REPORT

Mary River Project

2023 Ship-based Observer Program

Submitted to:

Baffinland iron Mines Corporation

2275 Upper Middle Road East - Suite 300 Oakville, Ontario

Submitted by:

WSP Canada Inc.

300- 3600 Uptown Boulevard Victoria, BC V87 0B9 Canada

+1 250 881 7372

166372402-494-R-Rev0-74000

15 March 2024

Distribution List

e-copy: Baffinland Iron Mines Corporation#

Executive Summary

WSP Canada Inc. (WSP) on behalf of Baffinland Iron Mines Corporation (Baffinland), conducted a Ship-based Observer (SBO) Program onboard the icebreakers *Botnica* and *Fennica* during the fall shoulder season (21-30 October) of 2023. The SBO Program was designed to meet Conditions No. 99, 101, 106, 108, 123 and 126 of Project Certificate No. 005. The primary objective of the SBO Program was to monitor for potential ship strikes on marine mammals and seabirds in the Regional Study Area (RSA). The second objective of the SBO program was to collect observational data on the presence, relative abundance and distribution of marine mammals and seabirds, as well as behavioural responses, within the boundaries of the RSA relative to Project vessel operations. Project shipping in 2023 began on 17 July 2023 and ended on 30 October 2023.

Data collection methodology for the 2023 SBO Program was similar to the 2018 and 2019 SBO Programs with slight adjustments in protocol to address recommendations provided by the Marine Environmental Working Group (MEWG). In addition to marine mammal observations, seabird sightings were recorded using the Canadian Wildlife Service's (CWS) Eastern Canada Seabirds at Sea (ECSAS) survey protocol.

Prior to the start of the 2023 SBO Program, Marine Wildlife Observer (MWO) candidates from Pond Inlet were trained in marine wildlife identification, monitoring techniques, and data entry protocols. From 16 to 22 September 2023, one Inuit MWO traveled to Ottawa, Ontario and participated in the Transport Canada approved marine safety training course "Small Domestic Vessel Basic Safety" and obtained his Transport Canada marine medical. WSP provided a one-day MWO training session for all three MWOs prior to commencement of the program.

The MWOs were responsible for recording marine wildlife sightings from the bridge of the *Botnica* and *Fennica* during dedicated watch periods. Monitoring protocol differed for marine mammals and seabirds. Marine mammal sightings were recorded over a daily monitoring period extending up to 9.5 hours (h) during the 2023 SBO Program, depending on available daylight hours. Seabird sightings were recorded during dedicated seabird surveys conducted periodically throughout the day (lasting one to two hours each). The total daily watch period for seabirds was variable depending on sighting conditions, ranging from 0.5 h to 4.5 h.

Marine Mammals

Total monitoring effort during the SBO Program was 89.5 h covering a total of 1,179.6 km between the two icebreakers. Most survey effort was from the *Botnica* from 21 to 27 October 2023 (52.2 h covering 675.1 km) with a dedicated observation team on each side of the vessel for 98% of the total survey period. From 28 to 30 October 2023, observations were conducted from both the *Botnica* (18.4 h covering 248.7 km) and the *Fennica* (18.7 h covering 255.8 km). Total monitoring effort for the *Botnica* from 21 to 27 October and considering the lead vessel only from 28 to 30 October 2023 was 70.7 hours covering 949.9 km.

Five different marine mammal species were observed during the 2023 SBO Program including narwhal, ringed seal, harp seal, bearded seal, and polar bear. Beluga, bowhead whale, killer whale, and walrus were not observed in the RSA during the 2023 SBO Program; however, these species are known to occur in the region. A total of 431 marine mammal sightings comprising 562 individuals were recorded during the 2023 SBO Program.

The relative abundance of marine mammals in the RSA during the 2023 SBO Program, expressed as the animal detection rate (no. of individuals relative to survey effort in km) was 0.503 individuals/km (0.382 sightings/km). Ringed seal had the highest detection rate at 0.401 individuals/km (0.350 sightings/km), followed by harp seal (0.058 individuals/km), narwhal (0.018 individuals/km), unidentified seal (0.015 individuals/km), bearded seal (0.007 individuals/km), and polar bear (0.004 individuals/km).

The relative abundance of marine mammals in the RSA was similar in fall of 2023 (0.503 individuals/km) to that observed in fall 2018 (0.530 individuals/km). Fall 2018 and 2023 had higher relative abundance rates compared to Fall 2019 (0.16 individuals/km). Harp seal was the species with highest relative abundance rates in 2018 (0.225 individuals/km) and 2019 (0.059 individuals/km), while ringed seal was the species with the highest relative abundance rate in 2023 (0.401 individuals/km). Species observed with higher relative abundance in fall 2023 than previous years included ringed seal, bearded seal, and polar bear.

The observed decrease in narwhal relative abundance from 2018 to 2023 may be a reflection of the difference in the time of year and ice cover conditions between the SBO Programs. In 2018, the SBO Program occurred earlier in the year (28 September to 17 October) than the 2019 SBO Program (5 to 28 October) and the 2023 SBO Program (21 to 30 October). It is possible that there were more narwhal remaining in the RSA in 2018 and 2019, compared to 2023. Additionally, there was less ice during both the 2018 and 2019 late shoulder season SBO Programs, with the majority of observation effort occurring in open water, compared to the 2023 SBO Program where most observation effort occurred in ice conditions. These heavier ice conditions may have impacted the observer's ability to detect narwhal and/or influence narwhal habitat use in the RSA.

The lowest mean closest point of approach (CPA) for all on-ice marine mammal observations was for bearded seal, followed by polar bear, ringed seal, and unidentified seal. The lowest mean CPA for in-water marine mammal observations was for bearded seal, followed by ringed seal, unidentified seal, harp seal, narwhal, and polar bear. The lowest minimum CPA of all marine mammals observed on ice was for ringed seal, followed by bearded seal, polar bear, and unidentified seal. The lowest minimum CPA of all marine mammals observed in water was for ringed seal, followed by unidentified seal, bearded seal, harp seal, narwhal, and polar bear.

Overall, the CPA results support impact predictions that animals demonstrate localized avoidance of the ship. This provides further confidence that a vessel strike on a marine mammal is unlikely to occur based on the current vessel speed restriction within the RSA (9-knot speed restriction). These results also further support impact predictions made in the Final Environmental Impact Statement (FEIS) Addendum for the Early Revenue Phase (ERP), that the Project was unlikely to result in significant residual adverse effects on narwhal in the RSA, defined as effects that compromise the integrity of the population either through mortality (i.e., ship strikes) or via large-scale displacement or abandonment of the RSA.

Behavioural responses recorded for seals on-ice included scan and flush and for seals in-water included swim away and rapid dive/splash. The only species for which flush activity was observed were ringed seal and bearded seal on ice while rapid dive/splash responses were observed for ringed seal, harp seal, and unidentified seal. Of the 399 sightings considered for the behavioural response analysis, one third demonstrated a behavioural response. Behavioural responses were observed in all species with the highest proportion of sightings with responses for polar bear followed by harp seal, unidentified seal, ringed seal, and narwhal.

Due to small sample sizes for most species, only a statistical analysis of response rates of ringed seals within 2 km of the vessels was assessed. The best fitting ordinal logistic regression model included vessel activity and distance of the vessel to the sighting as predictor variables for ringed seal responses on ice. The ordinal logistic regression model predicted that the probability of flush response increased at closer distances to the vessel and the probability of no response increased with increasing distance from the vessel. Model results suggested that ringed seals responded more strongly to the vessels during active icebreaking than when transiting open water. For ringed seals in water, the best fitting model included distance and vessel activity however this model was selected above the null model by a very narrow margin. The analysis of deviance found neither distance nor vessel activity had a significant effect on in water ringed seal responses ($p < 0.09$ for distance, and $p > 0.5$ for vessel activity).

Only two bearded seals were reported to flush, one during icebreaking and one while the vessel was transiting open water (CPA = 200 m and 275 m respectively). The remaining bearded seals on ice did not respond and bearded seal in water responded with regular dives which are not considered as energetically costly as the other 'response' behaviours. Due to the limited sample sizes of bearded and harp seals at distances beyond 1,000 m, further studies would be needed to validate the potential sensitivities of these species.

All five narwhal sightings occurred when the vessel was icebreaking and the only behavioural response observed was by one group of 3 narwhal that were observed traveling slowly away from the vessel at 1,200 m. Of the seven sightings of individual polar bears, one displayed vigilance at a CPA of 300 m, two ran away at CPAs of 1,000 m and 1,200 m and one walked away at a CPA of 900 m. There was no behavioural response observed during the other three observations. All polar bear sightings occurred when the vessel was icebreaking except for the one bear that was observed resting and then displaying vigilance at 300 m.

Similar to previous years, no ship strikes on marine mammals (or near misses) were recorded during the active monitoring periods on the *Botnica* or *Fennica* during 2023. Overall, the distances maintained by marine mammals from the survey vessel in 2023 (i.e., CPA results) lend confidence to existing environmental assessment predictions that marine mammals in the RSA are likely to demonstrate localized avoidance of Project vessels, and that vessel strikes on marine mammals are unlikely to occur based on current vessel speeds in the RSA (9 knot speed restriction).

Collectively, the 2023 SBO monitoring results support the impact predictions and significance determination in the FEIS Addendum for the Early Revenue Phase (ERP) in that the Project is unlikely to result in significant residual adverse effects on marine mammals in the RSA, defined as effects that compromise the integrity of marine mammal populations in the region either through mortality (i.e., ship strikes) or via large-scale displacement or abandonment of the RSA.

Continuation of the SBO Program is recommended for 2024 in accordance with Nunavut Impact Review Board (NIRB) Project Certificate No. 005 Terms and Conditions. Ongoing annual monitoring will allow for additional data comparison between monitoring years, which will serve to identify whether any additional adaptive management measures during the shoulder seasons are required.

Seabirds

Total monitoring effort for seabirds during the 2023 SBO Program was 15.7 h consisting of 188 5-min moving platform surveys and four instantaneous stationary platform surveys. A total of six species were identified (34 confirmed sightings comprising 47 individuals), with Glaucous gull (*Larus hyperboreus*) being the most common species.

Glaucous Gull was the most abundant species observed in 2023 (1.47 individuals/h) followed by Black Guillemot (0.38 individuals/h), Common Raven and Thick-billed Murre (0.32 individuals/h each), and Black-legged Kittiwake and Northern Fulmar (0.26 individuals/h each). The relative abundance of seabirds was highest in Fall 2018 (16.31 individuals/h) followed by Fall 2019 (5.13 individuals/h) and Fall 2023 (3.00 individuals/h). Glaucous Gull was the most abundant species observed in 2018 (9.91 individuals/h) and 2023 (1.47 individuals/h) while Northern Fulmar were the most abundant species observed 2019 (2.15 individuals/h). Black-legged kittiwake were much more commonly observed in 2018 than in 2019 and 2023 (3.85 individuals/h in 2018 vs. 0.4 individuals/h in 2019 and 0.26 individuals/h in 2023). Species observed across all survey years included Glaucous Gull, Northern Fulmar, Black- legged Kittiwake, and Black Guillemot.

ᐊᐅᓚᑦᑎᔨᓂᖕᒫᖅᑐᖅ ᓇᐃᓈᖅᓯᒪᔪᖅ

WSP ᑲᓇᑕ ᐃᖕᑯᐊᐳᕇᑎᑦ (WSP) ᐱᓕᕆᔾᔪᔨᓪᓗᑎᒃ ᐹᕗᓛᓐ ᓴᕕᒃᓴᓂᒃ ᐅᔭᕋᖕᓂᐊᖅᑏᑦ ᑯᐊᐳᕇᓴᓐᑯᓐᓂᒃ (ᐹᕗᓛᓐᑯᑦ), ᐱᓕᕆᐊᖃᓚᐅᖅᑐᑦ ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᖅᑎᐅᓪᓗᑎᒃ ᐱᓕᕆᐊᒥ ᓯᑯᓂᒃ ᐊᔭᐅᖅᑐᐃᓯᒥ ᐹᑦᓂᑲ ᐊᒻᒪᓗ ᕙᓂᑲ ᐅᑭᐊᒃᓵᒃᑯᑦ ᓯᑯᕚᓪᓕᐊᓕᖅᑎᓪᓗᒍ (21-30 ᐅᑐᐱᕆ) 2023-ᒥ. ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᖅ ᓴᓇᔭᐅᓯᒪᔪᖅ ᑎᑭᐅᒪᕐᑯᓪᓗᒋᑦ ᒪᓕᒃᑕᐅᔭᕆᐊᓖᑦ 99, 101, 106, 108, 123 ᐊᒻᒪᓗ 126 ᐅᔭᕋᖕᓂᐊᕈᓐᓇᐅᑎ ᓈᓴᐅᑖ 005-ᒥ. ᑐᕌᒐᓪᓗᐊᑕᖅ ᑕᕝᕙᓂ ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᖅᑏᑦ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᕐᓂᖃᕐᑯᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᒧᑦ ᐊᐳᖅᑕᐅᑐᐃᓐᓇᕆᐊᓖᑦ ᑕᕆᐅᒥ ᐳᐃᔩᑦ ᐊᒻᒪ ᑕᕆᐅᒥ ᑎᖕᒥᐊᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ. ᐊᐃᑉᐸᖓ ᑐᕌᒐᓪᓗᐊᑕᖅ ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᖅᑏᑦ ᐱᓕᕆᐊᒧᑦ ᑲᑎᑕᐅᕐᑯᓪᓗᒋᑦ ᐅᔾᔨᕆᔭᐅᔪᓄᑦ ᑎᑎᖅᑲᕐᑯᑏᑦ ᐱᑕᖃᖅᑐᑦ, ᐊᒃᑐᐊᔪᑦ ᐊᒥᓲᓂᖏᓐᓄᑦ ᐊᒻᒪᓗ ᓇᓃᖃᑦᑕᕐᓂᖏᓐᓄᑦ ᑕᕆᐅᒥ ᐳᐃᔩᑦ, ᑕᕆᐅᒦᓲᑦ ᑎᖕᒥᐊᑦ, ᐊᒻᒪᓗᑦᑕᐅᖅ ᐃᓕᖅᑯᓯᕆᓕᖅᐸᒃᑕᖕᒋᑦ ᑭᒡᓕᖕᒋᓐᓂ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ ᐊᒃᑐᐊᓂᓕᒃ ᐱᓕᕆᐊᒥ ᐅᒥᐊᕐᔪᐊᖃᖃᑦᑕᕐᓂᕐᒧᑦ ᐊᐅᓚᓂᕐᓄᑦ. ᐱᓕᕆᐊᒥ ᐅᒥᐊᕐᔪᐊᖃᖃᑦᑕᕐᓂᖅ ᐱᒋᐊᓚᐅᖅᑐᑦ 2023-ᒥ 17 ᔪᓚᐃ 2019-ᒥ ᐊᒻᒪᓗ ᐃᓱᓕᖓᓂ 30 ᐅᑐᐱᕆ 2023-ᒥ.

ᑎᑎᖅᑲᕐᑎᓂᒃ ᑲᑎᖅᓯᐃᔾᔪᓯᖅ 2023-ᒧᑦ ᐅᒥᐊᕐᒧᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᖅ ᐊᔾᔨᐸᓗᒋᓚᐅᖅᑕᖓ 2018-ᒥ ᐊᒻᒪᓗ 2019-ᒥ ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑐᖅᓯᕐᓃᑦ ᐋᖅᑭᐊᒌᕐᔫᒃᓯᒪᓪᓗᓂ ᒪᓕᒃᑕᐅᔪᒃᓴᓄᑦ ᑲᒪᒋᔭᐅᕐᑯᓪᓗᒋᑦ ᐊᑐᓕᖅᑯᔭᐅᓯᒪᔪᑦ ᑕᕆᐅᑉ ᐊᕙᑎᖓᓄᑦ ᐱᓕᕆᖅᑎᒌᓂᑦ. ᖄᒃᑲᓐᓂᐊᒍᑦ ᑕᕆᐅᒥ ᐳᐃᔨᓂᒃ ᓇᐅᑦᑎᖅᓱᕐᓃᑦ, ᑕᕆᐅᒦᓲᑦ ᑎᖕᒥᐊᓂᒃ ᑕᑯᒃᑕᕐᓂᕐᒧᑦ ᑎᑎᕋᖅᑕᐅᓯᒪᔪᑦ ᐊᑐᖅᖢᑎᒃ ᑲᓇᑕᒥ ᓂᕐᔪᑎᓄᑦ ᐱᔨᑦᑎᕋᖅᑏᑦ (CWS) ᐊᒻᒪᓗ ᑲᓇᖕᓇᖕᒫᖕᒥ ᑲᓇᑕᒥ ᑕᕆᐅᒦᓲᑦ ᑎᖕᒥᐊᑦ ᑕᕆᐅᒥ (ECSAS) ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᒪᓕᒃᑕᐅᔪᒃᓴᑦ.

ᐱᒋᐊᖅᑕᐅᖅᑳᖅᑎᓐᓇᒍ 2023-ᒥ ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᓄᑦ ᐱᓕᕆᐊᖅ, ᑕᕆᐅᒥ ᓂᕐᔪᑎᓂᒃ ᓇᐅᑦᑎᖅᓱᖅᑏᑦ ᓂᕈᐊᖅᑕᐅᓯᒪᔪᑦ ᒥᑦᑎᒪᑕᓕᖕᒥ ᐃᓕᓐᓂᐊᖅᑎᑕᐅᓚᐅᖅᑐᑦ ᑕᕆᐅᒥ ᓂᕐᔪᑎᓂᒃ ᓇᓗᓇᐃᔭᐃᓂᕐᒥᒃ ᐊᒻᒪᓗ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᕐᓂᕐᒧᑦ ᐱᓕᕆᔾᔪᑏᑦ, ᐊᒻᒪᓗ ᑎᑎᖅᑲᕐᑎᓂᒃ ᖃᕆᓴᐅᔭᒧᐊᖅᑲᐃᓂᕐᒧᑦ ᒪᓕᒃᑕᐅᔪᒃᓴᑦ. 16-ᒥᑦ 22-ᒧᑦ ᓯᑎᐱᕆ 2023-ᒥ, ᐊᑕᐅᓯᖅ ᐃᓄᒃ ᑕᕆᐅᒥ ᓂᕐᔪᑎᓂᒃ ᓇᐅᑦᑎᖅᓱᖅᑎᐅᓂᕐᒧᑦ (MWO) ᐋᑐᕚᒧᐊᓚᐅᖅᑐᖅ, ᐋᓐᑎᐅᕆᐆᒧᑦ ᐃᓚᐅᓪᓗᓂᓗ ᐃᖕᒋᕐᕋᔪᓕᕆᔨᒃᑯᑦ ᑲᓇᑕᒥ ᐊᖕᒋᖅᓯᒪᔭᖕᒋᓐᓄᑦ ᑕᕆᐅᒥ ᐊᑦᑕᕐᓇᖅᑕᐃᓕᒪᓂᕐᒧᑦ ᐃᓕᓐᓂᐊᕐᓂᕐᒧᑦ “ᐅᒥᐊᕋᓛᑦ ᐊᑦᑕᕐᓇᖅᑕᐃᓕᒪᓂᑐᐃᓐᓇᕐᒧᑦ” ᐊᒻᒪᓗ ᑐᓂᔭᐅᓗᓂ ᐃᖕᒋᕐᕋᔪᓕᕆᔨᒃᑯᑦ ᑲᓇᑕᒥ ᑕᕆᐅᒥ ᖃᓄᐃᙱᑦᑎᐊᕐᓂᕐᒧᑦ ᓇᓗᓇᐃᒃᑯᑕᖓ. WSP-ᑯᑦ ᐊᑐᐃᓐᓇᐅᑎᑦᑎᓯᒪᔪᑦ ᐅᓪᓗᕐᒥᒃ-ᐊᑕᐅᓯᕐᒥᒃ ᑕᕆᐅᒥ ᓂᕐᔪᑎᓂᒃ ᓇᐅᑦᑎᖅᓱᖅᑎᐅᓂᕐᒧᑦ (MWO) ᐃᓕᓐᓂᐊᒐᒃᓴᒥ ᑕᒪᐃᓐᓄᑦ ᐱᙵᓱᓄᑦ ᑕᕆᐅᒥ ᓂᕐᔪᑎᓂᒃ ᓇᐅᑦᑎᖅᓱᖅᑎᓄᑦ (MWO) ᐱᒋᐊᖅᑕᐅᖅᑳᖅᑎᓐᓇᒍ ᐱᓕᕆᐊᖅ.

ᑖᒃᑯᐊ ᑕᕆᐅᒥ ᓂᕐᔪᑎᓂᒃ ᓇᐅᑦᑎᖅᓱᖅᑏᑦ (MWO) ᐱᓕᕆᐊᒃᓴᖃᓚᐅᖅᑐᑦ ᑕᕆᐅᒥ ᓂᕐᔪᑎᓂᒃ ᑕᑯᔭᖕᒋᓂᒃ ᑎᑎᕋᖅᓯᕗᓪᓗᑎᒃ ᓯᕗᓂᐊᓂ ᐹᑦᓂᑲ ᐊᒻᒪᓗ ᕙᓂᑲ ᐋᖅᑭᒃᑕᐅᓯᒪᔪᓂ ᓇᐅᑦᑎᖅᓱᕐᓇᓄᑦ. ᖃᐅᔨᓴᖅᐸᓪᓕᐊᕐᓂᕐᒧᑦ ᒪᓕᒃᑕᐅᔪᒃᓴᑦ ᐊᔾᔨᑦᑎᐊᙳᑦᑕᖅᑕᖅᑦ ᑕᕆᐅᒥ ᐳᐃᔨᓄᑦ ᐊᒻᒪᓗ ᑕᕆᐅᒦᓲᓄᑦ ᑎᖕᒥᐊᓄᑦ. ᑕᕆᐅᒥ ᐳᐃᔩᑦ ᑕᑯᔭᐅᔪᑦ ᑎᑎᕋᖅᑕᐅᓲᑦ ᖃᐅᑕᒫᑦ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᕐᓂᕐᒥ ᑎᑭᒍᒧ 9.5 ᐃᑲᕐᕋᑦ 2023-ᒥ ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᒥ, ᒪᓕᒃᖢᒋᑦ ᖃᐅᒪᒃᑕᕐᓃᑦ ᐃᑲᕐᕋᖕᒋᑦ. ᑕᕆᐅᒦᓲᑦ ᑎᖕᒥᐊᑦ ᑕᑯᔭᐅᔪᑦ ᑎᑎᕋᖅᑕᐅᓲᑦ ᑲᒪᒋᔭᖅᑎᓪᓗᒋᑦ ᑕᕆᐅᒦᓲᓂᒃ ᑎᖕᒥᐊᓂᒃ ᖃᐅᔨᓴᕐᓂᕐᓂᒃ ᐱᓕᕆᐊᖑᓚᐅᖅᐸᒃᑐᖅ ᖃᐅᑕᒫᑦ (ᐊᑯᓂᐅᓂᓕᒃ ᐃᑲᕐᕋᒥᒃ ᒪᕐᕉᖕᓄᓪᓗ ᐊᑐᓂ). ᑲᑎᖕᒋᑦ ᖃᐅᑕᒫᑦ ᓇᐅᑦᑎᖅᓱᕐᓂᐅᕙᒃᑐᑦ ᑕᕆᐅᒦᓲᓄᑦ ᑎᖕᒥᐊᓄᑦ ᐊᔾᔨᒌᖃᑦᑕᓚᐅᙱᑦᑐᖅ ᒪᓕᒃᖢᒋᑦ ᑕᑯᖃᑦᑕᕐᓂᕐᒥ ᖃᓄᐃᓕᖓᓂᑦ, ᐊᓯᔾᔨᕐᒫᕆᓂᖕᒋᑦ 0.5-ᒥᑦ 4.5 ᐃᑲᕐᕋᓄᑦ.

ᑕᕆᐅᒥ ᐳᐃᔩᑦ

ᑲᑎᓗᒃᑖᖅᖢᒋᑦ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᕐᓇᕋᓱᖕᓃᑦ ᐱᓕᕆᐊᖑᑎᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᖅ 89.5 ᐃᑲᕐᕋᑦ ᑲᑎᓗᒃᑖᖅᖢᒋᑦ 1,189.6 ᑭᓛᒥᑕᑦ ᑕᒪᐃᓐᓂ ᒪᕐᕉᖕᓂ ᓯᑯᓂᒃ ᐊᔭᐅᖅᑐᐃᔨᓂᒃ. ᖃᐅᔨᓴᕐᓂᐅᓇᓱᒃᑐᒃᑖᐸᒍᐃᑦ ᐹᑦᓂᑲᒥᐅᓚᐅᖅᑐᑦ 21-27 ᐅᑐᐱᕆ 2023 (52.2 ᐃᑲᕐᕋᑦ ᐃᖏᕐᕋᓪᓗᑎᒃ 675.1 ᑭᓛᒥᑕᓂᒃ) ᓇᐅᑦᑎᖅᓱᖅᑎᖃᓪᓚᑦᑖᖅᖢᑎᒃ ᐱᓕᕆᖃᑎᒋᓂᒃ ᐊᑐᓂ ᐅᒥᐊᓂ 98% ᑲᑎᖢᒋᑦ ᖃᐅᔨᓴᖅᑎᓪᓗᒋᑦ. ᐅᑐᐱᕆ 28-30, ᓇᐅᑦᑎᖅᓱᕐᓃᑦ ᐱᓕᕆᐊᖑᓚᐅᖅᑐᑦ ᑕᒪᐃᓐᓂᒃ ᐹᑦᑎᓂᑲ (18.4 ᐃᑲᕐᕋᑦ ᐃᖏᕐᕋᓪᓗᑎᒃ 248.7 ᑭᓛᒥᑕᓂᒃ) ᐊᒻᒪᓗ ᕙᓂᑲ (18.7 ᐃᑲᕐᕋᑦ ᐃᖏᕐᕋᑎᓪᓗᒋᑦ 255.8 ᑭᓛᒥᑕᓂᒃ). ᖃᐅᔨᓴᖅᐸᓪᓕᐊᕐᓇᕋᓱᐊᕐᓂᓗᒃᑖᑦ ᐹᑦᓂᑲᒥ 21-27 ᐅᑐᐱᕆ ᐊᒻᒪᓗ ᐃᓱᒪᒋᖅᑲᓯᐅᑎᓪᓗᒋᑦ ᓯᕗᒃᑲᖅᑕᖅᑐᑐᐊᙳᓪᓗᓂ 28-30 ᐅᑐᐱᕆᒥ 70.7 ᐃᑲᕐᕋᓄᑦ ᐃᖏᕐᕋᑎᓪᓗᖕᒋᑦ 949.9 ᑭᓛᒥᑕᓂᒃ.

ᐊᔾᔨᒌᙱᑦᑐᑦ ᑕᕆᐅᒥ ᐳᐃᔩᑦ ᐆᒪᔪᑦ ᐊᔾᔨᒌᙱᐊᕐᔪᒃᑐᑦ ᐅᔾᔨᕆᔭᐅᓚᐅᖅᑐᑦ ᐱᓕᕆᐊᖃᖅᑎᓪᓗᒋᑦ 2023-ᒥ ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᒥᒃ ᐃᓚᐅᓪᓗᑎᒃ ᑑᒑᓖᑦ, ᓇᑦᑏᑦ, ᖃᐃᕈᓖᑦ, ᐅᒡᔪᐃᑦ, ᐊᒻᒪᓗ ᓇᓄᐃᑦ. ᖃᑯᖅᑕᑦ ᕿᓚᓗᒐᑦ, ᐊᕐᕕᑦ, ᐊᕐᓗᐃᑦ, ᐊᒻᒪᓗ ᐊᐃᕚᑦ ᑕᑯᔭᐅᓚᐅᙱᑦᑐᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᓂ ᐱᓕᕆᐊᖃᖅᑎᓪᓗᖕᒋᑦ 2023-ᒥ ᐅᒥᐊᕐᔪᐊᒦᖓᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒥ ᐱᓕᕆᐊᒥ; ᑭᓯᐊᓂᓕ, ᑕᒪᒃᑯᐊ ᐆᒪᔪᑦ ᐊᔾᔨᒌᙱᐊᕐᔪᒃᑐᑦ ᖃᐅᔨᒪᔭᐅᔪᑦ ᐱᑕᖃᖃᑦᑕᕐᓂᖏᓐᓂᒃ ᓄᓇᖓᓂ. ᑲᑎᓗᒃᑖᖅᖢᒋᑦ

431 ᑕᕆᐅᒥ ᐳᐃᔨᓂᒃ ᑕᑯᓂᕐᓂ ᐃᓗᓕᖅᖅᑐᑦ ᐃᓛᒃᑰᖅᑐᓂᒃ 562 ᐃᓛᒃᑰᖅᑐᓂ ᑎᑎᕋᖅᑕᐅᓚᐅᖅᑐᑦ ᐱᓕᕆᐊᖅᖅᑎᓪᓗᒋᑦ 2023-ᒥ ᐅᒥᐊᕐᔪᐊᒥᐅᓪᓗᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒥ ᐱᓕᕆᐊᒥ.

ᐊᒃᑐᐊᓂᓖᑦ ᐊᒥᓲᓂᖏᓐᓄᑦ ᑕᕆᐅᒥ ᐳᔮᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ ᐱᓕᕆᐊᖅᖅᑎᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᒥᐅᓪᓗᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᒥ, ᑕᐃᔭᐅᓯᒪᓪᓗᓂ ᓂᕐᔪᑎᓂᒃ ᑕᑯᓂᕐᒧᑦ ᓈᓴᐅᑎᖏᑦ (ᐃᓛᒃᑰᖅᑐᑦ ᐊᒃᑐᐊᓂᓖᑦ ᖃᐅᔨᓴᕐᕋᓱᒃᓂᕐᒧᑦ ᑮᓛᒥᑕᓂ) ᐃᒪᐃᑦᑑᓚᐅᖅᑐᖅ 0.505 ᐃᓛᒃᑰᖅᑐᑦ / ᑮᓛᒥᑕᒥ (0.384 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᒥ). ᓇᑦᑏᑦ ᑕᑯᔭᐅᓂᐊᖅᐹᖑᕙᑦᑕᓚᐅᖅᑐᑦ 0.403-ᒦᓪᓗᑎᒃ ᐃᓛᒃᑰᖅᑐᑦ / ᑮᓛᒥᑕᒥ (0.350 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᓂ), ᑭᖑᓂᐊᒍᑦ ᖃᐃᕈᓖᑦ (0.058), ᑑᒡᓖᑦ (0.18 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᓂ) ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᓇᑦᑏᑦ (0.015 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᓂ), ᐅᒡᔪᐃᑦ (0.007 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᒥ), ᐅᒡᔪᐃᑦ (0.007 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᒥ), ᐊᒻᒪ ᓇᓄᐃᑦ (0.004 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᒥ).

ᐊᒃᑐᐊᓂᓖᑦ ᐊᒥᓲᓂᖏᓐᓄᑦ ᑕᕆᐅᒥ ᐳᐃᔮᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᓂ ᐊᔾᔨᐸᓗᒋᓚᐅᖅᑕᖏᑦ ᐅᑭᐊᒃᓵᖓᓂ 2023-ᒥ (0.505 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᒥ), ᑕᑯᔭᐅᔪᑦ ᐅᑭᐊᒃᓵᖓᓂ 2018-ᒥ (0.530 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᒥ). ᐅᑭᐊᒃᓵᖓᓂ 2018 ᐊᒻᒪ 2023 ᐅᓄᓖᖑᓚᐅᖅᑐᑦ ᐊᒃᑐᐊᓂᓖᑦ ᐊᒥᓲᓂᖏᓐᓄᑦ ᓈᓴᐅᑏᑦ ᖃᓄᐃᓐᓂᖅᓴᐅᓂᖏᑦ ᕿᒥᕐᕈᓪᓗᒋᑦ ᐅᑭᐊᒃᓵᖓᓄᑦ 2019-ᒥ. (0.16 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᒥ) (ᑎᑎᕋᖅᓯᒪᔪᖅ 6). ᖃᐃᕈᓖᑦ ᐆᒪᔪᓂ ᐊᔾᔨᒌᙱᑦᑎᐊᕐᔪᒃᑐᓂ ᐅᓄᓖᖑᓚᐅᖅᑐᑦ ᐊᒃᑐᐊᓂᓖᑦ ᐊᒥᓲᓂᖏᓐᓄᑦ ᓈᓴᐅᑎᓄᑦ 2018-ᒥ (0.225 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᒥ) ᐊᒻᒪ 2019-ᒥ (0.403 ᑕᑯᔭᐅᔪᑦ/ᑮᓛᒥᑕᒥ). ᐆᒪᔪᑦ ᐊᔾᔨᒌᙱᑦᑎᐊᕐᔪᒃᑐᑦ ᑕᑯᔭᐅᔪᑦ ᐅᓄᕐᓂᖅᓴᐅᓪᓗᑎᒃ ᐊᒃᑐᐊᓂᓖᑦ ᐊᒥᓲᓂᖏᓐᓄᑦ ᐅᑭᐊᒃᓵᖓᓂ 2023-ᒥ ᑭᖑᓂᖑᑦᑎᓐᓂ ᐊᕐᕌᒍᓂ ᐱᖃᓯᐅᑎᓪᓗᒋᑦ ᓇᑦᑏᑦ, ᐅᒡᔪᐃᑦ ᐊᒻᒪ ᓇᓄᐃᑦ.

