half-normal distributions would overestimate the probability of detection and the resulting effective strip width. The gamma key function does not assume a 100% detection on the track line ($g(0) = 1$). A horizontal offset value can be applied to the gamma detection function data since that key function assumes zero detections at zero distance, although no offset was required for this data set. Environmental and observer covariates were included for fitting the detection function and mark-recapture models. Models were selected using the minimum AIC.

The combined ringed seal sightings (n = 2,207) for the Eclipse Sound survey grid were used for estimating the detection function and mark-recapture detection probabilities for ringed seal (Figure 24). Based on survey methods of focused scanning effort on a 1,000 m strip on each side of the aircraft, the histogram of the perpendicular distances of unique sightings was right-truncated at 1,000 m (i.e., discarding sightings beyond 1,000 m).

Model selection was performed on the three key functions and all the combinations of environmental covariates. A gamma key function and covariates for ObserverPair + CloudCover:Sightability with a cosine adjustment series (4^{th} and 5^{th} orders) had the lowest AIC for detection function models: (g(x) = 0.52 and CV = 0.05; Appendix B).

Selection among mark-recapture models was performed on all combinations of environmental covariates. The lowest AIC was a model with covariates for distance:observer:ObserverPair + ObserverPair + PercIceRough:Sightability (Appendix B). It resulted in a p(0) of 0.71 for observers 1 (Figure 25) and 0.65 for observers 2 (Figure 26), and a combined p(0) of 0.89 and (CV = 0.01). The combined models resulted in a detection probability of 0.58 (CV = 0.05).

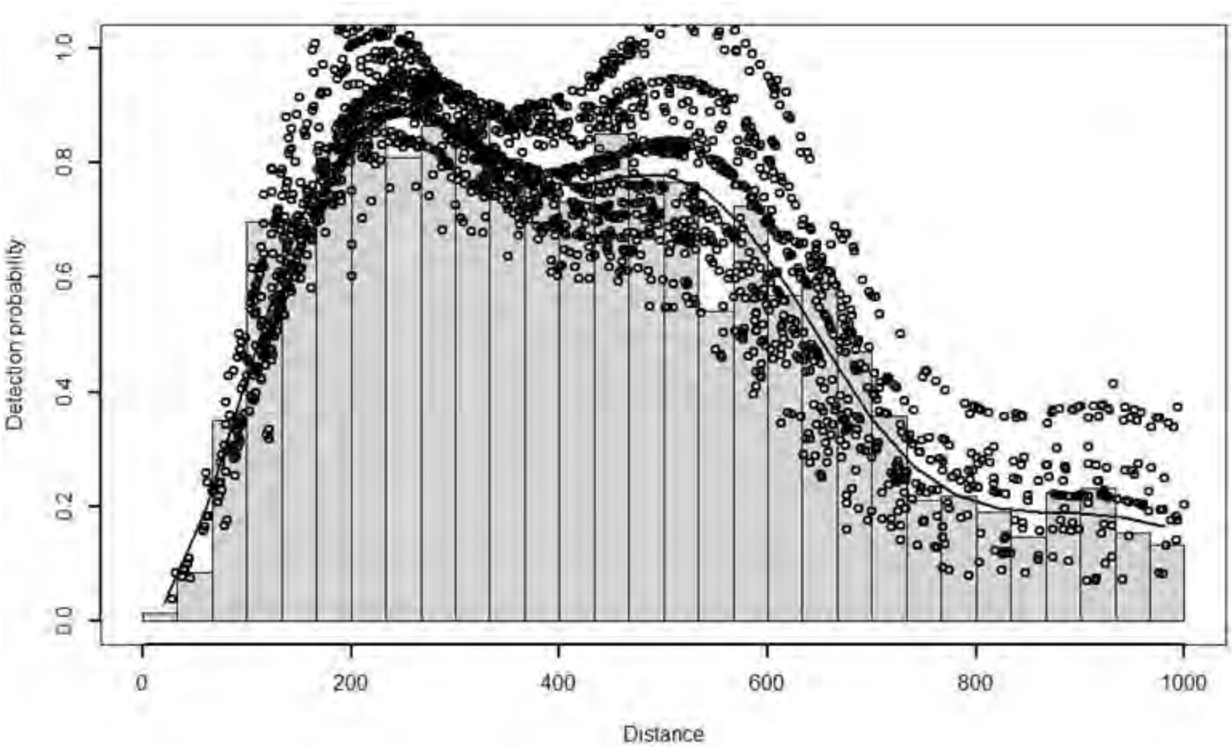

Figure 24: Histogram showing perpendicular distances of ringed seal sightings in Eclipse Sound survey grid. Note: Fitted gamma detection function is shown with right truncation at 1,000 m (no left truncation). O = probability of detection for each sighting based on perpendicular distance and other covariates.

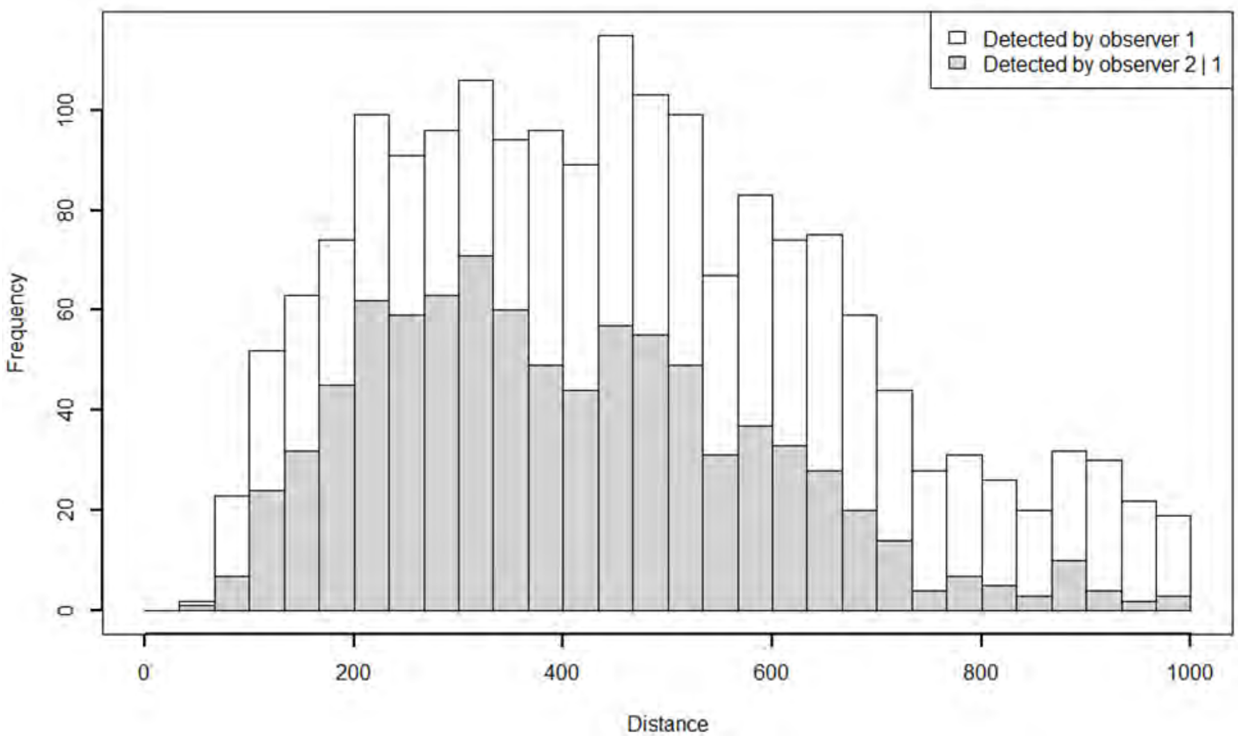

Figure 25: Distribution of ringed seal sighting distances for Observer 1 and Combined (Observers 1 and 2) in Eclipse Sound survey grid.

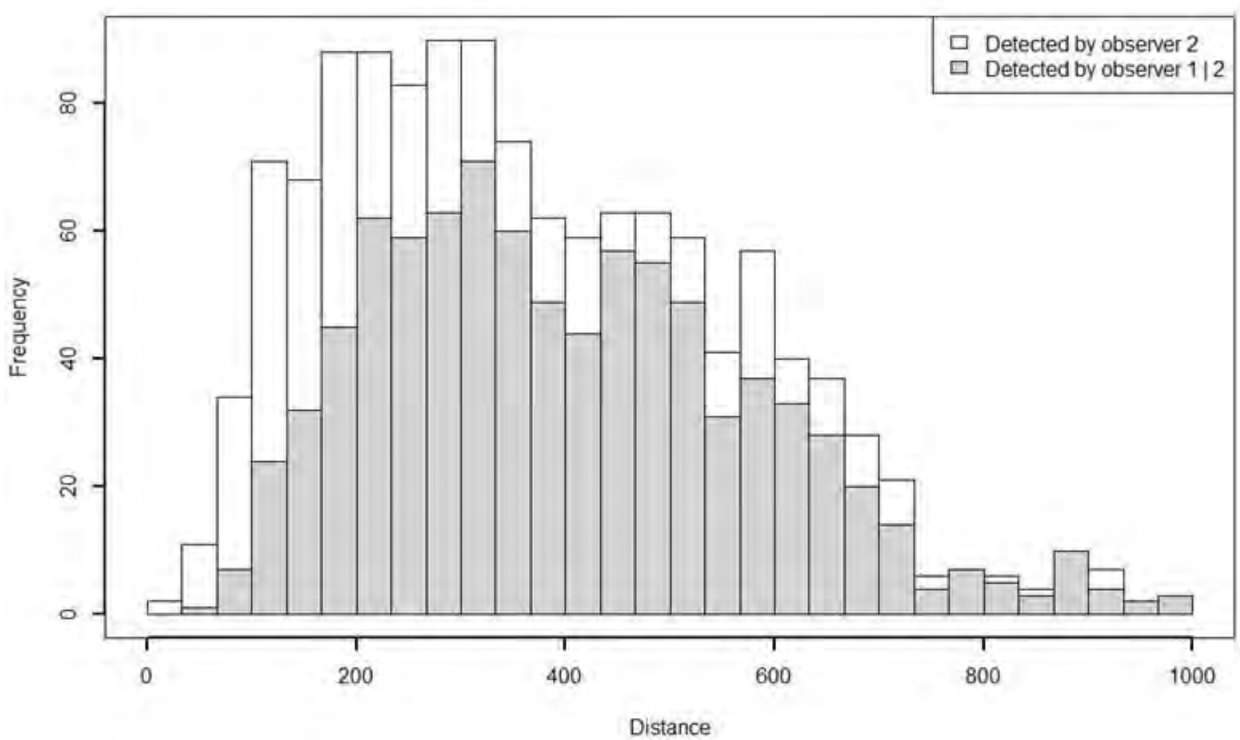

Figure 26: Distribution of ringed seal sighting distances for Observer 2 and Combined (Observers 1 and 2) in Eclipse Sound survey grid.

3.4.4.2.2 Line-Transect Densities

Overall, there were 2,433 ringed seal sightings observed on-effort by primary and secondary observers for Surveys 1 and 2 combined (Table 9). All sightings had perpendicular distances recorded during flight.

During Survey 1 (6–7 June 2014), a total of 1,087.9 km of transects were visually surveyed (Table 9). The total count of ringed seal sightings observed on-effort in the truncated visual survey area was 941 sightings (Table 9). Although variation of the density 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 component (Table 9). Ringed seal density for Survey 1 was estimated at 1.07 ringed seal/km^2 (CV = 0.09) in ES stratum and 1.14 ringed seal/km^2 (CV = 0.17) in MI stratum (Table 9).

The total length of transect lines visually surveyed during Survey 2 (8–10 June 2014) was 1,092.6 km (Table 9). The total count of ringed seal sightings observed on-effort in the truncated visual survey area was 1,266 sightings (Table 9). Although variation of the density 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 component (Table 9). Ringed seal density for Survey 2 was estimated at 1.27 ringed seal/km^2 (CV = 0.09) in ES stratum and 2.13 ringed seal/km^2 (CV = 0.12) in MI stratum (Table 9).

Table 9: Ringed seal density estimates from visual surveys during 2014 aerial surveys.

Survey	Strata[a]	Effort (km)	No. Sight. Before Trunc.	No. Sight. After Trunc.	Density Estimate (seals/km^2)	CV	% CV contributed by Encounter Rate	% CV contributed by Cluster Size	% CV contributed by MRDS function
1	ES	825.2	745	698	1.07	0.09	59.2	8.9	32.0
1	MI	262.7	261	243	1.14	0.17	86.3	3.6	10.1
2	ES	829.6	930	818	1.27	0.09	58.1	5.7	36.2
2	MI	263.0	497	448	2.13	0.12	68.6	10.7	20.8

[a] ES=Eclipse Sound, MI=Milne Inlet

In the ES stratum, ringed seal densities appeared higher in 2014 (ranged from 1.07 to 1.27 seals/km^2) compared to 2016 (ranged from 0.57 to 0.79 seals/km^2) surveys. A comparison of the highest estimate in 2014 (1.27 seals/km^2, CV = 0.09) with the highest estimate in 2016 (0.79 seals/km^2, CV = 0.11) indicated statistically significantly higher ringed seal density observed in 2014 in the ES stratum (t-test = 3.36, p = 0.004). Similarly, in the MI stratum, ringed seal densities appeared higher in 2014 (ranged from 1.14 to 2.13 seals/km^2) compared to 2016 (ranged from 0.93 to 1.27 seals/km^2) surveys. A comparison of the highest estimate in 2014 (2.13 seals/km^2, CV = 0.12) with the highest estimate in 2016 (1.27 seals/km^2, CV = 0.16) found a statistically significantly higher ringed seal density observed in 2014 in the MI stratum (t-test = 2.66, p = 0.013).