ᐅᔾᔨᕆᔭᐅᔪᑦ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᖅᑐᑦ ᑑᒡᓖᑦ ᐊᒃᑐᐊᓂᓖᑦ ᐊᒥᓲᓂᖏᓐᓄᑦ ᐊᑯᓐᓂᖓᓂ 2018 ᐊᒻᒪ 2023 ᓴᖑᔾᔭᖅᑎᑦᑎᑐᐃᓐᓇᕆᐊᓕᒃ ᐊᔾᔨᒌᙱᑦᑐᓂ ᖃᖓᒃᑰᓂᖓᓄᑦ ᐊᕐᕌᒍᒥ ᐊᒻᒪ ᓯᑯᖃᕐᓂᖓᑕ ᖃᓄᐃᓕᖓᓂᖓ ᐊᑯᓐᓂᖏᓐᓂ ᐅᒥᐊᕐᔪᐊᒥᐅᓪᓗᑎᒃ ᓇᐅᑦᑎᖅᓱᖅᑏᑦ ᐱᓕᕆᐊᓂ. 2018-ᒥ, ᐅᒥᐊᕐᔪᐊᒥᐅᓪᓗᑎᒃ ᓇᐅᑦᑎᖅᓱᖅᓂᕐᒧᑦ ᐱᓕᕆᐊᖅ ᐱᓕᕆᐊᖑᓴᕋᐃᓐᓂᖅᓴᐅᓚᐅᖅᑐᑦ ᐊᕐᕌᒍᒥ (28 ᓯᑎᐱᕆ - 17 ᐅᑐᐱᕆ) 2019-ᒥᓂᑦ ᐅᒥᐊᕐᔪᐊᒥᐅᓪᓗᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᖅ 5-28 ᐅᑐᐱᕆ) ᐊᒻᒪ 2023-ᒥ ᐅᒥᐊᕐᔪᐊᒥᐅᓪᓗᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᖅ (21-30 ᐅᑐᐱᕆ). ᐃᒪᐃᑐᐃᓐᓇᕆᐊᖅᖅᓯᒪᔪᖅ ᐅᒥᓲᓂᖅᓴᑦ ᑑᒡᓕᓖᑦ ᑕᐃᕙᓃᖏᓐᓇᖅᐸᓪᓗᑎᒃ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ 2018-ᒥ ᐊᒻᒪ 2019-ᒥ, ᖃᓄᐃᓐᓂᖅᓴᐅᓂᖏᑦ ᕿᒥᕐᕈᓪᓗᒋᑦ 2023-ᒧᑦ. ᖄᒃᑲᓐᓂᐊᒍᑦ, ᓯᑯᖃᙱᓐᓂᖅᓴᐅᓚᐅᖅᑐᑦ ᑕᒪᕐᒦᖏᓐᓂ 2018-ᒥ ᐊᒻᒪ 2019-ᒥ ᓯᑯᕙᓪᓕᐊᓕᖅᑎᓪᓗᒋ ᐅᒥᐊᕐᔪᐊᒥ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᑎᓪᓗᒋᑦ, ᐊᒥᓲᓂᖅᓴᑦ ᓇᐅᑦᑎᖅᓱᖅᑕᐅᓇᓱᒃᑐᑦ ᑕᑯᔭᐅᒃᑖᖅᐸᓪᓗᑎᒃ ᐃᒪᐃᓐᓇᕐᒥ, ᖃᓄᐃᓐᓂᖅᓴᐅᓂᖏᑦ ᑕᑯᓪᓗᒋᑦ 2023-ᒥ ᐅᒥᐊᕐᔪᐊᒥ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᑎᓪᓗᒋᑦ ᓇᐅᑦᑎᖅᓱᕐᓃᑦ ᑕᑯᔭᐅᒃᑕᓚᐅᖅᑎᓪᓗᒋᑦ ᑐᓯᖅᖅᑐᒥ. ᓯᑯᖃᕐᓂᖅᓴᐅᓂᖓ ᐊᒃᑐᐃᓯᒪᑐᐃᓐᓇᕆᐊᓕᒃ ᓇᐅᑦᑐᖅᓱᖅᑏᑦ ᑕᑯᔪᓐᓇᕐᓂᖏᓐᓂᒃ ᑑᒡᓕᖕᓂᒃ ᐊᒻᒪ/ᐅᕝᕙᓘᓐᓃᑦ ᐊᒃᑐᐃᓂᖃᕐᓗᓂ ᑑᒡᓖᑦ ᓇᔪᖅᐸᒃᑕᖏᓐᓂᒃ ᑕᐅᕙᓂ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ.

ᐅᓄᙱᓖᑦ ᖃᓂᓖᖑᔪᖅ ᖃᓪᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) ᑕᒪᐃᓐᓄᓪᓗᒃᑖᑦ ᓯᑯᒥ ᑕᕆᐅᒥ ᐳᐃᔮᑦ ᐅᔾᔨᕆᔭᐅᔪᑦ ᐅᒡᔪᓚᐅᖅᑐᑦ, ᑭᖑᓂᐊᒍᑦ ᓇᓄᐃᑦ, ᓇᑦᑏᑦ ᐊᒻᒪ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᓇᑦᑏᑦ. ᐅᓄᙱᓖ ᖃᓂᓖᖑᔪᖅ ᖃᓪᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) ᓯᑰᑦᑐᓪᓗᒃᑖᓄᑦ ᑕᕆᐅᒥ ᐳᐃᔨᓂᒃ ᑕᑯᓂᕐᒧᑦ ᐅᒡᔪᖓᓂᒃ, ᑭᖑᓂᐊᒍᑦ ᓇᓄᐃᑦ, ᓇᑦᑏᑦ, ᐊᒻᒪ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᓇᑦᑏᑦ. ᐊᒃᐸᓯᓖᖅ ᖃᓂᓖᖑᔪᖅ ᖃᓪᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) ᐃᓖᓂ ᑕᕆᐅᒥ ᐳᐃᔮᑦ ᑕᑯᔭᐅᔪᑦ ᐅᒡᔪᐃᑦ, ᑭᖑᓂᐊᒍᑦ ᓇᑦᑏᑦ, ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᓇᑦᑏᑦ, ᖃᐃᕈᓖᑦ, ᑑᒡᓖᑦ, ᐊᒻᒪ ᓇᓄᐃᑦ. ᐅᓄᙱᓖᑦ ᖃᓂᓖᖑᔪᖅ ᖃᓪᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) ᑕᒪᐃᓐᓄᓪᓗᒃᑖᖅ ᑕᕆᐅᒥ ᐳᐃᔨᓄᑦ ᑕᑯᔭᐅᔪᑦ ᓯᑯᒥ ᓇᑦᑏᑦ, ᑭᖑᓂᐊᒍᓪᓗ ᐅᒡᔪᐃᑦ, ᓇᓄᐃᑦ, ᐊᒻᒪ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᓇᑦᑏᑦ. ᐅᓄᙱᓖᑦ ᖃᓂᓖᖑᔪᖅ ᖃᓪᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) ᑕᒪᐃᓐᓄᑦ ᑕᕆᐅᒥ ᐳᐃᔮᑦ ᑕᑯᔭᐅᔪᑦ ᐃᓖᓂ ᓇᑦᑏᑦ, ᑭᖑᓂᐊᒍᑦ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᓇᑦᑏᑦ, ᐅᒡᔪᐃᑦ, ᖃᐃᕈᓖᑦ, ᑑᒡᓖᑦ ᐊᒻᒪ ᓇᓄᐃᑦ.

ᐃᓕᖅᑯᓯᐅᓕᖅᐸᒃᑐᑦ ᑎᑎᕋᖅᑕᐅᓯᒪᔪᑦ ᓇᑦᑎᕐᓂᑦ ᓯᑯᒦ ᐱᖃᓯᐅᑎᓪᓗᒋᑦ ᕿᒥᕐᕈᓚᐅᖅᓱᑎᒃ ᐊᖅᑲᖅᓱᑎᒃ ᐊᒻᒪ ᓇᑦᑎᕐᓄᑦ ᐃᓖᓃᑦᑐᓄᑦ ᐱᖃᓯᐅᑎᓪᓗᒋᑦ ᕿᒫᔪᑦ ᐊᒻᒪ ᐊᖅᑲᑲᐅᖅᑐᕐᓃᑦ. ᑖᒃᑯᐊᑐᐊᑦ ᐆᒪᔪᓂ ᐊᔾᔨᒌᙱᑦᑎᐊᕐᔪᒃᑐᓂ ᐊᖅᑲᑲᐅᖅᑐᖃᑦᑕᓚᐅᖅᑐᑦ ᐅᔾᔨᕆᔭᐅᔪᓂ ᓇᑦᑎᕐᓄᑦ ᐅᒡᔪᓐᓄᓪᓗ ᓯᑯᒥ ᑭᓯᐊᓂᓕ ᐊᖅᑲᑲᐅᖅᑐᕐᓃᑦ ᐃᓕᖅᑯᓯᐅᕙᒃᑐᑦ ᐅᔾᔨᕆᔭᐅᔪᑦ ᓇᑦᑎᕐᓄᑦ, ᖃᐃᕈᓕᖕᓄᑦ ᐊᒻᒪ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᓄᑦ ᓇᑦᑎᕐᓄᑦ. ᑖᒃᑯᓇᓂ 399-ᓂ ᑕᑯᔭᐅᔪᓂ ᐃᓯᒪᒋᖃᓯᐅᔾᔭᐅᓯᒪᔪᑦ ᐃᓕᖅᑯᓯᐅᓕᖅᐸᒃᑐᓂᒃ ᕿᒥᕐᕈᓂᕐᒥ, ᐊᑕᐅᓯᖅ ᐱᖓᓱᓂ, ᓴᖑᔾᔭᖅᑎᑦᑎᔪᑦ ᐃᓕᖅᑯᓯᐅᓕᖅᐸᒃᑐᒥᒃ. ᐃᓕᖅᑯᓯᐅᓕᖅᐸᒃᑐᑦ ᐅᔾᔨᕆᔭᐅᓚᐅᖅᑐᑦ ᑕᒪᐅᓐᓄᑦ ᐆᒪᔪᓄᑦ ᐊᔾᔨᒌᙱᑦᑎᐊᕐᔪᒃᑐᓄᑦ ᐅᓄᓖᖑᔪᑦ ᑕᑯᔭᐅᔪᓂ ᐃᓕᖅᑯᓯᖅᐸᒃᑐᑦ ᓇᓄᐃᑦ ᑭᖑᓂᐊᒍᑦ ᖃᐃᕈᓖᑦ, ᓇᓗᓇᐃᖅᑕᐅᓯᒪᙱᑦᑐᑦ ᓇᑦᑏᑦ, ᓇᑦᑏᑦ ᐊᒻᒪ ᑑᒡᓖᑦ.

ᐱᔾᔪᑕᐅᓪᓗᑎᒃ ᐅᓄᙱᓗᐊᕐᓂᖏᓐᓄᑦ ᖃᐅᔨᓴᒃᓴᓕᐅᖅᑕᐅᕙᒃᑐᑦ ᑕᒪᐃᓐᓄᓪᓗᒃᑖᐸᓗᒃ ᐆᒪᔪᓄᑦ ᐊᔾᔨᒌᙱᑦᑎᐊᕐᔪᒃᑐᓄᑦ, ᓈᓴᐅᓯᕆᔪᑎᒃᑯᑐᐊᖅ ᕿᒥᕐᕈᓃᑦ ᐃᓕᖅᑯᓯᐅᓕᖅᐸᒃᑐᑦ ᓈᓴᐅᑎᖏᓐᓂᒃ ᓇᑦᑎᕐᓄᑦ ᐃᓗᐊᓂ 2 ᑮᓛᒥᑦᑕ ᐅᒥᐊᕐᔪᐊᒥ ᕿᒥᕐᕈᔭᐅᓯᒪᔪᑦ. ᓈᒻᒪᓖᖑᔪᑦ ᓈᓴᐅᓯᕆᔪᑏᑦ ᐱᔪᑎᖃᐅᖅᓱᑎᒃ ᐋᖅᑭᒃᑯᐊᖅᑕᐅᓯᒪᔪᑦ ᕿᒥᕐᕈᓚᐅᖅᓱᑎᒃ ᐅᒥᐊᕐᔪᐊᑕᖃᖃᑦᑕᕐᓂᖓ ᐊᒻᒪ ᐅᖓᓯᒋᓐᓂᖏᑦ ᐅᒥᐊᕐᔪᐊᑦ ᑕᑯᔭᐅᔪᓂ ᓈᓴᐅᓯᕆᔪᑕᐅᓗᓂ ᓇᑦᑎᓂᕐᓄᑦ ᐃᓕᖅᑯᓯᖅᐸᒃᑐᓄᑦ ᓯᑯᒥ. ᓈᒻᒪᓖᖑᔪᑦ ᓈᓴᐅᓯᕆᔪᑏᑦ ᐱᔪᑎᖃᐅᖅᓱᑎᒃ

ᐋᖅᑭᕐᒍᐊᖅᑕᐅᓯᒪᔪᑦ ᒥᒃᓴᐅᓴᐃᓯᒪᔪᑦ ᑕᐃᒪᐃᑐᐃᓐᓇᕆᐊᖃᕐᓂᖏᓐᓂᒃ ᐊᖅᑲᑲᐅᖅᑐᕐᓗᑎᒃ ᖃᒡᓕᕙᓪᓕᐊᑎᓪᓗᒍ ᐅᒥᐊᕐᔪᐊᖅ ᐊᒻᒪᓗ ᑕᐃᒪᐃᑐᐃᓐᓇᕆᐊᖃᕐᒥᔪᖅ ᖃᓄᐃᓕᖕᒋᓪᓗᑎᒃ ᐅᒥᐊᕐᔪᐊᓄᑦ ᓯᑯᓂᒃ ᐊᔭᐅᖅᑐᐃᓪᓚᕆᒃᑎᓪᓗᖏᑦ ᐃᖏᕐᕋᑎᓪᓗᖏᑦ ᓯᑯᖃᑎᑎᓪᓗᒍ. ᓇᑦᑎᕐᓄᑦ ᐃᒫᓃᑦᑐᓄᑦ, ᓈᒻᒪᓛᖅ ᐋᖅᑭᕐᒍᐊᖅᑕᐅᓯᒪᒧᖅ ᐱᖃᓯᐅᔾᔨᔪᖅ ᐅᖓᓯᖕᓂᖓᓂᒃ ᐊᒻᒪᓗ ᐅᒥᐊᕐᔪᐊᖃᖃᑦᑕᕐᓂᖓᓄᑦ ᑭᓯᐊᓂᓕ ᑕᒪᓐᓇ ᐋᖅᑭᕐᒍᐊᖅᑕᐅᓯᒪᔪᖅ ᓂᕈᐊᖅᑕᐅᓯᒪᔪᖅ ᖁᓛᓂ ᐊᑑᑎᖃᕐᓯᕗᓂ ᐋᖅᑭᕐᒍᐊᖅᑕᐅᓯᒪᔪᖅ ᐊᑐᕆᕕᓗᒃᓯᒪᕐᓯᑦᑐᖅ. ᕿᒥᕐᕈᓂᖅ ᓴᖑᓂᕐᒋᓐᓄᑦ ᖃᐅᔨᔭᐅᓯᒪᕐᓯᑦᑐᑦ ᓇᓕᐊᑐᐃᓐᓇᖅ ᐅᖓᓯᖕᓂᖓ ᐅᒥᐊᕐᔪᐊᖃᖃᑦᑕᕐᓂᖓᓄᓘᓐᓃᑦ ᐊᒃᑐᐃᓂᖃᕐᔪᐊᖅᓯᒪᓂᖓᓂᒃ ᐃᒫᓃᑦᑐᑦ ᓇᑦᑏᑦ ᐃᓕᖅᑯᓯᕆᓕᖅᐸᒃᑕᖓᓂᒃ ($p < 0.09$ ᐅᖓᓯᖕᓂᕐᒧᑦ ᐊᒻᒪᓗ $p > 0.5$ ᐅᒥᐊᕐᔪᐊᖃᖃᑦᑕᕐᓂᖓᓄᑦ).

ᑕᒪᐃᓐᓅᖓᔪᑦ ᖃᓂᙲᖅᔪᖅ ᖃᒡᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) ᖃᐅᔨᔭᐅᔪᑦ ᐃᑲᔪᖅᑐᐃᔪᑦ ᐊᒃᑐᐃᓂᕐᒧᑦ ᒥᒃᓴᐅᒃᑕᐅᓯᒪᔪᓄᑦ ᓂᕐᔪᑏᑦ ᓴᖅᑮᔭᖅᑎᑦᑎᓂᕐᒋᓐᓄᑦ ᓄᓇᖓᓂ ᑕᑯᑦᑕᐃᓕᒪᓂᖏᒃ ᐅᒥᐊᕐᔪᐊᓂᒃ. ᑕᒪᓇ ᖁᓯᓐᓇᕈᓐᓂᒃᑲᓂᐅᔭᖅᓯᒪᔪᖅ ᐅᒥᐊᕐᔪᐊᑦ ᐊᐳᖅᓯᓇᔭᕐᒥᑦᑐᒃᓴᐅᔪᑦ ᑕᕆᐅᒥ ᐳᐃᔨᓂᒃ ᑐᙵᕕᒋᓪᓗᒋᑦ ᒫᓐᓇ ᐅᒥᐊᕐᔪᐊᑦ ᓱᒃᑲᓂᕐᒋᓐᓄᑦ ᑭᒡᓕᐅᔪᑦ ᐃᓗᐊᓂ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕝᕕᐅᔪᓂ (9–ᓈᑦ ᓱᒃᑲᓂᕐᒧᑦ ᑭᒡᓕᐅᔪᖅ). ᑖᒃᑯᐊ ᖃᐅᔨᔭᐅᔪᑦ ᐃᑲᔪᖅᑐᐃᒃᑲᓂᖅᓯᒪᔪᑦ ᐊᒃᑐᐃᓂᕐᓄᑦ ᒥᒃᓴᐅᒃᑕᐅᓯᒪᔪᓂ ᑕᐃᑲᓂ ᑭᖑᓪᓕᖅᐹᒥᑦ ᐊᕙᑎᒧᑦ ᐊᒃᑐᐃᓂᐊᓂᐊᖅᑐᑦ ᐅᓂᒃᑲᓂ ᐅᐃᒍᒥ ᑮᓇᐅᔾᔭᒃᓵᓕᓇᓱᖕᓂᕐᒧᑦ, ᐱᓕᕆᐊᕐᓗ ᓴᖅᑮᔭᕐᑎᑦᑐᒃᓴᐅᔪᖅ ᐊᖏᔪᒥᒃ ᐊᒥᐊᒃᑰᕝᕕᒃᑐᓂᒃ ᐊᒃᑐᐃᓂᕐᓗᓐᓂᕐᓂᒃ ᑑᓚᕐᒥᓄᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕝᕕᐅᔪᓂ, ᓇᓗᓇᐃᖅᑕᐅᔪᑦ ᐊᒃᑐᐃᓂᐅᓪᓗᑎᒃ ᐃᓗᓕᖅᖅᑐᑦ ᓱᓕᓂᕐᒋᓐᓄᑦ ᐅᓄᕐᓂᕐᒥᑦ ᐊᑐᖅᑐᒥᑦ ᑐᖁᑕᐅᖃᑦᑕᕐᓂᕐᒥᑦ (ᓱᕐᓗ ᐅᒥᐊᕐᔪᐊᒥ ᐊᐳᖅᑕᐅᔪᑦ) ᐅᕝᕙᓘᓐᓃᑦ ᐊᕐᕌᒥᒃ ᑕᐅᕙᓃᑦᑐᓐᓂᕐᓂᕐᒥᑦ ᐅᕝᕙᓘᓐᓃᑦ ᕿᒪᐃᓯᒪᓕᕐᓂᕐᒥᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕝᕕᐅᔪᒥ.

ᐃᓕᖅᑯᓯᕆᓕᖅᑕᐅᕙᒃᑐᑦ ᑎᑎᕋᖅᑕᐅᓯᒪᔪᑦ ᓇᑦᑎᕐᓄᑦ ᓯᑯᒥ ᐱᖃᓯᐅᔾᔨᔪᑦ ᕿᒥᕐᕈᐊᓚᐅᖅᓯᒪᑎᒃ ᐊᒻᒪᓗ ᐊᖅᑲᖅᓯᒪᑎᒃ ᐃᓕᖅᑯᓯᕆᓕᖅᑕᐅᕙᒃᑐᑦ ᑎᑎᕋᖅᑕᐅᓯᒪᔪᑦ ᐃᒪᓂ ᐱᖃᓯᐅᔾᔨᔪᑦ ᕿᒪᒃᓗᑎᒃ ᐊᒻᒪᓗ ᐊᖅᑲᑲᐅᖅᑐᖅᓯᒪᑎᒃ. ᐆᒪᔪᓂ ᐊᔾᔨᐅᙱᑦᑐᓂᑐᐊᖅ ᐊᖅᑲᑲᐅᖅᑐᓯᑦ ᐅᔾᔨᕆᔭᐅᔪᑦ ᓇᑦᑏᑦ ᐊᒻᒪᓗ ᐅᒃᑐᐃᑦ. ᒥᒃᓴᐅᓴᐃᔾᔪᑏᑦ ᖃᔅᓯᓪᓚᙳᓂᒃ ᐱᔾᔪᑎᖃᖅᑎᓪᓗᒋᑦ ᐋᖅᑭᕐᒍᐊᖅᑕᐅᓯᒪᔪᑦ ᒥᒃᓴᐅᒃᑕᐅᓯᒪᒧᑦ ᑕᐃᒪᐃᓐᓇᔭᕐᓂᖓᓄᑦ ᐊᖅᑲᑲᐅᖅᑐᕐᓗᑎᒃ ᐱᕙᓪᓕᐊᔾᔨᑦ ᐊᒻ ᐱᕙᓪᓕᐊᔾᔨᐊᓕᐊᓂᒃᑐᑦ ᐅᖓᓯᒃᓕᕙᓪᓕᐊᑎᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᒥ ᓇᑦᑎᕐᓄᑦ ᓯᑯᑦᑐᓄᑦ ᐊᒻᒪᓗ ᑕᐃᒪᐃᓐᓇᔭᕐᓂᕐᒥᑦ ᖃᓄᐃᓕᖓᕐᒥᓪᓗᑎᒃ ᐱᓗᐊᕈᓐᓃᖅ ᐅᖓᓯᒃᓕᕙᓪᓕᐊᑎᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᒥᑦ. ᓯᑯᓂᒃ ᐊᔭᐅᖅᑐᐃᑎᓪᓗᒋᑦ, ᓇᑦᑏᑦ ᓂᕆᐅᒋᔭᐅᓚᐅᖅᑐᑦ ᐅᖓᑕᐅᔾᔨᒪᓂᐊᕐᓂᕆᓂᒃ 50%-ᒥᒃ ᑕᐃᒪᐃᓐᓇᔭᕐᓂᕆᓐᓄᑦ ᐊᖅᑲᑲᐅᖅᑐᖅᐸᓪᓗᑎᒃ ᑎᑭᓪᓗᒍ ᐅᖓᓯᓂᐅᔪᑦ 1,000 ᒦᑕᑦ. ᐋᖅᑭᕐᒍᐊᖅᑕᐅᓯᒪᔪᓂ ᖃᐅᔨᔭᐅᔪᑦ ᐃᒪᐃᓐᓇᓱᒋᓈᔪᑦ ᑕᒪᒃᑯᐊ ᓇᑦᑏᑦ ᓯᑯᒦᑦᑐᑦ ᐃᓕᖅᑯᓯᖅᑖᖅᓴᕋᐃᓐᓂᖅᓴᐃᑦ ᐅᒥᐊᕐᔪᐊᒧᑦ ᓯᑯᓂᒃ ᐊᔭᐅᖅᑐᐃᑎᓪᓗᒋᑦ ᐃᖏᕐᕋᑐᐃᓐᓇᕐᓂᕐᒥ ᓯᑯᖃᑎᑦᑐᒃᑯᑦ. ᒪᕐᕉᑐᐊᒃ ᐅᒃᑐᐃᑦ ᐊᖅᑲᑲᐅᖅᑐᕐᓂᕋᖅᑕᐅᓯᒪᒧᑦ, ᐊᑕᐅᓯᖅ ᓯᑯᓂᒃ ᐊᔭᐅᖅᑐᐃᑎᓪᓗᒋᑦ ᐊᒻᒪᓗ ᐊᑕᐅᓯᖅ ᐅᒥᐊᕐᔪᐊᖅ ᐃᖏᕐᕋᑎᓪᓗᒍ ᓯᑯᖃᑎᑦᑐᒥ (ᖃᓂᙲᖅᔪᖅ ᖃᒡᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) = 200 ᒦᑕᑦ ᐊᒻᒪᓗ 275 ᒦᑕᑦ ᐅᖃᐅᓯᖅᖃᖅᑎᓪᓗᑕ). ᐊᒥᐊᒃᑯᑦ ᐅᒃᑐᐃᑦ ᓯᑯᒦᑦᑐᑦ ᖃᓄᐃᓕᐅᕐᒪᑦᑐᑦ ᐊᒻᒪᓗ ᐅᒃᑐᐃᑦ ᐃᒫᓃᑦᑐᑦ ᐃᒫᓃᕐᓇᑐᐃᓐᓇᖃᑦᑕᓚᐅᖅᑐᑦ ᐊᖅᑲᑐᐃᓐᓇᖅᓱᑐᒃ ᐃᓱᒪᒋᖃᓯᐅᔾᔭᐅᕐᒥᑦᑐᑦ ᐱᓗᐊᕐᓂᕐᒥᓂᒃ ᐊᓯᕐᒥᓐᓄᑦ 'ᐃᓕᖅᑯᓯᐅᓕᖅᐸᒃᑐᓄᑦ'. ᐱᔾᔪᑎᒋᓪᓗᒋᑦ ᐅᓄᙱᓗᐊᕐᒪᑦ ᖃᐅᔨᓴᖕᖓᒃᓯᓕᐅᕐᓂᑦ ᐅᒃᑐᖕᓂᒃ ᐊᒻᒪᓗ ᖃᐃᕈᓕᖕᓂᒃ ᐅᖓᓯᒃᑐᒦᓗᐊᕐᒥᑦᑐᓄᑦ 1,000 ᒦᑕᓂᒃ, ᖃᐅᔨᓴᖅᑕᐅᒃᑲᓐᓂᕆᐊᖃᕐᓂᖅ ᓱᓕᓂᕋᖅᑕᐅᖁᓪᓗᖏᑦ ᐃᒃᐱᖕᓂᖅᓴᕋᐃᓂᐅᑐᐃᓐᓇᕆᐊᖃᕐᓂᖅ ᑕᒪᒃᑯᓇᖓ ᐆᒪᔪᓄᑦ ᐊᔾᔨᐅᙱᑦᑐᓄᑦ.

ᐊᑕᖏᖅᑯᖏᑦ ᑕᓪᓕᒪᐅᔪᑦ ᑑᓚᖕᓂᒃ ᑐᑯᓅᑦ ᐅᒥᐊᕐᔪᐊᒥ ᓯᑯᓂᒃ ᐊᔭᐅᖅᐃᑐᑎᓪᓗᒋᑦ ᐊᒻᒪᓗ ᐃᓕᖅᑯᓯᕆᓕᖅᐸᒃᑕᖏᑦᑐᐊᖅ ᑕᑯᔭᐅᓚᐅᖅᑐᑦ ᐊᑕᐅᓯᕐᒥ ᑲᑎᙶᓚᐅᖅᑐᓂ 3-ᖑᓪᓗᑎᒃ ᑑᓚᖓᑦ ᑕᑯᔭᐅᔪᑦ ᕿᒫᖁᔭᖅᑎᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᒥᑦ 1,200 ᒦᑕᓂᒃ ᐅᖓᓯᖕᓂᖃᖅᖢᑎᒃ. ᐊᕝᕙᓂᖓᑦ ᒪᕐᕉᒃ ᑕᑯᔭᐅᔪᑦ ᐃᓄᑐᐊᑦ ᓇᓄᐃᑦ, ᐊᑕᐅᓯᖅ ᐅᖓᓯᖕᓂᖓ ᖃᓂᙲᖅᔪᖅ ᖃᒡᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) 300 ᒦᑕᒥᖕᓂᒃ, ᒪᕐᕉᒃ ᕿᒫᓪᓗᑎᒃ ᖃᓂᙲᖅᔪᖅ ᖃᒡᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) 1,000 ᒦᑕᒥᖕᓂᒃ ᐊᒻᒪᓗ 1,200 ᒦᑕᒥᖕᓂ ᐊᑕᐅᓯᖅ ᐱᓯᑐᐃᓐᓇᖅᑐᑦ ᕿᒪᐃᕙᓪᓕᐊᖕᖑᖅᖢᓂ ᖃᓂᙲᖅᔪᖅ ᖃᒡᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) 900 ᒦᑕᒥᖕᓂ. ᐱᑕᖃᙱᑦᑐᖅ ᐃᓕᖅᑯᓯᕆᓕᖅᑕᐅᕙᒃᑐᒥᒃ ᑕᑯᔭᐅᓯᒪᔪᓂᒃ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᔪᓂ ᐊᓯᙱᓐᓂ ᐱᖓᓱᓂ ᑕᑯᓂᐅᔪᓂ. ᓇᓄᓗᒃᑖᑦ ᑕᑯᔭᐅᔪᑦ ᐅᒥᐊᕐᔪᐊᖅ ᓯᑯᓂᒃ ᐊᔭᐅᖅᑐᐃᑎᓪᓗᒍ ᑭᓯᐊᓂ ᐊᑕᐅᓯᖅ ᓇᓄᖅ ᑕᑯᔭᐅᓚᐅᖅᑐᖅ ᐃᓂᓪᓚᖓᓪᓗᓂ ᐊᒻᒪᓗ ᐅᖓᓯᖕᓂᖓ 300 ᒦᑐᓂ.

ᐊᔾᔨᐸᓗᐊ ᐊᕐᕋᒎᓯᒪᔪᓂ, ᐅᒥᐊᕐᔪᐊᒥ ᐊᐳᖅᓯᔪᖃᓚᐅᖅᓯᒪᙱᑦᑐᖅ ᑕᕆᐅᒥ ᐳᐃᔨᓂᒃ (ᐊᔭᐃᖅᑕᐅᔪᓐᓃᖅᑐᓐᓂᑦ) ᑎᑎᕋᖅᑕᐅᓯᒪᔪᑦ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᕆᐊᓇᓪᓚᑦᑖᖅᑎᓪᓗᒋᑦ *ᐹᑦᓂᕕᒥ ᐅᕙᓗᓈᓐ ᕙᓂᕕᒥ* 2023-ᖑᑎᓪᓗᒍ. ᑕᒪᐃᓐᓄᒃᑖᖅ, ᐅᖓᓯᓈᖅᑕᖅᑕᕐᓂᖏᑦ ᑕᕆᐅᒥ ᐳᐃᔩᑦ ᖃᐅᔨᓴᖅᑎᓂᒃ ᐅᒥᐊᕐᔪᐊᓂᒃ 2023-ᒥ (ᓱᕐᓗ ᖃᓂᙲᖅᔪᖅ ᖃᒡᓕᔭᐅᕙᓪᓕᐊᑎᓪᓗᒋᑦ (CPA) ᖃᐅᔨᔭᐅᔪᑦ) ᖁᓯᓐᓇᕐᒥᑎᑦᑎᔪᖅ ᐱᑕᖃᖅᐸᓕᕐᒥᑐᓂᒃ ᐊᕙᑎᒥᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᒥᒃᓵᓄᑦ ᒥᒃᓵᒃᑕᐅᓯᒪᔪᓂᒃ, ᑕᒪᒃᑯᐊ ᑕᕆᐅᒥ ᐳᐃᔩᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᓕᒥ ᖃᐅᔨᓴᕝᕕᐅᔪᒥ ᓴᖅᑮᔭᖅᑎᑦᑐᐃᓐᓇᕆᐊᖃᕐᒥᔪᑦ ᓄᓇᖓᓂᑐᐊᖅ ᑕᑯᑦᑕᐃᓕᒪᓂᖏᓐᓂ ᐱᓕᕆᐊᒥ ᐅᒥᐊᕐᔪᐊᓂᒃ, ᐊᒻᒪᓗ ᐅᒥᐊᕐᔪᐊᑦ ᐊᐳᖅᓯᓂᖏᑦ ᑕᕆᐅᒥ ᐳᐃᔨᓂᒃ ᑕᐃᒪᐃᓐᓇᔭᕐᒥᑦᑐᒃᓴᐅᔪᑦ ᒫᓐᓇ ᐅᒥᐊᕐᔪᐊᑦ ᓱᒃᑲᓂᕐᒋᓐᓄᑦ ᓄᓇᓂ ᐊᕕᒃᑐᖅᓯᒪᓕᒥ ᖃᐅᔨᓴᕝᕕᐅᔪᒥ (9 ᓈᑦᒥᒃ ᓱᒃᑲᓂᕐᒧᑦ ᑭᒡᓕᖃᖅᑐᖅ).

ᑕᒪᐃᓐᓃᖕᒐᓪᓗᒋᑦ, 2023-ᒥ ᐅᒥᐊᕐᔪᐊᒦᔪᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᓂᑦ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᖕᒋᓐᓇᕐᓂᕐᒥ ᖃᐅᔨᔭᐅᔪᑦ ᐃᑲᔪᖅᑐᑦ ᐊᒃᑐᐃᓂᕐᓄᑦ ᒥᒃᓴᐅᓴᐃᔾᔪᑎᓂᒃ ᐊᒻᒪᓗ ᐊᖏᓂᖕᒐᓄᑦ ᓇᓗᓇᐃᖅᓯᓂᕐᒥᒃ ᑕᐃᑲᓂ ᑭᖑᓪᓕᖅᐹᒥ ᐊᕙᑎᒥᒃ ᐊᒃᑐᐃᓂᕐᒧᑦ ᐅᓂᒃᑳᓄᑦ ᐅᐃᒍᓂ ᑕᒪᑐᒨᖓ ᖄᓇᐅᔾᔭᒃᓴᓵᓕᓇᓱᖕᓂᕐᒧᑦ (ERP) ᐱᓕᕆᐊᒥ ᓴᖅᑮᓇᔾᔪᑎᑦᑐᒃᓴᐅᔪᑦ ᐊᖏᔪᓂᒃ ᐊᒥᐊᒃᑯᓂᒃ ᐊᒃᑐᐃᓂᕐᓗᖕᓂᕐᓂᒃ ᑕᕆᐅᒥ ᐳᐃᔩᓂᒃ ᓄᓇᓂ ᐊᕙᒃᑐᖅᓯᒪᔪᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ, ᓇᓗᓇᐃᖅᑕᐅᓯᒪᓪᓗᑎᒃ ᐊᒃᑐᐃᓅᑦ ᐃᓗᓕᖅᑐᑦ ᓱᓕᔫᓂᖕᒋᓐᓄᑦ ᑕᕆᐅᒥ ᐳᐃᔫᑦ ᐊᒥᓱᓂᖕᒋᑦ ᓄᓇᖕᒐᓂ ᐊᑐᖅᔪᒋᓪᓘᓐᓃᑦ ᑐᕐᑯᑕᐅᒃᑲᓐᑕᕐᓂᖕᒋᑦ (ᓲᕐᓗ ᐅᒥᐊᕐᔪᐊᒥ ᐊᐳᖅᑕᐅᔪᑦ) ᐅᖕᕙᓘᓐᓃᑦ ᐊᖏᔪᒃᑯᑦ ᑕᐅᕙᓃᑎᑦᑎᔪᓐᓃᕐᓂᑦ ᕿᒪᐃᓃᓪᓘᓐᓃᑦ ᓄᓇᓂ ᐊᕙᒃᑐᖅᓯᒪᔪᒥ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ.