Table 10: Comparison of ringed seal densities

Year	Date	Strata[a]/Survey#	Density	CV	Source
2014	6/7 June	ES1	1.07	0.09	Current Study
2014	8/10 June	ES2	1.27	0.09	Current Study
2016	17 June	ES1	0.57	0.16	Young et al. 2019
2016	19/22 June	ES2	0.79	0.11	Young et al. 2019
2014	6 June	MI1	1.14	0.17	Current Study
2014	8 June	MI2	2.13	0.12	Current Study
2016	17 June	MI1	0.97	0.16	Young et al. 2019
2016	21 June	MI2	0.93	0.18	Young et al. 2019
2016	22 June	MI3	1.27	0.16	Young et al. 2019

[a] ES=Eclipse Sound, MI=Milne Inlet

3.5 Discussion

Ringed seal densities were calculated for the 2014 aerial surveys using visual strip-transect and line-transect analysis methods. This allowed a comparison of the 2014 ringed seal densities with the 2016 densities and would show if ringed seal numbers were increasing, decreasing or remaining stable in the RSA since the onset of shipping operations in 2015. Two complete aerial surveys were flown in the RSA in 2014.

3.5.1 Strip-Transect Densities

High-level Summary: *Results from the 2014 aerial survey indicated that ringed seal densities were stable in ES stratum and decreased in MI stratum in 2016. Baseline surveys flown in 2007 and 2008 indicated MI stratum varied in ringed seal densities annually.*

Young et al. (2019) calculated ringed seal densities for surveys flown in the RSA in 2016 using visual strip-transect analysis methods. Following Young et al. (2019) analysis methods, ringed seal densities were calculated for the 2014 surveys using visual strip-transect analysis.

A comparison of 2014 surveys with subsequent 2016 surveys flown in ES stratum showed similar density estimates (Table 10). A comparison of the highest estimate in 2014 (0.60 seals/km^2, CV = 0.07) with the highest estimate in 2016 (0.52 seals/km^2, CV = 0.10) indicated no statistically significant difference in ringed seal densities (z-score = 1.25, p = 0.21). In the MI stratum ringed seal densities appeared higher in 2014 compared to subsequent surveys in 2016 (Table 10). A comparison of the highest estimate in 2014 (1.45 seals/km^2, CV = 0.14) with the highest estimate in 2016 (0.31 seals/km^2, CV = 0.17) indicated statistically significant higher density observed in 2014 in the MI stratum (t-test = 5.49, $p < 0.001$).

Strip-transect densities were calculated for ringed seal baseline surveys flown in the MI stratum in 2007 and 2008 (Baffinland 2012). In 2007, ringed seal densities of 0.18 seals/km^2 in Koluktoo Bay and 0.30 seals/km^2 in North Milne Inlet were calculated in the MI stratum (Baffinland 2012). The combined estimate (Koluktoo Bay/North Milne Inlet) for the MI stratum in 2007 was 0.27 seals/km^2. In 2008, ringed seal densities of 2.16 seals/km^2 in Koluktoo Bay and 1.27 seals/km^2 in North Milne Inlet were calculated in the MI stratum (Baffinland 2012). The combined estimate (Koluktoo Bay/North Milne Inlet) for the MI stratum in 2008 was 1.44 seals/km^2.

The MI stratum appeared to fluctuate in ring seal density annually. Ringed seal surveys flown in 2008 and 2014 saw high densities of ringed seal in MI (1.44 seals/km^2 and 1.45 seals/km^2, respectively; Baffinland 2012) whereas ringed seal surveys flown in 2007 and 2016 observed lower densities of ringed seal in MI (0.27 seals/km^2 and 0.31 seals/km^2, respectively; Baffinland 2012; Young et al. 2019). Based on visual strip-transect surveys flown in 2007, 2008, 2014, and 2016, ringed seal densities appeared to be stable in ES and variable in MI strata.

Survey and data recording procedures for the ringed seal surveys differed in all four years (2007, 2008, 2014, and 2016) and may contribute to some of the differences observed in the densities. In 2007, ringed seal surveys were conducted from a helicopter (Eurocopter A Star), at an altitude of 150 m above sea level (asl) and a ground speed of 220 km/h (Baffinland 2012). The survey strip width was 400 m on each side of the aircraft, offset 100 m from the centreline of the aircraft. In 2008, surveys were conducted from a fixed-wing aircraft (Twin Otter DHC-6), at an altitude of 91 m asl and at a ground speed of 220 km/h (Baffinland 2012). The survey strip width was 297 m on each side of the aircraft, offset 69 m from the centreline of the Twin Otter. In 2014, surveys were conducted from a fixed-wing aircraft (Twin Otter DHC-6), at an altitude of 91 m asl and at a ground speed of 220 km/h. The survey strip width was 300 m on each side of the aircraft, offset 100 m from the centreline of the Twin Otter. In 2016, a fixed-wing aircraft (Twin Otter DHC-6) was used, and surveys were conducted at an altitude of 305 m asl and at a ground speed of 220 km/h (Young et al. 2019). The survey strip width was 300 m on each side of the aircraft, offset 100 m from the centreline of the Twin Otter.

3.5.2 Line-Transect Densities

High-level Summary: *Results from the 2014 aerial survey indicated that ringed seal densities decreased in ES and MI strata in 2016, although results from the 2021 aerial survey indicated that ringed seal densities have remained stable in ES and MI stratum since 2014.*

Young et al. (2019) calculated ringed seal densities for surveys flown in the RSA in 2016 using a combination of infrared and observer data analyzed using distance analysis. Ringed seal densities were calculated for the 2014 surveys using distance analysis from a double observer platform.

Survey and distance analysis procedures for the ringed seal surveys differed between 2014 and 2016, and may have contributed to some of the differences observed in the densities. In 2014, surveys were conducted from a fixed-wing aircraft (Twin Otter DHC-6), at an altitude of 91 m asl and at a ground speed of 220 km/h. Line-transect analysis used the Mark-Recapture Distance Sampling (MRDS) analysis package, which uses double observer platform to account for observer missed seal sightings. In 2016, a fixed-wing aircraft (Twin Otter DHC-6) was used, and surveys were conducted at an altitude of 305 m asl and at a ground speed of 220 km/h. The 2016 survey did not use a double-observer platform with four observers, instead it used a combination of infrared data (0-125 m from track-line) and observer data (125-800 m from track-line) and analyzed as a line-transect survey.

In the ES stratum, ringed seal densities appeared higher in 2014 (ranged from 1.07 to 1.27 seals/km^2) compared to 2016 (ranged from 0.57 to 0.79 seals/km^2) surveys. A comparison of the highest estimate in 2014 (1.27 seals/km^2, CV = 0.09) with the highest estimate in 2016 (0.79 seals/km^2, CV = 0.11) indicated a statistically significantly higher ringed seal density observed in 2014 in the ES stratum (t-test = 3.36, p = 0.004). Similarly, in the MI stratum ringed seal densities appeared higher in 2014 (ranged from 1.14 to 2.13 seals/km^2) compared to 2016 (ranged from 0.93 to 1.27 seals/km^2) surveys. A comparison of the highest estimate in 2014 (2.13 seals/km^2, CV = 0.12) with the highest estimate in 2016 (1.27 seals/km^2, CV = 0.16) indicated a statistically significantly higher ringed seal density observed in 2014 in the MI stratum (t-test = 2.66, p = 0.013).

Young et al. (2019) compared infrared strip-transect analysis with line-transect distance analysis on the same dataset using a pairwise comparison and found they produced densities that were not statistically different (P = 1.000). Although, both methods produced density estimates that were, on average, approximately 2–3 times greater than the observer strip-transect method (infrared: P = 0.023; distance: P = 0.012). Comparing 2021 infrared strip-transect densities (1.04 seals/km^2 in ES and 2.84 seals/km^2 in MI) to 2014 line-transect distance analysis densities (1.27 seals/km^2 in ES and 2.13 seals/km^2 in MI), no statistical difference was observed between the two years (t-test = 1.63, p = 0.013 and t-test = 1.44, p = 0.017, respectively). These results indicated that ringed seal densities have not changed in the RSA since the onset of shipping operations in 2015, and since Project icebreaking activities began in the shoulder seasons in 2018. However, there were annual fluctuations in ringed seal densities primarily in the MI stratum.

4.0 SUMMARY

Ringed seal densities fluctuated in the MI stratum with lower densities observed in 2007 and 2016 and higher densities observed in 2008, 2014, and 2021 (Table 11). Statistically significant differences were observed between the high-density years in 2014 and 2021 and the low-density year in 2016. Comparison of a baseline density in 2014 of 2.13 seals/km^2 to a current density in 2021 of 2.84 seals/km^2, identified no statistical difference between the two years (t-test = 1.44, p = 0.017). In the ES stratum, ringed seal densities were stable in three (2014, 2016, 2021) of the four years surveyed, with lower densities observed in 2017 (Table 11; Figure 27). A comparison in the ES stratum of the highest estimate in 2021 (1.04 seals/km^2, CV = 0.08) with the highest estimate in 2016 (0.92 seals/km^2, CV = 0.09) indicated no statistically significant difference in density estimates in ES stratum (z-score = 1.02, p = 0.31). Similarly, a comparison in the ES stratum of the highest estimate in 2021 (1.04 seals/km^2, CV = 0.08) with the highest estimate in 2014 (1.27 seals/km^2, CV = 0.09) indicated no statistically significant difference in density estimates in ES stratum (t-test = 1.63, p = 0.013). In the NB stratum, ringed seal densities were stable in two (2016, 2021) of the three years surveyed, with lower densities observed in 2017 (Table 11; Figure 27). A comparison in the NB stratum of the highest estimate in 2021 (0.83 seals/km^2, CV = 0.12) with the highest estimate in 2016 (0.74 seals/km^2, CV = 0.43) indicated no statistically significant difference in density estimates in NB stratum (t-test = 0.27, p = 0.79).

The results of the 2021 RSASP showed ringed seal densities have overall remained stable since the onset of shipping operations in 2015, and since Project icebreaking activities began in the shoulder seasons in 2018. These results confirmed that mitigation measures were functioning as intended and that Project activities are being managed in a way that has not adversely affected ringed seals. Given that no changes to icebreaking operations are proposed within Baffinland's Phase 2 Proposal, these results also lend confidence to predictions made in Phase 2 impact assessment, which states that effects on ringed seal as a result of the Project would not result in population level effects (Golder 2018).

Table 11: Ringed seal density and CV from surveys flown in the RSA, during spring of 2007, 2008, 2014, 2016, 2017, and 2021. Highest or only density for each year are presented. Text in bold from current study.

Stratum[a]	Year			Comparable Analysis Methods				Source
		Visual Strip-Transect		FLIR Strip-Transect		Distance Analysis		
		Density	CV	Density	CV	Density	CV	
MI	2007[b]	0.27	—	—	—	—	—	Baffinland 2012
	2008[b]	1.44	—	—	—	—	—	Baffinland 2012
	2014	**1.45**	**0.14**	—	—	**2.13**	**0.12**	**Current Study**
	2016	0.31	0.17	1.40	0.12	1.27	0.16	Young et al. 2019
	2021	—	—	**2.84**	**0.15**	—	—	**Current Study**
ES	**2014**	**0.60**	**0.07**	—	—	**1.27**	**0.09**	**Current Study**
	2016	0.52	0.1	0.92	0.09	0.79	0.11	Young et al. 2019
	2017[b]	—	—	0.45	0.15	—	—	Young et al. 2019
	2021	—	—	**1.04**	**0.08**	—	—	**Current Study**
NB	2016	0.17	0.21	0.74	0.43	0.77	0.36	Young et al. 2019
	2017[b]	—	—	0.24	0.28	—	—	Young et al. 2019
	2021	—	—	**0.83**	**0.12**	—	—	**Current Study**
TS	**2021**	—	—	**1.27**	**0.46**	—	—	**Current Study**

[a] ES=Eclipse Sound, MI=Milne Inlet, TS=Tremblay Sound, NB=Navy Board Inlet
[b] Only one survey flown in that year

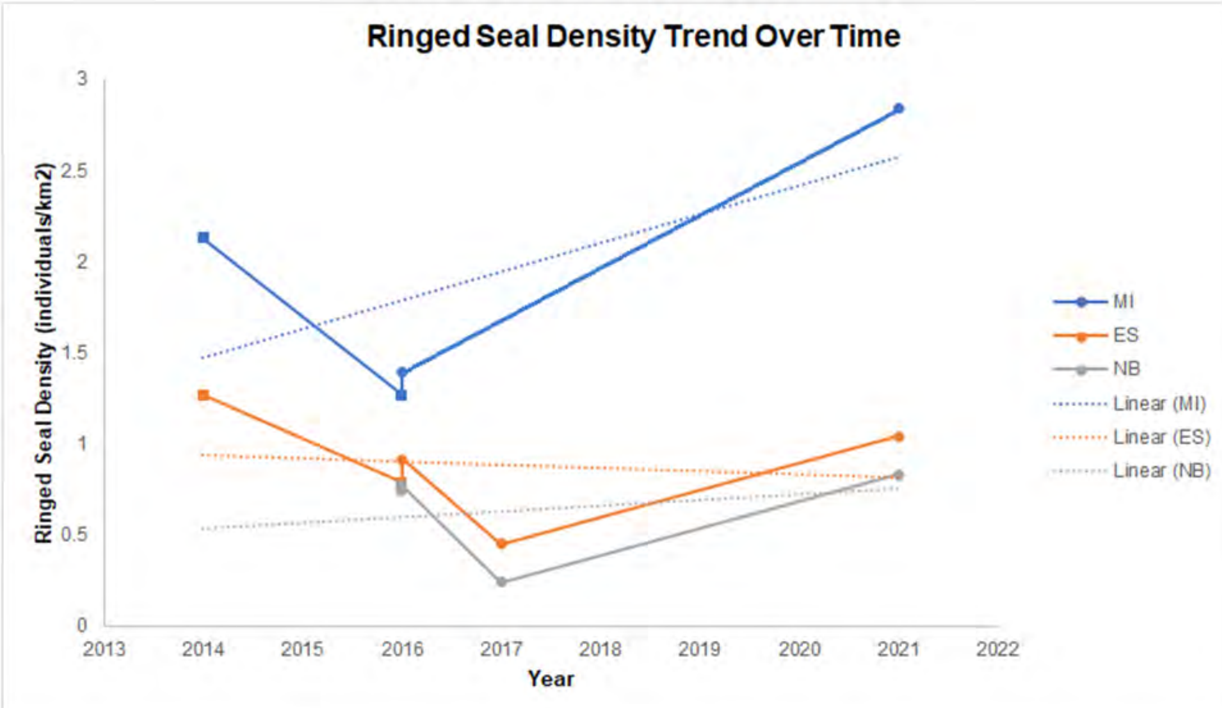

Figure 27: Ringed seal density trend over time (2014 to 2021) for FLIR strip-transect (circle symbol) and distance analysis (square symbol). Trend line (dotted line) represent ringed seal density over an eight-year span. ES=Eclipse Sound (orange), MI=Milne Inlet (blue), NB=Navy Board Inlet (grey).

The 2021 RSASP addressed Project Certificate No. 005 Terms and Conditions 101, 109, 119, and 126, and demonstrated how Project Certificate Terms and Conditions were met through the 2021 RSASP (Table 12).

Table 12: NIRB Project Certificate No. 005 Terms and Conditions relevant to the 2021 RSASP.

Project Certificate Terms and Conditions	Condition / Evidence of Conditions Met
101	Efforts to involve Inuit in monitoring studies at all levels: ■ Inuit involvement was not possible for the 2021 season due to the COVID-19 global pandemic and operational restrictions. Monitoring protocols that are responsive to Inuit concerns: ■ Aerial surveys allow for evaluation of ringed seal large-scale displacement effects, abandonment of the RSA, moderate to large changes in density estimates. Schedule for periodic aerial surveys as recommended by the MEWG: ■ Aerial surveys were conducted in 2021. ■ The results of the 2021 RSASP will be presented to the MHTO and the community of Pond Inlet once COVID-19 restrictions allow it.
109	Conduct a monitoring program to confirm the predictions in the FEIS: ■ Aerial survey confirmed FEIS prediction that no large-scale displacement or abandonment of the RSA has occurred.
119	Monitor ringed seal birth lair abundance and distribution for at least two years prior to the start of ice-breaking to develop a baseline, with continue monitoring over the life-time of the project. ■ Ringed seal hotspots show areas of high ringed seal densities in the RSA
126	Design monitoring program to ensure that local users can assist with monitoring and evaluating potential impacts: ■ Inuit involvement was not possible for the 2021 season due to the COVID-19 global pandemic and operational restrictions. ■ The results of the 2021 RSASP will be presented to the MHTO and the community of Pond Inlet once COVID-19 restrictions allow it.

Mitigation measures in place for ringed seal have been carefully developed to completely avoid shipping impacts on ringed seal during periods when they are “grouped up” (i.e., the winter and spring) when group behaviour is critical to reproductive activities such as mating. The timing of the shipping season protects seals during the basking period, and aims to avoid impacts on seals at the time when they start maintaining breathing holes during initial ice freeze-up.

5.0 RECOMMENDATIONS

The following recommendations should be considered with respect to future ringed seal aerial survey monitoring program:

- Ringed seal surveys are not recommended in 2022 for the Eclipse Sound area based on the current survey results.

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

Density Surface Modelling Diagnostics

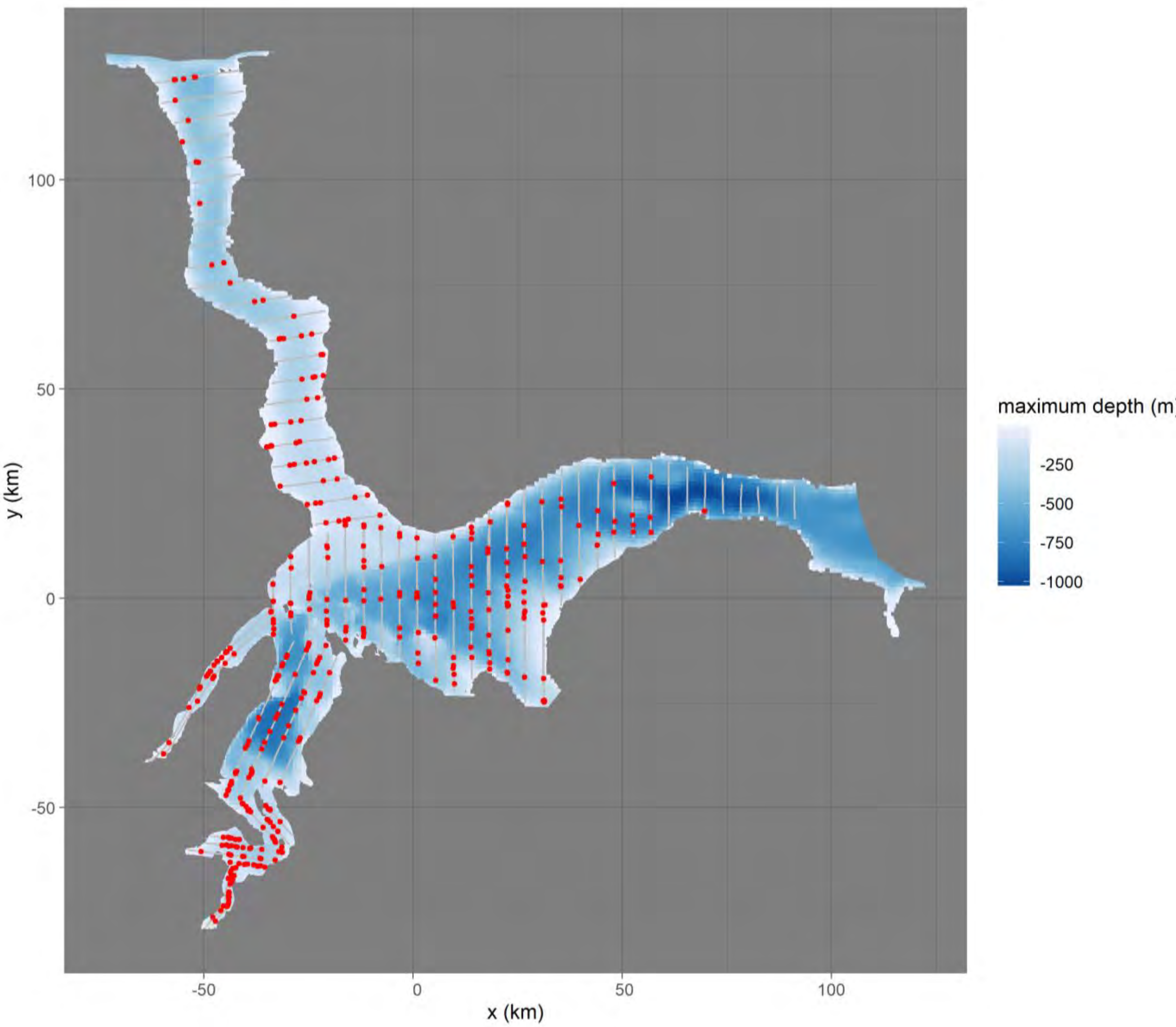


Figure A-1: Example of covariate “maximum depth”, computed for the study area. Red circles: sightings of ringed seals.

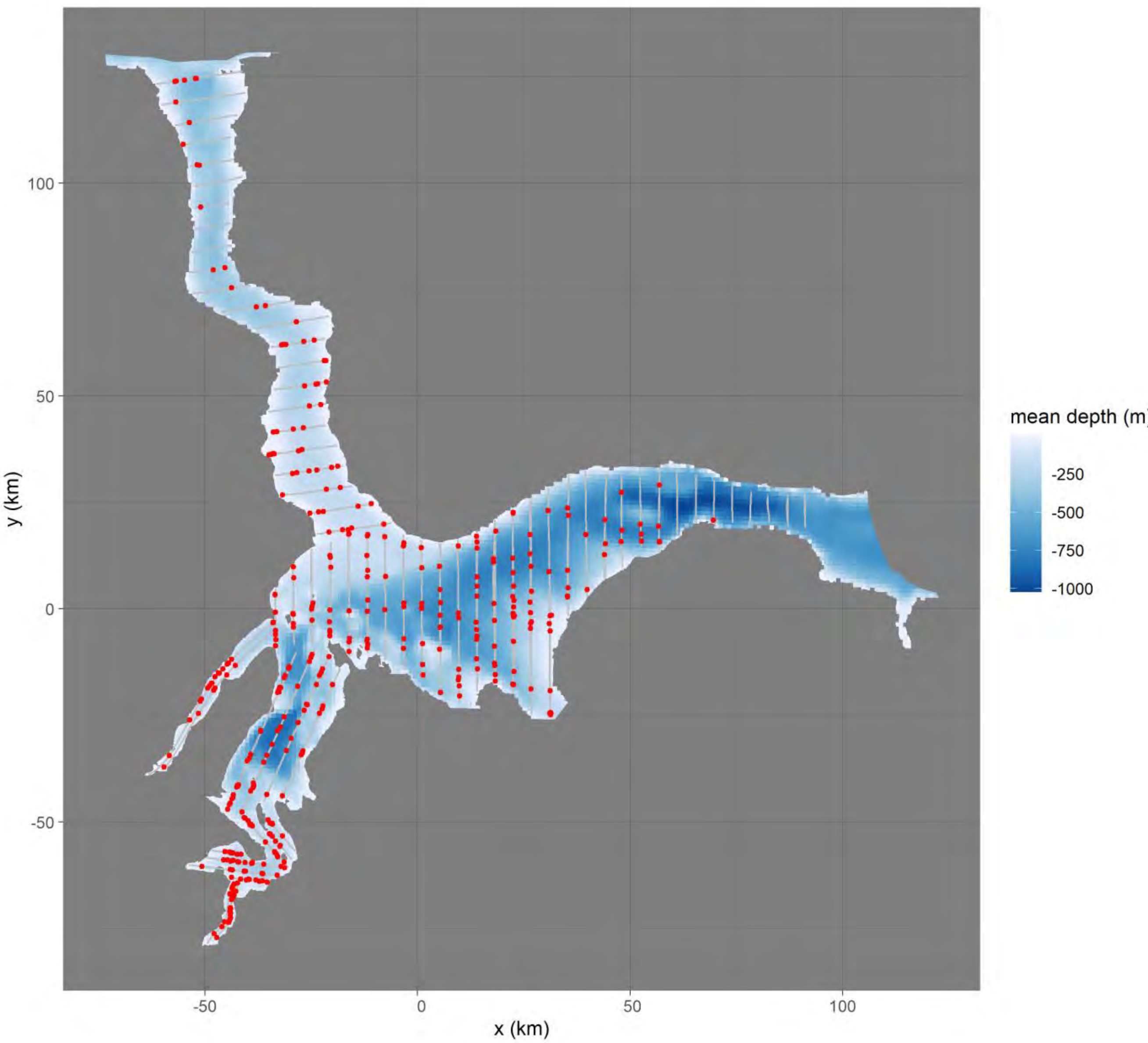


Figure A- 2: Example of covariate “mean depth”, computed for the study area. Red circles: sightings of ringed seals.