ᑲᔪᓯᑎᑕᐅᖕᒋᓐᓇᕐᓂᖕᒐ ᐅᒥᐊᕐᔪᐊᒦᔪᑎᒃ ᓇᐅᑦᑎᖅᓱᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᖅ ᐅᑐᕐᑯᔭᐅᓯᒪᔪᖅ 2024-ᒥ ᒪᓕᒃᑐᒋᑦ ᓄᓇᕗᒻᒥ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᑲᑎᒪᔨᖏᑦᑕ ᐅᔾᔪᕐᓂᐊᖅᓇᐅᑎ ᓈᓴᐅᑖ 005 ᑕᐃᒎᓯᖓ ᐊᒻᒪᓗ ᒪᓕᒋᐊᓕᖕᓂᒃ. ᑲᔪᓰᓐᓇᖅᑐᑦ ᐊᕐᕌᒍᑕᒫᑦ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᖕᒋᓐᓇᕐᓂᑦ ᖁᒃᑲᓐᓂᐊᒍᑦ ᑎᑎᖅᑲᖁᑎᑦ ᖃᓄᐃᓐᓂᖅᓴᐅᖕᒪᖕᒋᑕ ᕿᒥᕐᕈᓂᖅ ᑖᒃᑯᓇᓂ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᖕᒋᓐᓇᕐᓂᕐᒧᑦ ᐊᕐᕌᒍᓂ, ᐊᑐᖅᑕᐅᓂᐊᖅᑐᑦ ᓇᓗᓇᐃᔭᐃᓇᓱᒃᑎᓪᓗᒋᑦ ᖃᓄᐃᓐᓇᖅ ᖃᒃᐊᓂᐊᒍᑦ ᐋᖅᑭᒃᓱᖃᐃᓐᓇᖅᑐᒥᒃ ᐊᐅᓚᑦᑎᔾᔨᑎᑦ ᓯᑯᐃᖅᐸᓪᓕᐊᑎᓪᓗᒍ ᓯᑯᕙᓪᓕᐊᑎᓪᓗᒍ ᐱᑕᖅᑲᓐᖏᑉᐹᖕᒪᑕ.

ᑕᕆᐅᒦᓲᑦ ᑎᖕᒥᐊᑦ

ᑲᑎᓗᒃᑖᖅᔪᒋᑦ ᖃᐅᔨᓴᖅᐸᓪᓕᐊᖕᒋᓐᓇᕋᓱᐊᕐᓃᑦ ᑕᕆᐅᒦᓲᓄᑦ ᑎᖕᒥᐊᓂᒃ ᐱᓕᕆᐊᖅᑎᓪᓗᒋᑦ 2023 ᐅᒥᐊᕐᔪᐊᒦᔪᑎᒃ ᓇᐅᑦᑎᖅᓱᖅᓱᖅᑏᑦ ᐱᓕᕆᐊᖅ 15.7 ᐃᑲᕐᕋᑦ ᐱᑕᖃᖅᔪᑎᒃ 188 5-ᑎᑦᑕᓪᓚᓂᒃ ᓅᒻᒪᓪᓕᐊᓪᓗᑎᒃ ᑐᙵᕕᒋᔭᐅᔪᑦ ᖃᐅᔨᓴᕐᓂᑦ ᐊᒻᒪᓗᓗ ᑎᓴᒪᑦ ᐱᑕᖅᓯᕈᑦᑲᓪᓚᒃᔪᑎᒃ ᑐᙵᕕᒋᔭᐅᔪᑦ ᖃᐅᔨᓴᕐᓂᑦ. ᑲᑎᔪᒋᑦ ᐊᕐᕕᓂᓖᑦ ᐆᒪᔪᑦ ᐊᔾᔨᒌᙱᐊᕐᔭᒃᑐᑦ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᖅᑐᑦ (34 ᓇᓗᓇᐃᖅᑕᐅᓯᒪᓪᓗᑎᒃ ᑕᑯᔭᐅᓂᒃᑯᑦ ᐃᓗᓕᖅᖢᑦ 47-ᓂᒃ ᐃᓛᒃᑰᖅᑐᓂᒃ) ᖃᕐᑯᓪᓗᑦ (*Larus hyperboreus*) ᑕᑯᔭᐅᕙᓪᓛᖑᓪᓗᑎᒃ ᐆᒪᔪᓂ ᐊᔾᔨᒌᙱᐊᕐᔭᒃᑐᓂ.

ᖃᕐᑯᓪᓗᐃᑦ ᐅᓄᓛᖑᓚᐅᖅᑐᑦ ᐆᒪᔪᓂ ᐊᔾᔨᒌᙱᐊᕐᔭᒃᑐᓂ ᑕᑯᔭᐅᖃᑦᑕᖅᑐᓂ 2023-ᒥ (1.47 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ) ᑭᖑᓂᐊᒍᑦ ᐱᑦᑎᐅᓛᑦ (0.38 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ), ᑐᓗᑦ ᐊᒻᒪᓗ ᐊᐸᑦ (0.32 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ), ᐊᒻᒪᓗ ᓇᐅᔮᑦ ᖃᕐᑯᓪᓗᐃᓪᓗ (0.26 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ). ᐊᒃᑐᐊᓂᓛᑦ ᐊᒥᓲᓂᖕᒋᓐᓄᑦ ᑕᕆᐅᒦᓲᑦ ᑎᖕᒥᐊᑦ ᐅᓄᓛᖑᓚᐅᖅᑐᑦ ᐅᑭᐊᒃᓵᖕᒐᓂ 2018 (16.31 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ) ᑭᖑᓂᐊᒍᓪᓗ ᐅᑭᐊᒃᓵᖕᒐᓂ 2019 (5.13 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ), ᐊᒻᒪᓗ ᐅᑭᐊᒃᓵᖕᒐᓂ 2023 (3.00 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ). ᖃᕐᑯᓪᓗᐃᑦ ᐊᒥᓲᓛᖑᖅᑕᖅᑐᑦ ᐆᒪᔪᓂ ᐊᔾᔨᒌᙱᐊᕐᔭᒃᑐᓂ ᑕᑯᔭᐅᔪᓂ 2018-ᒥ (9.91ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ) ᐊᒻᒪᓗ 2023-ᒥ (1.47 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ) ᖃᕐᑯᓪᓗᑦ ᐅᒥᓲᓛᖑᓪᓗᑎᒃ ᑕᑯᔭᐅᔪᑦ 2019-ᒥ (2.15 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ). ᓇᐅᔮᑦ ᑕᑯᔭᐅᕙᓪᓕᐊᖕᓂᖅᓴᐅᓪᓗᑎᒃ 2018-ᒥ ᑕᑯᙳᐊᕐᓗᒋᑦ 2019-ᒥ ᐊᒻᒪᓗ 2023 (3.85 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ 2018-ᒥᑦ ᑕᑯᙳᐊᕐᓗᒋᑦ 0.4 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ 2019-ᒥ ᐊᒻᒪᓗ 0.26 ᑕᑯᔭᐅᔪᑦ/ᑭᓛᒥᑕᒥ 2023-ᒥ). ᐋᓚᔪᑦ ᐊᔾᔨᒌᙱᐊᕐᔭᒃᑐᑦ ᑕᑯᔭᐅᖃᑦᑕᖅᓯᒪᔪᑦ ᖃᐅᔨᓴᕐᕕᐅᔪᒃᑖᓂ ᐊᕐᕌᒍᓂ ᐱᖃᓯᐅᔾᔨᔪᑦ ᖃᕐᑯᓪᓗᕐᓂᒃ, ᓇᐅᔭᕐᓂᒃ, ᓇᐅᔮᓂᒃ, ᐊᒻᒪᓗ ᐊᐸᓂᒃ.

Study Limitations

WSP Canada Inc. has prepared this document in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this document. No warranty, express or implied, is made.

This document, including all text, data, tables, plans, figures, drawings, and other documents contained herein, has been prepared by WSP for the sole benefit of Baffinland Iron Mines Corporation (Baffinland). The Executive Summary was translated into Inuktitut and provided by Baffinland to WSP. In the event of discrepancies in information or interpretation, the English version shall prevail. This report represents WSP's professional judgement based on the knowledge and information available at the time of completion. WPS is not responsible for any unauthorized use or modification of this document. All third parties relying on this document do so at their own risk.

The factual data, interpretations, suggestions, recommendations, and opinions expressed in this document pertain to the specific project, station conditions, design objective, development and purpose described to WSP by Baffinland, and are not applicable to any other project or station location. To properly understand the factual data, interpretations, suggestions, recommendations and opinions expressed in this document, reference must be made to the entire document.

This document, including all text, data, tables, plans, figures, drawings, and other documents contained herein, as well as all electronic media prepared by WSP are considered its professional work product and shall remain the copyright property of WSP. Baffinland may make copies of the document in such quantities as are reasonably necessary for those parties conducting business specifically related to the subject of this document or in support of or in response to regulatory inquiries and proceedings. Electronic media is susceptible to unauthorized modification, deterioration, and incompatibility and therefore no party can rely solely on the electronic media versions of this document.

Table of Contents

TABLES

FIGURES

APPENDICES

Abbreviation and Acronym list

AIC	Akaike's Information Criterion
ASL	Above Sea Level
Baffinland	Baffinland Iron Mines Corporation
CIS	Canadian Ice Service
CI	Confidence Interval
CPA	closest point of approach
CWS	Canadian Wildlife Service
dB	Decibel
ECSAS	Eastern Canada Seabirds at Sea
ESRI	Environmental Systems Research Institute, Inc.
EEM	Environmental Effects Monitoring
FEIS	Final Environmental Impact Statement
Golder	Golder Associates Ltd.
GIS	Geographic Information System
GPS	Global Positioning System
Hz	Hertz
km	Kilometres
LSA	Local Study Area
MEWG	Marine Environmental Working Group
MMP	Marine Monitoring Plan
Mtpa	million tonnes per annum
MWO	Marine Wildlife Observer
NA	not applicable
NIRB	Nunavut Impact Review Board
OLR	Ordinal Least Squares Regression
Project	Mary River Project
PC No. 005 / The Project certificate	Project Certificate Number 005
PRASP	Project Risk Assessment and Safety Plan
RSA	Regional Study Area
SEM	Sikumiut Environmental Management Ltd.
SBO	Ship-based Observer
SPUE	Sightings Per Unit Effort
STCW	Standard for Training, Certification and Watchkeeping
SVDBS	Small Vessel Domestic Basic Safety
TC	Transport Canada
WSP	WSP Canada Inc.

1.0 INTRODUCTION

This report presents the results of the 2023 Ship-based Observer (SBO) Program (the Program), a vessel-based marine wildlife monitoring program conducted onboard two icebreakers, the MSV *Botnica* (*Botnica*) and MSV *Fennica* (*Fennica*), that provided ice escort services along the Northern Shipping Route Figure 1) during the 2023 fall shoulder shipping season (21 to 30 October 2023). A team of Marine Wildlife Observers (MWOs) stationed onboard the vessels were responsible for systematically collecting marine wildlife sightings data during icebreaker transits in the marine mammal Regional Study Area (RSA; Figure 2) The objectives of the Program were to monitor for potential ship strikes on marine mammals during icebreaker transits in the RSA; to document the occurrence, relative abundance and spatial distribution of marine mammals along the Northern Shipping Route relative to local ice conditions and Project vessel movements in the RSA, and to investigate potential marine mammal behavioural responses to shoulder season shipping activities. Seabird sightings were also recorded in accordance with the Eastern Canada Seabirds at Sea (ECSAS) monitoring protocol with the data submitted to the Canadian Wildlife Service (CWS) to support their regional monitoring program. The previous SBO Program was conducted during the 2019 shipping season (Golder 2020).

1.1 Project Background

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

To date, Baffinland has been operating in the Early Revenue Phase (ERP) of the Project and is authorized to transport 4.2 million tonnes per annum (Mtpa) of ore by truck to Milne Port for shipping through the Northern Shipping Route using chartered ore carrier vessels. A production increase to ship 6.0 Mtpa from Milne Port was approved for 2018 to 2025 through Project Certificate amendments (Baffinland 2018, 2020, 2022, 2023). During the first year of ERP operations in 2015, Baffinland shipped ~918,000 tonnes of iron ore from Milne Port involving 13 return ore carrier voyages. In 2016, the total volume of ore shipped out of Milne Port reached 2.6 million tonnes involving 37 return ore carrier voyages. In 2017, the total volume of ore shipped out of Milne Port reached 4.1 million tonnes involving 58 return ore carrier voyages. Following approved production increase to 6.0 Mtpa, a total of 5.1 million tonnes of ore were shipped via 71 return voyages in 2018, 5.9 million tonnes of ore were shipped via 81 return voyages in 2019, 5.5 million tonnes were shipped via 72 return voyages in 2020, 5.6 million tonnes were shipped via 73 (one vessel was released unloaded) return voyages in 2021, and 4.7 million tonnes were shipped via 62 return voyages in 2022. In 2023, a total of 6.02 million tonnes of iron ore were shipped via 75 return voyages with the first inbound transit of the season occurring on 9 August and the last outbound transit of the season occurring on 31 October 2023.

LEGEND

- COMMUNITY
- PROJECT SITE
- FUTURE SOUTH RAILWAY
- MILNE INLET TOTE ROAD
- NUNAVUT SETTLEMENT AREA
- SHIPPING ROUTE
- MARINE MAMMAL REGIONAL STUDY AREA
- SIRMILIK NATIONAL PARK
- WATER

0 125 250

1:5,000,000 KILOMETRES

REFERENCE(S)

BASE MAP: © ESRI DATA AND MAPS (ONLINE) (2016). REDLANDS, CA: ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

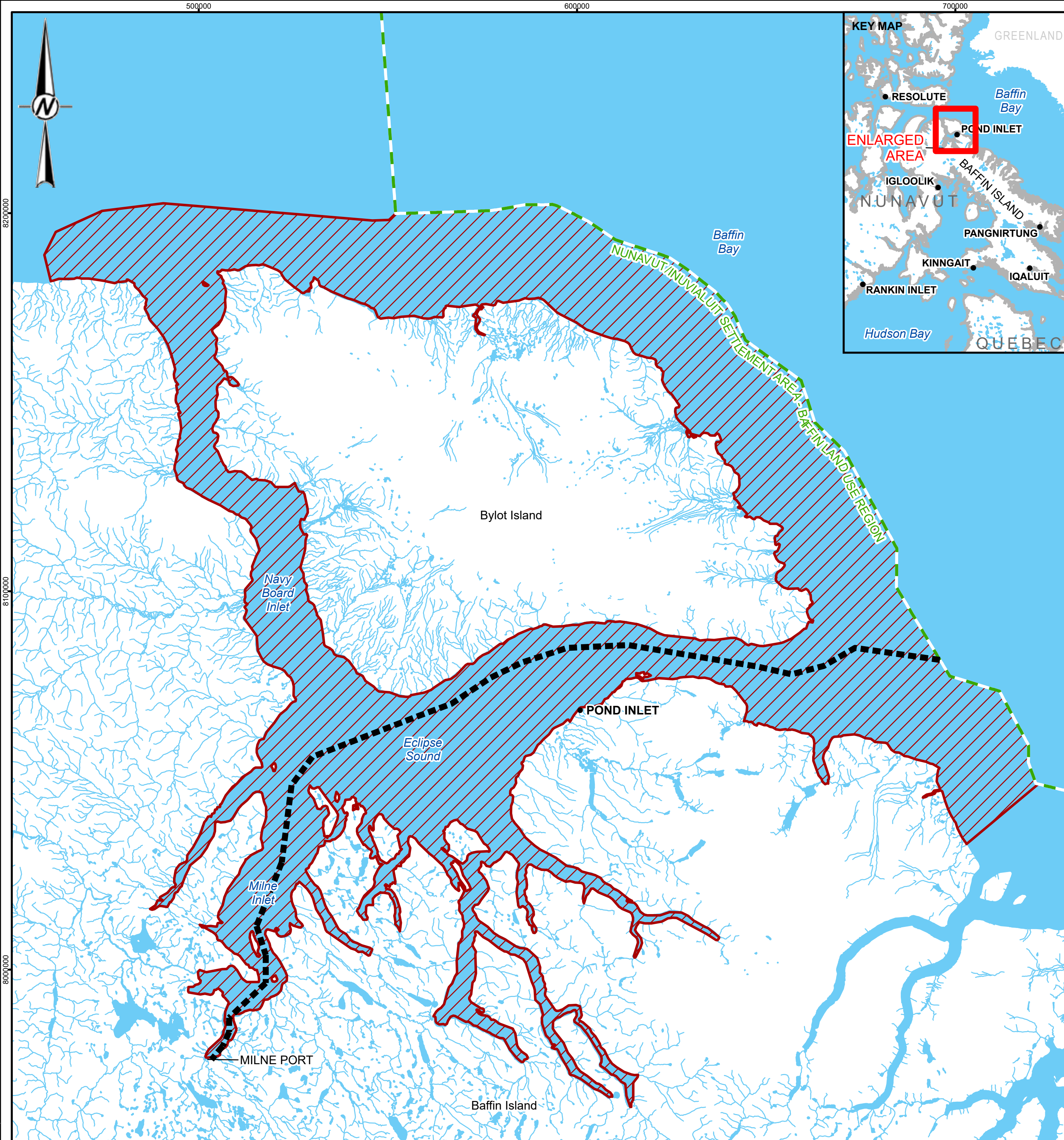
TITLE
PROJECT LOCATION

CONSULTANT
wsp

YYYY-MM-DD	2024-03-12
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	1

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



LEGEND

- COMMUNITY
- SHIPPING ROUTE (APPROXIMATE)
- WATERCOURSE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- MARINE MAMMAL REGIONAL STUDY AREA
- 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.
PROJECTED COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
MARINE MAMMAL REGIONAL STUDY AREA

CONSULTANT

YYYY-MM-DD	2023-10-06
DESIGNED	KG
PREPARED	AA
REVIEWED	KG
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000	0	2

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

25mm

PRINTED ON: 2024-03-06 AT: 1:25:27 PM

1.2 Program Objective

The main objective of the SBO Program is to monitor for potential ship strikes on marine mammals in the RSA. The secondary objective of the SBO program is to collect observational data on the occurrence, relative abundance and spatial distribution of marine mammals along the Northern Shipping Route relative to local ice conditions and Project vessel movements in the RSA, and to investigate potential marine mammal behavioural responses to shoulder season shipping activities.

1.3 Regulatory Context

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

- Measure the relevant effects of the Project on the marine environment.
- Confirm that the Project is being carried out within the terms and conditions relating to the protection of the marine environment.
- Assess the accuracy of the predictions contained in the Final Environmental Impact Statement (FEIS) for the Project.

The Program represents one of several environmental effects monitoring (EEM) programs for marine mammals conducted by Baffinland in support of the Mary River Project. The Program was designed to specifically address PC conditions related to evaluating potential ship strikes on marine mammals and potential disturbance of marine mammals from shipping activities that may result in changes to animal distribution, relative abundance, and behaviour in the RSA. Specifically, this included the following PC conditions:

- Condition No. 99 — “*The Proponent, working with the Marine Environmental Working Group (MEWG), shall consider and identify priorities for conducting the following supplemental baseline assessments:*
  - *c. Enhance baseline data on marine wildlife (fish, invertebrates, birds, mammals, etc.) and to provide more details on species abundance and distribution found in the Project area.*”
- 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.*”
- Condition No. 106 — *“The Proponent shall ensure that shipboard observers are employed during seasons where shipping occurs and provided with the means to effectively carry out assigned duties. The role of shipboard observers in shipping operations should be taken into consideration during the design of any ore carriers purpose-built for the Project, with climate-controlled stations and shipboard lighting incorporated to permit visual sightings by shipboard observers during all seasons and conditions.”*

- Condition No. 108 — "*The Proponent shall ensure that data produced by the surveillance monitoring program is analysed rigorously by experienced analysts (in addition to being discussed as proposed in the FEIS) to maximize their effectiveness in providing baseline information, and for detecting potential effects of the project on marine mammals, seabirds and seaducks in the Regional Study Area. It is expected that data from the long-term monitoring program be treated with the same rigor.*"
- Condition No. 123 — *"The Proponent shall provide sufficient marine mammal observer coverage on project vessels to ensure that collisions with marine mammals and seabird colonies are observed and reported through the life of the Project. The marine wildlife observer protocol shall include, but not be limited to, protocols for marine mammals, seabirds, and environmental conditions and immediate reporting of significant observations to the ship masters of other vessels along the shipping route, as part of the adaptive management program to address any items that require immediate action".*
- 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.*"

1.4 Program Background

Sikumiut Environmental Management Ltd. (SEM), on behalf of Baffinland, first initiated a SBO Pilot Program in 2013 onboard cargo vessels transiting between Quebec City and Milne Inlet during the initial Milne Port construction phase (SEM 2014). During 2014 and 2015, SEM conducted the SBO Program onboard fuel tanker and sealift vessels with observers boarding the ships near Pond Inlet (i.e., at-sea crew transfer) and disembarking at Milne Port. Results for these programs are presented in the respective annual monitoring reports (SEM 2015, 2016). Survey effort in 2014 and 2015 was limited to three one-way ship transits per season, with nine hours of survey effort completed in each year. Low numbers of marine mammals and seabirds were observed along the shipping route during the 2014 and 2015 programs (SEM 2015, 2016). Potential explanations included: 1) the time of year (mid-August to late September), which might not have provided adequate sighting opportunities; 2) the relatively short length of the transit; 3) the limited (two to four hours) number of daylight hours available for observations and, 4) the observer position on the bridge situated at the rear of the vessel did not allow sufficient viewing opportunities.

In 2016, Baffinland suspended the SBO Program due to safety concerns regarding the observer crew boarding the vessel while at sea. The introduction of an icebreaker in 2018 to support Baffinland's shipping operations during the shoulder seasons (July and October) provided an opportunity to safely re-establish the SBO Program during the 2018 and 2019 shipping seasons (Golder 2019, 2020). Data collection methods and monitoring protocols were revised in 2018 to better address terms and objectives of the Project Certificate. In 2019, several further modifications to the monitoring protocol were incorporated based on recommendations provided by the MEWG. These modifications included the following components:

- Ice cover data was collected during active watch periods at two spatial scales:
  - Ice cover in the Near Field (within 100 m of the vessel) was recorded to estimate the proportion of time that the *Botnica* was actively engaged in icebreaking relative to prevalent ice conditions.
  - Ice cover in the Far Field (beyond 100 m of the vessel, over the full extent of the MWO's view from the bridge) was recorded to assess marine mammal detectability as a function of ice cover.

- Median and mean ice conditions were used to define sea ice normal values.
- Weekly ice chart maps were produced for inclusion in the annual monitoring report.
- The relationship between sightability parameters and detection rates was evaluated.
- Seal group size was defined in the SBO training manual and data collection methods for seal group size were explained to Inuit researchers during the SBO training program.

In 2020 and 2021, Baffinland suspended the SBO Program due to COVID-19 safety concerns. In 2022 and 2023, the SBO Program did not take place during the early shoulder season due to Baffinland's decision to avoid icebreaking operations during this period (as a precautionary-based mitigation measure). In 2022, the SBO Program did not take place during the fall shoulder season due to the presence of multi-year ice in the RSA which resulted in early termination of the 2022 shipping season (last day of Project shipping in RSA was 13 October 2022). In 2023, the SBO Program was successfully completed during the fall shoulder season. The *Botnica* icebreaker first arrived in the RSA on 26 September 2023 and the *Fennica* icebreaker first arrived in the RSA on 30 September 2023. Both vessels provided ice escort services until shipping operations were concluded on 31 October 2023. As in 2019, modifications were made to the monitoring protocol based on recommendations provided by MEWG members and included the following components:

- Modifications to improve methods for measuring or estimating distances to marine mammal sightings:
  - As part of training, MWOs received additional instruction/guidance on measuring distances using available field equipment, e.g., reticle binoculars.
  - An additional distance measurement tool, the clinometer, was adopted into the field data collection protocol.
  - A pair of Big Eye binoculars (40x100) were used during active monitoring to aid in species identification and recording behavioural responses.
  - MWOs regularly practiced using reticle binoculars and clinometers to measure distances to objects/landmarks (e.g., land features, icebergs, other vessels) on the water that were validated using onboard radar and/or electronic mapping/plotting tools.
  - For each sighting, data was recorded on how distance was measured or estimated.
- Distance to sightings was accounted for in the analyses for relative abundance, closest point of approach (CPA), and behavioural responses:
  - Sightings were truncated by distance (≤ 2 km) to remove sightings at farther ranges e.g., to minimize uncertainty in species identification and group sizes.
- Additional text from the training manual was included in the main body of the report to clarify details on field and analytical methods.
- Additional behavioural response data were collected and analyzed in 2023.

1.5 Effect Pathways of Concern

This section provides background information on the primary effect pathways of concern investigated as part of the Program, this being potential ship strikes on marine mammals and potential behavioural disturbance of marine mammals from icebreaking.

Marine Mammal Ship Strikes

Vessel strikes on marine mammals may result in serious injury or death by means of blunt force trauma from direct impact with the hull of a vessel, or from lacerations due to contact with rotating propellers (Knowlton and Kraus 2001; Silber et al. 2010; Neilson et al. 2012). Depending on the severity of the strike and the injuries inflicted, the animal may or may not recover. In general, most lethal and severe injuries are linked to large vessels with bulbous bows travelling at speeds greater than 13 knots (Laist et al. 2001; Jensen and Silber 2003; Dolman et al. 2006). This vessel speed is considered to be the critical threshold above which vessel strikes resulting in severe injury and/or mortality are more likely to occur (Dolman et al. 2006; Jensen and Silber 2003). The probability of a lethal vessel strike is thus positively correlated with vessel speed and gross tonnage of the vessel (Dolman et al. 2006; Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Mitigation measures limit the speeds of project related vessels in the RSA to 9 knots, substantially slower than the critical threshold for serious injury or death and provides animals more time to avoid being in the direct path of collision. Since shipping began, there have been no reported strikes or near misses between project shipping/icebreaking and marine mammals.

Species-specific behavioral and physical differences are also factors that determine a given species' vulnerability to a vessel strike (Laist et al. 2001; Nichol et al. 2017). Toothed whales have sensitive hearing and actively use echolocation (i.e., biosonar) to scan and perceive their environment, enabling them to effectively detect and avoid ship traffic by manoeuvring out of the way of oncoming vessels. There are relatively few documented cases of vessel strikes in toothed whales (Wells and Scott 1997; Richardson et al. 1995; Van Waerebeek et al. 2007) and none for narwhal or beluga specifically. These animals are considered to be at relatively low risk of vessel strike owing to their fast-swimming speed, manoeuvrability and agility (Richardson et al. 1995; Laist et al. 2001; Jensen and Silber 2003, Silber et al. 2010; Lawson and Lesage 2013).

Baleen whales such as bowheads are particularly susceptible to vessel strikes as a result of their large body size, slow swimming speed and inability to manoeuvre (Vanderlaan and Taggart 2007; Reeves et al. 2012; Allen 2014). This vulnerability is further compounded by their inability to echolocate (Nichol et al. 2017). Further to this, baleen whales often spend extended periods of time at the surface either foraging or recovering from a dive than do toothed whales (Constantine et al. 2015; Goldbogen et al. 2006; Nichol et al. 2017), thus making them particularly vulnerable to vessel strikes. Although there is relatively little data available to fully evaluate the susceptibility of bowhead whales to vessel strike specifically, it is reasonable to draw from what is known about its close relative, the North Atlantic right whale (*Eubalaena glacialis*), who is highly vulnerable to lethal and sub-lethal vessel strike (Allen 2014). North Atlantic right whales have been found to exhibit no avoidance response when presented with sounds of approaching vessels (either real or play-back recordings) (Nowacek et al. 2004) and have been the subject of numerous vessel strike casualties in the past year alone. Given that the two species share many similar morphological characteristics and life history strategies, it is reasonable to assume that bowhead whales are similarly vulnerable to serious injury or death as a result of being struck by transiting vessels in the RSA. For this reason, Baffinland has implemented a speed limit of 9 knots for Project vessels transiting along the Northern Shipping Route. In the rare event that a marine mammal strike were to occur, the consequence is more likely to be a non-lethal injury (laceration from propeller and/or blunt force injury) than direct mortality (Vanderlaan and Taggart 2007). The lower vessel speeds during operations are predicted to reduce the likelihood of ship strikes on bowhead by providing ample time for these animals to avoid oncoming vessels, as well as time for crew on Project vessels to detect and avoid marine mammals during active vessel operations. Furthermore, the likelihood of occurrence of a ship strike on bowhead is predicted to be low, given the low number of bowhead occurring along the Northern Shipping Route during the open-water season, based on results from extensive aerial surveys and shore-based marine mammal monitoring programs conducted to date in the Local Study Area (LSA) (Smith et al. 2015; 2016; 2017).

Polar bear are anticipated to detect and actively avoid icebreakers (Smultea et al. 2016; Golder 2019) before a risk of collision can occur. The potential for a polar bear to be struck by an icebreaking vessel is considered low. During five years (2013-2015; 2018, 2019) of ship-based marine mammal monitoring as part of the SBO Program, no ship strikes on polar bear, or near misses, were observed (SEM 2014, 2015, 2016; Golder 2019, Golder 2020).

There are relatively few documented cases of vessel strikes in pinnipeds (seals and walrus) (Wells and Scott 1997; Richardson et al. 1995; Van Waerebeek et al. 2007). These animals are considered to be at relatively low risk of vessel strike owing to their fast-swimming speed, manoeuvrability and agility (Richardson et al. 1995; Laist et al. 2001; Jensen and Silber 2003).

In addition to normal open-water shipping, icebreakers (along with escorted vessels) may transit the shipping corridor during the break-up period in late spring and during initial ice formation (i.e., freeze-up) in the fall. The marine mammal species considered to be most susceptible to ship strikes during these periods is the ringed seal (*Pusa hispida*), with individuals commonly hauled out on ice pans or floating ice. Although there is no evidence of ringed seal injury or mortality due to icebreaker movements in the available literature, seals have been reported to demonstrate fleeing behaviour when a ship approached within 0.4 to 0.8 km (Richardson et al. 1995). Ringed seals are considered to have a low likelihood of being struck by a vessel due to their maneuverability and agility in the water, and in light of Project vessel speed restrictions (9 knots) in the RSA. Icebreaking during winter would have an increased chance of separating pups from their mothers or causing injury or mortality by striking seals in the dens during active icebreaking. However, as Project icebreaking along the Northern Shipping Route is limited to the shoulder seasons, there is no overlap between icebreaking activities and sensitive periods for ringed seal including denning, pupping and nursing activities which occur between January and April.

Behavioural Disturbance from Icebreaking

Underwater noise generated during icebreaking operations has the potential to result in disturbance effects in marine mammals including avoidance and displacement behavior, and potential abandonment of suitable habitat areas.

Narwhal and Beluga

The most comprehensive studies of narwhal and beluga in terms of behavioural responses to icebreaking activities were undertaken during June 1982, 1983 and 1984 in Lancaster Sound (LGL and Greeneridge 1986; Finley et al. 1990). In each study year, the *MV Arctic*, an icebreaking ore carrier (20,000 DWT) was accompanied by the *CCG John A. MacDonald* (1982, 1983) or the *CCG Louis St. Laurent* (1984) in Lancaster Sound as it approached the landfast ice-edge and then moved through landfast ice enroute to the Nanisivik mine in Admiralty Inlet.

Narwhal holding along the ice edges waiting to continue their inshore migration to their traditional summering ground areas were shown to respond to oncoming vessels and periodic icebreaking by 1) demonstrating a “freeze” response, typically lying motionless or swimming slowly away (as far as 37 km along the ice edge), 2) huddling in groups, and 3) ceasing sound production. After initially being displaced from the floe edge in response to relatively low levels of noise from the approaching ship (94–105 dB re 1µPa in the 20–1,000 Hz band), some narwhal returned to the floe edge 1–2 days later and engaged in diving and foraging behaviour when icebreaker noise levels were still as high as 120 dB in the same band even though the icebreaker was >13 km away and moving in the opposite direction (Finley et al. 1990). The strong reactions of narwhal (and beluga) at long exposure ranges are unique in the literature with respect to documented marine mammal responses to vessel noise. Possible explanations suggested for the overt response included 1) animals might have felt trapped along the ice edge as the ships approached, 2) a lack of familiarity or experience with icebreaker noise in the High Arctic during late spring, and/or 3) long-range sound propagation conditions in surface waters at that time of year. The fact that narwhal later returned to the area of disturbance when noise levels were higher than those to which they initially reacted suggests this initial reaction may have been a startle response and that some level of habituation or tolerance may have occurred (LGL and Greeneridge 1986).

Unlike narwhal, beluga observed at the floe edge waiting to start their in-migration to summering areas were shown to respond to approaching icebreaking vessels at distances ranging from 20 to 80 km. Observed reactions included fleeing at speeds of up to 20 km/h, abandoning their normal group structure, and modifying their vocal behaviour and/or emitting alarm calls. Strong avoidance reactions were elicited when ships were 35 to 50 km away (Finley et al. 1990). At those distances, received sound levels were 94 to105 dB re 1 µPa in the 20–1,000 Hz band, which was likely near the level of natural background noise. In 1982, after the *MV Arctic* had travelled 48 km into the landfast ice from the ice edge and 43 hours had passed, the belugas returned and resumed apparently normal activities along the ice edge, although the ship was still audible to them. In 1983, beluga distribution along the ice edge and offshore appeared to return to normal only >60 hours after the ships had passed and were >45–50 km into the ice (Finley et al. 1990).

Cosens and Dueck (1988) reported less intense reactions by narwhal and beluga to icebreakers in 1986 than in previous study years (1982 to 1984). Possible explanations included easier avoidance opportunities by animals in 1986 due to sparser ice conditions and/or potential evidence of habituation to icebreaking noise, although this was considered less likely based on animal orientation data collected over the same study period (Cosens and Dueck 1988). Cosens and Dueck (1988) also noted a two-week delay in the timing of narwhal in-migration in 1986 compared to previous study years (1982 and 1984). Possible explanations for the observed delay included different ice conditions in 1986 and/or possible avoidance or displacement behaviour due to near continuous ship traffic in Admiralty Inlet in 1986. Other studies (Mansfield 1983) have also suggested that icebreaking activities along the floe edge may cause narwhal to leave the immediate area and migrate into inshore fiords where there is less shipping activity. A study by Finley et al. (1990) noted that narwhal appeared to be initially attracted to open leads in the ice caused by an icebreaker transit and conducted “exploratory” dives of the rubble-filled ship track, although the attraction was demonstrated to be short-lived.