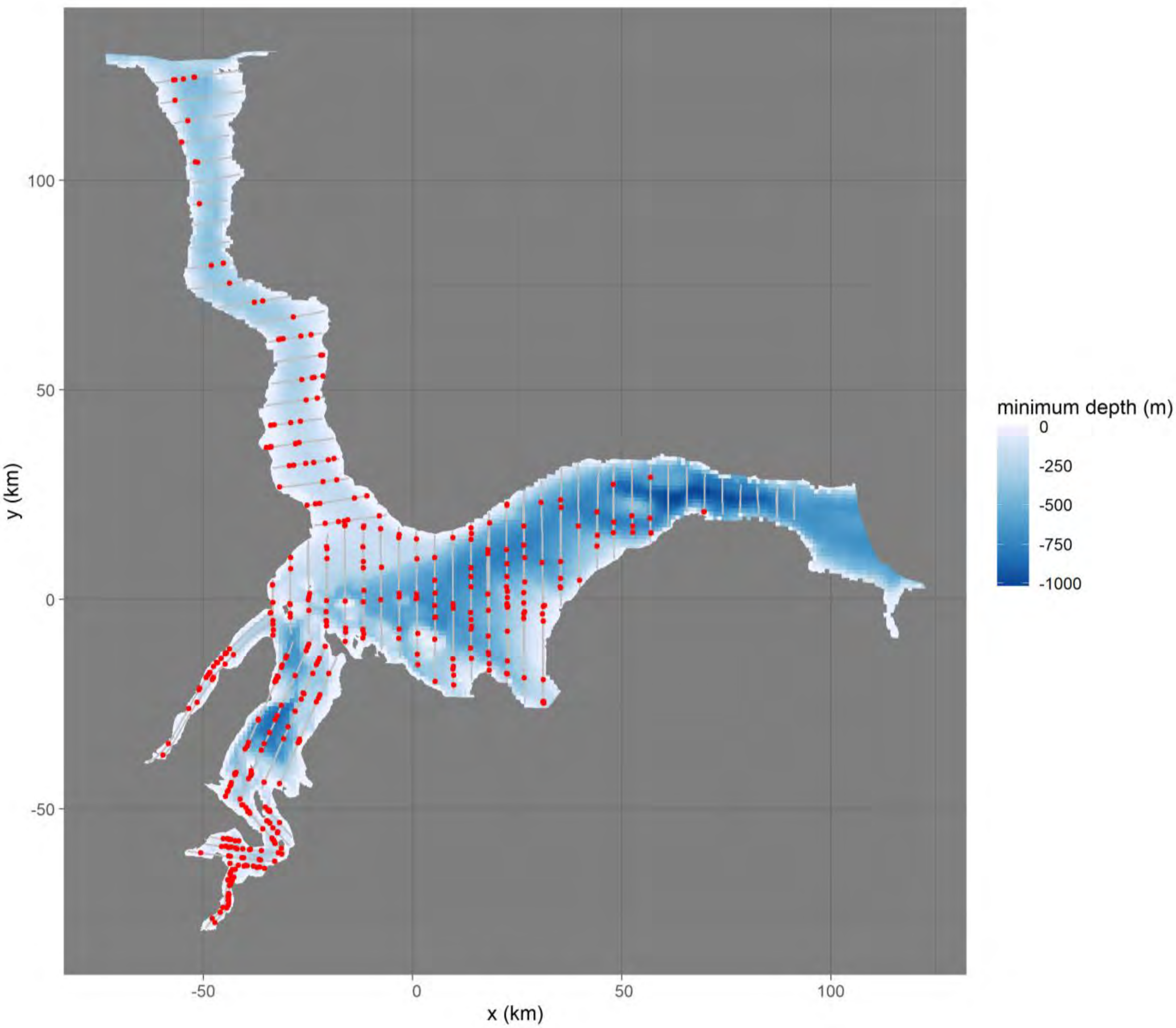


Figure A- 3: Example of covariate “minimum depth”, computed for the study area. Red circles: sightings of ringed seals.

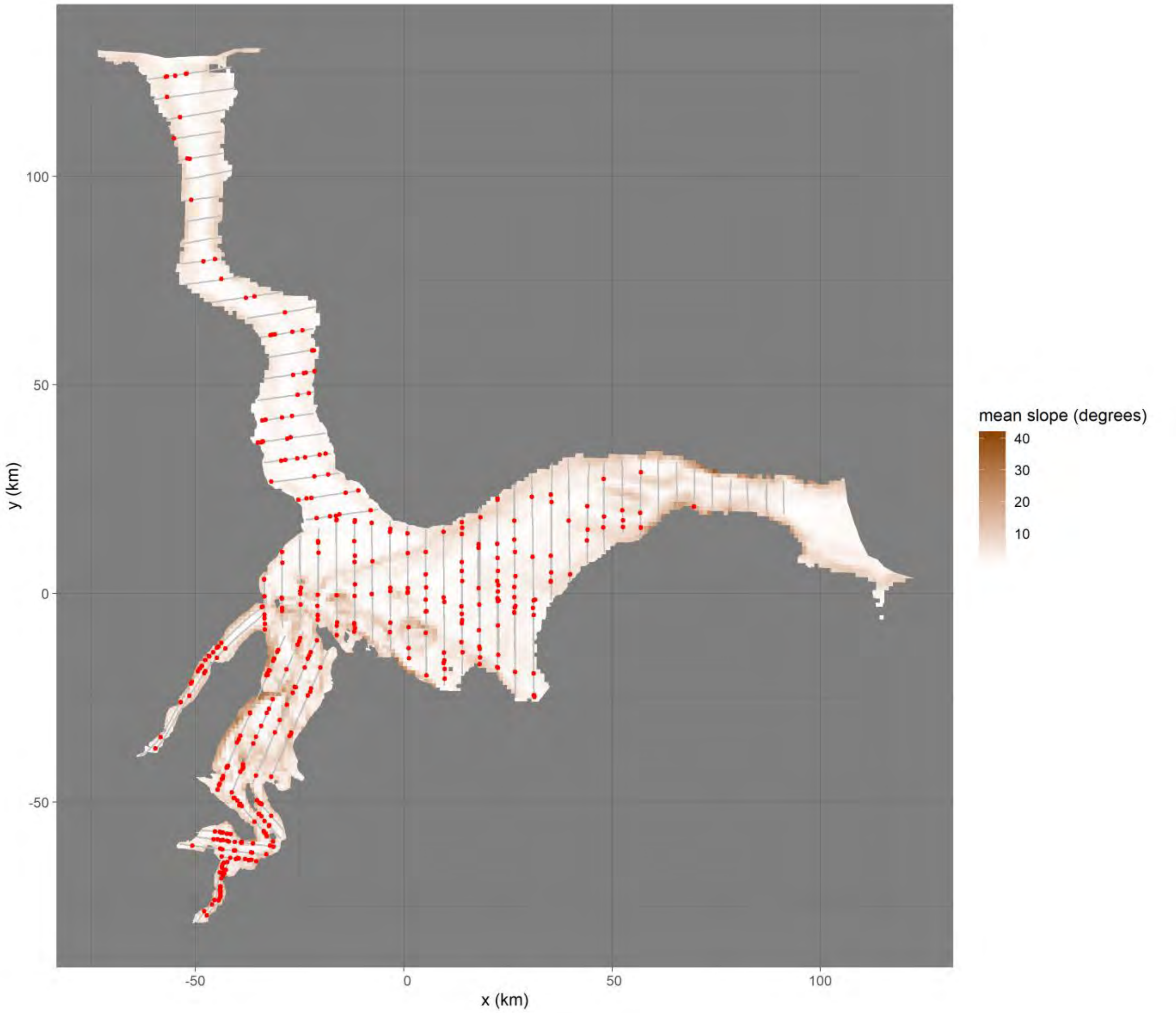


Figure A- 4: Example of covariate “mean slope”, computed for the study area. Red circles: sightings of ringed seals.

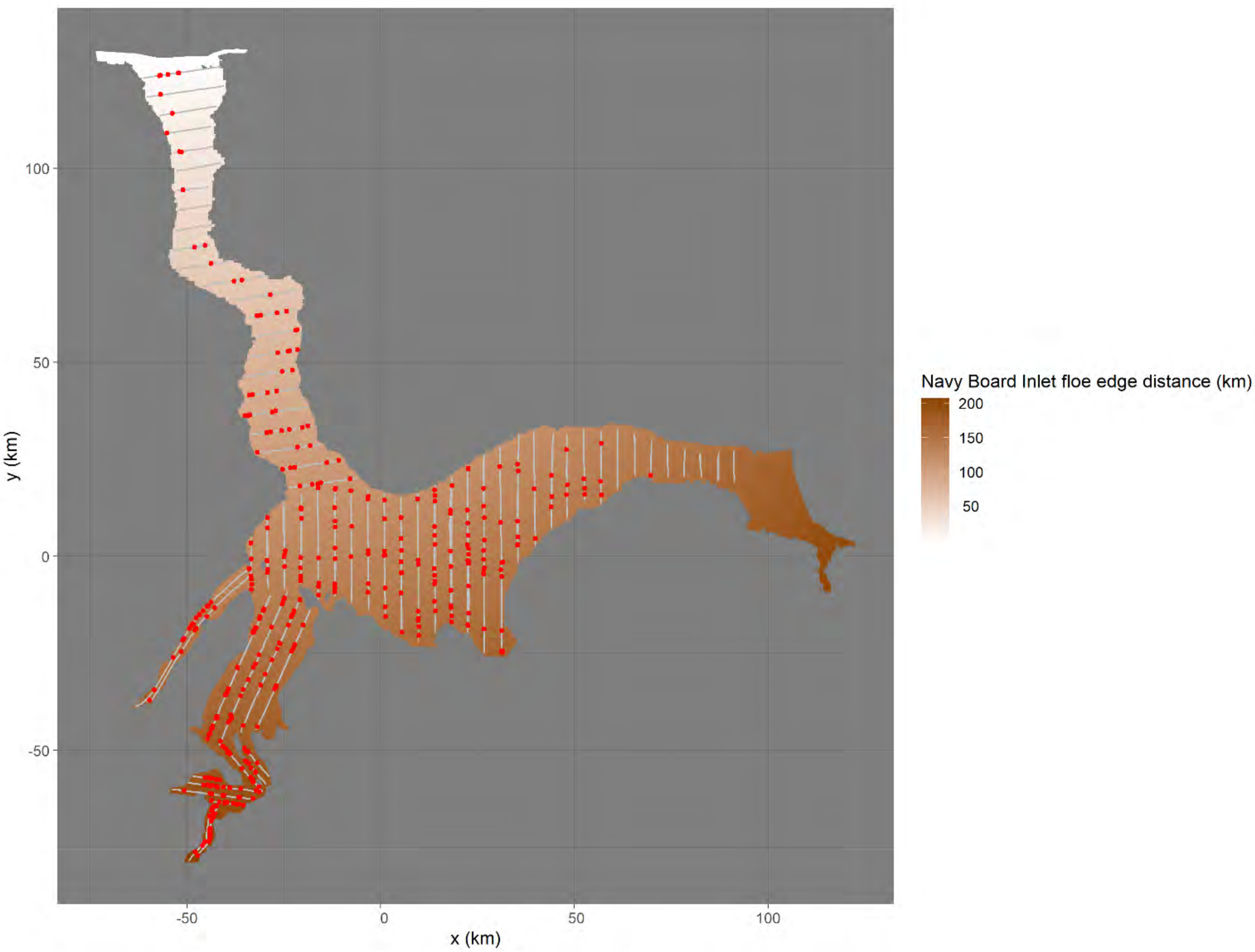


Figure A- 5: Example of covariate “distance from Navy Board Inlet floe edge”, computed for the study area. Red circles: sightings of ringed seals.

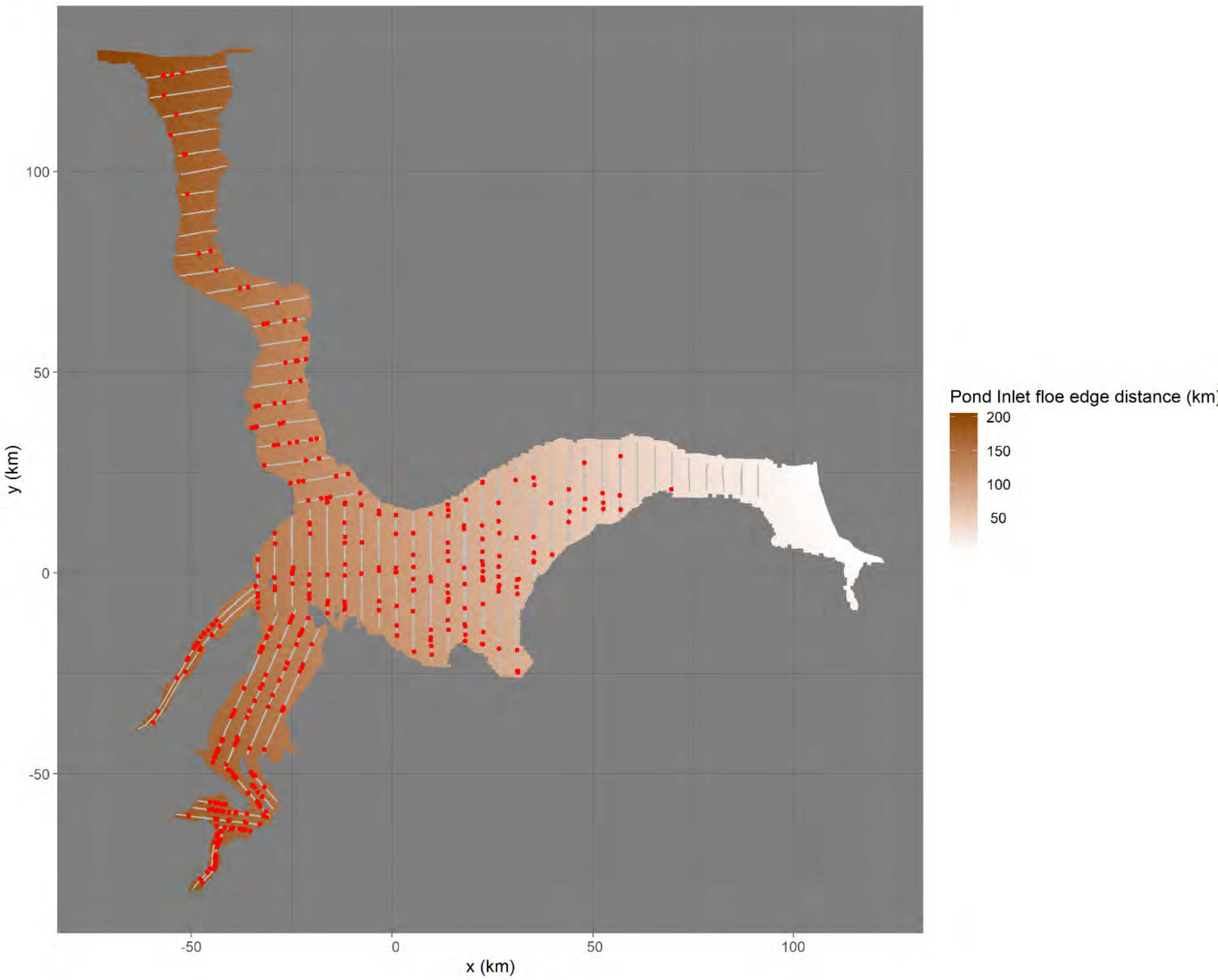


Figure A- 6: Example of covariate “distance from Pond Inlet floe edge”, computed for the study area. Red circles: sightings of ringed seals.

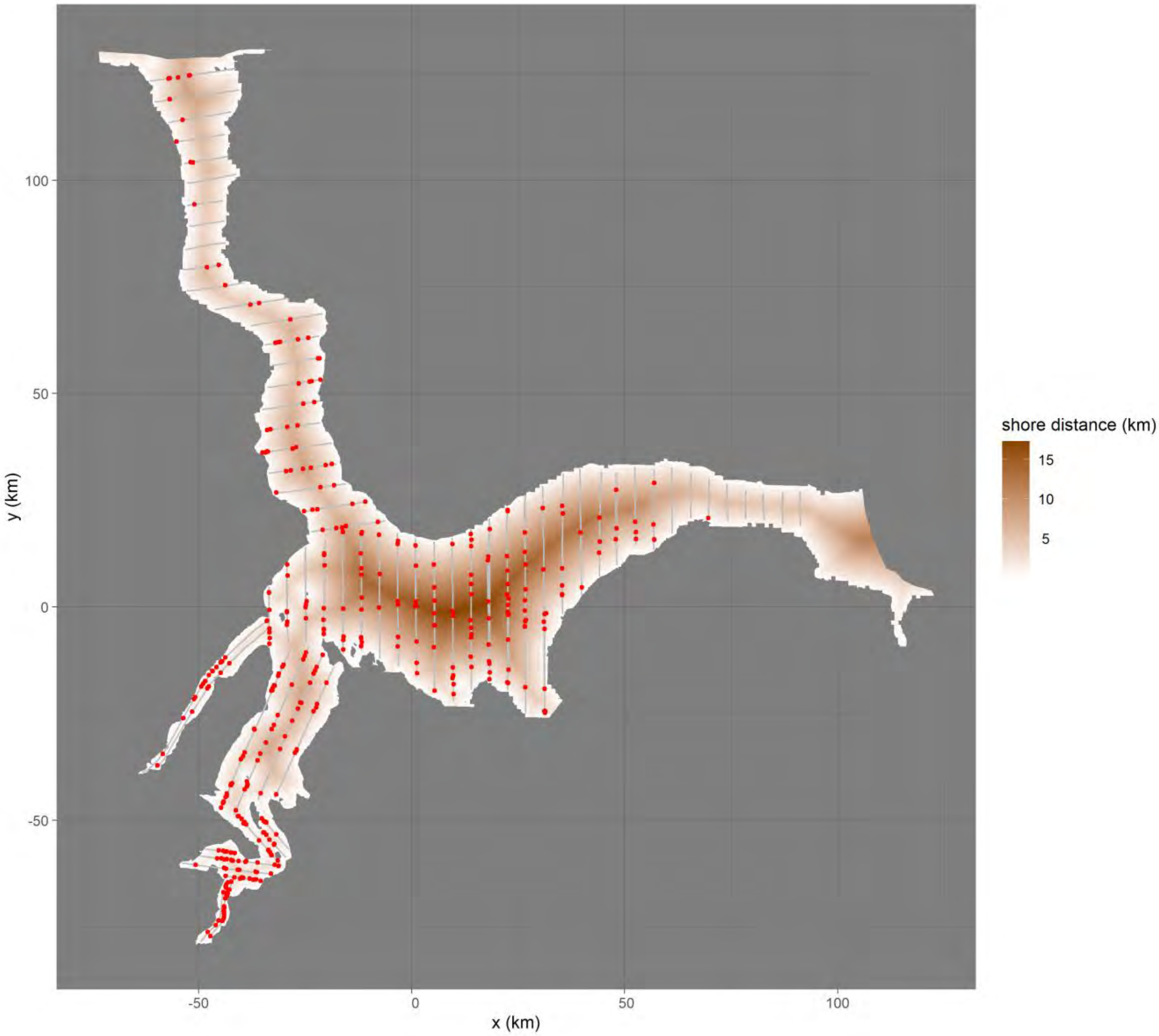


Figure A- 7: Example of covariate “distance from shore”, computed for the study area. Red circles: sightings of ringed seals.

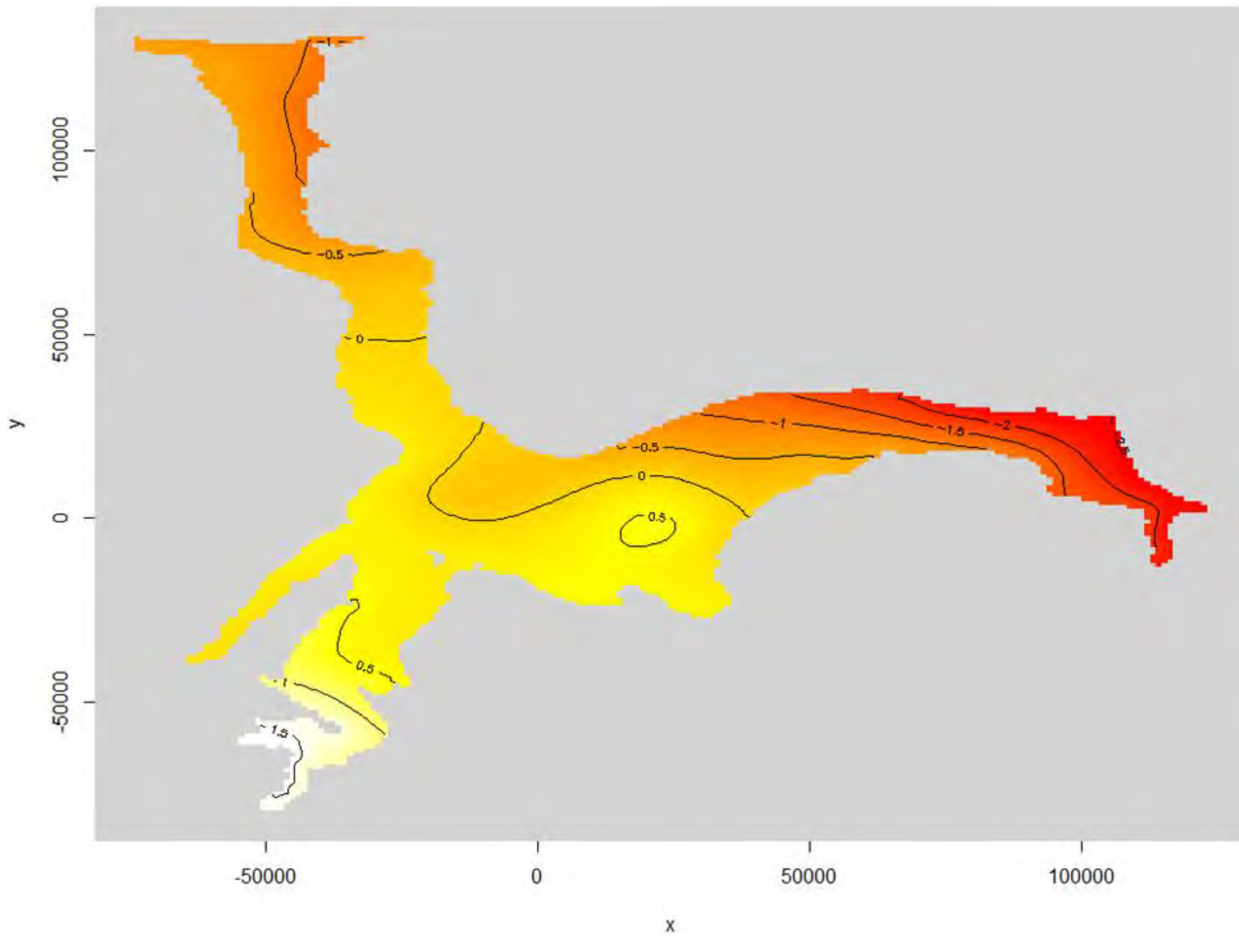


Figure A- 8: Soap film smoother of xy coordinates (edf 15.01)

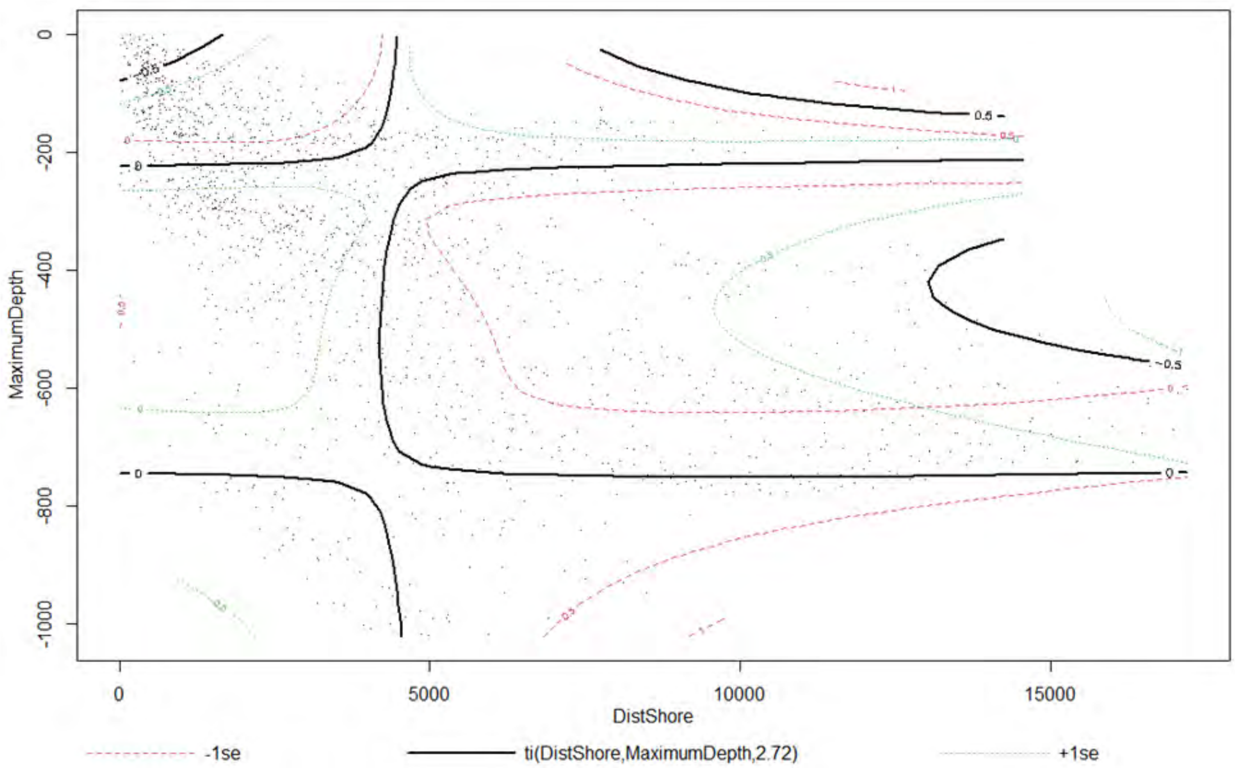


Figure A-9: Tensor smooth of distance from shore and maximum depth (edf 2.72)