Erbe and Farmer (2000) estimated that an icebreaker would be audible to beluga at distances ranging from 35 to 78 km depending on location, with the zone of behavioral disturbance only slightly smaller than this. Richardson et al. (1995) recorded reactions of beluga and bowhead whale to playbacks of underwater propeller cavitation noise from the icebreaker *Robert Lemeur* operating in heavy ice in the Alaskan Beaufort Sea. Data were collected on 17 groups for two days. At least six groups of beluga appeared to alter their path in response to the playbacks but approached within a few hundred (and occasionally tens of) metres before exhibiting a response. However, Richardson et al. (1995) also noted that given the much larger anticipated radius of influence around an actual icebreaker and their small sample size, any conclusions about the effects of icebreaker playbacks on belugas cannot be applied directly to actual icebreaker effects.

During consultation with Inuit communities discussing icebreaking operations undertaken for the Nanisivik Mine in Admiralty Inlet, it was noted that narwhal would leave the area for three days in response to ship transits when there was ice present and would return three days later (Arctic Bay Working Group Meeting, anonymous, pers. comm.). It was also noted that narwhal avoided using leads in the ice during May because of icebreakers transiting to Nanisivik at this time, but that narwhal returned to this area after Nanisivik closed (Arctic Bay Public Meeting, Koonoo, pers. comm.). Conversely, other community members reported no negative effects on narwhal (or other marine mammal species) caused by icebreakers servicing Nanisivik (Iqaluit City Council Public Meeting, Councillor S. Nattaq, pers. comm.). During more recent risk assessment workshops for the Phase 2 Proposal, one workshop participant noted that they did not notice any changes in the population or abundance of narwhal during the life of the Nanisivik Project, while other participants suggested a link between lower numbers of narwhal in Eclipse Sound and increased ship traffic in this area, with animals potentially being displaced to Arctic Bay (JPCS 2017/TSD 03).

Bowhead Whale

Richardson et al. (1995) recorded reactions of bowhead whale to playbacks of underwater propeller cavitation noise from an icebreaker operating in heavy ice in the Alaskan Beaufort Sea. Reponses varied with some bowhead whales tolerating the 20 dB sound level increase while others appeared to divert their paths to remain farther away from the projected sounds. The authors suggested that such responses were possible at 10 to 50 km distance from the icebreaker, but reactions were dependent on context of exposure and site-specific variables (e.g., ice thickness, distance from vessel).

Seals

Data suggest that seals are fairly tolerant of vessel sound and vessel activities and are known to return to areas of previous disturbance (full review in Richardson et al. 1995a). A study by Brueggeman et al. (1992) reported that ringed and bearded seal that were approached by an icebreaker when hauled out on ice were shown to dive into the water within ~1 km of the vessel. Both species were shown to be less responsive when the same ship was in open-water. During Baffinland's Ship-based Observer (SBO) Programs in 2018 (onboard the icebreaker *Botnica*), ringed seals were recorded at closer distances to the ship when in water (mean 184 m; range 15 to 600 m) compared to when they were hauled-out on ice (mean 323 m; range 50 to 700 m) (Golder 2019). In another study, ringed and harp seal remained on the ice when an icebreaker was 1 to 2 km away, but often dove into the water when the vessel approached at closer distances (Kanik et al. 1980). Ringed seal have also been observed feeding amongst overturned ice floes following an icebreaker passage (Brewer et al. 1993). Crew members of the MV *Arctic* icebreaker reporting sightings of ringed seal within the track of broken ice behind their ship (Canarctic and Roche 1993). During IQ workshops held with Inuit communities for the Phase 2 Proposal, several community members' experiences were shared with respect to shipping through ice at the Nanisivik Mine near Arctic Bay; it was noted by one individual that while seals would initially flee from shipping activities, they would generally return to the area a day after a ship had passed through (JPCS 2017/TSD 03).

A quantitative study of icebreakers transiting ice-breeding habitat of a phocid seal between late January and mid- March reported impacts on seal that included displacement and separation of mothers and pups, breakage of birth or nursery sites and vessel-seal collisions (Wilson et al. 2017). Ringed seal mother and pup separation typically occurs when the landfast ice breaks up (Lydersen 1988), thus will occur prior to the start of icebreaking activities along the Northern Shipping Route. Stirling (2005) noted that in spring, pups are independent of their mothers. Human disturbance at harbour seal haul-out sites resulting in seals entering the water during their moult period may have thermal consequences and potential energetic costs (Paterson et al. 2012). The primary moulting period for ringed seal is in June when animals spend up to 60% of their time on the ice. By early July, the proportion of time ringed seal spend on the ice drops to 30% (Kelly et al. 2010), suggesting the moulting process is mostly complete by this time. Ringed seal that have not fully completed their moult by the time icebreaking operations commence may incur a slight energetic cost as a result of entering the water when their skin temperatures are elevated due to basking, but this would be temporary, and well within their ability to adapt.

Lomac-MacNair, Andrade and Esteves (2019) found that ringed, harp (*Pagophilus groenlandicus*), hooded (*Cystophora cristata*) and bearded (*Erignathus barbatus*) seals hauled out on ice responded to icebreakers by flushing into the water when the icebreaker came within approximately 700 m, with some species, such as harp seals, showing less responsiveness than ringed, hooded and bearded seals. Harbour seals in Alaska that were hauled out on ice were observed responding to cruise ships, with the majority of seals flushing into the water when the ship came within 200 m. The likelihood of response increased at closer distances (Jansen et al. 2010). These flush responses are generally considered to have energetic costs, especially during sensitive periods such as brooding and moulting (Harding et al. 2005; Lomac-Macnair, Andrade and Esteves et al. 2019).

Polar Bear

For polar bears, varied responses have been observed such as vigilance (i.e. sniff, look), avoidance, and approach, with, generally, more polar bears showing a response than not (Lomac-MacNair, Andrade and Esteves 2019; Smultea et al. 2015).

2.0 MARINE MAMMAL MONITORING

2.1 Materials and Methods

2.1.1 Field Methodology

The 2023 SBO program took place over a 10-day period during the fall shoulder season (21 to 30 October 2023). Survey data was collected on both the MSV *Botnica* and MSV *Fennica* icebreakers during active ice escorts in the RSA. The seven-person MWO team consisted of two WSP marine mammal biologists, one MWO contractor, one seabird observer contractor, and three Inuit MWOs, all with previous marine wildlife survey experience (Figure 3). The full team was on the *Botnica* from 20 to 27 October. On 27 October, the SBO team was split between the two icebreakers; three personnel (one WSP Biologist, one southern MWO, and one Inuit MWO) were transferred to the *Fennica* while four personnel (one WSP Biologist, two Inuit MWOs, and one southern seabird observer) remained on the *Botnica*.

Figure 3: 2023 MWO survey team for 2023 Ship-based Observer (SBO) Program

As required by Transport Canada (TC), all SBO personnel possessed current certification in marine safety training (e.g., STCW "Personal Survival Techniques" or TC's Small Domestic Vessel Basic Safety [SDVBS] training) and had a valid TC Marine Medical certificate to work on the vessels. Prior to the start of the SBO Program, one Inuit MWO candidate from Pond Inlet completed the one-day "Small Domestic Vessel – Basic Safety" marine offshore safety certification program in Ottawa, Ontario and obtained his TC Marine Medical.

The team arrived at Baffinland's Milne Port on 18 October 2023. WSP provided a one-day MWO training session for the Inuit and contractor MWOs prior to the start of the field survey. The training session was conducted by the lead WSP Biologist with MWO certification and local marine wildlife survey experience. Additional practical training was provided on 21 October 2023 during the first day of data collection with ongoing mentorship throughout the Program. MWO training manuals were provided to all MWOs at the training session (see Appendix A).

MWO theoretical and practical training sessions included the following components:

- Review and discussion of the Project Risk Assessment and Safety Plan (PRASP).
- An overall introduction to the SBO Program including survey objectives.
- Marine wildlife species identification and observation techniques.
- Data entry and data QA/QC procedures.
- Practical training using the Environmental Systems Research Institute, Inc. (ESRI) *Survey 123* digital sightings database, Global Positioning System (GPS) units, peloruses, clinometers, and binoculars.

2.1.1.1 Position and Field Schedule

The MWOs were stationed on the bridges of the *Botnica* and *Fennica* as these were the highest accessible and protected vantage point on the vessels. The height of the bridge of the *Botnica* was 20 m above sea level (ASL) and the bridge of the *Fennica* was 27 m ASL. Tables of distances to sightings for the 7x50 reticle binoculars and clinometers used during MWO observations were created using these vessel bridge heights for the range of observer eye heights (1.4–1.7 m). Printed copies of these tables were available at both port and starboard observer stations for rapid reference in the event of a sighting. At the eye height of the tallest observer on the bridge of the *Botnica* (21.7 m ASL) and *Fennica* (28.7 m ASL), the distance to the horizon was approximately 16.6 and 19.1 km, respectively.

Marine wildlife sightings were recorded over a daily monitoring period extending up to 9.5 h during the 2023 SBO Program (from ~08:00 to 17:30), depending on available daylight hours. Observers focused their survey effort on either the port or starboard side of the vessel with some overlap at the bow (~10°) to ensure coverage where the two observation areas meet. When the vessel was in-transit, observers scanned the water from the bow (0°) to the stern (180°), focusing on the water ahead and to the side(s) of the moving vessel (from 350° on port to 120° on starboard for starboard observer and 240° on starboard to 10° on port for the port observer). When the vessel was stationary, the observers regularly moved to shift their visual search zone and cover the entire area on their side and behind the vessel. The vessel was only stationary for one hour during the survey (1% of total survey effort). When there was only one dedicated visual observer, the observer moved around the bridge to ensure complete coverage around the vessel. The bridges on the *Botnica* and *Fennica* offered good visibility of the main observation area ahead of the vessel to 120° on the starboard side and 240° on the port side (Figure 4 to Figure 8). Of note, from the centre of the bridge of the *Fennica*, the extent of the observer's view to starboard was limited due to the configuration of the bridge. Therefore, the observers moved from port to starboard regularly to ensure adequate coverage of both sides of the vessel (Figure 7 and Figure 8).

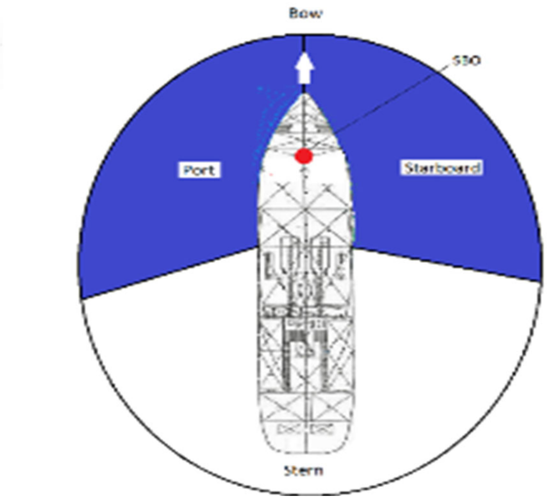


Figure 4: Observer Focus Area Ahead and To Port/Starboard of The Vessels.

Figure 5: The *Botnica* Bridge – view of the port side (left) and starboard side (right)

Figure 6: View forward from the *Botnica* Bridge (photo taken using a wide-angle lens on a GoPro10; actual observer visual coverage extended beyond the limits of this photograph).

Figure 7: The *Fennica* Bridge as viewed from the port side.

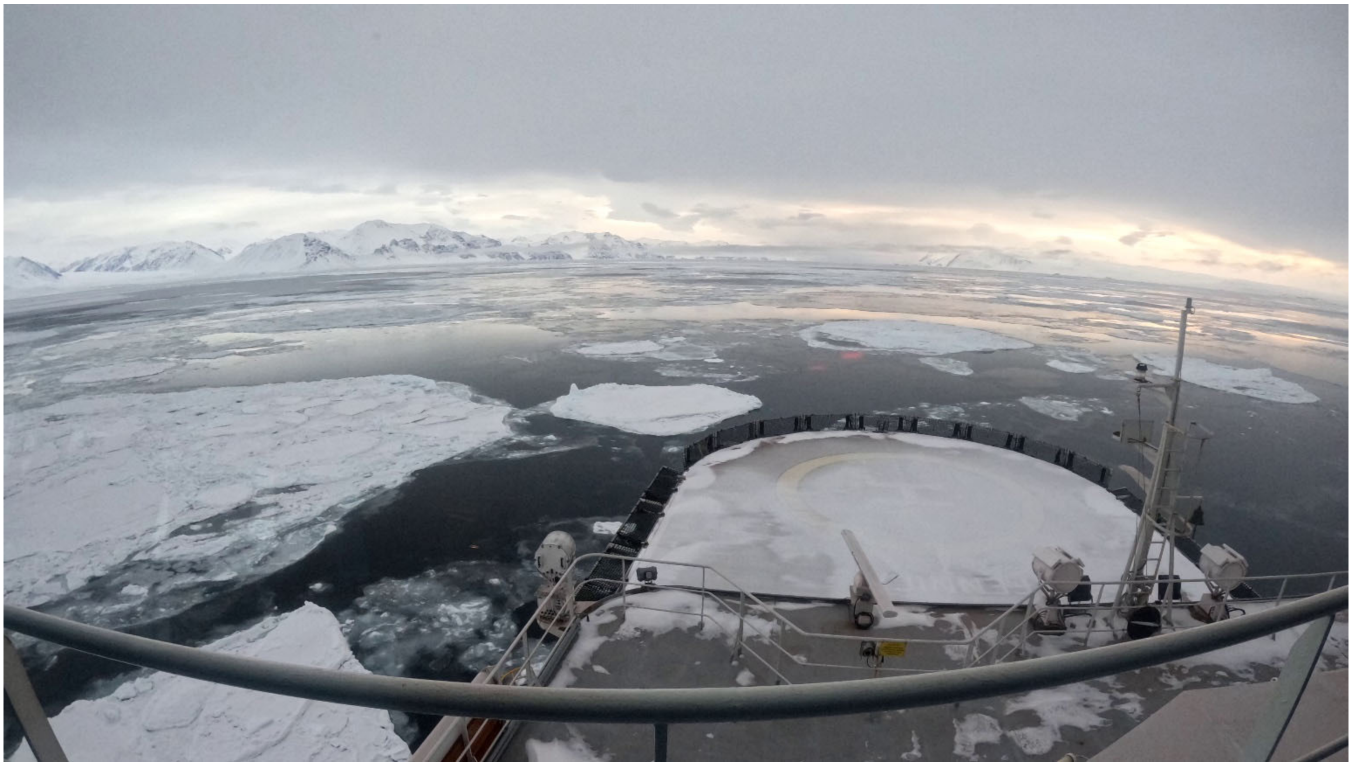


Figure 8: View forward from the *Fennica* Bridge (photo taken using a wide-angle lens on a GoPro10; actual observer visual coverage extended beyond the limits of this photograph).

Observer watch periods occurred in two-hour watches with four observers on watch at a time when the full team was working on the *Botnica* (single-vessel schedule) and two observers on watch at a time when the team was split between the two vessels (two-vessel schedule). The seabird observer assisted with MWO watches during both single and two-vessel schedules when not surveying for seabirds.

To ensure adequate coverage on both sides of the vessel, observations were conducted by a port team and a starboard team, each including one observer and one data recorder. A dedicated data recorder was assigned to each team so the visual observer could focus on observing marine mammal groups while dictating marine mammal sighting data to the data recorder. Each observation team rotated between observer and data recorder positions (at each hourly rotation one observer returned from break to begin their watch as visual observer, the visual observer shifted to data recorder, and the data recorder went for their break). To foster knowledge exchange between Inuit MWOs and southern MWOs and vice versa, each team consisted of at least one southern MWO and one Inuit MWO working together on the port or starboard observation teams.

When the observers were split between the two vessels, the observers switched to a two-vessel schedule; one observer covered both sides of the vessel, one observer assisted with observations (e.g., species identification, tracking sightings, and acted as dedicated data recorder), and the third observer was on break. The single-vessel and two-vessel observation team watch schedules can be found in Section 6.1 of the training manual (see Appendix A).

At times when mitigation was required, there were many sightings, or on-watch observers were feeling fatigued and unable to observe and collect data accurately, the off-shift observer helped with data collection. When the SBO team was split between the two vessels, they communicated relevant sightings, e.g., potential mitigating sightings, directly to each other via the ships' handheld VHF radios. The MWO team lead alternated between port and starboard teams to mentor the observers during active watch periods, help with data recording, and review data quality. The MWO team lead communicated directly with the officers on watch during potential mitigating situations.

MWOs were responsible for recording marine wildlife sightings from the bridge of the *Botnica* and *Fennica* during dedicated watch periods. Systematic data on marine wildlife sightings and sighting conditions were recorded by the MWOs and entered in electronic database forms using ESRI's *Survey 123* application on a Samsung tablet and an iPad. An *MS Access* database was also available as a back-up data entry platform. The database included forms for recording observer effort, environmental conditions, vessel activity, marine mammal sightings, breaks in survey effort and end of survey day times (see Appendix A).

Surveying was conducted with the naked eye and using 7x50 reticle binoculars for initial scanning and estimating distances, and 10x42 binoculars and 40x100 tripod mounted Big Eye® binoculars for higher magnification to identify species, confirm group size, and track behaviour. The MWOs were also responsible for photo-documentation of wildlife sightings and reporting observed ship strikes on marine mammals or seabirds, including near misses. Two cameras were available for collecting photographic data: a Canon EOS 5DS DSLR with 100–400 mm lens and a Nikon CoolPix P1000 Super-telephoto (3000 mm zoom) camera. Due to potential satellite connection issues in the region, three different types of GPSs were available to collect GPS data during the survey: Garmin GLO2 GPS, Garmin GlobalSat BU-353 GPS and Bad Elf GPS (see Appendix A). At the beginning of each watch period, a GPS track file was initiated to record the path and speed of the survey vessel and to record sighting locations.

2.1.1.2 Survey Conditions

During SBO watches, the MWOs were responsible for recording the following environmental conditions: sunglare (intensity and % field of view), ice cover (Near Field [<100m] and Far Field [observation area], in tenths), wind force (Beaufort), wind direction, sea state (Beaufort scale), weather (e.g., precipitation and cloud cover), visibility, and sightability. Environmental conditions were recorded at the start of every watch or observer rotation, every 30 minutes, or every time there was a change in at least one environmental variable (see Appendix A). Observers were encouraged to discuss environmental conditions with each other during their watches to ensure consistency in environmental data recording.

The area ahead of the vessel was also photographed continuously using a GoPro10 camera system recording time lapse data. The primary aim of the time lapse data was to record ice conditions throughout the SBO program, especially in relation to icebreaking operations. One forward facing GoPro camera was mounted on the bridge window of each vessel using a suction cup mount. The GoPro collected time lapse data from sunrise to sunset every day and took a photo every 30s using the wide-angle lens option on the camera. A 30s time-lapse interval was selected because at typical travel speeds of 5–8 kts, the vessel would travel ~100 m between each 30s timelapse photo providing complete coverage of ice conditions encountered during vessel transit.

2.1.1.3 Vessel Activity

In addition to recording observer effort and sightings conditions, the MWOs were also responsible for recording vessel activity and any other vessels in the area. A vessel activity form was completed at the beginning of every observer watch or rotation, every 30 minutes, and when conditions changed (e.g., change of direction or activity). For the *Botnica* and *Fennica*, activities were recorded in six categories (based on Smultea et al. 2016) including transiting in open water, icebreaking (including transiting in a broken ice track[1]), maneuvering, drifting, ice management (pushing but not breaking ice), and anchored. Data recorded for other vessels encountered included type of vessel, vessel size, and vessel activity (see Appendix A).

2.1.1.4 Marine Mammal Sightings

Marine mammal sightings were entered into the marine mammal database by the data recorder while the observer on watch provided sighting details. When first observed, the MWOs prioritised recording the sighting time, location and vessel course (automatically entered by *Survey123* at the start of a new sighting), distance to sighting which was either measured (using reticle binoculars or a clinometer) or estimated (using reference to known objects or naked eye), and bearing (using a pelorus mounted on the bridge on each side of the vessel) (see Appendix A).

Depending on the species group selected (Seals and Walrus, Polar Bear, or Whales), different fields were available for entry in the Sightings form. Information recorded for all sightings included: observer name, species group, whether an observation was a re-sighting, species, certainty of identification, CPA, distance estimation method, minimum and best group size estimates, behaviour upon initial sighting, response behaviours, vessel activity and comments (see Appendix A). When species identification was uncertain, animals were recorded as unidentified to the most recognizable level (e.g., unidentified seal or unidentified whale).

For seals and walrus and polar bear sightings the behavioural response form included sections for behaviour responses of groups on ice or in water. Data recorded included response behaviour, time of response, location, distance when response observed, and bearing when response observed. The following behavioural response data recorded for seal and walrus on ice included: no response, scan, flush, and unknown (based on Lomac-MacNair, Andrade and Esteves 2019). The behavioural response data recorded for seal and walrus in water included: no response, scan, rapid dive/splash, swim away, regular dive, and unknown. Regular dives were also recorded to distinguish from rapid dives/splashes and, though data were collected on these dives during the 2023 SBO Program, they were not classified by Lomac-MacNair, Andrade and Esteves. (2019) as a response behaviour. Behavioural responses were classified as unknown when the observer was not confident whether there was or was not a response. Seal and walrus that were >5 body lengths from each other were recorded as separate groups.

For polar bears, additional data were recorded on the number of cubs or juveniles in the group and the age class of each bear (Smultea et al. 2016; see Appendix A). Polar bears >10 body lengths apart from each other were recorded as separate groups (Smultea et al. 2016; see Appendix A).

For whale sightings, the sightings form included fields to enter data on the number of calves or juveniles, direction of travel relative to the vessel's direction of travel (clock direction), and behavioural response. Whale response behaviours included: no response, traveling slowly away, traveling quickly away (including porpoising), approaching, change direction, rapid dive/splash, breach, lobtail, or none observed.

---

[1] Transiting broken ice track was included in the icebreaking category. When transiting a broken ice track, the vessels typically engaged in pushing or breaking through some form of ice as they transited through the previously broken ice track.

2.1.1.5 Data Quality Assurance / Quality Control and Back Up

At the end of each survey day, a quality assurance/quality control (QA/QC) of the data was done by the WSP lead to verify that no records/fields were missing. Once the QA/QC was completed, the MWO database was submitted by the WSP lead to WSP's internal ESRI Geographic Information System (GIS) platform in the cloud. An additional QA/QC and clean up of the data was completed prior to data analysis.

2.1.2 Data Analysis

This section describes the methods used for analyzing survey effort, sightings conditions, marine mammal detection rates and marine mammal behavioural responses during the 2023 fall shoulder season icebreaking activities. Data were analysed for the two vessels separately. From 21–27 October, surveys were only conducted from the *Botnica*. From 28–30 October, surveys were conducted from both the *Botnica* and *Fennica*.

2.1.2.1 Survey Effort

Survey effort was calculated relative to the distance travelled in linear kilometres using track line GPS data extracting segments of effort using start and end times recorded during each MWO shift. All marine mammal data analyses were completed based on spatial survey effort (effort/km) and not temporal effort (effort/h). Survey effort consisted of either one observer on each of the port and starboard sides of the vessel or one observer covering both sides, therefore, total effort for each day was averaged by the number of observers on watch during that time. This was done by calculating the distance traveled based on the start and end time of port and starboard watches (if different) and then dividing that distance by two when there were two observers. Otherwise, when there was only one observer on watch, the calculated linear distance was used.

2.1.2.2 Survey Conditions

Various environmental variables were systematically recorded during the active survey watch periods as these can influence an observer's ability to detect and identify marine mammals, in addition to potentially altering animal behaviour and distribution. Environmental variables were recorded at the beginning of each watch or watch rotation, every 30 minutes, and whenever conditions noticeably changed during a watch (see Section 2.1.1.2). Environmental variables considered in the study included Near Field Ice Cover (ice cover within 100 m of the vessel as estimated by observers), Far Field Ice Cover (ice cover ≥ 100 m from vessel but within line of sight of the observer), Sea State (Beaufort), Wind Force (Beaufort scale), Weather (e.g., precipitation and cloud cover), Visibility, Sun Glare and Sightability (a subjective assessment based on a the quality of sighting conditions based on a combination of Sun Glare, Beaufort Sea State, Visibility, and Weather). Relative representations of environmental conditions were calculated as percentages of observational effort and were used to summarise environmental conditions throughout the survey and for each individual sighting.

2.1.2.3 Relative Abundance

To compare results of the 2023 SBO Program with the 2018 and 2019 SBO Programs, animal detection rates were calculated and expressed as sightings per unit effort (SPUE; number of sightings/km) and number of individuals/km (used as a proxy for relative abundance). Sightings were therefore expressed relative to spatial observational effort consistent with other similar studies and methods (Nichols et al. 2005). Detection rates were also analysed in relation to environmental conditions as these had the potential to influence detectability of marine mammals by the MWOs. Therefore, relative abundance was calculated using a dedicated (i.e., non-systematic) method where the shipping route is the survey transect line. For all analyses, seals, walrus and polar bear that were observed hauled-out on ice were considered separately from seals, walrus and polar bear observed in-water due to the differences in animal detectability between the two environments (i.e., both species are more easily detected on ice than in water). To accommodate for uncertainty of sightings (e.g., species identification and distance measurement or estimation with increasing distance), detection rates were calculated using data within two kilometres from the vessel from the 2018, 2019 and 2023 SBO Programs. Detection rates were also calculated based on the lead vessel only, to account for potential marine mammal responses to the lead vessel influencing the detection rate of marine mammals for the following vessel.

2.1.2.4 Behavioural Responses

For the 2023 SBO Program, additional survey protocol was developed to assess the behavioural responses of marine mammals to icebreaking activities in the RSA. Behavioural response data were collected for all species groups, however, the only species with sufficient records to enable quantitative analyses was the ringed seal (363 sightings). To accommodate for uncertainty of sightings (e.g., species identification and distance measurement or distance measurement/estimation with increasing distance), behavioural responses were analysed using data within two kilometres from the vessel from the 2023 SBO Program. As a result of the low number of sightings for the remaining species, only descriptive analyses of their responses are presented.

Response behaviour categories for seals and walrus followed categories used by Lomac-MacNair, Andrade and Esteves (2019) and response behaviours for polar bears followed categories used by Smultea et al. (2016) (see Section 2.1.2.4). For seals and walrus, these behavioural responses included scan and flush responses for groups on ice and rapid dive/splash and swim away for groups in the water. A flush response occurs when a seal or walrus displays a progression of behaviours that begin with a seal hauled out and resting on ice, becoming alert and scanning, and then transitioning from resting to finally flushing off the ice into the water (see Appendix A). Flush responses are associated with having the highest energetic costs for seals and walrus on ice (Harding et al. 2005). Regular dives were also recorded during the 2023 SBO Program, however, these dives were not included in the analysis as “response” behaviours (Lomac-MacNair, Andrade and Esteves 2019).

2.1.2.5 Statistical Analysis of Behavioural Response

Statistical analyses were limited to ringed seals, as no other species were present in sufficient numbers.

An ordinal logistic regression (OLR) was used to determine if there was a significant relationship between ringed seal response type (i.e., flush, scan, no response, etc.) and vessel activity and distance. This type of regression was selected since the response variables were ordinal (i.e., response variables have a meaningful order of progression) (Parry 2020).

Seals in water were analyzed separately from seals observed on ice. As a result of the limited numbers of sightings during times when vessels were drifting, maneuvering, and anchored, the only vessel activities considered in this analysis were icebreaking (includes transit of broken ice tracks) and open water transits. Animals with an “unknown” response type were excluded from analysis.

For each sighting scenario (in water vs. on ice), a series of OLR models were built using the “clm” package in Rstudio (RStudio Team. 2023) using seal response as a response variable and vessel activity as well as the distance of the vessel from the seal as predictor variables. For seals that displayed an observed response, the distance at the time of response was used. For seals that did not display an observed response, the closest point of approach was considered. Initial behaviour of the seals was also considered as a predictor variable, however, it was only assessed for seals in water, as seals on ice were almost always resting when initially observed.

OLR regression models were run with various combinations (including interactions) of these predictor variables and were compared to the null model with no predictor variables (H_0: Response ~ 1) using Akaike’s Information criterion (AIC) to select which model that best explained seal response.

An analysis of deviance was then run on the selected model to determine the significant effects of its predictor variables and *p*-values were determined for explanatory variables in the selected model. Significant effects were assessed with at $\alpha = 0.05$. Model assumptions were then checked by running goodness of fit tests using the nominal_test() and scale_test() commands from the “ordinal” package to test the assumptions of proportional odds and scale effects, respectively. To visualize the magnitude and uncertainty in the effect of predictor variables on seal behaviour, the probability of the behavioural responses was plotted against each predictor variable, while holding the other categorical predictor variable(s) constant at its reference level, which was ‘icebreaking’ for distance from vessel and “500 m” for icebreaking/transiting. All statistical analyses were performed using R 4.3.2 in Rstudio 2023.9.1 (RStudio Team. 2023).

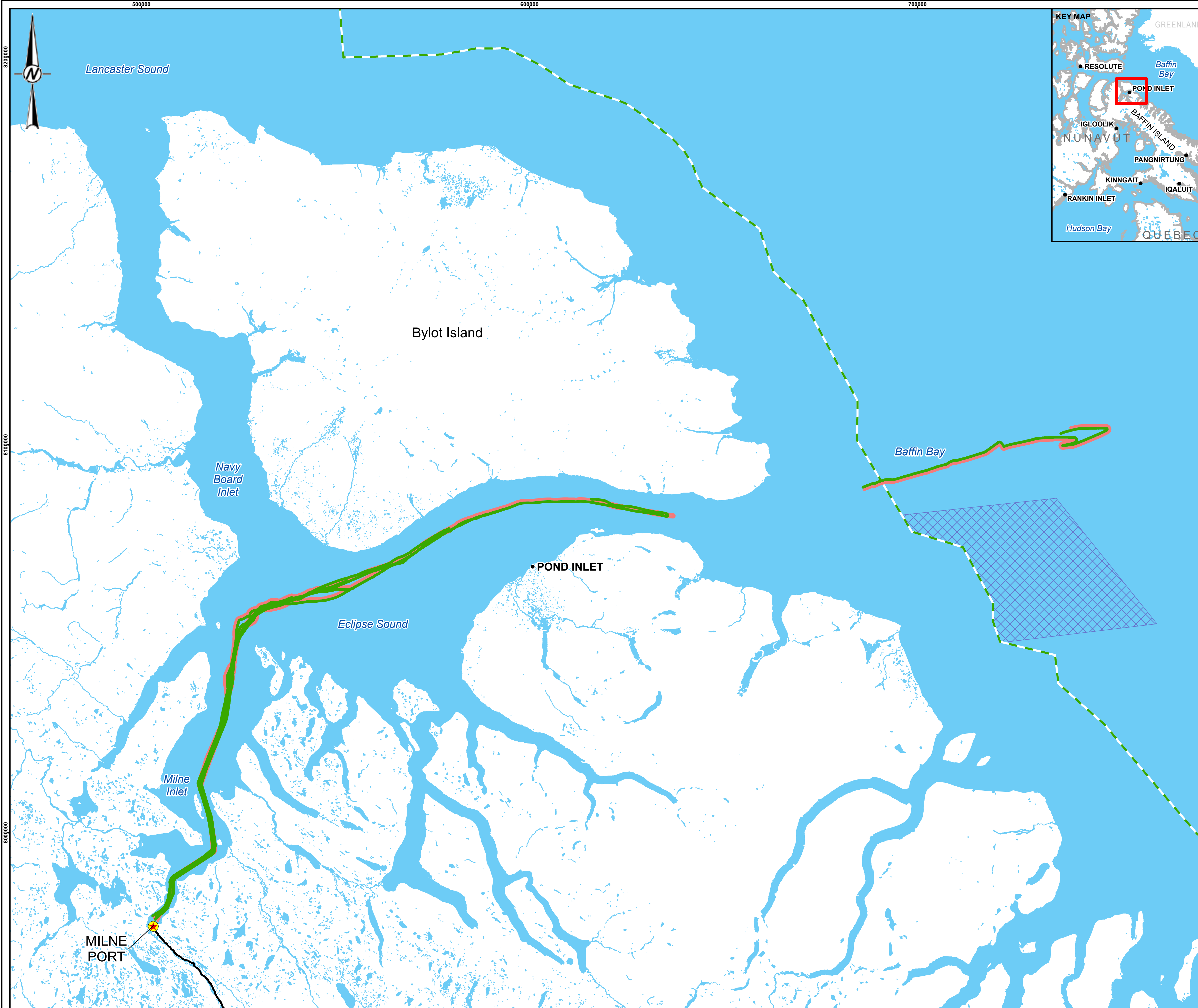
2.2 Survey Results

The 2023 SBO Program occurred on both icebreakers along the Northern Shipping Route in the RSA from 21 to 30 October. The primary objective of the SBO Program was to monitor for potential ship strikes on marine mammals and seabirds in the RSA. A secondary objective of the SBO program was to collect observational data on the presence, relative abundance and distribution of marine mammals and seabirds, as well as any behavioural responses relative to Project vessel operations.

2.2.1 Survey Effort

At the start of the program, all seven MWOs were stationed on the *Botnica* conducting marine mammal and seabird watches as a single-vessel team from 21 to 27 October 2023. On 27 October, once the *Botnica* and *Fennica* started escorting ore carriers in tandem, three observers transferred to the *Fennica* to allow marine mammal surveys to be conducted from both vessels. The two-vessel teams worked from separate vessels for the remainder of the SBO Program (28 to 30 October). During the tandem icebreaking and iron ore escort operations, the *Fennica* was the lead vessel on 28 and 29 October, while the *Botnica* was the lead vessel on 30 October.

Total monitoring effort during the SBO Program was 89.5 h covering a total of 1,179.6 km between the two icebreakers. Most survey effort was from the *Botnica* from 21 to 27 October (52.2 h covering 675.1 km; Figure 9) with a dedicated observation team on each side of the vessel for 98% of the total survey period. From 28–30 October, observations were conducted from both the *Botnica* (18.4 h covering 248.7 km; Figure 9) and the *Fennica* (18.7 h covering 255.8 km; Figure 10). Total monitoring effort for the Botnica from 21 to 27 October and considering the lead vessel only from 28-30 October was 70.7 hours covering 949.9 km. Figures of daily survey effort for each vessel and daily ice cover conditions are provided in Appendix B.