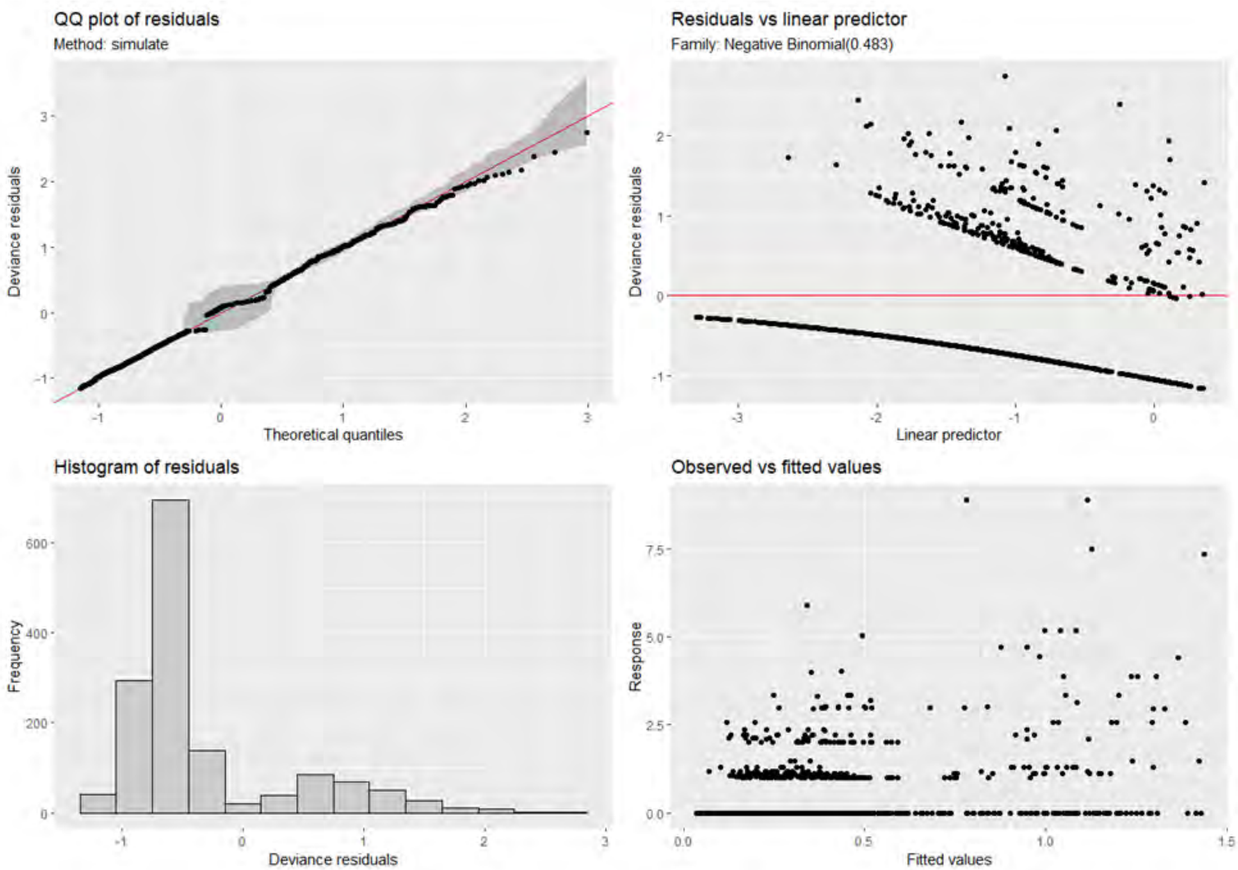


Figure A-10: Diagnostic plots of fitted GAM model

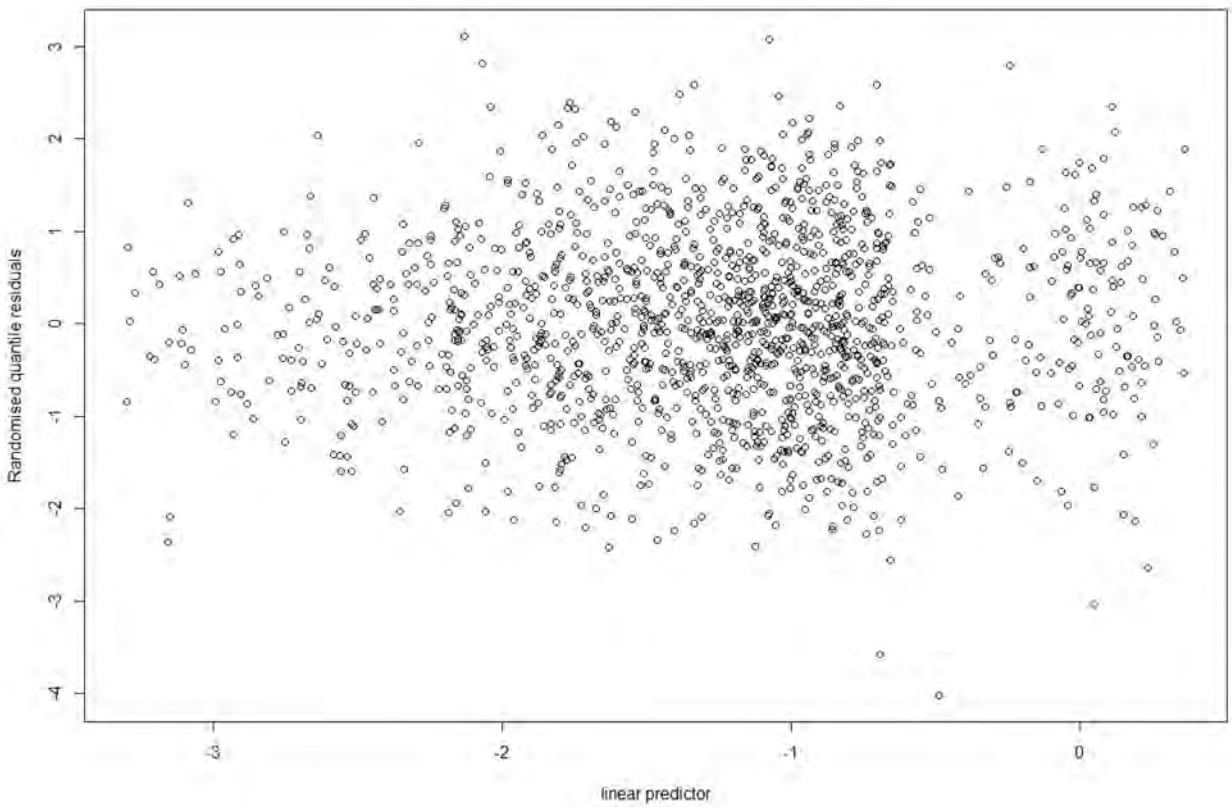


Figure A-11: Randomized quantile residuals vs linear predictor

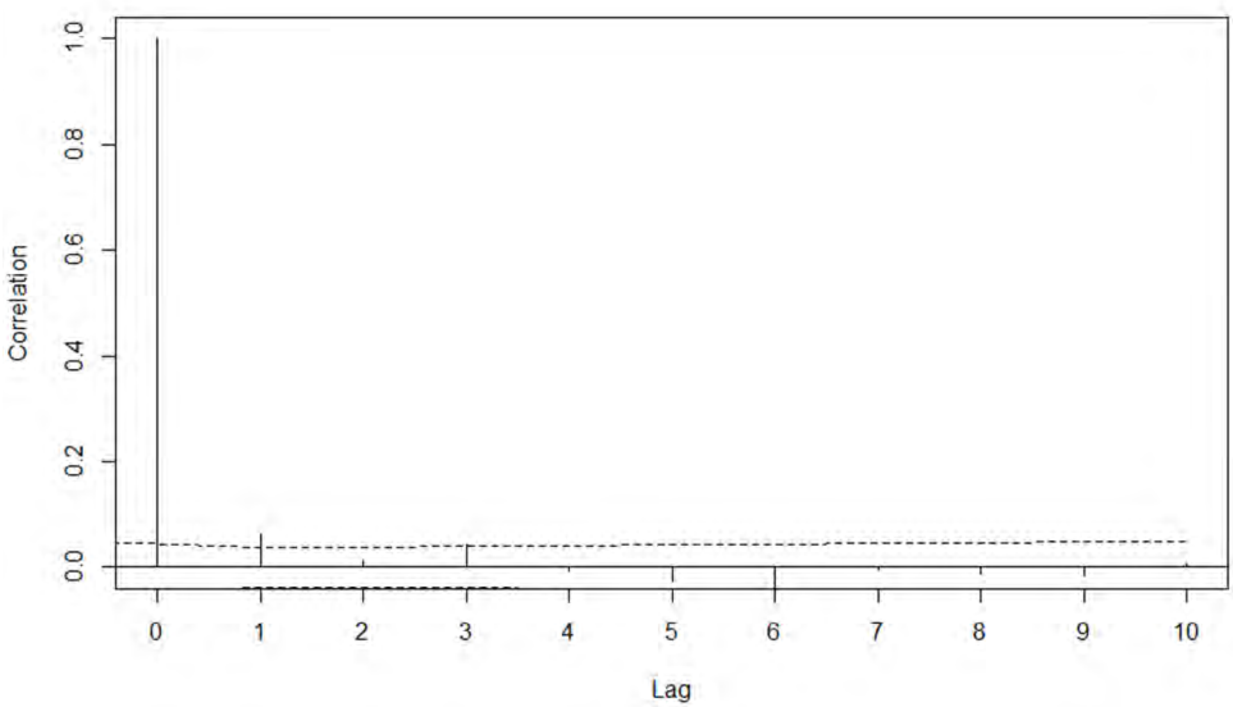
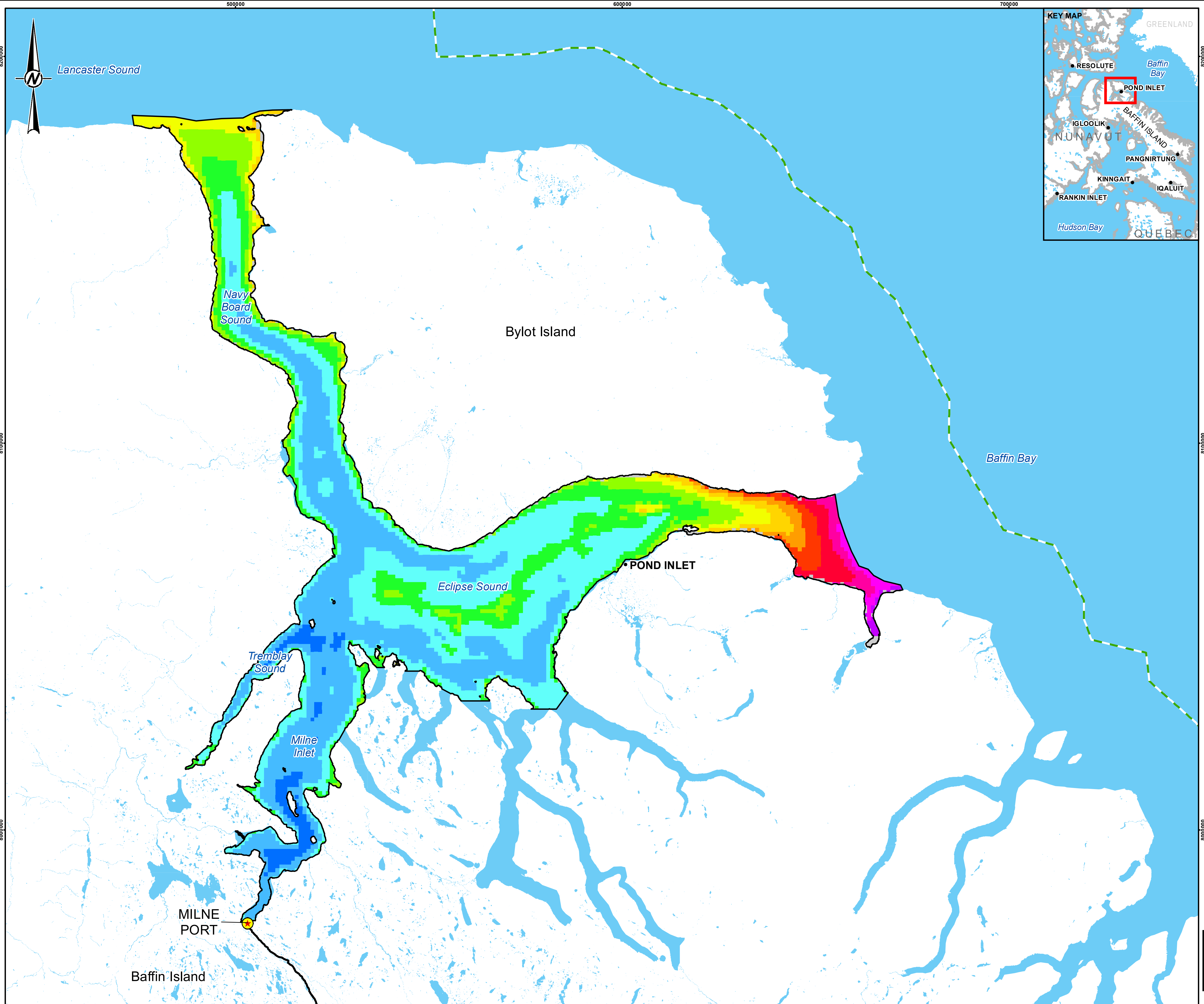


Figure A-12: Autocorrelation in residuals for transect segments



LEGEND

- COMMUNITY
- MILNE PORT
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA BOUNDARY
- STUDY AREA

UNCERTAINTY IN PREDICTION SURFACE OF DENSITY SURFACE MODEL

- ≤ 0.20
- > 0.20 AND ≤ 0.25
- > 0.25 AND ≤ 0.30
- > 0.30 AND ≤ 0.55
- > 0.35 AND ≤ 0.40
- > 0.40 AND ≤ 0.45
- > 0.45 AND ≤ 0.50
- > 0.50 AND ≤ 0.55
- > 0.55 AND ≤ 0.60
- > 0.60 AND ≤ 0.65
- > 0.65 AND ≤ 0.70
- > 0.70 AND ≤ 0.75
- > 0.75
- INSUFFICIENT DATA

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2021 RINGED SEAL AERIAL SURVEYS

TITLE
UNCERTAINTY IN PREDICTION SURFACE OF DENSITY SURFACE MODEL

CONSULTANT
[redacted]

YYYY-MM-DD	2022-06-21
DESIGNED	MF
PREPARED	AJA
REVIEWED	TT
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	41000-05	0	A-13

APPENDIX B

Distance Sampling and Mark-Recapture Models

Table B-1: Ringed Seal Distance Sampling and Mark-Recapture Models

Distance Sampling (all top models included gamma key function and series expansion using cosine orders 4 and 5)			Mark-Recapture	
AIC	Model[1]		AIC	Model[1]
29672.96	~ObsPair + CloudCover:Sightability		4457.861	~distance:obsrv:ObsPair + ObsPair + PercDeform:Sightability
29673.85	~ObsPair + CloudCover:Sightability + PercMelt:PercDeform		4460.542	~ distance:obsrv:ObsPair + ObsPair + Sightability + size
29675.04	~ObsPair + CloudCover		4460.705	~ distance:obsrv:ObsPair + ObsPair + IceDeform + Sightability + size
29675.35	~ObsPair + CloudCover + PercDeform		4461.104	~ distance:obsrv:ObsPair + ObsPair + Sightability + size
29675.97	~ObsPair + CloudCover + Sightability		4461.278	~ distance:obsrv:ObsPair + ObsPair + PercDeform + size
29676.94	~ObsPair + CloudCover:IceType		4461.505	~ distance:obsrv:ObsPair + ObsPair + PercDeform + Sightability
29677.01	~ObsPair + CloudCover + IceType		4461.904	~ distance:obsrv:ObsPair + ObsPair + PercDeform:IceType + size
29677.01	~ObsPair + CloudCover + Sightability + PercMelt:PercDeform		4462.139	~ distance:obsrv:ObsPair + ObsPair + PercDeform
29681.47	~ObsPair + CloudCover:PercDeform		4462.278	~ distance:obsrv:ObsPair + ObsPair + CloudCover + PercDeform + size
29682.26	~ObsPair + CloudCover:PercDeform + Glare		4462.957	~ distance:obsrv:ObsPair + ObsPair + PercDeform:IceType
29682.59	~ObsPair + Side:CloudCover:PercDeform		4462.963	~ distance:obsrv:ObsPair + ObsPair + PercDeform + IceType + size

Distance Sampling (all top models included gamma key function and series expansion using cosine orders 4 and 5)			Mark-Recapture	
AIC	Model[1]		AIC	Model[1]
29682.94	~ObsPair + PercMelt:Sightability		4463.084	~ distance:obsrv:ObsPair + ObsPair + CloudCover + PercDeform
29683.46	~ObsPair + CloudCover:PercDeform + IceType		4463.176	~ distance:obsrv:ObsPair + ObsPair + CloudCover:PercDeform + size
29683.77	~ObsPair		4463.199	~ distance:obsrv:ObsPair + ObsPair + PercDeform + PerIce + size
29684.15	~ObsPair + PercMelt:PercIce		4463.275	~ distance:obsrv:ObsPair + ObsPair + PercMelt + PercDeform + size
29684.25	~ObsPair + CloudCover:PercDeform + Glare + IceType		4463.791	~ distance:obsrv:ObsPair + ObsPair + CloudCover:PercDeform + Glare + size
29684.32	~ObsPair + PercMelt:PercDeform		4463.854	~ distance:obsrv:ObsPair + ObsPair + PercDeform + IceType
29684.44	~ObsPair + CloudCover:PercIce		4463.998	~ distance:obsrv:ObsPair + ObsPair + CloudCover:PercDeform
29684.46	~ObsPair + PercDeform		4464.038	~ distance:obsrv:ObsPair + ObsPair + PercDeform + PercIce
29684.67	~ObsPair + Glare		4464.13	~ distance:obsrv:ObsPair + ObsPair + PercMelt + PercDeform

1) CloudCover = percent cloud cover, distance = horizontal distance, Glare = glare intensity, IceType = ice type, ObsPair = pairing of individual observers, obsrv = primary/secondary observer, PercDeform = percent ice deformation, PercIce = percent ice cover, PercMelt = percent ice melt, Sightability = sighting conditions, Side = side of aircraft, size = group size.

APPENDIX C

Response to MEWG Comments

Baffinland

Baffinland Mary River Project Report Working Group Comment Form

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

Comment No.:	*DFO-11*
Section Reference:	*4.0 Summary*
Comment:	

Issue:
The conclusion "effects on ringed seal as a result of the Project would not result in population effects" is not supported by the data on ringed seal densities observed in June by aerial surveys methodology. The movements and immigration/emigration of seals into and out of the study area would be required in order to assess this assertion since this region may be a sink with ringed seals continuing to re-population the area despite adverse effects of the shipping activity.

Recommendation:
Further, as population density is likely a lagging indicator of population health, DFO recommends other indicators such as body condition indices (e.g., seasonal fat) and other demographic (e.g., reproductive success) that would potentially provide early indications of adverse effects on ringed seals.

NOTE:
The final recommendation does not fully satisfy TC119, as it states the baseline should inform the continued monitoring for life span of the project. Continued engagement with the MEWG to determine future monitoring and should address aspects such as condition, and spatial migration.

Baffinland Response:

We acknowledge DFO's comment but are of the opinion that seal body condition (i.e., fat layer) and reproductive success are not appropriate indicators for testing impact predictions related to Project shipping effects on ringed seal. Research conducted by DFO (Ferguson 2017) has demonstrated that declining ringed seal body condition is concurrent with sea-ice decline, one of the many consequences of climate change in the Canadian Arctic. Specifically, the study documents a relationship between the 2010 climatic event (i.e., warming event resulting in the earliest spring breakup and the latest ice formation on record) and ringed seal demographic changes, as body conditions were reduced, seals were stressed, and ovulation in seals decreased, leading to fewer pups in the following years. Arctic cod, which are an important component of ringed seal diet during early spring, are also thought be declining in numbers due to the increased length of the open water season associated with climate change. Although body condition is a potentially useful measurement of health, observed changes in body condition may be the result of a change in local and regional environmental conditions rather than a result of exposure to shipping (i.e., noise disturbance) (Booth et al. 2020), and therefore are not ideal indicators for evaluating for potential Project-induced effects as predicted in the impact assessment. The other constraining issue is that there is no existing reliable baseline for either of the indicators suggested by DFO. The Mary River Project is currently in its seventh year of shipping in the RSA, so there is no opportunity at this stage of the Project to collect additional baseline data (given that the Project is currently operational).

The relevant monitoring objective stated in TC119 is as follows: "*The Proponent shall, in conjunction with the Marine Environment Working Group, monitor ringed seal birth lair abundance and distribution for at least two years prior to the start of icebreaking to develop a baseline, with continued monitoring over the life of the Project as necessary to test the accuracy of the impact predictions and determine if mitigation is needed.*" Ringed seal density estimates in the RSA collected in 2016 and 2017 (Young et al. 2019 provide two years of collected ringed seal abundance and distribution data prior to the start of icebreaking operations in 2018. An additional year of ringed seal aerial survey data collected by Baffinland in 2021 (which partially meets the requirement for 'continued monitoring' throughout the life of the Project) has allowed for a comparison of seal numbers in the RSA between pre- and post- icebreaking periods. Baffinland will continue to collect ringed seal aerial survey data in the RSA at an appropriate sampling frequency throughout the life of the Project to continue to monitor and evaluate this potential impact pathway for ringed seal.

Booth, C.G., R.R. Sinclair, and J. Harwood. 2020. Methods for monitoring for the population consequences of disturbance in marine mammals: a review. Frontiers in Marine Science. 7: 15.

Ferguson, S.H., B.G. Young, D.J. Yurkowski, R. Anderson, C. Willing, O. Nielsen. 2017. Demographic, ecological, and physiological responses of ringed seals to an abrupt decline in sea ice availability. PeerJ 5:e2957 https://doi.org/10.7717/peerj.2957.

Young, B.G., D.J. Yurkowski, J.B. Dunn, and S.H. Ferguson. 2019. Comparing infrared imagery to traditional methods for estimating ringed seal density. Wildlife Society Bulletin; DOI: 10.1002/wsb.958.

Baffinland

Baffinland Mary River Project Report Working Group Comment Form

Reviewer Agency/Organization:	QIA
Reviewers:	Jeff W. Higdon, D. Bruce Stewart
Document(s) Reviewed:	Mary River Project 2021 Ringed Seal Serial Survey (file "2021 Ringed Seal Aerial Survey Report Draft for MEWG.pdf") 23 March 2022
Date Review Completed	2022-06-08

Comment No.:	QIA-01
Section Reference:	General (e.g., sections 2.4.4, 2.5.1, 3.4.4.1, 3.5.2)
Comment:	

Throughout the draft document it can be complicated and difficult to identify and assess trends and patterns based on the text. Summary figures (e.g., plotting the various density estimates over time, with different symbols for strip- and line-transect results) would greatly help here. Figures should show the full temporal span of the data, showing trends from 2014 to 2021(rather than comparisons of 2014 and 2016 only, 2016 and 2021 only, etc.).

Baffinland Response:

A summary table is provided in the report in Section 4.0. It provides all density estimates over the full temporal span from 2007 to 2021 from all available data sources and for each stratum. Figure 27 has been added to the report showing various density estimates over time, with different symbols for strip and line transect results.

Comment No.:	QIA-02
Section Reference:	Executive Summary (and s. 4.0, etc.)
Comment:	

A mix of Z- and t-tests were used for density comparisons. What factors were used to decide which test was used?

Baffinland Response:

When dealing with small sample sizes (< 30), it is recommended to use the t-test in place of the Z-score (Buckland et al. 2001). When comparing between years at the region level, sample sizes were sufficient to use the Z-score for comparisons. For strata comparisons, sample sizes were small and therefore a t-test was used.

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

Comment No.:	QIA-03
Section Reference:	General (e.g., Executive Summary, 2.3.1, 2.4.2
Comment:	

Sea ice conditions (including the amount of ridging and snow cover) can have a significant influence on ringed seal habitat selection, and weather conditions (e.g., temperature, wind speed, cloud cover) can influence haul-out behaviour.

More information on weather and sea ice conditions is needed to interpret any differences in density between surveys and changes in hot spot locations. The information on sighting conditions (section 2.4.2) provides a summary of the overall conditions encountered in each survey, but what is important here is an understanding of how conditions (as model covariates) influence haul out behaviour and resulting density estimates and hot spot identification.

Section 2.3.1 states that air temperature values were obtained Windy.com’s European Centre for Medium-Range Weather Forecasts model of the surface conditions.

1. What is the temporal resolution of the data?

Sections 2.4.2 and 3.4.2 summarize air temperatures but provide limited information, and none of the models shown in Appendix B includes air temperature.

2. Was air temperature included in the analyses as a covariate?
3. If it was included, how was it defined (spatial resolution, etc.)?

Section 3.4.3 notes that seal numbers varied between surveys despite being separated by only 72 hours, which highlights the importance of considering weather (cloud cover, air temperature, etc.) as explanatory factors. For snow/ice roughness values, these were subjective estimates (e.g., section 2.3.1).

4. Was there any attempt to measure observer variability or determine the level of consistency in assessments from different observers? Ice roughness was included in some of the mark-recapture models (e.g., section 3.4.4.2.1), underscoring its’ importance.
5. Have Golder and Baffinland considered using satellite-based snow thickness measurements?

See Zhou et al. (2021) for a discussion of snow depth over Arctic sea ice products, and Braakmann-

Folgmann and Donlon (2019) and Lee et al. (2021) for snow depth estimation using satellite radiometer measurements. Finally, Iacozza and Ferguson (2004) provide a Canadian Arctic example, where snow on sea ice data were acquired from the AMSR-E sensor onboard the Aqua satellite. There have also been significant recent advances in using satellite products to measure ice roughness and surface topography (e.g., Farrell et al. 2020; Han et al. 2020; Segal et al. 2020, among others) which should be reviewed and evaluated for their usefulness in measuring these parameters.

Braakmann-Folgmann, A. and Donlon, C.: Estimating snow depth on Arctic sea ice using satellite microwave radiometry and a neural network, The Cryosphere, 13, 2421–2438, https://doi.org/10.5194/tc-13-2421-2019, 2019.

Farrell, S.L., Duncan, K., Buckley, E.M., Richter-Menge, J., and Li, R. 2020. Mapping sea ice surface topography in high fidelity with ICESat-2. Geophysical Research Letters 47(21): e2020GL090708.

Han, H., Kim, J.-I., Hyun, C-U., Kim, C.H., Park, J-W., Kwon, Y-J., Lee, S., Lee, S., and Kim, H-C. 2020. Surface roughness signatures of summer arctic snow-covered sea ice in X-band dual-polarimetric SAR. 2020. GIScience & Remote Sensing 57(5): 650-669.

Iacozza, J., and Ferguson, S.H. 2014. Spatio-temporal variability of snow over sea ice in western Hudson Bay, with reference to ringed seal pup survival. Polar Biology 37: 817-832.

Lee, S.-M., Shi,H., Sohn, B.-J., Gasiewski, A.J., Meier, W.N., and Dybkjær, G. 2021. Winter snow depth on Arctic sea ice from satellite radiometer measurements (2003–2020): Regional patterns and trends. Geophysical Research Letters 48(15): e2021GL094541

Segal, R.A., Scharien, R.K., Cafarella, S., and Tedstone, A. 2020. Characterizing winter landfast sea-ice surface roughness in the Canadian Arctic Archipelago using Sentinel-1 synthetic aperture radar and the Multi-angle Imaging SpectroRadiometer. Annals of Glaciology 61(83): 284-298.

Zhou, L., Stroeve, J., Xu, S., Petty, A., Tilling, R., Winstrup, M., Rostosky, P., Lawrence, I. R., Liston, G. E., Ridout, A., Tsamados, M., and Nandan, V. 2021. Inter-comparison of snow depth over Arctic sea ice from reanalysis reconstructions and satellite retrieval, The Cryosphere 15: 345-367.

Baffinland Response:

1. The ECMWF model used for assessing wind speed on Windy.com has a temporal resolution of 3 hours.

2. Air temperature was not included as a covariate in the Density Surface Modelling (DSM). For a covariate to be valid, it has to be available for every cell in the density prediction grid and it was not practical to record air temperature for thousands of locations using this method.