LEGEND

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

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

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
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
DISTRIBUTION OF SURVEY EFFORT FROM THE MSV BOTNICA

CONSULTANT

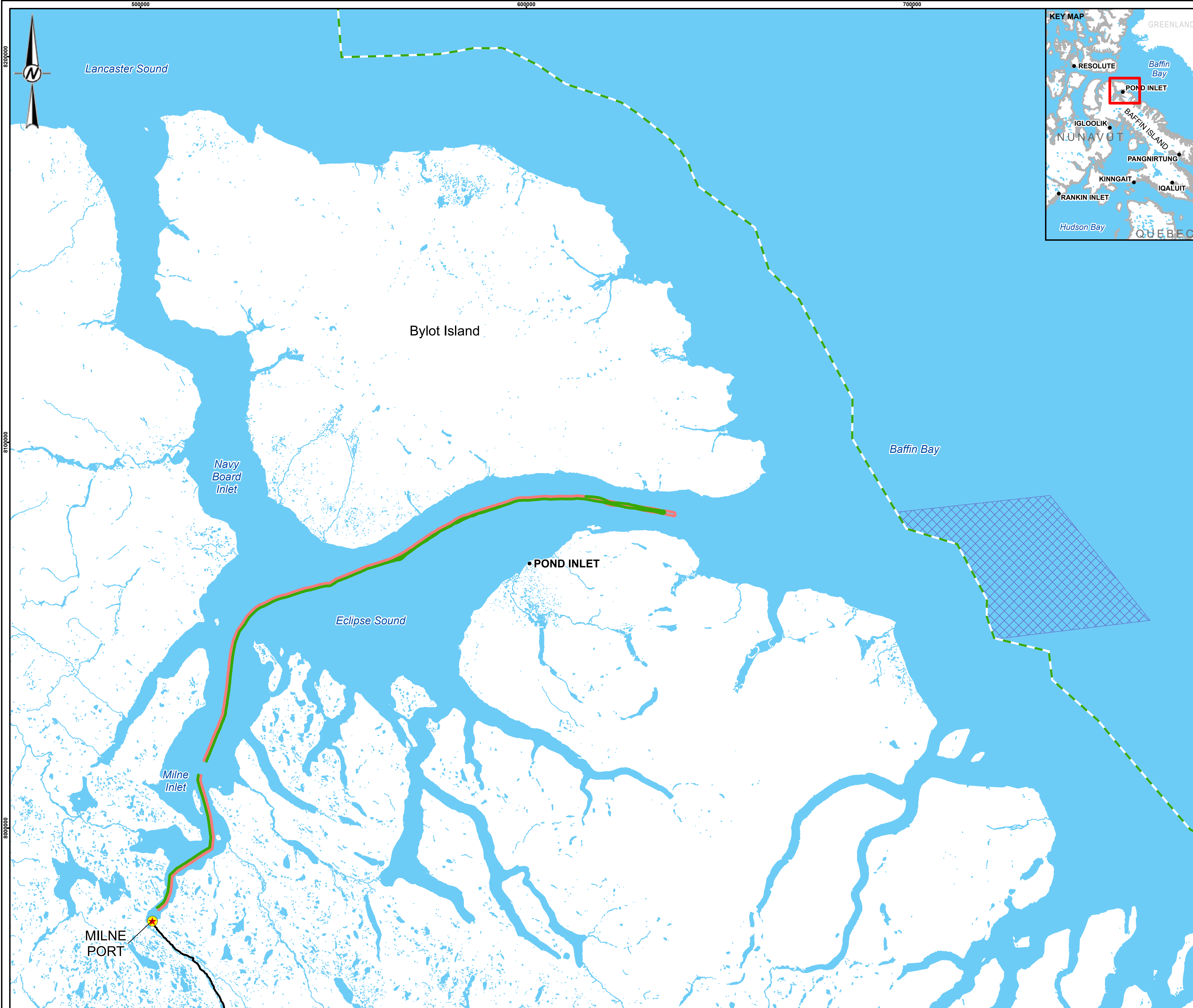
wsp

YYYY-MM-DD	2024-03-12
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	9

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

25mm



LEGEND

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

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

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
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
DISTRIBUTION OF SURVEY EFFORT FROM THE MSV FENNICA

CONSULTANT

wsp

YYYY-MM-DD	2024-03-12
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

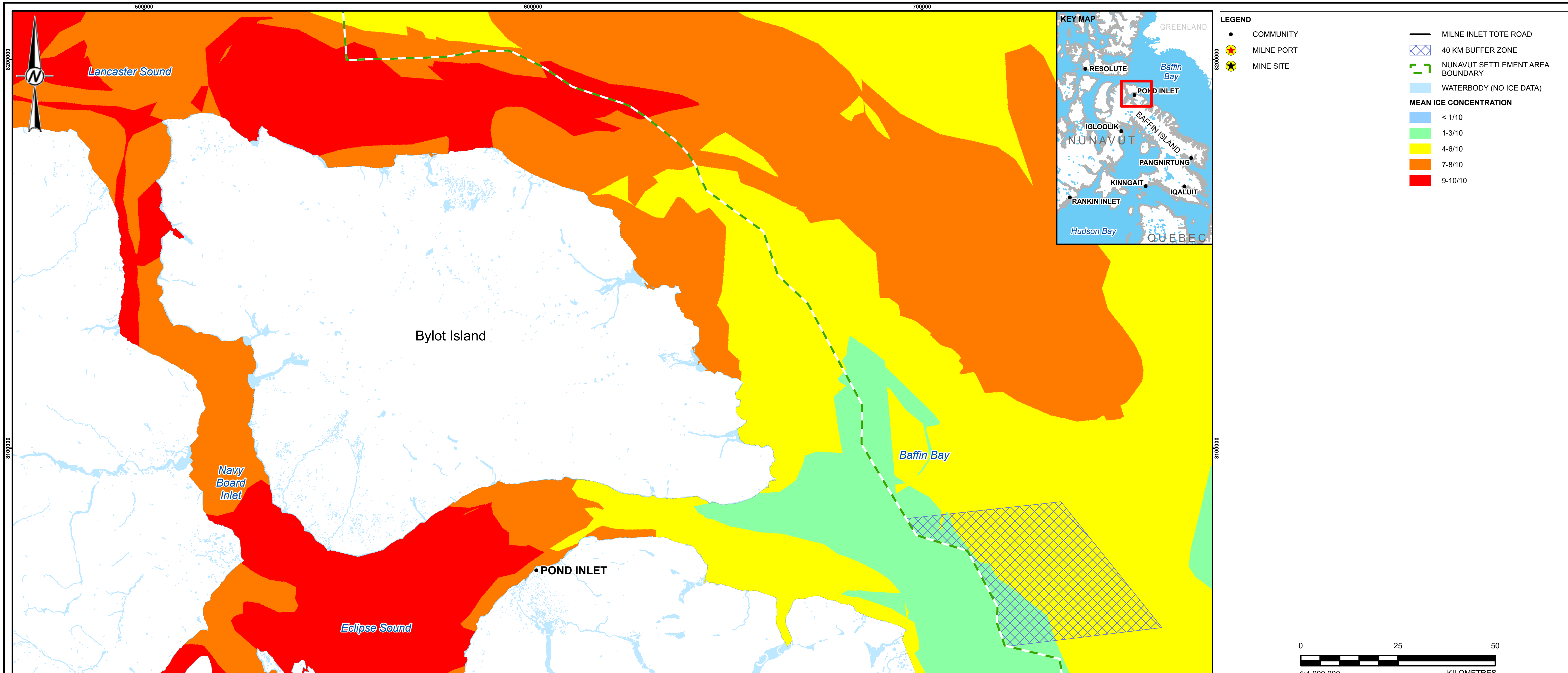
PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	10

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

2.2.2 Survey Conditions

2.2.2.1 Ice Concentrations

In addition to recording percent and type of ice cover during the survey, daily ice concentration charts were downloaded from the Canadian Ice Service (CIS) archive. Daily CIS ice charts for each survey period were layered through time in GIS (ArcGIS, Redlands CA) and clipped to the RSA. A raster analysis at a 100 m x 100 m scale was completed to exhibit typical (mean and median) ice cover (tenths) encountered during each survey period. Figure 11 and Figure 12 show mean ice cover during the 2023 SBO Program. Additional ice cover analyses were completed to show ice cover throughout the RSA on each day of the survey (see Appendix B).



REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

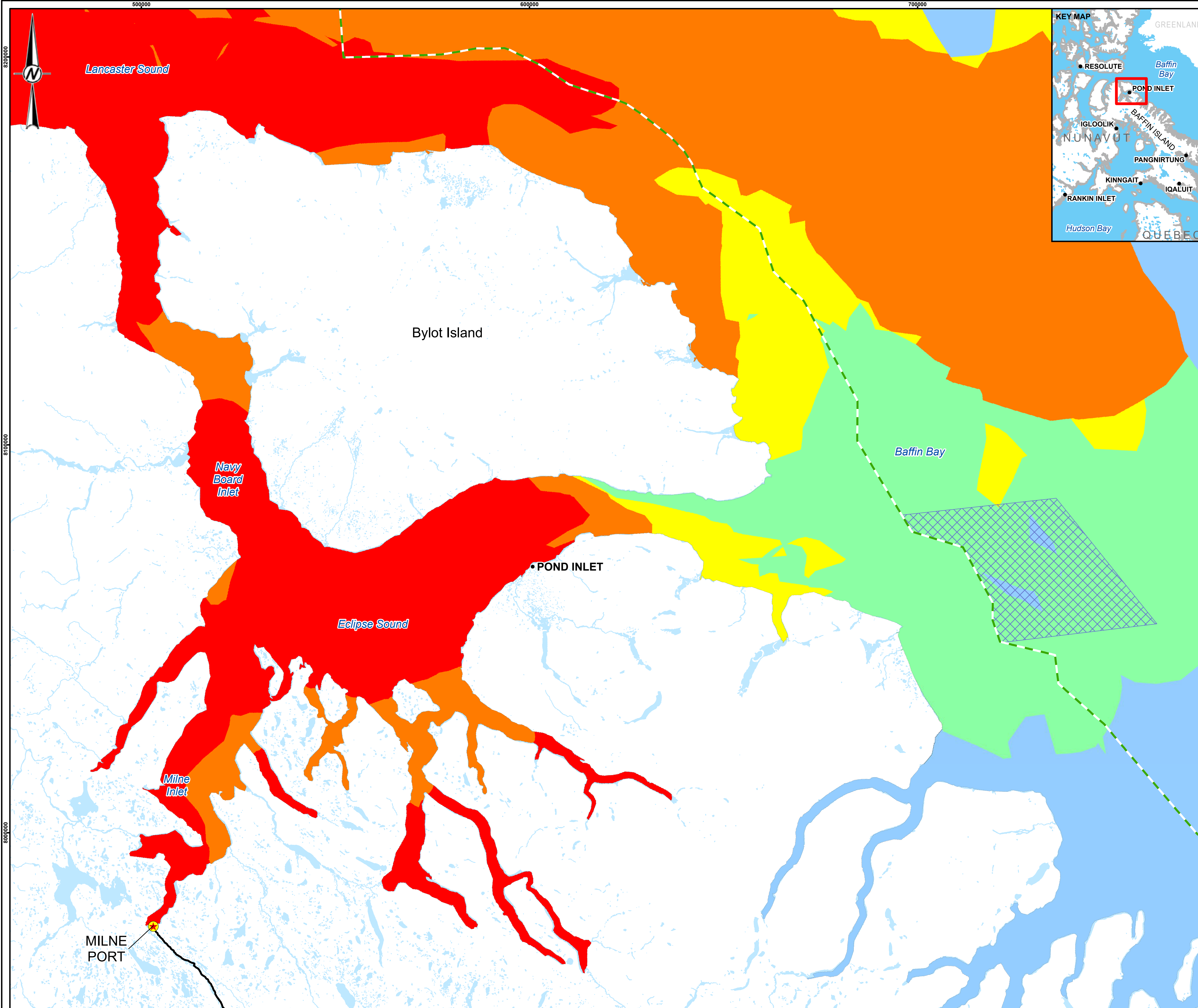
PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
MEAN ICE CONCENTRATION IN THE RSA DURING THE 2023 SBO PROGRAM (21-30 OCTOBER)

CONSULTANT

YYYY-MM-DD	2024-03-12
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	11



LEGEND

- • COMMUNITY
- MILNE PORT
- MINE SITE
- MILNE INLET TOTE ROAD
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

MEDIAN ICE CONCENTRATION

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

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
MEDIAN ICE CONCENTRATION IN THE RSA DURING THE 2023 SBO PROGRAM (21-30 OCTOBER)

CONSULTANT

YYYY-MM-DD	2024-03-12
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	12

2.2.2.2 *Sighting Conditions*

MWOs recorded sighting conditions at the beginning of each watch period, including at the start of an observer shift change, every 30 minutes, and anytime environmental conditions changed. Sighting conditions were evaluated based on the percentage of geographic survey effort conducted in each condition. Sighting detection rates were then assessed in relation to Ice Cover, Beaufort Sea State, Visibility and Sightability as these variables have the greatest impact on the MWO's ability to detect marine mammals (see Section 2.2.3.3).

Ice Cover

Ice cover was recorded across two spatial scales relative to the vessel: Near Field (≤100 m) and Far Field (>100 m from vessel but within sighting range of the observer). MWOs estimated the Near Field range by using the length of the *Botnica* (97 m) or *Fennica* (116 m) as a reference. Additionally, based on a figure of the vessel's dimensions posted on the bridge of the *Botnica,* the MWOs knew that water observed directly off the bow (at 0˚) was ~100 m away from the observer on the bridge given the angle of view from the bridge to the water. Ice cover ranged from 0 to >90% coverage for both spatial ranges. The majority of the 2023 SBO Program survey effort occurred in icy conditions (Figure 13).

Approximately two thirds of the total survey effort from the *Botnica* (67.8%) occurred when the Near Field ice cover was greater than 70%. Survey effort occurred in >90% Near Field ice cover 41% of the time, 81–90% Near Field ice cover 16.8% of the time, and 71–80% Near Field ice cover 10% of the time. The remaining survey effort occurred with Near Field conditions of 0% ice cover (10.4%) or between 1–70% ice cover (21.7%) (Figure 13).

Near Field ice cover was also greater than 70% for most of the survey effort from the *Fennica* from 28–30 October; most of the survey effort occurred with >90% Near Field ice cover (67.5%), followed by 81–90% Near Field ice cover (24.3%). The remaining survey effort from the *Fennica* consisted of 31–60% ice cover (8.2%; Figure 13).

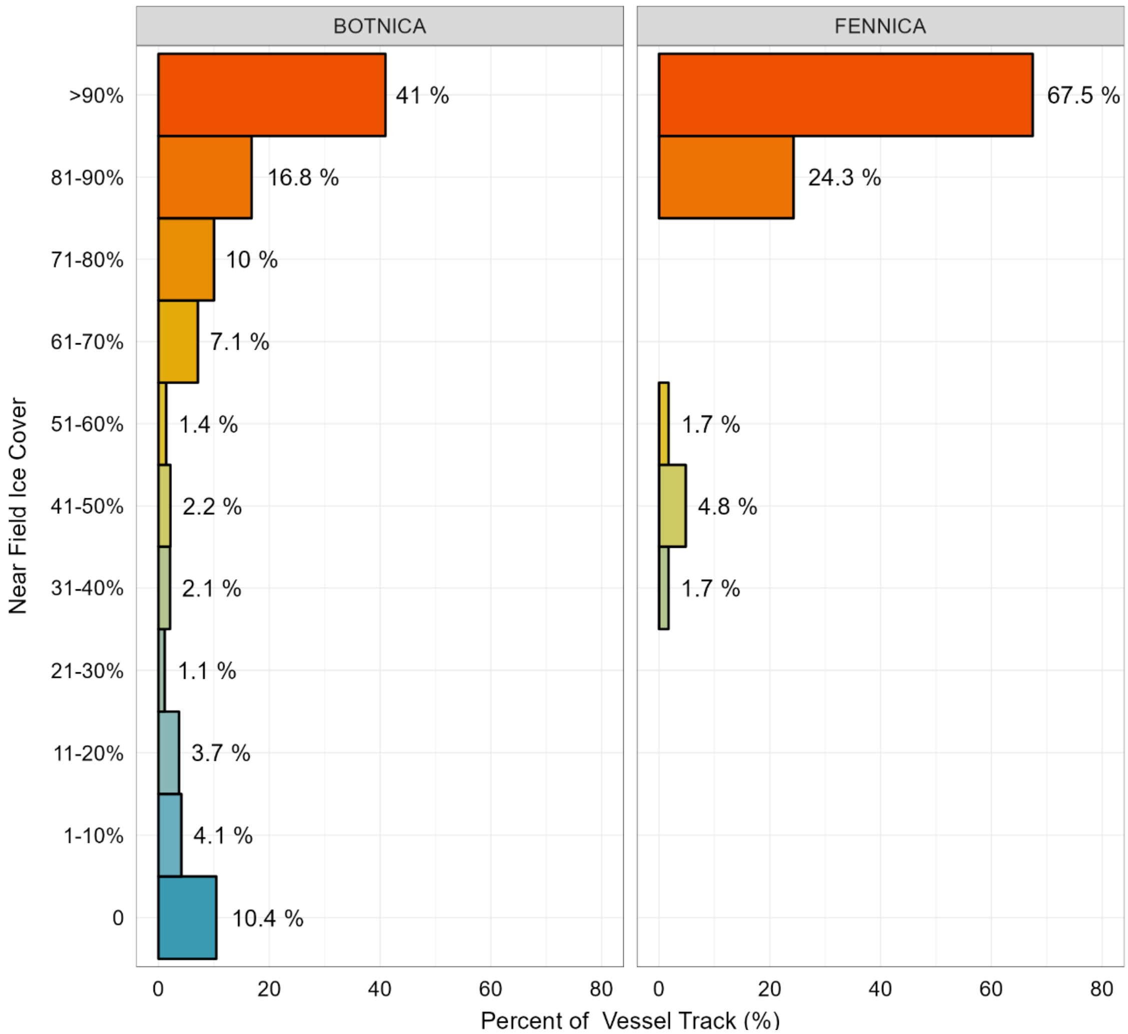


Figure 13: Figure Proportional Breakdown of Ice Cover in Near Field During 2023 SBO Program.

Far Field ice cover was >90% during most of the survey effort, comprising 39.6% of effort from the *Botnica* and 55.5% of effort from the *Fennica*. Far Field ice cover on the *Botnica* was 81–90% for 15.8% of the survey effort, 71–80% for 8.7% of the survey effort, 0% for 14.7% of the survey effort and 1–70% for 21.1% of the survey effort. Far Field ice cover was 81–90% and 31–50% for 41.1% and 3.4% of the survey effort, respectively, on the *Fennica* (Figure 14).

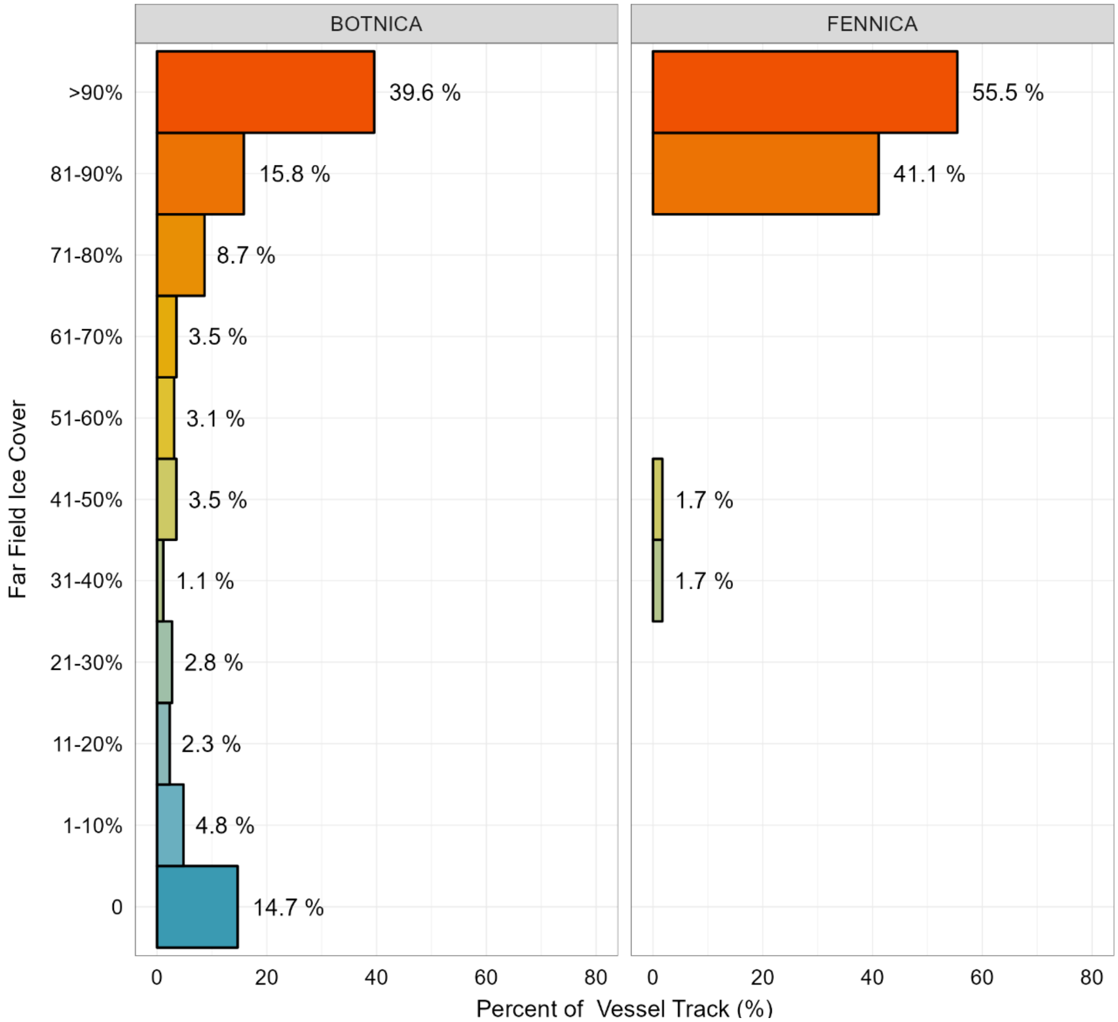


Figure 14: Figure Proportional Breakdown of Ice Cover in Far Field During 2023 SBO Program.

The proportion of Near and Far Field ice cover was >70% during all survey days (Figure 15 and Figure 16, respectively), with exception to 22 October when the *Botnica* spent most of the day in the open waters of Baffin Bay and 25 October when Near and Far Field ice cover was >70% for a lower proportion of survey effort (~50% of effort). Near and Far Field ice cover was almost exclusively >70% when the *Botnica* and *Fennica* were operating in tandem from 28 to 30 October.

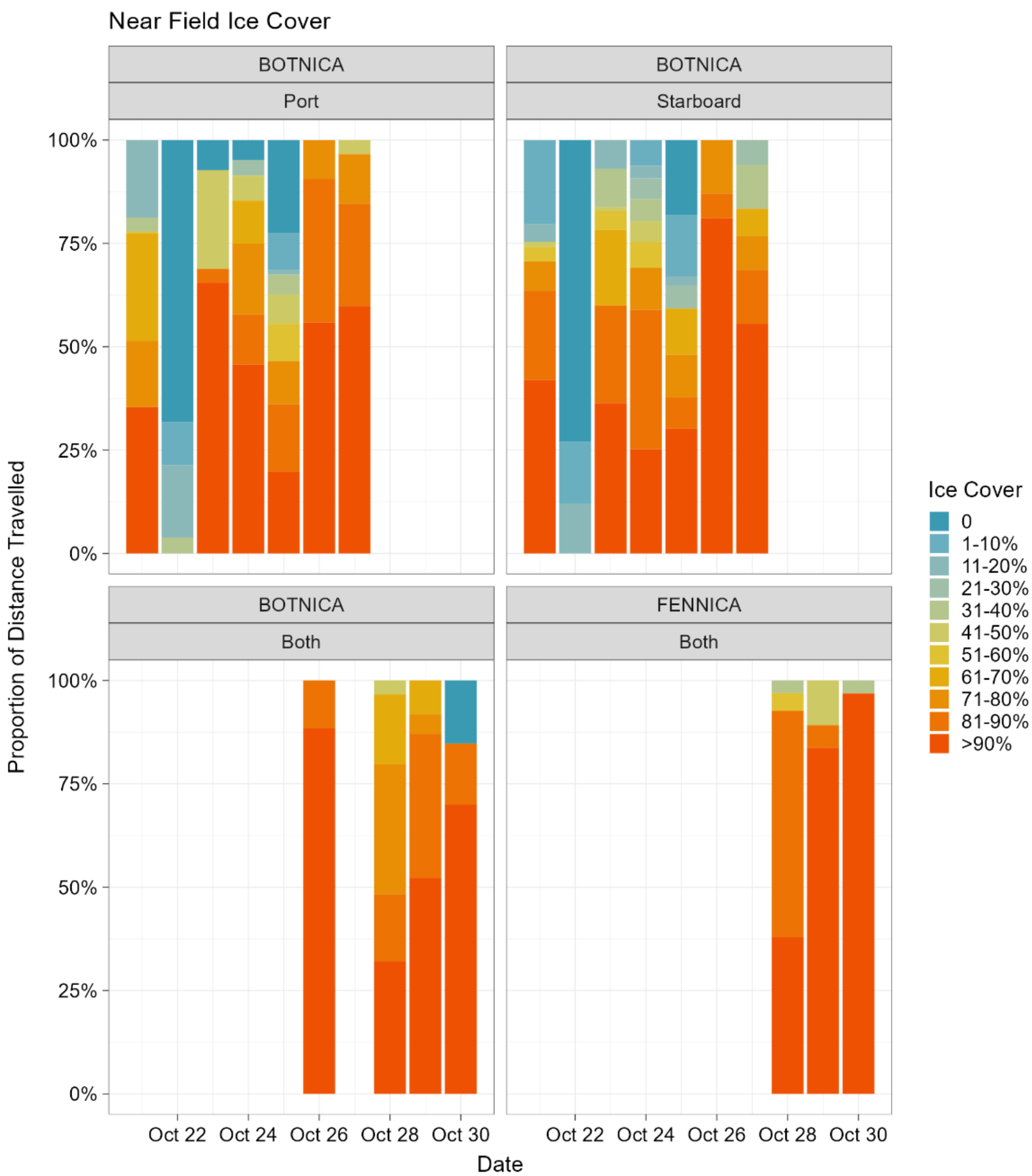


Figure 15: Figure Proportional Breakdown of Ice Cover in Near Field by Survey Day During 2023 SBO Program. Note: Both = one observer covering both sides of the vessel)

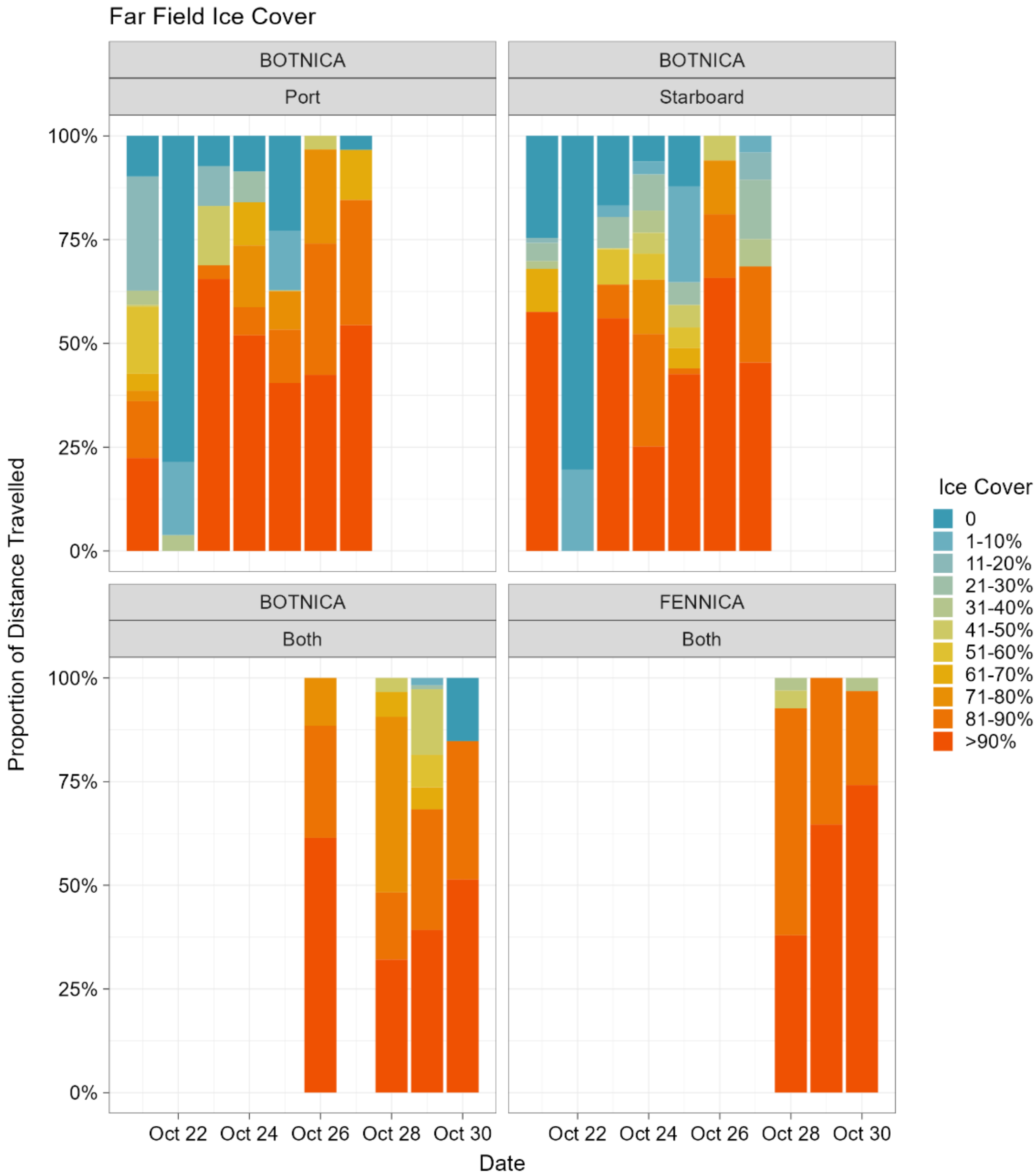


Figure 16: Figure Proportional Breakdown of Ice Cover in Far Field by Survey Day During 2023 SBO Program. Note: Both = one observer covering both sides of the vessel)

Sunglare Intensity and Cover

Data on two measurements of sunglare, intensity and proportion of field of view (cover), were collected during the 2023 SBO Program. Glare intensity was recorded at five levels: “No glare” when there was no sun reflection on the water, “Weak glare” when animals were likely detected in the centre of reflection angle, “Moderate glare” when animals were likely missed in the centre of reflection angle, “Strong glare” when animals were definitely missed in the centre of reflection angle, and “Variable glare” when glare changed regularly, e.g., every couple of minutes, and it was not reasonable to update environmental conditions every time it changed. Glare cover was also recorded in 10% increments (0–10%, 11%–20%, 21–30%, etc.) of the observation area affected by sun’s reflection.

Glare was present for 95.6% and 100% of total survey effort from the *Botnica* and *Fennica*, respectively. Glare was Weak for the majority of survey effort for both vessels, 84.1% from the *Botnica* and 100% from the *Fennica*. During surveys from the *Botnica*, glare was also Moderate (4.6% of survey effort), Variable (3.5% of survey effort), and Strong (3.4% of survey effort). There was No glare for 4.4% of total survey effort from the *Botnica* (Figure 17). Glare was Weak for most survey days with exception to 22-24 October when there was Strong glare up to ~5% on 22-23 October and up to ~30% on 24 October. (Figure 18).

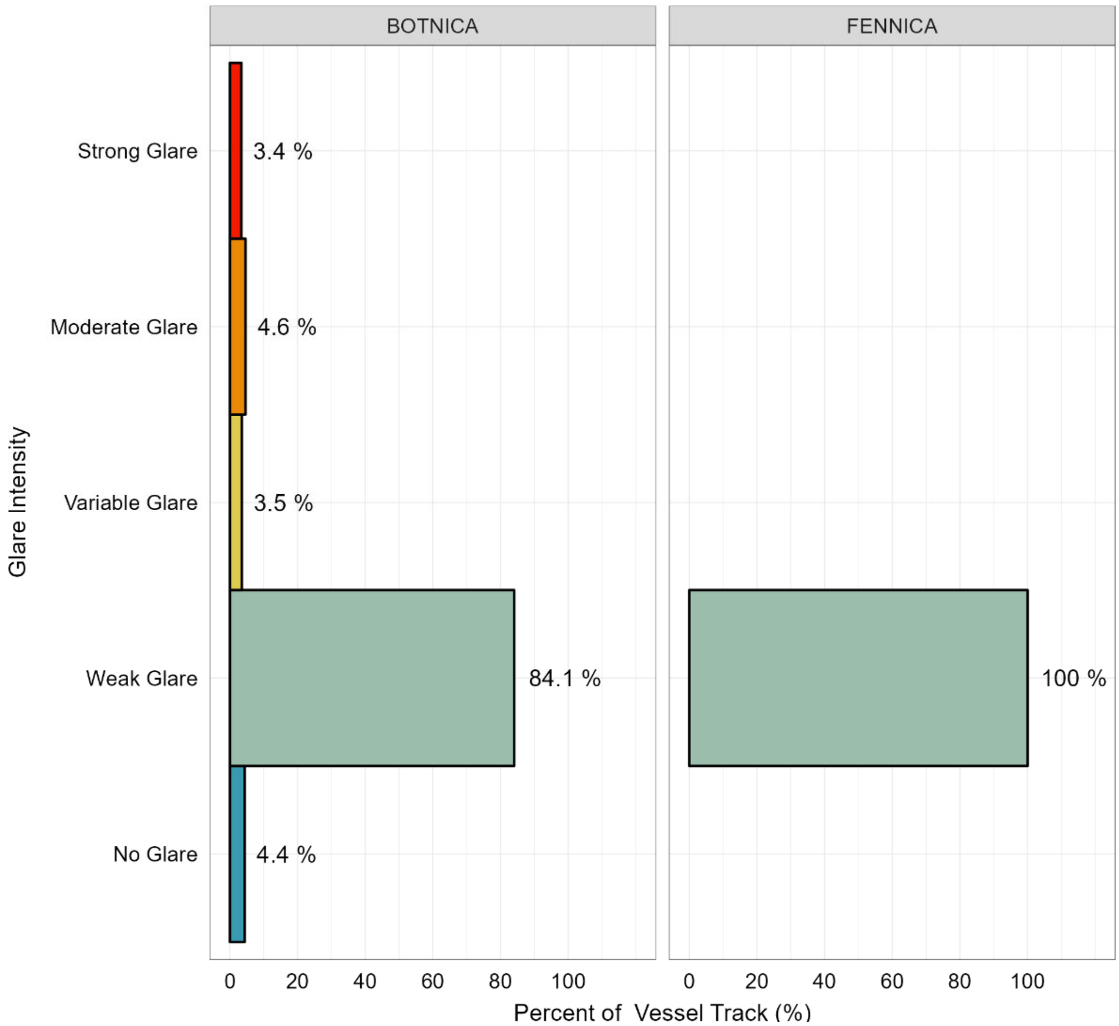


Figure 17: Glare Intensity during the 2023 SBO Program

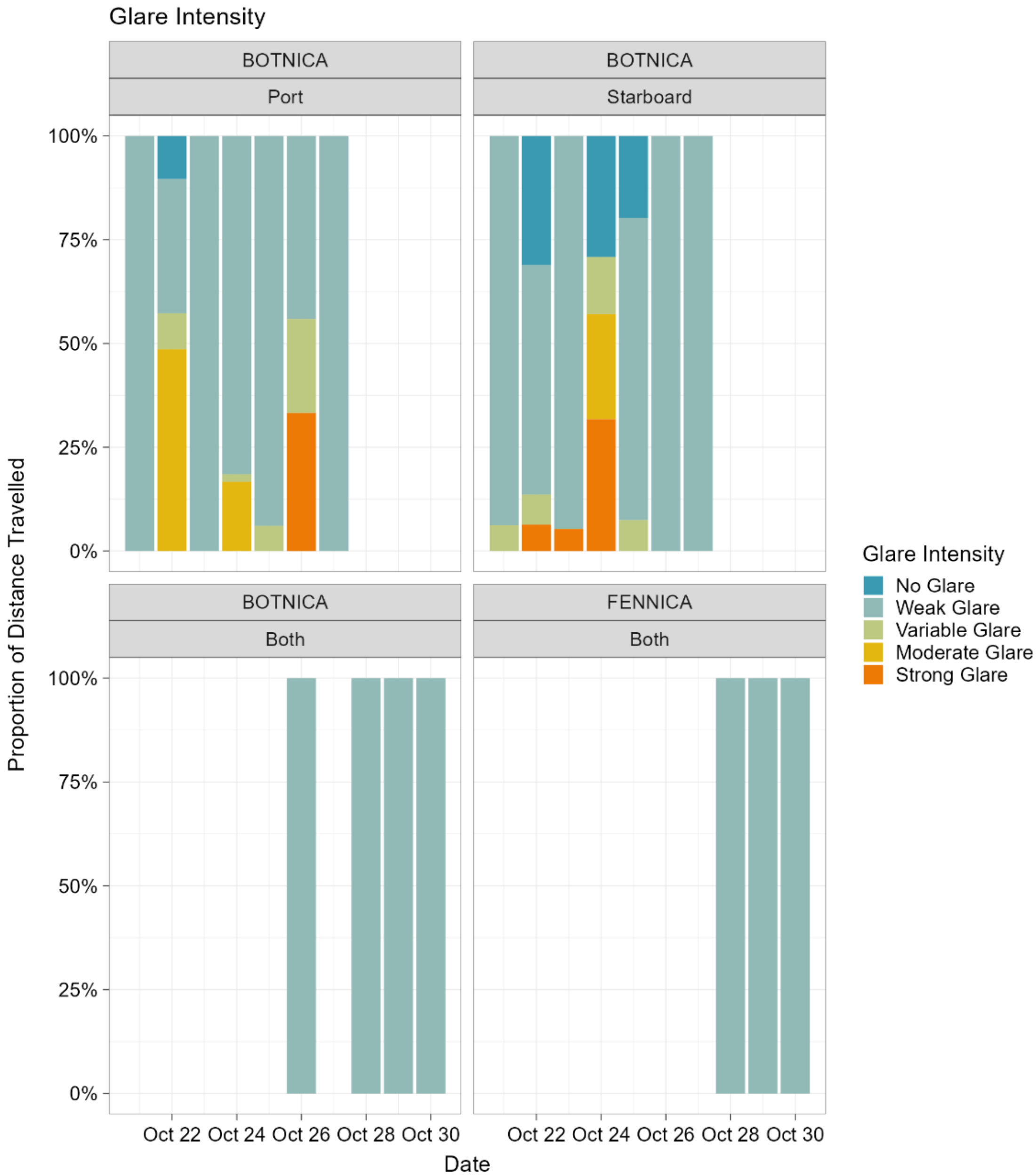


Figure 18: Proportional Breakdown of Glare Intensity by Survey Day During 2023 SBO Program

Glare coverage over the observation area was not applicable for much of the 2023 SBO Program because the glare was weak during 71.2% of observation effort from the *Botnica* and 100% of effort from the *Fennica*, and it did not cover a clear field of view. The remaining glare cover over the observation area for the *Botnica* was <5% (17.6% of survey effort), 5–10% (7.9% of survey effort), 11–20% (1.6% of survey effort), and >20% (1.8% of survey effort) (Figure 19). Glare cover was <10% across most survey days except 22 October when glare cover was a maximum of 41-50% (~5% of survey effort, 23 October when glare cover was a maximum of 61-70% (~5%), and 24 October when glare cover was a maximum of 31-40% (~8%) (Figure 20).

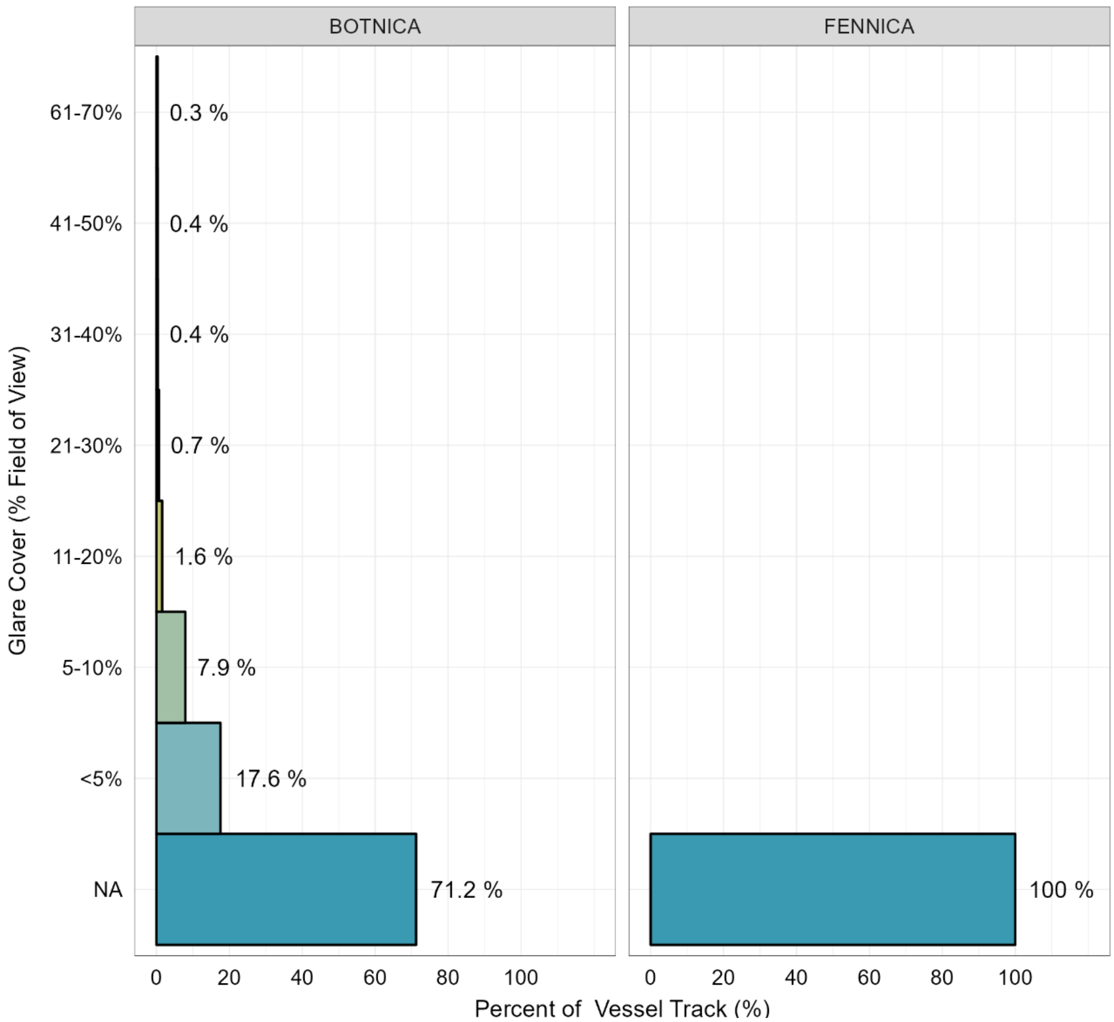


Figure 19: Glare Coverage (Cover) Proportion of Field of View during the 2023 SBO Program

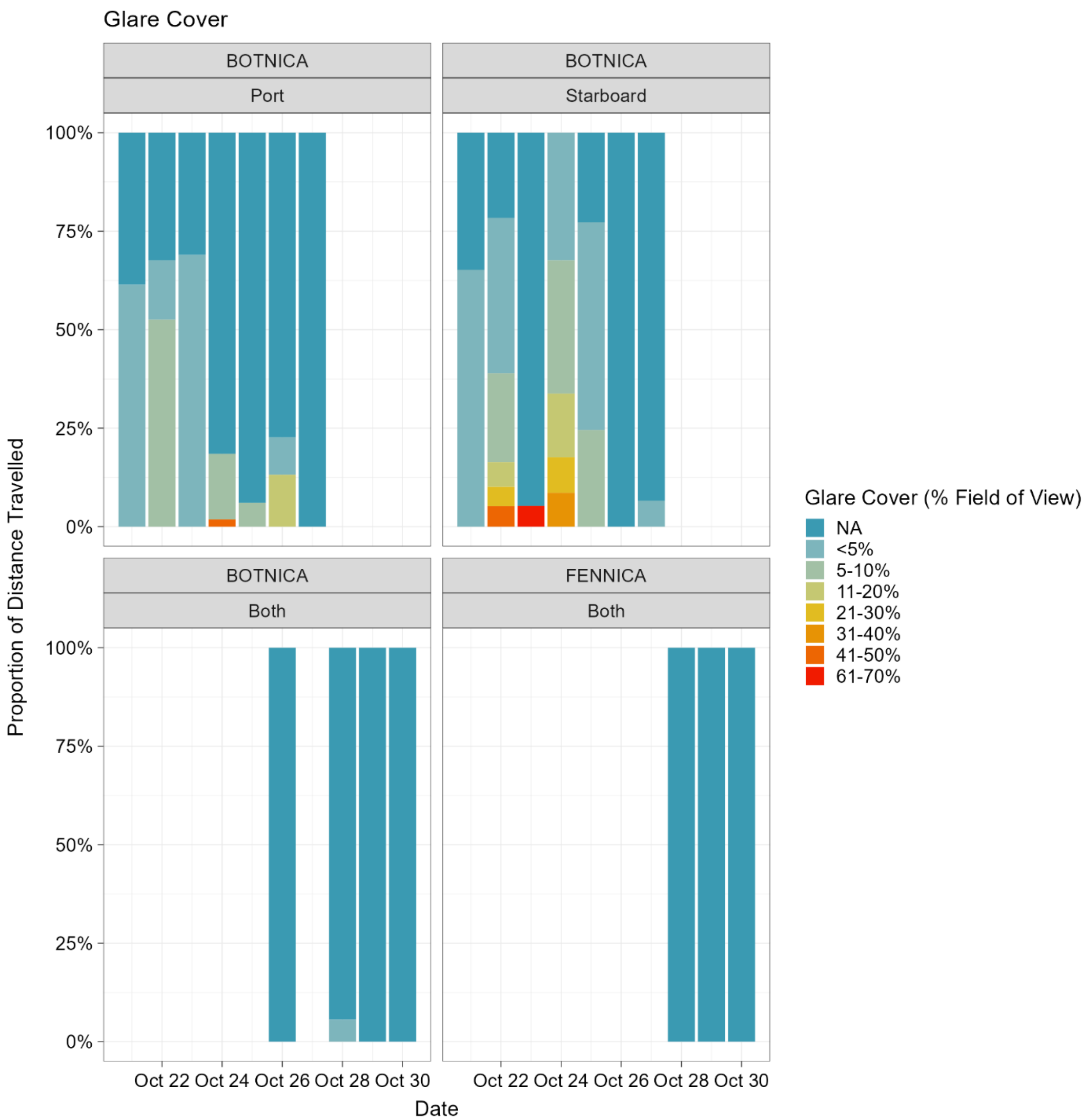


Figure 20: Proportional Breakdown of Glare Cover by Survey Day During 2023 SBO Program

Beaufort Wind Force

Beaufort Wind Force recorded during the 2023 SBO Program ranged from 0 (<1 knot, Calm) to 6 (22–27 knots, Strong Breeze) (Figure 21). Most monitoring effort from the *Botnica* and *Fennica* took place in Beaufort Wind Force 2 (4–6 knots, Light Breeze) (39.8% and 41% of survey effort, respectively). For the *Botnica* this was followed by Beaufort Wind Force 3 (7–10 knots, Gentle Breeze) (23.1% of survey effort), Beaufort Wind Force 1 (1–3 knots, Light Air) (19.3% of survey effort), Beaufort Wind Force 4 (11–16 knots, Moderate Breeze) (11.9% of survey effort), Beaufort Wind Force 0 (<1 knot, Calm) (3.6% of survey effort), Beaufort Wind Force 5 (17–21 knots, Fresh Breeze) (2.1% of survey effort), and Beaufort Wind Force 6 (22–27 knots, Strong Breeze) (0.1% of survey effort). For the *Fennica*, most of the survey effort, other than Beaufort Wind Force 2, was in Beaufort Wind Force 3 (22.1%), Beaufort Wind Force 1 (15.4%), Beaufort Wind Force 0 (11.3%), and Beaufort Wind Force 4 (10.3%). Conditions above Beaufort Wind Force 6 (i.e., Beaufort Wind Force categories 7 through 12) were not recorded during the 2023 SBO Program (Figure 21).

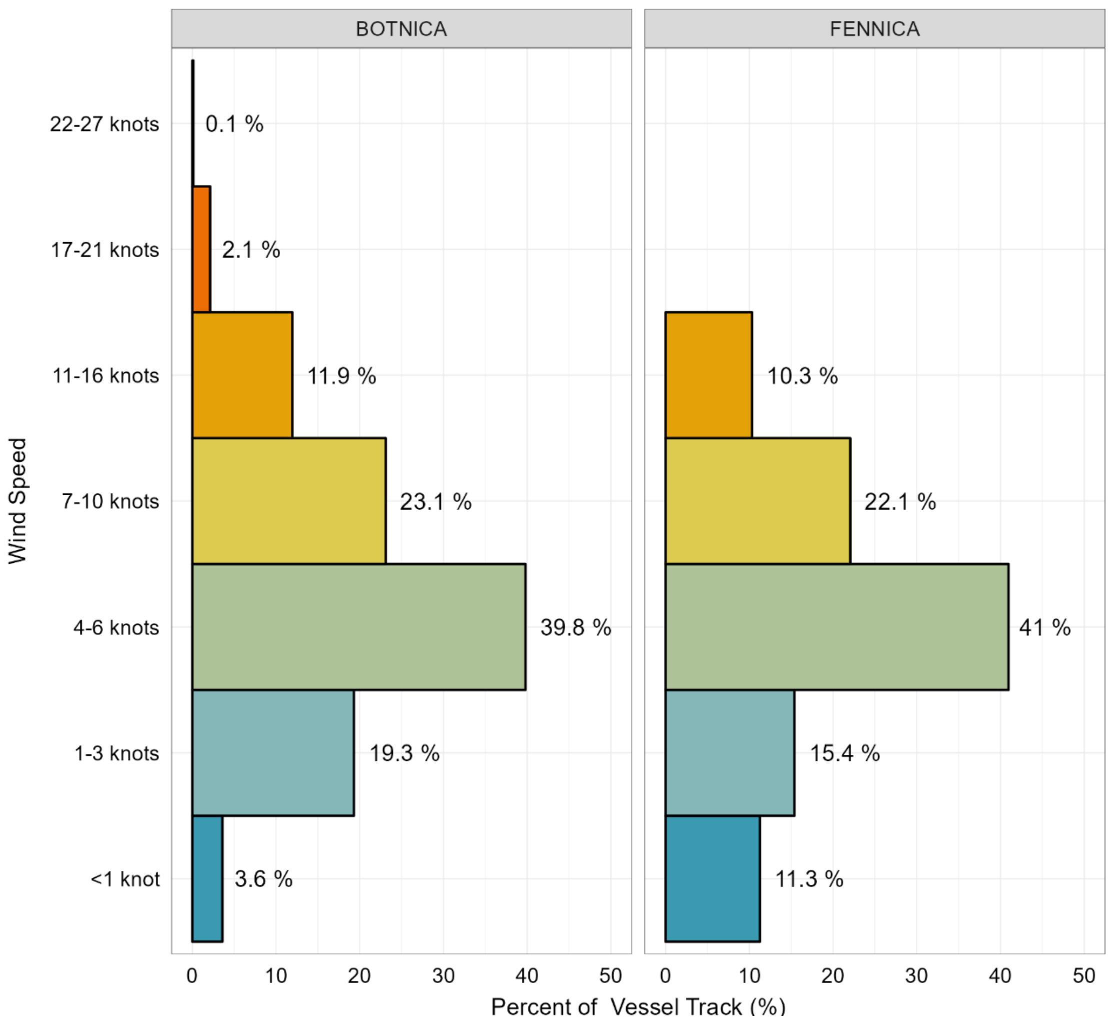


Figure 21: Beaufort Wind Force during the 2023 SBO Program

The daily proportional breakdown of wind speed during the 2023 SBO Program is presented in Figure 22.

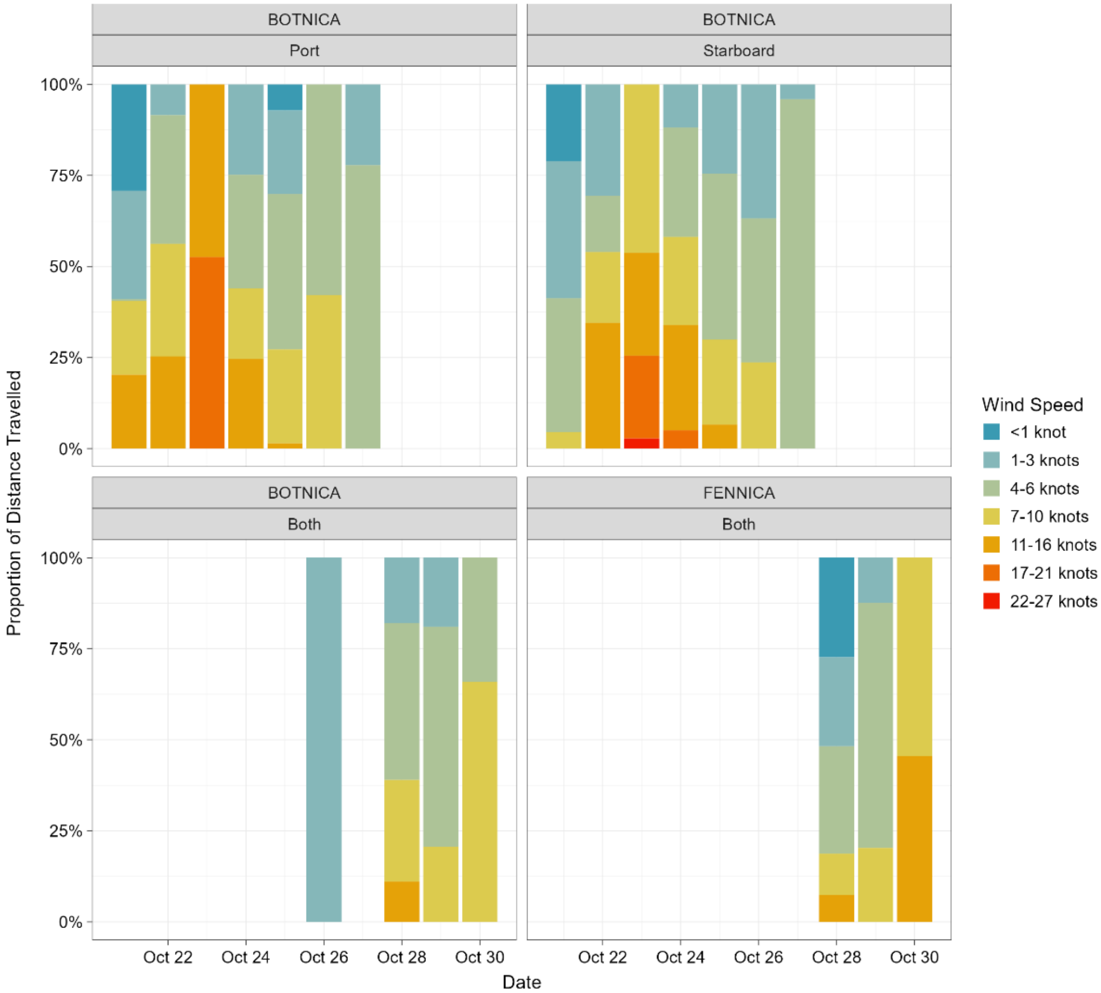


Figure 22: Proportional Breakdown of Beaufort Wind Force by Survey Day During 2023 SBO Program

Beaufort Sea State

Of the 12 categories of the Beaufort Scale, the sea state conditions recorded during the 2023 SBO Program were limited to the following categories:

- 0 = Glassy, like a mirror
- 1 = Ripples without crests, appearance of scaling, no foam crests
- 2 = Small wavelets, crests of glassy appearance, not breaking
- 3 = Large wavelets, crests begin to break, scattered whitecaps
- 4 = Small waves becoming longer, numerous whitecaps

Conditions above sea state 4 were not recorded during 2023 SBO Program. Most monitoring took place in sea state 3 or less from both vessels (51.4% and 49.2% of survey effort from the *Botnica* and *Fennica*, respectively; Figure 23). Additional sea state conditions observed from the *Botnica* during the 2023 SBO Program included, in decreasing order of survey effort percentage, sea state 0 (32,7%), sea state 2 (9.3%), sea state 3 (4.2%), and sea state 4 (2.4%). Additional sea state conditions observed from the *Fennica* from 28 to 30 October included sea state 0 (40.5% of survey effort) and Sea State 2 (10.3% of survey effort; Figure 23).

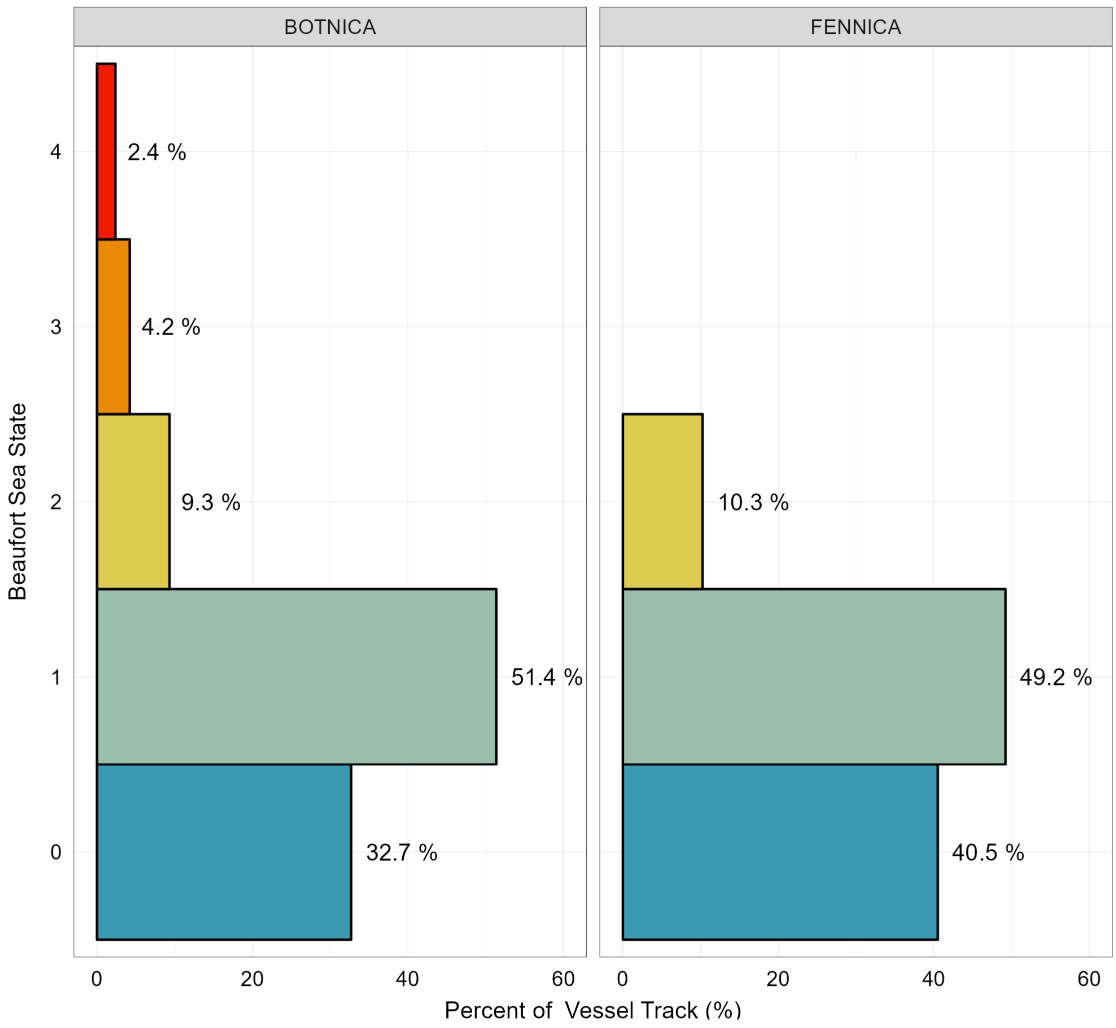


Figure 23: Beaufort Sea States during the 2023 SBO Program

The daily proportional breakdown of Beaufort Sea State during the 2023 SBO Program is presented in Figure 24.

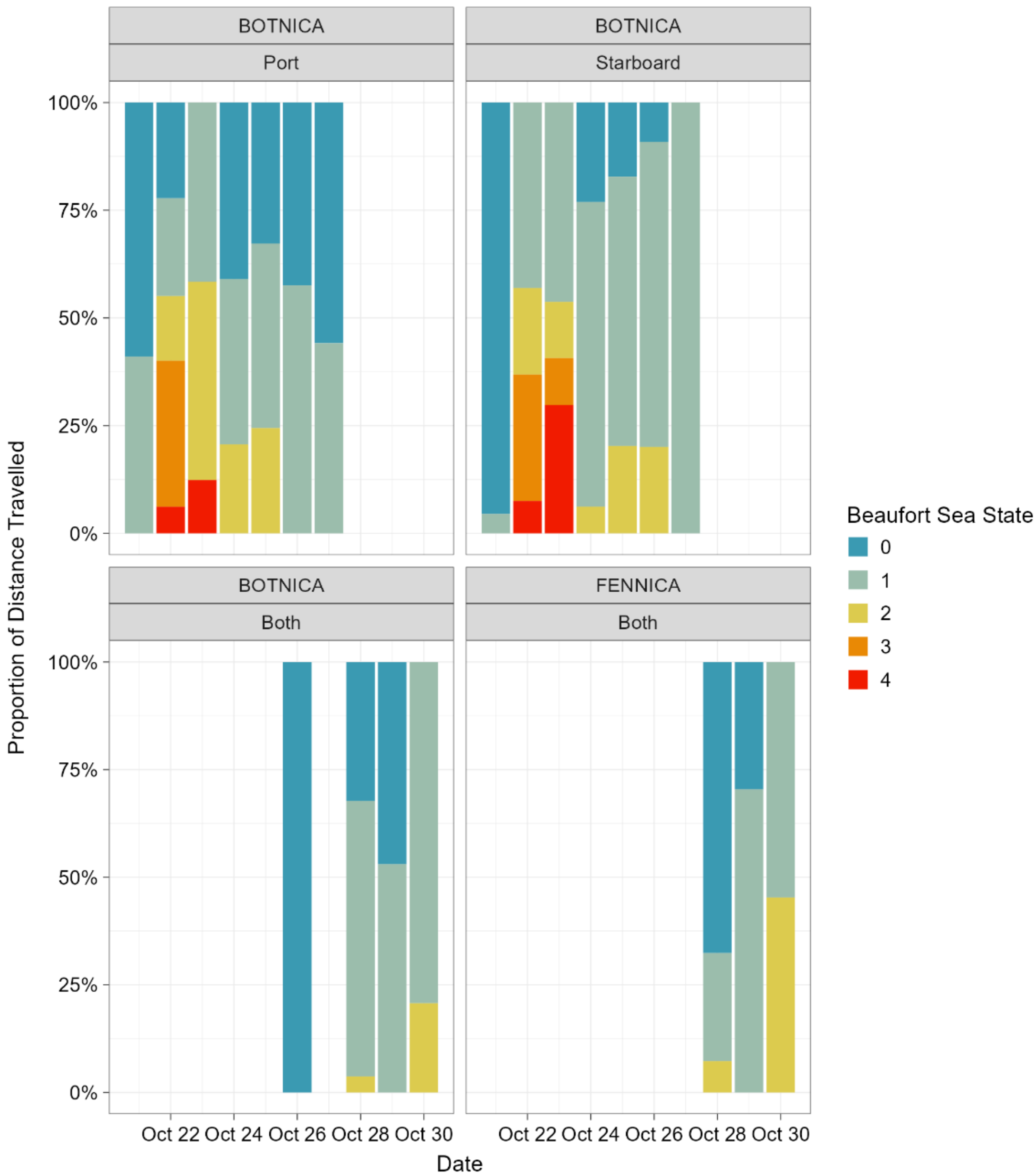


Figure 24: Proportional Breakdown of Beaufort Sea States by Survey Day During 2023 SBO Program

Visibility

Visibility recorded during the 2023 SBO Program ranged from poor (501–1,000 m) to excellent (>10,000 m). For the *Botnica*, visibility was good (2,501 m) or better for 87.9% of survey effort, followed by moderate visibility (1,001-2,500 m) for 10.1% of survey effort and poor visibility (501-1,000 m) for 3.2% of survey effort (Figure 25). For the *Fennica*, visibility was good or better for 80.8% of survey effort and moderate for 19.2% of survey effort 28–30 October.

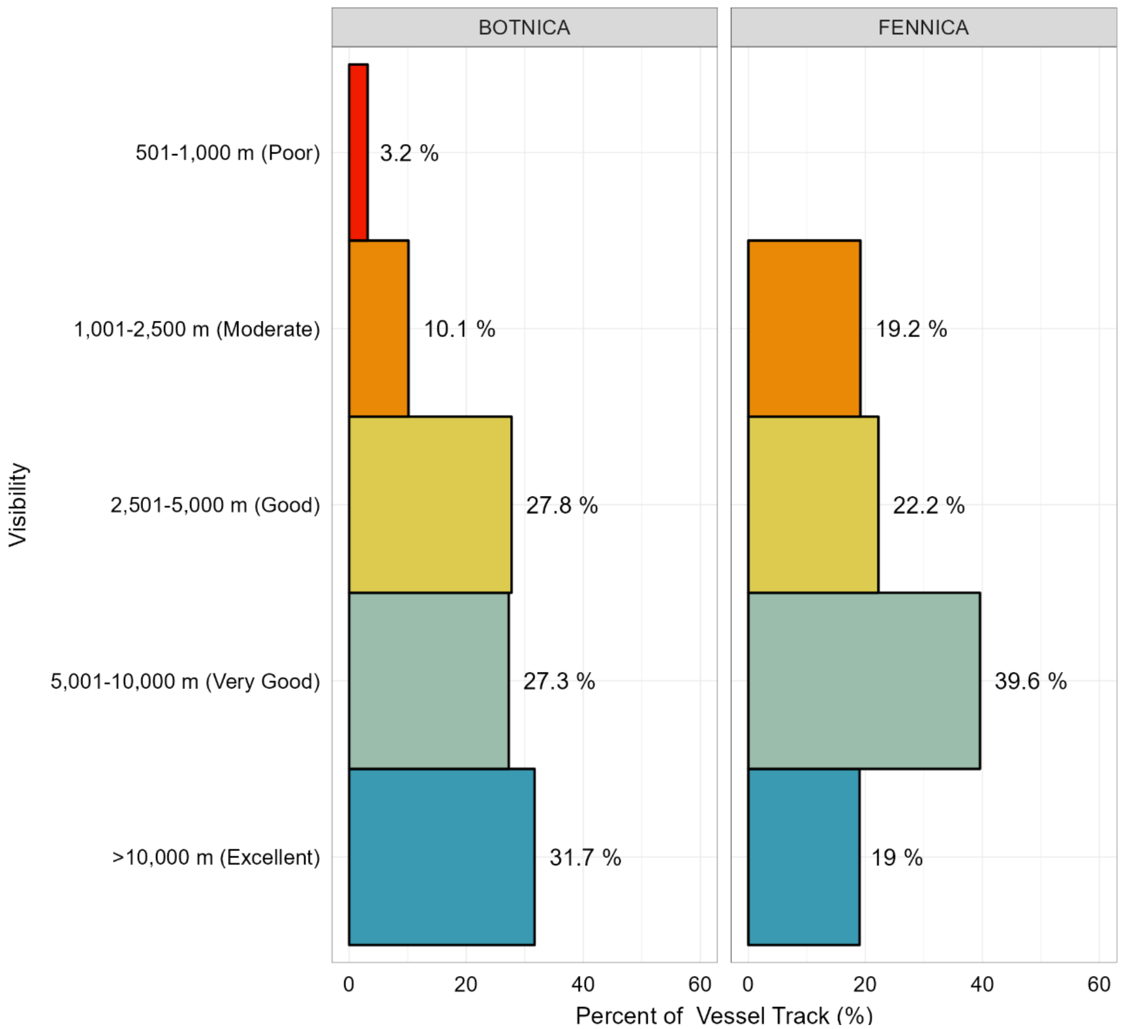


Figure 25: Visibility during the 2023 SBO Program

The daily proportional breakdown of visibility during the 2023 SBO Program is presented in (Figure 26).