3. As noted above, air temperature was not included as a covariate in the DSM.

4. Only one observer collected environmental data throughout the survey, thus observer variability is not a factor.

5. WSP Golder will evaluate using satellite-based snow thickness measurements in future survey efforts.

Comment No.:	QIA-04
Section Reference:	Executive Summary and Section 4.0
Comment:	

Executive Summary (p. iii) and repeated in Section 4.0 (p. 48) - "These results confirmed that mitigation measures were functioning as intended and that Project activities are being managed in a way that has not adversely affected ringed seals."

Not necessarily, Golder has shown that June density is variable but has remained similar. This is not the same as "no adverse effects", which Inuit have described. What impacts have Inuit observed and reported, and in what seasons?

Baffinland Response:

Through consultation undertaken for the Project, the key potential impacts of the Project on ringed seal that were first identified by Inuit were potential effects of icebreaking on seal dens/pupping and associated impacts on seal harvests on the sea ice. In this case, mitigation was introduced to avoid these critical life cycle periods altogether. For managing potential project effects outside of these critical life cycle periods, other notable mitigation measures have been proposed that are known to be highly effective, such as vessel speed restrictions in the RSA and limited transits during the shoulder seasons. In 2021 icebreaking in the spring was avoided entirely (note the surveys occurred prior to the shipping season, even if icebreaking had occurred).

Since this time, several community members voiced concerns that seal numbers in the Ragged Island anchorage location had decreased and this was thought to be linked to boat anchoring activities in this area. In more recent years, there have been reports by Inuit of lower harvesting success and lower number of ringed seals throughout the general RSA and at different times of the calendar year. Community members have also indicated that seal harvesting was impacted near Pond Inlet in 2020 due to noise disturbances caused by the Small Craft Harbour (SCH) construction in Pond Inlet.

Comment No.:	QIA-05
Section Reference:	Section 1.1 Project Background
Comment:	

The text lists ore production and ore carrier numbers for 2015 and 2017 to 2021. Why is 2016 not included?

Baffinland Response:

2016 has been added to the Project Background section.

Comment No.:	QIA-06
Section Reference:	Section 1.2, Section 4.0
Comment:	

Section 1.2, p. 3 notes that "[t]he RSASP was designed to address PC conditions related to evaluating potential disturbance to ringed seals from shipping activities that may result in changes in animal distribution, abundance, and migratory movements in the RSA."

1. How is the program evaluating migratory movements?

Table 12 (section 4.0, p. 49) summarizes Project Certificate conditions and, for PCC 101 re: monitoring that is "responsive to Inuit concerns", states that surveys allow "for evaluation of ringed seal large-scale displacement effects, abandonment of the RSA, moderate to large changes in density estimates".

2. What impacts have Inuit reported with respect to ringed seals, and how does the aerial survey program monitor these impacts and address concerns?
3. Are reported impacts limited to spring distribution and abundance and, if not, how are these additional impacts being monitored?
4. What impacts to ringed seals have harvesters identified that are not addressed by the aerial surveys, for example with respect to harvesting and food security, and how are these being assessed?

Baffinland Response:

1. Ringed seals generally demonstrate high site fidelity, with seals occupying similar home ranges used the previous winter and spring, and adopting similar annual migration behaviour (Kelly et al. 2010). If the Project (or a separate stressor external to the Project) were to result in changes to the home range or migratory behaviour of ringed seal in the RSA, we would expect to see this reflected through corresponding changes in ringed seal density in the various strata of the RSA. The results of the 2021 RSASP indicate that ringed seal densities are currently similar to densities recorded in 2016-2017 (noting ore shipping began in 2015 and icebreaking activities began in 2018).

2. See response to QIA-04. Aerial surveys allow Baffinland to derive density estimates (i.e. relative abundance) of ringed seals in the RSA and identify if there is a change in ringed seal density in the RSA (across strata) beyond natural annual variability.

3. As stated in the above response, ringed seals demonstrate high site fidelity. Thus, the densities presented in the present report are relevant to the periods ringed seal are closely associated with land-fast ice (fall, winter, spring). During the summer months, the relative abundance of ringed seal in the RSA is captured as part of the Marine Mammal Aerial Survey Program (where sightings data is collected for all marine mammals included ringed seal). To date, ringed seal sighting rates have not shown to be decreasing in the RSA (Golder 2022).

4. Impacts on ringed seal harvesting and food security is beyond the scope of the ringed seal aerial survey report. The present report is focused on quantifying ringed seal density and distribution in the RSA. With monitoring program results for ringed seal in 2021 remaining similar to previous years, the availability of seal for harvest should have also remained similar to previous years. Further discussion is required with the MHTO to reconcile differences between monitoring results and harvester's experiences.

Golder. 2022. 2021 Marine Mammal Aerial Survey Program (MMAS) – Draft Report. Golder Report No.1663724-353-R-RevB. Prepared by Golder Associates Ltd., Victoria, BC for Baffinland Iron Mines Corporation, Oakville, Ontario. 96 p.+ appendices.

Kelly, B. P., et al. 2010. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biology 33:1095–1109.

Comment No.:	QIA-07
Section Reference:	2.2 Study Area and Design
Comment:	

Figure 2 on page 8 is mis-labeled in the bottom right corner of the map as Figure 1.

Baffinland Response:

This has been corrected in the final version.

Comment No.:	QIA-08
Section Reference:	Section 2.3.2.2, section 2.4.5
Comment:	

The hotspot analysis used bathymetry data that was not uniform across the study area, ranging from 5 m resolution in Assomption Harbour, to 20 m resolution in Milne Inlet and western Eclipse Sound, to 500 m in eastern Eclipse Sound and Navy Board Inlet (section 2.3.2.2).

1. What were the various data sources?

Version 4 of the International Bathymetric Chart of the Arctic Ocean (IBCAO) is now available at 200 m resolution (and v. 3 released in 2012 was 400 m, so still an improvement over the 500 m resolution used here).

Bathymetry data informed the majority of the model covariates and it is therefore important that the best available data be used.

2. Why was a 500 m resolution used in some areas when finer resolution data are available?
3. How sensitive are results to variable bathymetric resolution?

Section 2.4.5, p. 35 states: "The low deviance explained value and issues with the diagnostic plots indicate that important covariates are likely missing from the models. Ice type/thickness and tidal currents/heights are likely to be import [sic] covariates that could help to explain the distribution of seal sighting [sic] but are not available in detail for the study area. Reducing the segment length and width when correlating bathymetry data may improve the model fit but this would require removing the 500 m bathymetry grid area from the model."

QIA recommends exploring a simpler solution here with respect to bathymetry - use a higher resolution data set.

Ice and snow thickness can be estimated from satellite imagery, as noted in a previous comment, and tidal data are available from stations at Cape Liverpool (northern Bylot Island) and Milne Inlet (Head).

4. Were any attempts made to include tidal data?
5. Snow roughness estimates were collected during the survey, was this included as a co-variate?

Jakobsson, M., Mayer, L.A., Bringensparr, C. et al. 2020. The International Bathymetric Chart of the Arctic Ocean Version 4.0. Scientific Data 7: 176. https://doi.org/10.1038/s41597-020-0520-9

Baffinland Response:

1. Bathymetry data sources: 500 m resolution bathymetry is from the ICBAO while both of the 5 and 20 m resolution bathymetry was compiled from Canadian Hydrographic Survey charts. We will investigate using the 200m IBCAO data in future models.

2. We were unaware that finer resolution bathymetry data was available.

3. We did not perform a sensitivity analysis for any variable in the model, but we would expect that the inclusion of refined bathymetry data would improve model performance.

4. The availability of tide data was investigated but no sources were apparent that would populate all cells of the prediction grid.

5. Snow roughness data was not included as a covariate in the model since it was not collected for all the cells in the prediction grid. For a covariate to be valid, it has to be available for every cell in the density prediction grid and it was not practical to record snow roughness for thousands of locations using this method.

Comment No.:	QIA-09
Section Reference:	Section 2.4.3
Comment:	

One polar bear was observed during the 2021 seal survey (section 2.4.3). Were no bears observed in the 2014 survey conducted by LGL?

Baffinland Response:

Two polar bear sightings were observed in the 2014 survey conducted by LGL. One sighting of a single polar bear was observed on 7 June 2014 in the Pond Inlet stratum. One sighting of a mother with two cubs was observed on 10 June 2014 in the Pond Inlet stratum.

Comment No.:	QIA-10
Section Reference:	Section 2.4.5, section 2.5.2
Comment:	

Did the ringed seal hotspot analysis use the same methods as that in Yurkowski et al. (2018)?

1. If not, how might this affect comparability?

Section 2.5.2 notes that a ringed seal hotspot identified in 2016 and 2017 in eastern Eclipse Sound was not present in 2021.

2. Why? What explanatory factors were considered?

Baffinland Response:

1. The ringed seal hotspot analysis in the 2021 Ringed Seal Aerial Survey Program did not use the same methods as that described in Yurkowski et al. (2018). The present study used density surface modelling (Miller et al. 2021; Wood 2021; Miller 2021), as indicated and referenced in Section 2.3.2.2 of the report. The ringed seal hotspot analysis methods employed by Yurkowski et al. (2018) involved the use of 5 km x 5 km grid cells for analysis, in combination with a 'diagonal' grid orientation and ~4.5km inter-transect spacing in the Eclipse-Milne region. This approach results in an unbalanced survey effort amongst the grid cells. Additionally, the inter-transect spacing of the transects in Navy Board Inlet were approximately twice that of the inter-transect spacing in Milne and Eclipse. This resulted in grid cells that were often associated with zero survey effort. There is no indication in Yurkowski et al. (2018) that seal counts were weighted by effort in the analysis. The statistic presented by Yurkowski et al. (2018) for spatial clustering (i.e., 'significant' hotspots) involved a comparative analysis of seal densities in nearby grid cells. Since the survey effort in adjacent grid cells would have varied considerably (due to variable survey effort across grid cells), the results presented for hot spots are likely skewed. For these reasons,

it was considered inappropriate to employ the methods used by Yurkowski et al. (2018) for the 2021 ringed seal hotspot analysis. As a result, results for the seal hotspot analysis are not statistically comparable between the present study and Yurkowski et al. (2018). The comparative analysis of ringed seal density between 2021 and the previous surveys in the RSA (Yurkowski et al. 2018) is based on the strip transect density data (i.e., the current report provides a comparative analysis of ringed seal density from strip transect data in 2021 to that in 2016-2017 as presented in Yurkowski et al. 2018).

2. Surveys flown in 2016 and 2017 surveyed the eastern Eclipse Sound stratum up to the Pond Inlet floe edge. The location of the ringed seal hotspot in Eastern Eclipse was located more westward in 2017 than in 2016. The most eastward survey transects in the 2021 survey were not flown at the request of the Mittimatalik Hunters & Trappers Organization (MHTO) to avoid potential interference with community harvesting at the floe edge (i.e., 2021 surveys did not include effort at or near the floe edge). Therefore, the 2021 survey transects only overlapped with the hotspot identified in 2017 and not 2016. This might explain why no similar hotspot in eastern Eclipse was identified in 2021. The text provided in Section 2.5.2 acknowledges this point with the following statement: "A possible explanation for the lack of a hotspot in eastern Eclipse Sound in 2021 may be a result of some transects being removed from the eastern portion of ES stratum".

Miller, D.L. 2021. Distance: Distance sampling detection function and abundance estimation. R package version 1.0.4.

Miller, D.L., Rexstad, E., Burt, L., Bravington, M.V. and S. Hedley. 2021. dsm: Density surface modelling of line transect data. R package version 2.3.1.

Wood, S. 2021. mgcv: Generalized additive (mixed) models. R package version 1.8-38.

Yurkowski, D.J., B.G. Young, J.B. Dunn, and S.H. Ferguson. 2018. Spring distribution of ringed seals (*Pusa hispida*) in Eclipse Sound and Milne Inlet, Nunavut: implications for potential ice-breaking activities. Arctic Science https://doi.org/10.1139/as-2018-0020.

Comment No.:	QIA-11
Section Reference:	Section 2.4.5, Appendix A
Comment:	

Re: co-variates, why use "distance from Navy Board Inlet floe edge" and "distance from Pond Inlet floe edge" for all sightings? Distance to the Eclipse Sound floe edge would be more relevant for some sightings, whereas Navy Board Inlet could be more relevant to others. Using a "distance to closest floe edge" variable might better reflect the influence of floe edge locations on seal distribution throughout the RSA.

Baffinland Response:

During the data analysis stage, we did explore the use of one co-variable for 'distance to floe edge', as opposed to a separate co-variable for each floe edge during the analysis stage. This approach resulted in a poor (i.e., unrealistic) fit of the modelled data relative to the actual recorded observations. Assigning a separate co-variable for each floe edge location allowed for a better fit of the modelled data.

A 'closest floe-edge' variable was attempted but its inclusion in the model would cause the resulting prediction to produce drastically skewed results when compared to actual observations. The interpretation was that with a high concentration of sightings in the southeast of the study area combined with the floe edges occurring in the north and east of the study area, that the simple linear relationship between the variables overwhelmed other variables in the model including the spatial portion of the model.

Comment No.:	QIA-12
Section Reference:	5.0 Recommendations
Comment:	

No 2022 survey is recommended. There was no icebreaking activity in 2021, is it proposed for 2022?

Baffinland Response:

No icebreaking activity is proposed to occur during the 2022 early shoulder season.

Comment No.:	QIA-13
Section Reference:	Appendix B - Distance Sampling and Mark-Recapture Models
Comment:	

Table B-1 caption says "Narwhal".

Baffinland Response:

The caption in Table B-1 was mislabeled (should read 'ringed seal'). The text in the table caption has been corrected in the final report.

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