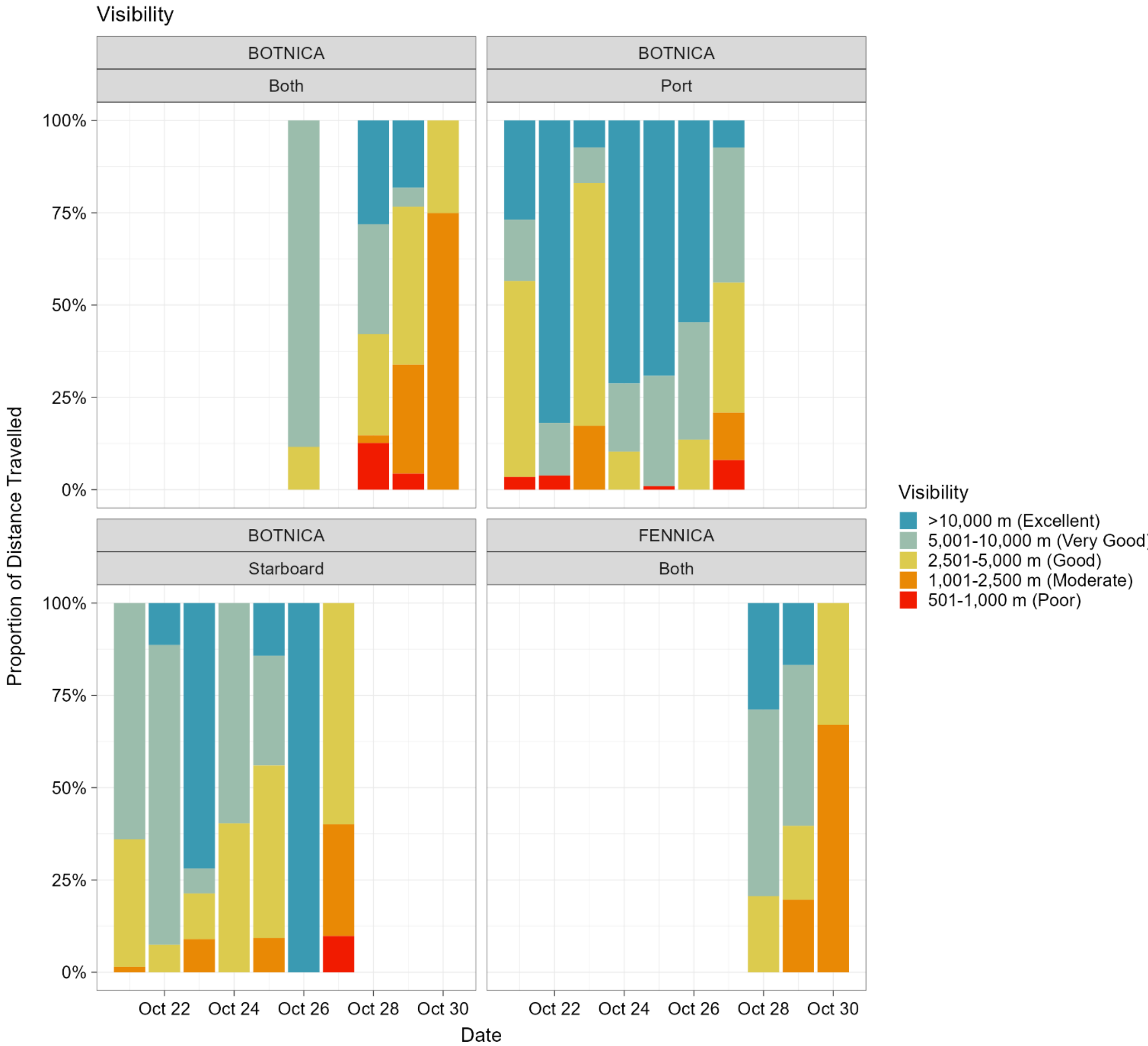


Figure 26: Figure Proportional Breakdown of Visibility by Survey Day During 2023 SBO Program

Weather

Predominant weather conditions recorded on the *Botnica* during the 2023 SBO Program were overcast 100% cloud cover (35% of survey effort) and partly cloudy >50% (29.6% of survey effort). Other weather conditions included light snow (9.1%), partly cloudy <50% (7.9%), heavy snow (4.6%), patchy fog (1.4%), thick fog (1.2%), and clear skies (1%) (Figure 27). The majority of weather conditions during survey effort from the *Fennica* was overcast 100% cloud cover (72.9%), followed by light snow (24.1%), and partly cloudy <50% (3%) (Figure 27).

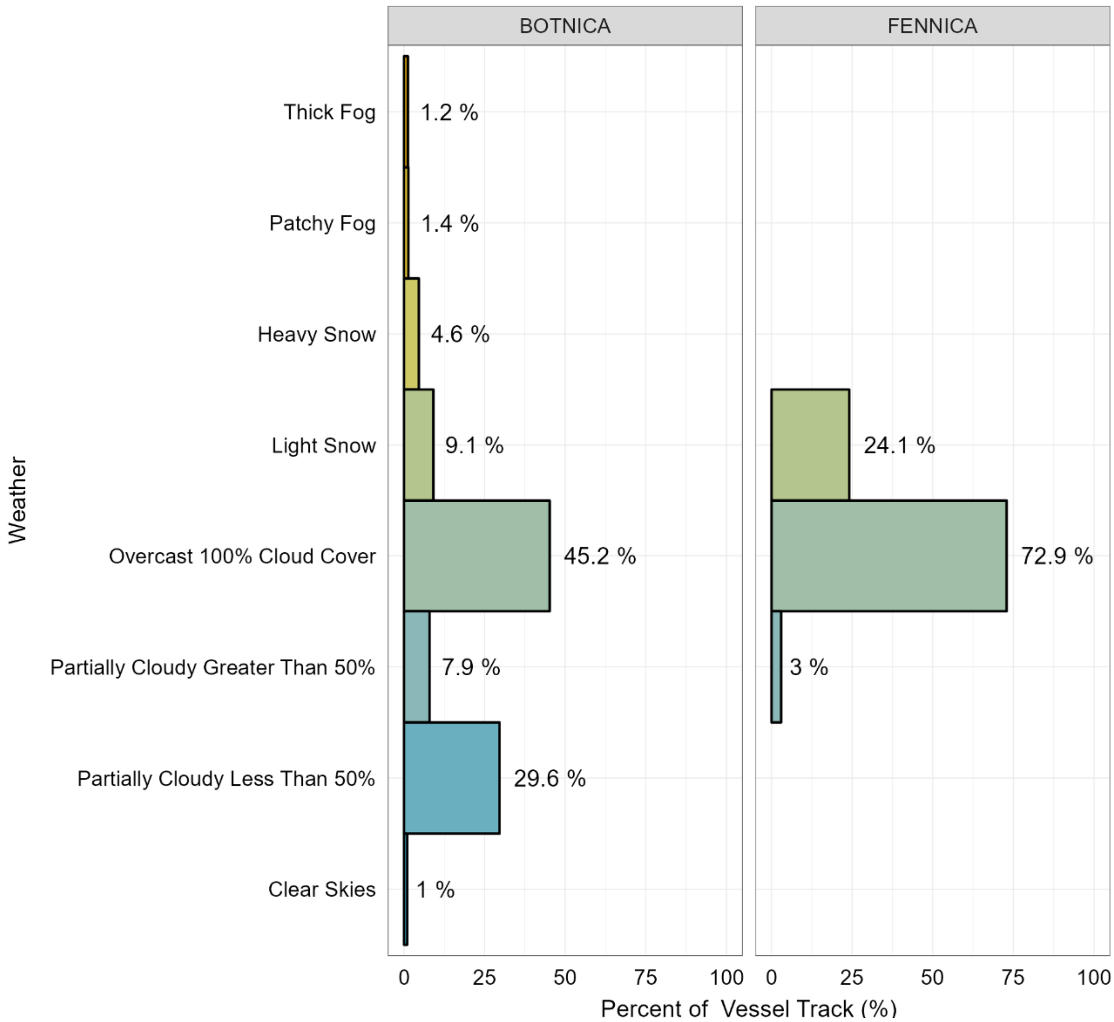


Figure 27: Weather during the 2023 SBO Program

The daily proportional breakdown of weather during the 2023 SBO Program is presented in Figure 28 *Botnica*.

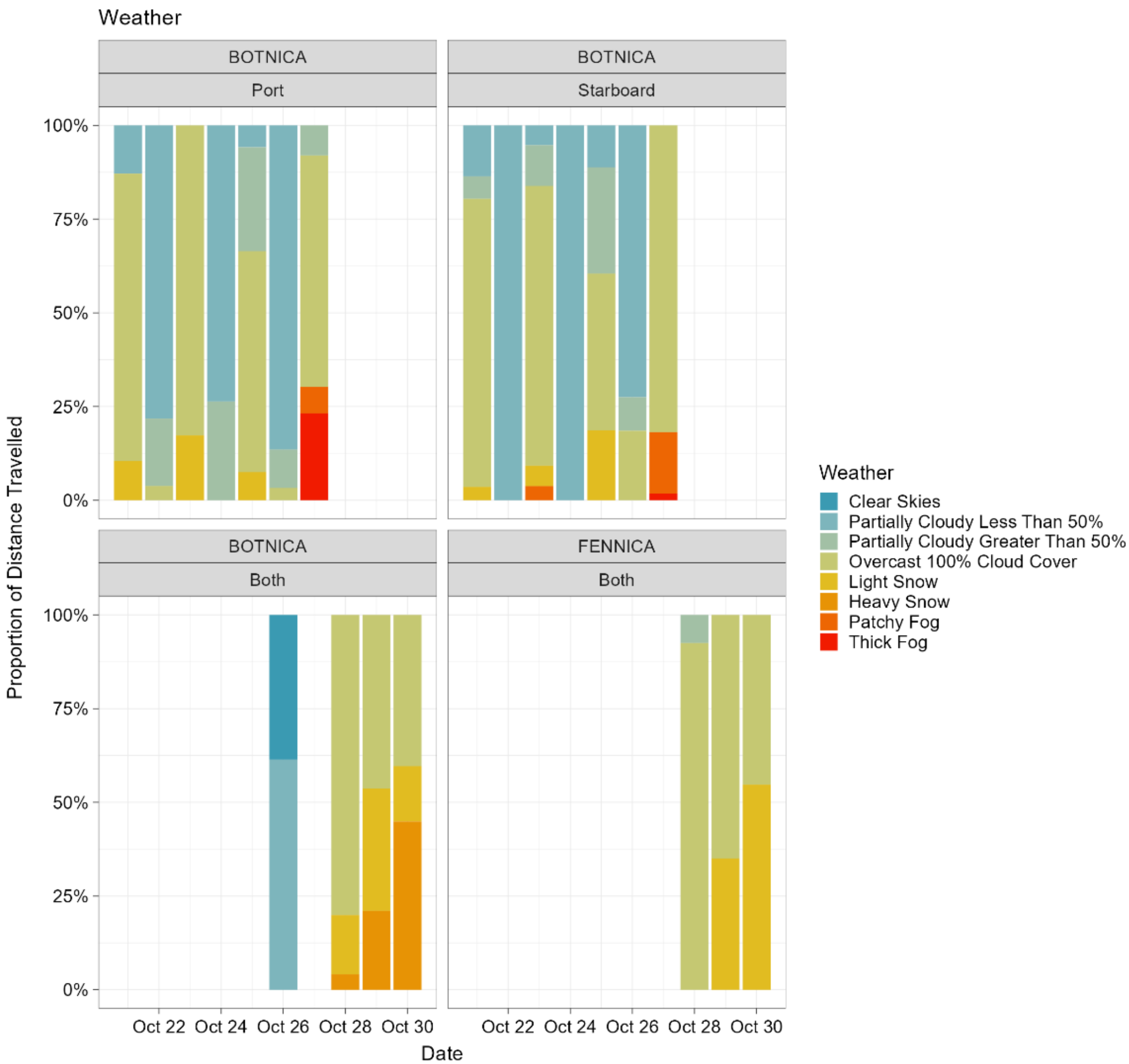


Figure 28: Figure Proportional Breakdown of Weather by Survey Day During 2023 SBO Program

Sightability

Sightability was a qualitative metric used by MWOs to estimate and describe the perceived ability of an observer to detect wildlife based on the combined influence of environmental variables (sunglare, Beaufort Sea State, visibility, and weather). Sightability does not account for other factors that may influence an observer's ability to detect a marine mammal, e.g., observer experience, vessel activity, species detectability, etc. Based on the combination of these factors, sightability was classified using the following categories:

- Poor – The observation area is highly obscured, e.g., conditions are very poor, therefore, *marine mammals would most definitely be missed*.
- Fair – The observation area is somewhat obscured, e.g., conditions are poor, therefore *marine mammals would most likely be missed*.
- Good – Almost all of the observation area can be seen, e.g., conditions are good, therefore *most marine mammals would be detected*.
- Excellent – All of the observation can be seen, e.g., conditions are excellent, therefore all *marine mammals would be detected.*

Sightability during the 2023 SBO Program ranged from poor to excellent. Most of the survey effort was conducted when sightability was good (49.6% and 49.7% from the MSV *Botnica* and *Fennica*, respectively). Survey effort was conducted when sightability was excellent 21.7% and 25.3 % of the time from the *Botnica* and *Fennica*, respectively. Surveys were only conducted in poor sightability for 8% and 0% of total survey effort for the *Botnica* and *Fennica*, respectively (Figure 29).

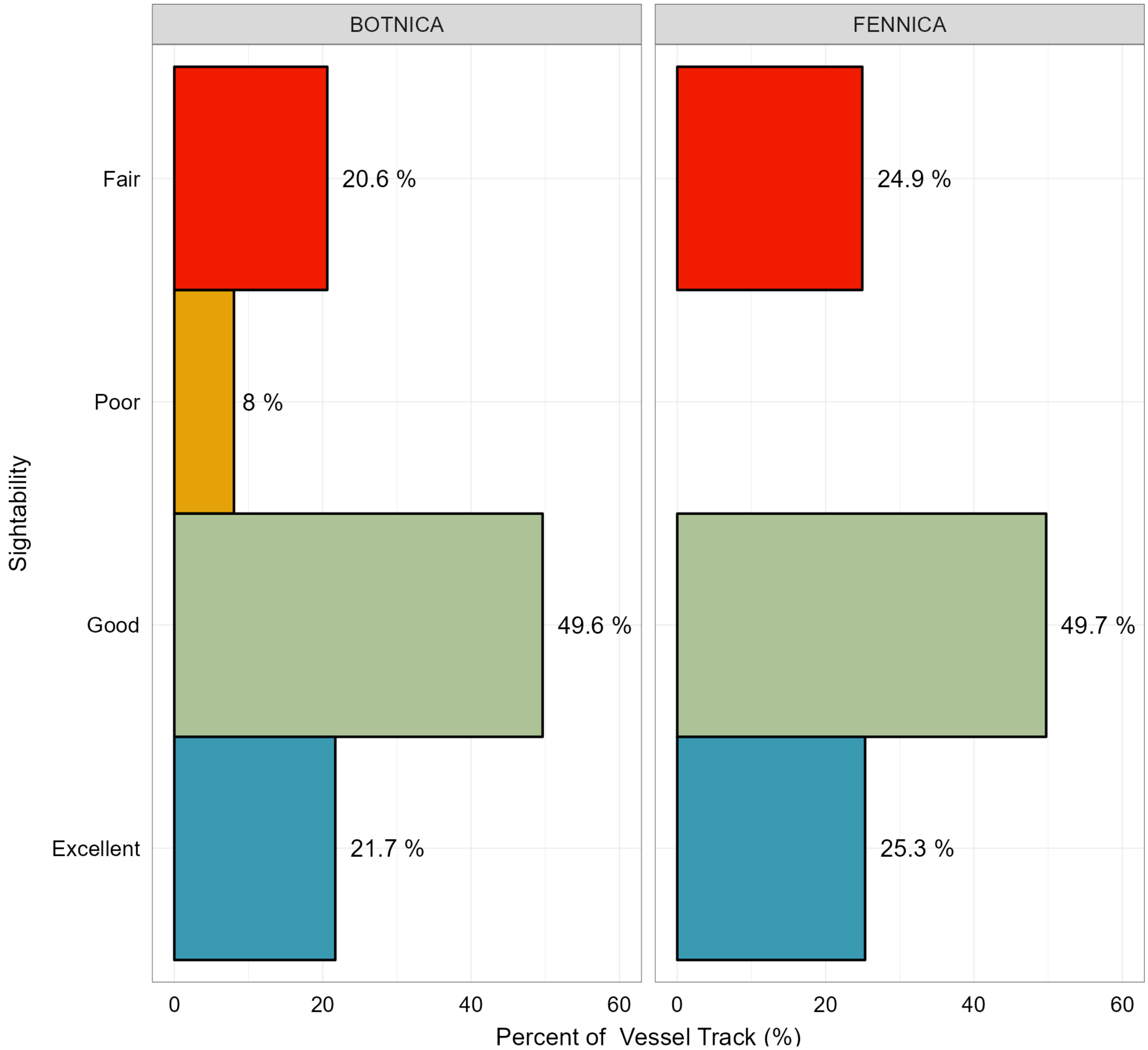


Figure 29: Sightability during the 2023 SBO Program.

The daily proportional breakdown of sightability during the 2023 SBO Program is presented in Figure 30.

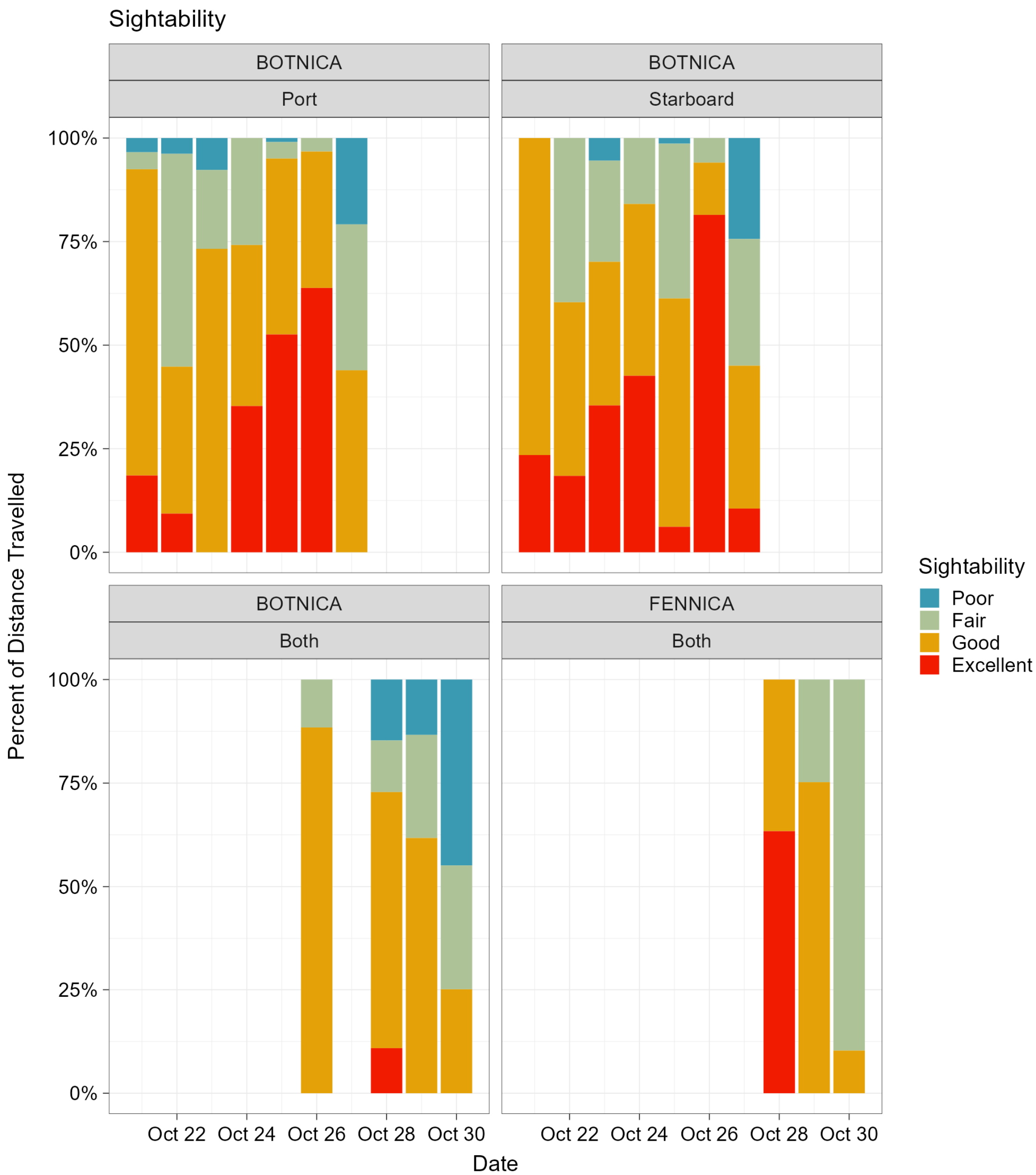


Figure 30: Figure Proportional Breakdown of Sightability by Survey Day During 2023 SBO Program

2.2.3 Marine Mammal Observations

Five different marine mammal species were observed during the 2023 SBO Program including narwhal, ringed seal, harp seal, bearded seal, and polar bear. Beluga, bowhead whale, killer whale (*Orcinus orca*), and walrus were not observed in the RSA during the 2023 SBO Program; however, these species are known to occur in the region. A total of 431 marine mammal sightings comprising 562 individuals were recorded during the 2023 SBO Program (Table 1). The majority of all marine mammal sightings during the 2023 SBO Program were of ringed seal (90%, 389 sightings of 452 individuals) between both vessels combined (Table 1). Most ringed seal sightings were in water (67%, 262 sightings of 290 individuals). The remaining species included harp seal (nine sightings of 56 seals), polar bear (seven sightings of individual bears), and narwhal (five sightings of 20 individuals) (Table 1). Some seal sightings could not be identified to a species level. In total, 13 sightings of 19 unidentified seal were recorded.

Table 1: Marine Mammal Sightings Recorded During the 2023 Ship-based Observer Program (Both Vessels)

Species	In Water		On Ice		Combined	
	No. of Sightings	No. of Individuals	No. of Sightings	No. of Individuals	No. of Sightings	No. of Individuals
Narwhal	5	20	NA	NA	**5**	**20**
Ringed Seal	262	290	126	162	**389**	**452**
Harp Seal	9	56	0	0	**9**	**56**
Bearded Seal	4	4	4	4	**8**	**8**
Unidentified Seal	8	13	5	6	**13**	**19**
Polar Bear	1	1	6	6	**7**	**7**
Total	**290**	**384**	**141**	**178**	**431**	**562**

Survey effort was only based on the *Fennica* from 28 to 30 October when the *Botnica* and *Fennica* operated in tandem escorting ore carriers. The *Fennica* was the lead icebreaker on 28 and 29 October and the *Botnica* was the lead icebreaker on 30 October. A comparison of marine mammal sightings observed by vessel is presented in Table 2. During tandem vessel operations, the *Fennica* recorded approximately twice as many marine mammal sightings compared to the *Botnica* with 90 sighting of 128 individuals compared to 44 sightings of 59 individuals, respectively (Table 2). The only species for which the *Botnica* observed a higher number of sightings when both vessels were operating in tandem was unidentified seal (two sightings totalling six seals).

Table 2: Marine Mammal Sightings Recorded from the *Botnica* and the *Fennica* During the 2023 Ship-based Observer Program

Species	*Botnica*				*Fennica*	
	Total No. of Sightings (21-30 Oct)	Total No. of Individuals (21-30 Oct)	No. of Sightings (Oct 28-30)	No. of Individuals (Oct 28-30)	No. of Sightings (Oct 28-30)	No. of Individuals (Oct 28-30)
Narwhal	1	3	1	3	4	17
Ringed Seal	308	362	38	47	81	90
Bearded Seal	7	7	1	1	1	1
Harp Seal	7	38	1	1	2	18
Unidentified Seal	13	19	2	6	0	0
Polar Bear	5	5	1	1	2	2
Total	**341**	**434**	**44**	**59**	**90**	**128**

2.2.3.1 Species-based Observations

Narwhal

There were five sightings of a total of 20 narwhal on 28 October 2023 (Table 1 and Table 2). All narwhal sightings were observed in Eclipse Sound near Pond Inlet and Mount Herodier (Figure 31). No mothers with calves were identified but the group composition could not be determined for three of these sightings due to the distance and short duration of the observations. There was one sighting of a single narwhal, two sightings of groups of five narwhal, and one sighting of a group of six narwhal observed from the *Fennica*, which was the lead vessel for the convoy on 28 October. On this same day, there was one sighting of three narwhal from the *Botnica*.

Ringed Seal

A total of 389 ringed seal sightings comprising 452 individuals were recorded in the RSA during the 2023 SBO Program (Table 1). Of these sightings, 263 consisted of 290 seals observed in water and 126 consisted of 162 seals observed on ice. In-water sightings consisted primarily of solitary individuals (242 of 263 sightings, 92%) resulting in an average group size of 1.1 seals. On-ice sightings also consisted primarily of solitary individuals (107 of 126 sightings, 85%) with other group sizes ranging from two to seven individuals for an average group size of 1.3 seals.

Ringed seals were distributed along the entire shipping corridor with the largest groups recorded in Baffin Bay (Figure 32), all within a 30-minute window on 22 October, when the ship was transiting through drift ice in Baffin Bay. These larger group sightings comprised of two sightings of five seals on ice, one sighting of seven seals on ice and one sighting of five seals in water. When MWOs were stationed on both vessels (28 to 30 October), the lead vessel, the *Fennica*, had more ringed seal sightings (on ice and in water) than the *Botnica* (81 sightings of 90 seals vs 38 sightings of 47 seals, respectively).

Harp Seal

During the 2023 SBO Program there were nine sightings of 56 harp seals in the water in the RSA (Table 1). No harp seals were observed on ice during the 2023 SBO Program. Harp seal groups ranged from one to 15 seals for an average group size of 6.2 seals. Harp seal groups were observed in northern Milne Inlet, Eclipse Sound, Pond Inlet, and Baffin Bay (Figure 32). Six of the harp seal sightings occurred from the *Botnica* when the SBO team was conducting observations from 21–27 October. After the team was split between both vessels, there were two harp seal sightings from the *Fennica* on 28 October (one group of three seals and one group of 15 seals) and one sighting of a single harp seal from the *Botnica* on 29 October.

Bearded Seal

A total of eight bearded seal sightings (all solitary individuals) were recorded in the RSA during the 2023 SBO Program (Table 1). Four bearded seals were observed in water and four were observed on ice. Bearded seals were observed throughout the RSA from Milne Port to Baffin Bay (Figure 32), Six sightings (three on ice and three in water) were observed from the *Botnica* during surveys from 21–27 October. On 28 October, the MWOs on the *Fennica* observed a sighting of a bearded seal in the water. On 30 October, the MWOs on the *Botnica* observed a sighting of a bearded seal on ice (this sighting was also observed by the MWOs on the *Fennica*).

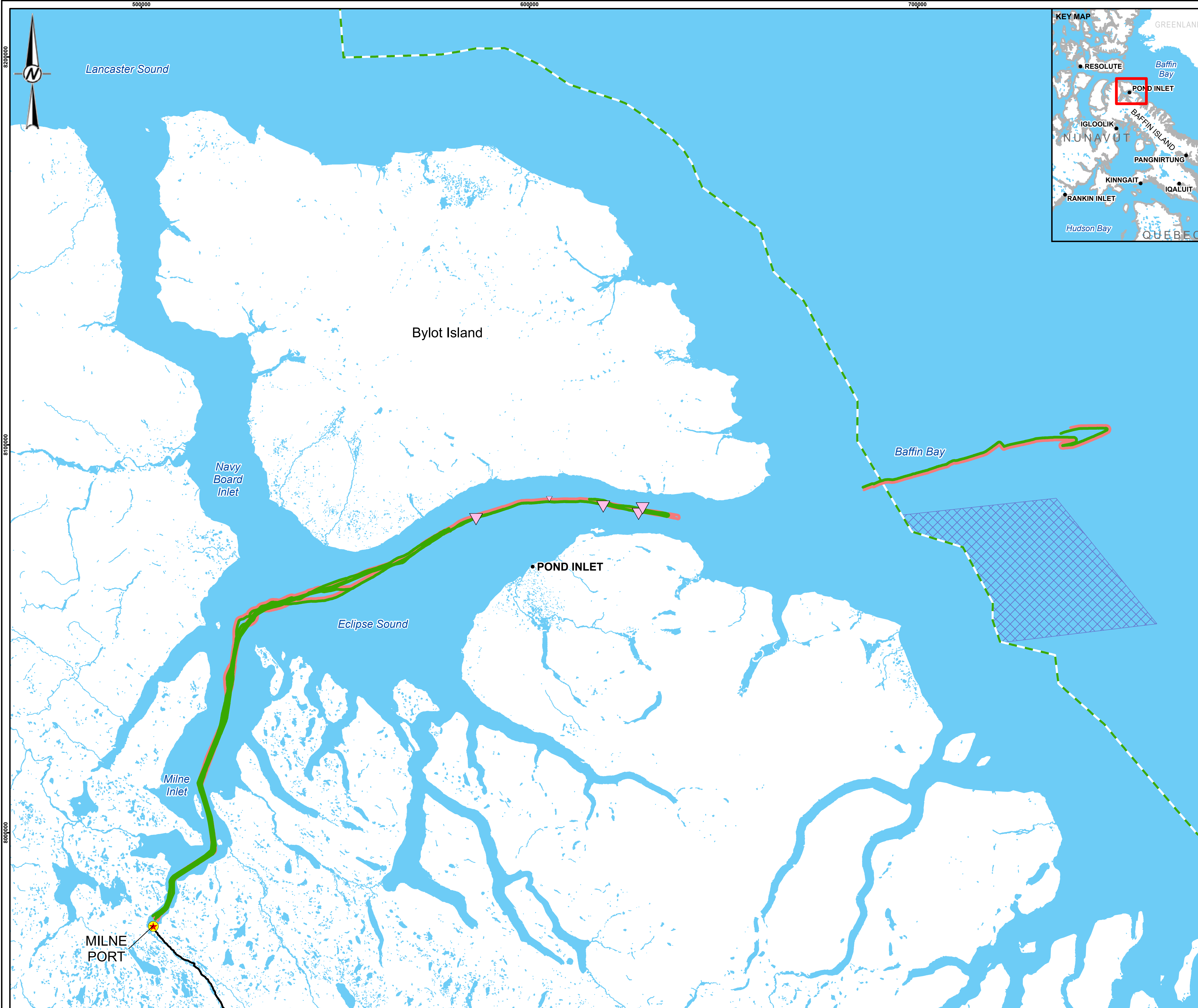
Unidentified Seal Species

A total of 13 sightings of unidentified seal species comprising 19 individuals were recorded during the 2023 SBO Program (Table 1). Eight of these sightings (62%) were in-water sightings of 13 seals comprised of six sightings of individual seals, one sighting of two seals, and one sighting of five seals. The remaining five sightings were of unidentified seals on ice (38%), all comprised of individual seals with the exception of one sighting of two seals. Sightings of unidentified seals were observed along the entire northern shipping route except in eastern Eclipse Sound and Pond Inlet (Figure 32). All unidentified seals were observed from the *Botnica*.

Polar Bear

Seven sightings of individual polar bears were recorded in the RSA during the 2023 SBO Program (Table 1). All sightings except one were observed on ice (86%). Observers were able to identify and recorded the age class for three of the bears, including one sub-adult bear and two adult bears. Four could not be classified to age class (three were too far and one was swimming). Except for one polar bear observed in Baffin Bay, all polar bears were observed in Eclipse Sound, near Bylot Island (Figure 33). Four polar bear sightings occurred when the full MWO team was observing from the *Botnica* from 21–27 October. After the team was split between the *Botnica* and *Fennica*, two sightings of individual polar bears were recorded from the *Fennica* on 28 and 29 October, and another sighting was recorded from the *Botnica* on 29 October. During these observations, the first team to observe the polar bears called the other team via the vessels' VHF radios to inform them of the observation so both vessels could track the bears in the event that mitigations were needed, e.g., not approach the bears closer than 300 m.

The first polar bear was observed on ice in Baffin Bay on 22 October, approximately 1.7 km from the icebreaker. The second and third polar bears were observed on ice at the same time on 24 October, approximately 3 km from the vessel. The fourth polar bear was observed in the water on 25 October, approximately 1 km from the vessel. The fifth polar bear was initially observed by the *Fennica* on 28 October, approximately 3 km from the icebreakers. The sixth and seventh polar bears were observed ten minutes apart from each other on 29 October, approximately 1.7 km and 2.2 km from the vessels.



LEGEND

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

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

CETACEAN SPECIES OBSERVATIONS (GROUP SIZE)

NARWHAL

- 1
- 2-10

0 25 50
1:1,000,000 KILOMETRES

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. 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
2023 SHIP-BASED OBSERVER PROGRAM

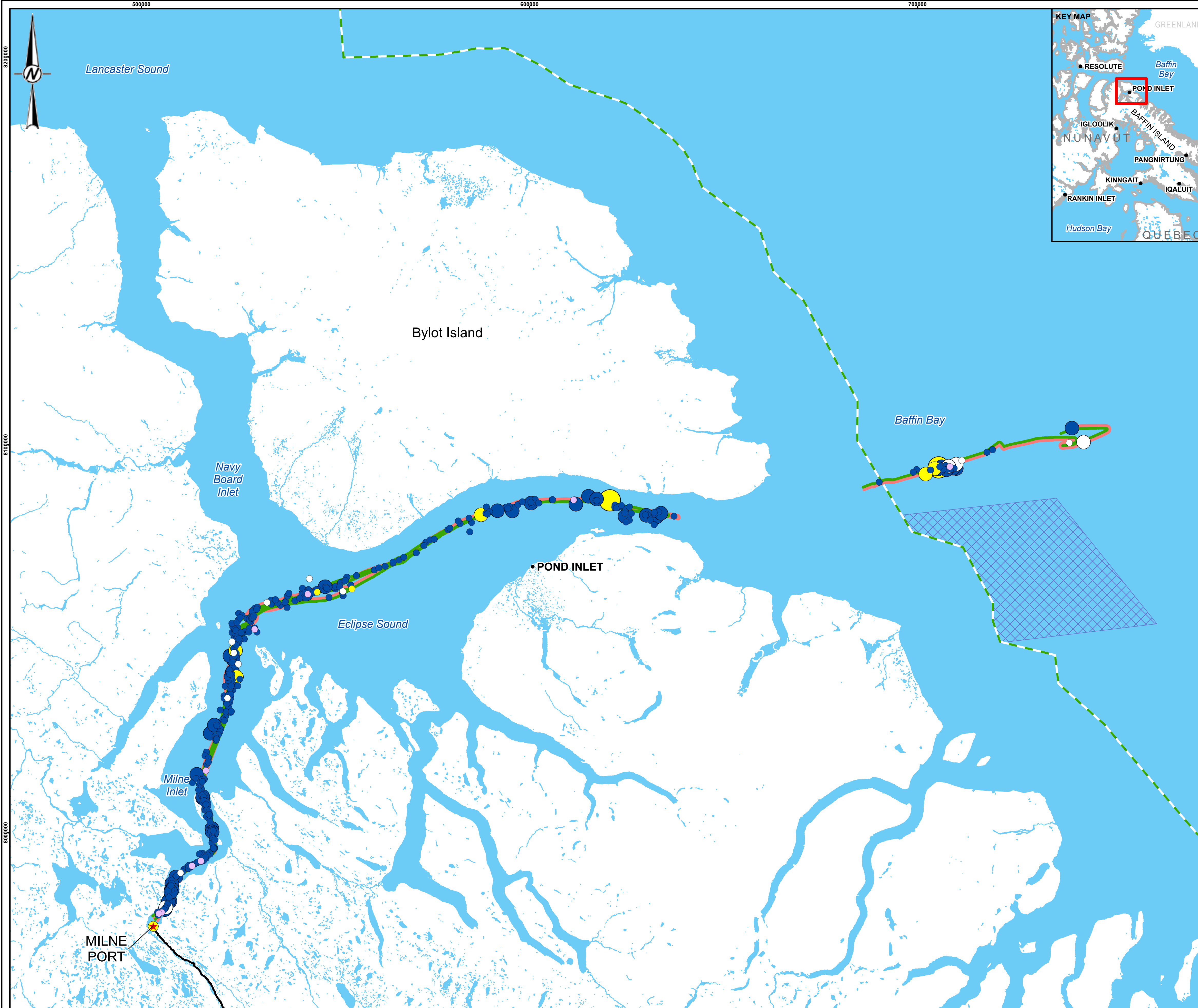
TITLE
LOCATION OF CETACEAN SIGHTINGS DURING THE 2023 SBO SURVEY (21 – 30 OCTOBER)

CONSULTANT

YYYY-MM-DD	2024-03-12
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	31

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm 0



LEGEND

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

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

PINNIPED SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL

- 1

HARP SEAL

- 1
- 2-10
- 10+

RINGED SEAL

- 1
- 2-10
- 10+

UNIDENTIFIED SEAL

- 1
- 2-10

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. 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

2023 SHIP-BASED OBSERVER PROGRAM

TITLE

LOCATION OF PINNIPED SIGHTINGS DURING THE 2023 SBO SURVEY (21 – 30 OCTOBER)

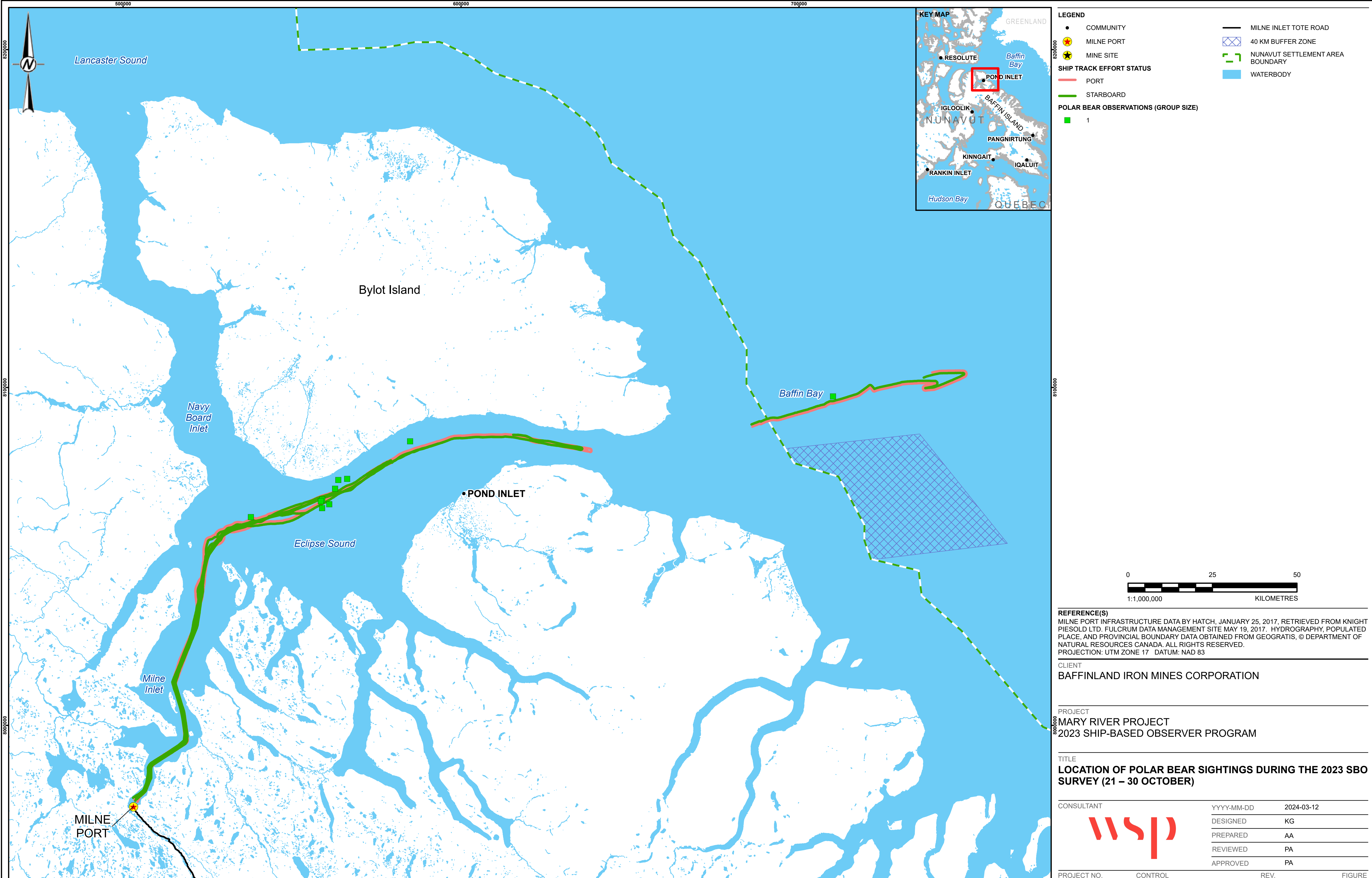
CONSULTANT

wsp

YYYY-MM-DD	2024-03-12
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	32

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



REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. 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
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
LOCATION OF POLAR BEAR SIGHTINGS DURING THE 2023 SBO SURVEY (21 – 30 OCTOBER)

CONSULTANT
wsp

YYYY-MM-DD	2024-03-12
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	33

2.2.3.2 Relative Abundance of Marine Mammals in the RSA

Relative abundance calculations were based on sightings observed within 2 km of the vessel (using CPA distance) and sightings from the lead vessel when both icebreakers operated in tandem. Total monitoring effort from the Botnica from 21 to 27 October plus monitoring effort from the lead vessel only from 28 to 30 October was 949.9 km. Table 3 provides a summary of sighting rates and animal detection rates by species. There were a total of 363 sightings of 478 marine mammals available for relative abundance analyses after truncating the data to sightings within 2 km and from the lead vessel (Table 3). The number of marine mammal sightings to assess relative abundance rates included four sightings of 17 narwhal, 331 sightings of 381 ringed seal, seven sightings of seven bearded seal, eight sightings of 55 harp seal, nine sightings of 14 unidentified seal, and four sightings of four polar bear (Table 3).

Table 3: Marine Mammal Sightings Recorded from Lead Vessels (Truncated at 2 km) During the 2023 Ship-based Observer Program

Species	In Water		On Ice		Combined	
	No. of Sightings	No. of Individuals	No. of Sightings	No. of Individuals	No. of Sightings	No. of Individuals
Narwhal	4	17	NA	NA	**4**	**17**
Ringed Seal	234	257	97	124	**331**	**381**
Bearded Seal	4	4	3	3	**7**	**7**
Harp Seal	8	55	0	0	**8**	**55**
Unidentified Seal	8	13	1	1	**9**	**14**
Polar Bear	1	1	3	3	**4**	**4**
Total	**253**	**341**	**90**	**110**	**363**	**478**

The relative abundance of marine mammals in the RSA during the 2023 SBO Program, expressed as the animal detection rate (no. of individuals relative to survey effort in km) was 0.503 individuals/km (0.382 sightings/km; Table 4). Ringed seal had the highest detection rate at 0.401 individuals/km (0.350 sightings/km), followed by harp seal (0.058 individuals/km), narwhal (0.018 individuals/km), unidentified seal (0.015 individuals/km), bearded seal (0.007 individuals/km), and polar bear (0.004 individuals/km).

Table 4: Sighting and Animal Detection Rate (Relative Abundance) of Marine Mammals in the RSA During the 2023 Ship-based Observer Program

Species	No. of Sightings	Sighting Rate (SPUE)	No. of Individuals	Animal Detection Rate
Narwhal	4	0.004	17	0.018
Ringed Seal	331	**0.350**	381	**0.401**
Bearded Seal	7	0.007	7	0.007
Harp Seal	8	0.008	55	0.058
Unidentified Seal	9	0.010	14	0.015
Polar Bear	4	0.004	4	0.004
Total	**363**	**0.382**	**478**	**0.503**

2.2.3.2.1 Comparison to Previous SBO Programs

The main species observed during SBO programs in 2013, 2014 and 2015, prior to the 2018, 2019 and 2023 SBO Programs conducted from icebreakers, were narwhal, ringed seal, and harp seal (SEM 2014, 2015, 2016). Less observation effort during earlier SBO programs (5.5 hours in 2013 and 9 hours each in 2014 and 2015) resulted in lower numbers of sightings compared to the 2018, 2019 and 2023 programs. In 2013, five narwhal, 45 ringed seal, 10–15 harp seal and one unidentified seal were observed (SEM 2014). In 2014, 7–9 narwhal, two ringed seal, and one unidentified seal were observed (SEM 2015). In 2015, 5–10 narwhal and one ringed seal were observed (SEM 2016) (Table 5).

Table 5: Number of Marine Mammal Observations in the RSA – A Comparison Between 2013, 2014, and 2015 SBO Programs

Species	2014	2015	2016
	No. of Individuals	No. of Individuals	No. of Individuals
Narwhal	5	7–9	5–10
Ringed Seal	45	2	1
Bearded Seal	0	0	0
Harp Seal	10–15	0	0
Unidentified Seal	1	1	0
Polar Bear	0	0	0
# Observation Hours	**5.5**	**9.0**	**9.0**
Total	**61 to 66**	**10 to 19**	**6 to 16**

2.2.3.2.2 Comparison to 2018, 2019 and 2023 SBO Programs

The relative abundance of marine mammals in the RSA was similar in fall of 2023 (0.503 individuals/km) to that observed in fall 2018 (0.530 individuals/km). Fall 2018 and 2023 had higher relative abundance rates compared to fall 2019 (0.16 individuals/km) (Table 6). Harp seal was the species with highest relative abundance rates in 2018 (0.225 individuals/km) and 2019 (0.059 individuals/km), while ringed seal was the species with the highest relative abundance rate in 2023 (0.401 individuals/km). Species observed with higher relative abundance in fall 2023 than previous years included ringed seal, bearded seal, and polar bear.

Narwhal relative abundance rate were highest in fall 2018 (0.076 individuals/km), followed by fall 2019 (0.051 individuals/km) and fall 2023 (0.018 individuals/km) (Table 6). Ringed seal relative abundance rate were higher in fall 2023 (0.401 individuals/km) compared to 2018 (0.154 individuals/km), and both were higher compared to fall 2019 (0.029 individuals/km). Bearded seal relative abundance rate was higher in 2023 (0.007 individuals/km) compared to 2018 (0.000) and to 2019 (0.001 individuals/km). Harp seal relative abundance rate were highest in fall 2018 (0.226 individuals/km), followed by fall 2019 (0.059 individuals/km) and fall 2023 (0.058 individuals/km). Unidentified seal relative abundance was highest in fall 2018 (0.073 individuals/km), followed by fall 2019 (0.019 individuals/km) and fall 2023 (0.015 individuals/km). Polar bear relative abundance rate for fall 2023 (0.0042 individuals/km) were greater than fall 2018 (0.001 individuals/km) and both years were higher than fall 2019 when no polar bears were sighted.

The observed decrease in narwhal relative abundance in from 2018 to 2023 may be reflective of the difference in the time of year and ice cover conditions between the SBO Programs. In 2018, the SBO Program occurred earlier in the year (28 September to 17 October) than the 2019 SBO Program (5 to 28 October) and the 2023 SBO Program (21 to 30 October). It is possible that there were more narwhal remaining in the RSA in 2018 and 2019, compared to 2023. Additionally, there was less ice during the 2018 and 2019 late shoulder season SBO Program, with the majority of observation effort occurring in open water, compared to the 2023 SBO Program where most observation effort occurred in ice conditions. These heavier ice conditions may have impacted the observer's ability to detect narwhal and/or influence narwhal habitat use in the RSA.

Table 6: Relative Abundance of Marine Mammals in the RSA – Comparison between Fall 2018, 2019, and 2023 Programs

Species	Fall 2018 (2049.1 km)		Fall 2019 (1970.0 km)		Fall 2023 (949.9 km)	
	No. of Individuals	Relative Abundance*	No. of Individuals	Relative Abundance*	No. of Individuals	Relative Abundance*
Narwhal	156	0.0761	101	0.0513	17	0.0179
Ringed Seal	315	0.1537	58	0.0294	381	**0.4011**
Bearded Seal	0	0.0000	1	0.0005	7	0.0074
Harp Seal	462	**0.2255**	117	**0.0594**	55	0.0579
Unidentified Seal	0	0.0732	38	0.0193	14	0.0147
Polar Bear	2	0.0010	0	0.0000	4	0.0042
Total	**1,085**	**0.5295**	**315**	**0.1599**	**478**	**0.5032**

Bold = highest detection rate that year.

2.2.3.3 Survey Conditions and Relative Abundance

2.2.3.3.1 Ice Cover

Ice cover was recorded during active MWO watch periods on the icebreakers as one of several environmental conditions. It was recorded as "percent cover" at the following two spatial scales: Near Field (≤100 m of the ship) and Far Field (>100 m from the ship but within line of sight of the observer). Seals and walrus that were observed hauled-out on ice were considered separately from seals and walrus observed in water.

Near Field Ice Cover

Ice cover conditions within 100 m of the ship (Near Field) were recorded during active MWO watches to estimate the proportion of time that the *Botnica* and *Fennica* engaged in icebreaking activities. Sighting detection rates, corrected for effort (distance traveled), are presented for each ice cover category in Table 8.

During the 2023 SBO Program, the majority of narwhal sightings occurred in heavy (81–100%) ice cover conditions in the Near Field (mean = 92.5%, range = 90–100%; Table 7), corresponding with a sighting detection rate of 0.006 sightings/km (Table 8).

Ringed seal in water and on ice were observed in all Near Field ice cover conditions with a mean of 77.2% (range 0–100%) for in-water sightings and 61.4% (range 0–100%) for on-ice sightings (Table 7). Ringed seal detection rates in water were greatest in high (61–80%) ice cover conditions in the Near Field (0.358 sightings/km) and lowest in moderate ice cover (41–60%) conditions in the Near Field (0.189 sightings/km). Ringed seal detection rates on ice were highest in open water (0–20%) conditions in the Near Field (0.172 sightings/km) and lowest in heavy (81100%) ice cover conditions in the Near Field (0.079 sightings/km; Table 8).

Sightings of bearded seal in water occurred in high and heavy ice cover conditions in the Near Field (mean = 92.5%, range 61–100%) with the highest detection rate of 0.018 sightings/km in high (61-80%) Near Field ice cover conditions (Table 8). Bearded seal observed on ice occurred in open water conditions (0–20%) with a detection rate of 0.010 sightings/km and heavy ice cover conditions (81-100%) with a detection rate of 0.006 sightings/km.

Sightings of harp seal in water occurred in either open water (0–20%) or heavy (81–100%) ice cover conditions in the Near Field (mean = 42.5%, range 11–100%) (Table 7). The highest detection rate for harp seal in water was 0.026 sightings/km during open water conditions (Table 8). No harp seal were observed on ice during the 2023 SBO Program.

Most unidentified seal sightings were of seals in water in open water (0–20%), high (61–80%), or heavy (81–100%) ice cover conditions in the Near Field (mean = 72.5%, range 0–100%) (Table 7). The highest detection rate for unidentified seals in water was in high ice cover conditions in the Near Field. The one unidentified seal sighting on ice occurred in open water conditions with a detection rate of 0.005 sightings/km (Table 8).

The one in-water polar bear sighting occurred in heavy (81–100%) ice cover conditions in the Near Field and the remaining sightings of polar bear on ice occurred in moderate (mean = 60%, range 0-90%) ice conditions (Table 7). The detection rate for the one polar bear in water was greatest 0.002 sightings/km in heavy ice cover conditions in the Near Field, while the highest detection rate for the polar bears on ice was 0.005 sightings/km in open water conditions (Table 8).

Table 7: Near Field Ice Cover Recorded During Marine Mammal Sightings During the 2023 SBO Program

	Narwhal	Ringed seal	Bearded seal	Harp seal	Unidentified seal sp.	Polar bear
2023 SBO Program (Fall: 21–30 October)						
In Water						
Mean Near Field Ice Cover (%)	92.5	77.2	92.5	42.5	72.5	100.0
Near Field Ice Cover Range (%)	90–100	0–100	80–100	10–100	0–100	100
# Sightings	4	234	4	8	8	1
On Ice						
Mean Near Field Ice Cover (%)	NA	61.4	0.0	NA	NA	60.0
Near Field Ice Cover Range (%)	NA	0-100	0	NA	NA	0–90
# Sightings	NA	97	3	0	1	3

Table 8: Sighting Detection Rates as a Function of Near Field Ice Cover During the 2023 SBO Program

	Narwhal	Ringed seal	Bearded seal	Harp seal	Unidentified Seal sp.	Polar Bear
Ice Cover—In Water						
0–20% (Open water)	0.000	0.198	0.000	**0.026**	0.010	0.000
21–40% (Low)	0.000	0.266	0.000	0.000	0.000	0.000
41–60% (Moderate)	0.000	0.189	0.000	0.000	0.000	0.000
61–80% (High)	0.000	**0.358**	**0.018**	0.000	**0.018**	0.000
81–100% (Heavy)	**0.006**	0.258	0.005	0.005	0.008	**0.002**
# Sightings	4	234	4	8	8	1
Ice Cover—On Ice						
0–20% (Open water)	NA	**0.172**	**0.010**	0.000	**0.005**	**0.005**
21–40% (Low)	NA	0.107	0.000	0.000	0.000	0.000
41–60% (Moderate)	NA	0.081	0.000	0.000	0.000	0.000
61–80% (High)	NA	0.089	0.000	0.000	0.000	0.000
81–100% (Heavy)	NA	0.079	0.006	0.000	0.000	0.003
# Sightings	0	97	3	0	1	3

Note: **Bold** indicates ice cover category with highest detection rate.

Far Field Ice Cover

To assess sighting detection rates as a function of ice cover over the wider extent of the observation area, data on Far Field ice cover were recorded, along with other environmental variables, during active MWO watches. Table 9 presents a summary for Far Field ice cover conditions present at the time of the recorded sightings. Sighting detection rates, corrected for effort (distance traveled), are presented for each ice cover category in Table 10.

The majority of narwhal sightings occurred in heavy (91–100%) ice cover conditions in the Far Field (mean = 92.5%, range = 91–100%; Table 9), with the highest detection rate (0.007 sightings/km) occurring in heavy ice conditions (Table 10).

In-water sightings of ringed seal occurred in all ice cover conditions in the Far Field (mean = 79.7%, range = 0–100%; Table 9). The highest detection rate (0.309 sightings/km) for ringed seals in water occurred in low (21–40%) ice cover in the Far Field while the lowest detection rate for ringed seal in water occurred in moderate (41–60%) ice cover in the Far Field. On-ice sightings of ringed seal occurred in high (61-80%) ice cover conditions in the Far Field (mean = 62.4%, range = 0–100%). The highest detection rate for ringed seals on ice occurred with open water (0–20%%) Far Field ice cover conditions (0.200 sightings/km), while the lowest detection rate for ringed seals on ice was in high (61–80%) ice cover in the Far Field (Table 10).

Sighting of bearded seal in water occurred mainly in heavy (81–100%) ice conditions in the Far Field (mean = 92.5%, range 80–100%; Table 9). Bearded seal in water detection rates were highest in high ice cover conditions (0.010 sightings/km) (Table 10). On-ice sightings of bearded seals occurred primarily in open water (0–20%) conditions in the Far Field (mean = 10%, range 0–100%;Table 10) corresponding with a detection rate of 0.012 sightings/km (Table 10).

All sightings of harp seal were in water and occurred in either open water (0–20%) or heavy (81–100%) Far Field ice conditions (mean = 46.3%, range = 11–90%; Table 9). The highest detection rate for harp seal was during open water conditions (0.030 sightings/km; Table 10).

The one in-water sighting of a polar bear occurred in heavy (81–100%) ice cover conditions in the Far Field. The remaining sightings of polar bears on ice were during either open water (0–20%) or heavy (81–100%) ice conditions in the Far Field (mean = 60%, range 0–90%; Table 9). Polar bear detection rates were highest during open water conditions (0.006 sightings/km), followed by heavy ice conditions in the Far Field (0.005 sightings/km; Table 10).

Table 9: Far Field Ice Cover Recorded During Marine Mammal Sightings During the 2023 SBO Program

	Narwhal	Ringed seal	Bearded seal	Harp seal	Unidentified seal sp.	Polar bear
2023 SBO Program (Fall: 21–30 October)						
In Water						
Mean Near Field Ice Cover (%)	92.5	79.7	92.5	46.3	67.5	90
Near Field Ice Cover Range (%)	90–100	0–100	80–100	10–100	0–100	90
# Sightings	4	234	4	8	8	1
On Ice						
Mean Near Field Ice Cover (%)	NA	62.4	10.0	NA	NA	60.0
Near Field Ice Cover Range (%)	NA	0–100	0–10	NA	NA	0–90
# Sightings	NA	97	3	0	1	3

Table 10: Sighting Detection Rates as a Function of Far Field Ice Cover During the 2023 SBO Program

	Narwhal	Ringed seal	Bearded seal	Harp seal	Unidentified Seal sp.	Polar Bear
Ice Cover—In Water						
0–20% (Open water)	0.000	0.231	0.000	**0.030**	**0.012**	0.000
21–40% (Low)	0.000	**0.309**	0.000	0.000	0.000	0.000
41–60% (Moderate)	0.000	0.153	0.000	0.000	0.000	0.000
61–80% (High)	0.000	0.207	**0.010**	0.000	0.010	0.000
81–100% (Heavy)	**0.007**	0.266	0.005	0.005	0.008	**0.002**
# Sightings	4	234	4	8	8	1
Ice Cover—On ice						
0–20% (Open water)	NA	**0.200**	**0.012**	0.000	**0.006**	**0.006**
21–40% (Low)	NA	0.124	0.000	0.000	0.000	0.000
41–60% (Moderate)	NA	0.065	0.000	0.000	0.000	0.000
61–80% (High)	NA	0.052	0.000	0.000	0.000	0.000
81–100% (Heavy)	NA	0.082	0.000	0.000	0.000	0.003
# Sightings	0	97	3	0	1	3

Note: **Bold** indicates ice cover categories with highest detection rate.

2.2.3.3.2 Sea State

Table 11 presents detection rates for all marine mammal species observed in the RSA, broken down by sea state category.

The highest detections rates for narwhal occurred in sea s 2 (0.011 sightings/km), followed by sea state 0 (0.007 sightings/km), and sea state 1 (0.002 sightings/km; Table 11).

The highest detection rate for ringed seal in water occurred in sea state 0 (0.345 sightings/km), followed by sea state 1 (0.267 sightings/km), sea state 3 (0.061 sightings/km), and sea state 2 (0.032 sightings/km; Table 11). The highest detection rate for ringed seal on ice occurred in sea state 0 (0.163 sighting/km), followed by sea state 1 (0.098 sightings/km), and sea state 2 (0.011 sightings/km; Table 11).

In-water sightings of bearded seal occurred with the highest detection rate in sea state 2 (0.011 sightings/km) and sea state 1 (0.002 sightings/km; Table 11). The highest detection rate for bearded seal on ice occurred in sea state 1 (0.005 sightings/km), followed by sea state 0 (0.004 sightings/km).

The highest detection rate for harp seal in water occurred in sea state 1 (0.012 sightings/km), followed by sea state 0 (0.007 sightings/km; Table 11). No harp seals were observed on ice during the 2023 SBO Program.

The one in-water polar bear sighting was observed in sea state 0 and had a detection rate of 0.004 sightings/km, while the on-ice sightings of polar bear occurred with a higher detection rate in sea state 0 (0.007 sightings/km), followed by sea state 1 (0.002 sightings/km; Table 11).

Table 11: Sighting Detection Rates as a Function of Sea State During the 2023 SBO Program

	Narwhal	Ringed seal	Bearded seal	Harp seal	Unidentified Seal	Polar Bear
Sea State—In Water						
0 (Glassy)	0.007	**0.345**	0.000	0.007	0.007	**0.004**
1 (Ripples)	0.002	0.267	0.002	**0.012**	**0.010**	0.000
2 (Small wavelets)	**0.011**	0.032	**0.011**	0.000	0.000	0.000
3 (Large wavelets, crests begin to break)	0.000	0.061	0.000	0.000	0.000	0.000
4 (Small waves becoming longer, numerous whitecaps)	0.000	0.000	0.000	0.000	0.000	0.000
# Sightings	4	234	4	8	8	1
Sea State—On Ice						
0 (Glassy)	NA	**0.163**	0.004	0.000	0.000	**0.007**
1 (Ripples)	NA	0.098	**0.005**	0.000	**0.002**	0.002
2 (Small wavelets)	NA	0.011	0.000	0.000	0.000	0.000
3 (Large wavelets, crests begin to break)	NA	0.000	0.000	0.000	0.000	0.000
4 (Small waves becoming longer, numerous whitecaps)	NA	0.000	0.000	0.000	0.000	0.000
# Sightings	0	97	3	0	1	3

Note: **Bold** indicates sea state with highest detection rate.

2.2.3.3.3 Visibility

Table 12 presents detection rates for all marine mammal species observed in the RSA during the 2023 SBO Program, broken down by visibility category.

All narwhal sightings occurred in either very good or excellent visibility conditions with an equal detection rate (0.007 sightings/km) (Table 12).

The highest detection rate for ringed seal in water occurred in poor visibility conditions (0.839 sightings/km), while the lowest detection rate for ringed seal in water occurred in very good visibility conditions (0.160 sightings/km; Table 12). The highest detection rate for ringed seal on ice occurred in excellent visibility conditions (0.142 sighting/km) and the lowest detection rate occurred in moderate visibility conditions (0.055 sightings/km; Table 12).

Sightings of bearded seal in water occurred with the highest detection rate in very good visibility conditions (0.007 sightings/km), while sightings of bearded seal on ice occurred with the highest detection rate in excellent visibility conditions (0.007 sightings/km; Table 12).

The highest detection rate for harp seal in water occurred in very good visibility conditions (Table 12). No harp seals were observed on ice during the 2023 SBO Program.

Unidentified seal sightings in water occurred with the highest detection rate in excellent visibility conditions (0.021 sightings/km), followed by moderate visibility conditions (0.018 sightings/km). The one sighting of an unidentified sea on ice occurred in excellent visibility conditions and had a corresponding detection rate of 0.003 sightings/km (Table 12).

All polar bear sightings occurred in very good visibility conditions for both in water and on ice observations and ha corresponding detection rates of 0.003 sightings/km and 0.010 sightings/km, respectively (Table 12).

Table 12: Sighting Detection Rates as a Function of Visibility During the 2023 SBO Program

	Narwhal	Ringed seal	Bearded seal	Harp seal	Unidentified Seal	Polar Bear
Visibility—In Water						
501-1,000 m (Poor)	0.000	**0.839**	0.000	0.000	0.000	0.000
1,001-2,500 m (Moderate)	0.000	0.249	0.000	0.000	0.018	0.000
2,501-5,000 m (Good)	0.000	0.372	0.004	0.000	0.000	0.000
5,001-10,000 m (Very Good)	**0.007**	0.160	**0.007**	**0.020**	0.000	**0.003**
>10,000 m (Excellent)	**0.007**	0.214	0.003	0.007	**0.021**	0.000
# Sightings	4	234	4	8	8	1
Visibility—On ice						
500-1,000 m (Poor)	NA	0.093	0.000	0.000	0.000	0.000
1,001-2,500 m (Moderate)	NA	0.055	0.000	0.000	0.000	0.000
2,501-5,000 m (Good)	NA	0.081	0.000	0.000	0.000	0.000
5,001-10,000 m (Very Good)	NA	0.098	0.003	0.000	0.000	**0.010**
>10,000 m (Excellent)	NA	**0.142**	**0.007**	0.000	**0.003**	0.000
# Sightings	0	97	3	0	1	3

Note: **Bold** indicates Visibility with highest detection rate.

2.2.3.3.4 Sightability

Table 13 presents detection rates for all marine mammal species observed in the RSA during the 2023 SBO Program, broken down by sightability category.

The highest detection rates for narwhal occurred during excellent sightability conditions (0.012 sightings/km; Table 13). Narwhal were also observed in good sightability conditions with a detection rate of 0.002 sightings/km.

The highest detection rate for ringed seal in water occurred in poor sightability conditions (0.538 sightings/km), followed by good (0.276 sightings/km), excellent (0.209 sightings/km), and fair (0.168 sightings/km) sightability conditions (Table 13). The highest detection rate for ringed seal on ice occurred in good sightability conditions (0.169 sighting/km), followed by poor (0.067 sightings/km), excellent (0.053 sightings/km), and fair (0.028 sightings/km) sightability conditions (Table 13).

The highest detection rate for bearded seal in water occurred in fair sightability conditions (0.005 sightings/km), followed by equal detection rates in both good and excellent sightability conditions (0.004 sightings/km; Table 13). All on ice observations of bearded seal were observed in good sightability conditions and a corresponding detection rate of 0.007 sightings/km (Table 13).

The highest detection rate for harp seal in water occurred in good sightability conditions (0.013 sightings/km; Table 13). Harp seal were also detected in water in excellent sightability conditions with a detection rate of 0.008 sightings/km (Table 13). No harp seal were observed on ice during the 2023 SBO Program.

The one in-water sighting of a polar bear occurred during a period of good sightability condition with a corresponding detection rate of 0.002 sightings/km. All on-ice sightings of polar bear occurred during excellent sightability conditions with a corresponding detection rate of 0.012 sightings/km (Table 13).

Table 13: Sighting Detection Rates as a Function of Sightability During the 2023 SBO Program

	Narwhal	Ringed seal	Bearded seal	Harp seal	Unidentified Seal	Polar Bear
Sightability—In Water						
Poor	0.000	**0.538**	0.000	0.000	**0.022**	0.000
Fair	0.000	0.168	**0.005**	0.000	0.005	0.000
Good	0.002	0.276	0.004	**0.013**	0.007	**0.002**
Excellent	**0.012**	0.209	0.004	0.008	0.012	0.000
# Sightings	4	234	4	8	8	1
Sightability—On ice						
Poor	NA	0.067	0.000	0.000	0.000	0.000
Fair	NA	0.028	0.000	0.000	0.000	0.000
Good	NA	**0.169**	**0.007**	0.000	**0.002**	0.000
Excellent	NA	0.053	0.000	0.000	0.000	**0.012**
# Sightings	0	97	3	0	1	3

Note: **Bold** indicates Sightability with highest detection rate.

2.2.3.4 Closest Point of Approach to Vessel

During each recorded marine mammal sighting, the distance between the detected marine mammal and the ship was estimated. The initial distance at which a marine mammal was observed by the MWO was noted and if the animal was subsequently observed at a closer distance to the ship, the CPA was updated. Distances were either measured using reticle binoculars (when the horizon was in view) or a clinometer or estimated with naked eye and in reference to distances to known objects, when possible. Table 14 summarises how distances were estimated for sightings by species; 40% of sightings were measured using either reticle binoculars or a clinometer, 5% of sightings were estimated in reference to a known distance (e.g., using the ship's radar), 54% of sightings were estimated using naked eye, and for 1% of sightings, this data was not recorded. CPA calculations were based on all sightings observed within 2 km of both the *Botnica* and *Fennica*.

Table 14: Method used for distance measurement or estimation during marine mammal sightings during the 2023 SBO Program (# of Sightings and Proportion of Sightings)

Distance Measurement or Estimation Method	Narwhal (%)	Ringed seal (%)	Bearded seal (%)	Harp seal (%)	Unidentified Seal (%)	Polar Bear (%)	Total (%)
Reticle binoculars	0 (0)	42 (12)	2 (29)	2 (22)	3 (30)	1 (20)	50 (13)
Clinometer	4 (80)	101 (28)	1 (14)	1 (11)	2 (20)	1 (20)	110 (28)
Reference to known distance	0 (0)	16 (4)	0 (0%)	0 (0)	1 (10)	1 (20)	18 (5)
Naked eye	1 (20)	198 (55)	4 (57)	6 (67)	4 (40)	2 (40)	215 (54)
Not recorded	0 (0)	6 (2)	0 (0)	0 (0)	0 (0)	0 (0)	6 (1)
# Sightings	5	363	7	9	10	5	399

Table 15 presents a summary of CPAs recorded for sightings during all marine mammal watches in 2023. CPAs for polar bears and pinnipeds on ice and in-water were calculated separately given differences in animal detectability and behaviours between the two environments (i.e., as pinnipeds are more easily detected on ice than in water).

Table 15: Initial and Closest Point of Approach (CPA) Distances Recorded during the 2023 SBO Program

Distance	Narwhal		Ringed Seal		Bearded Seal		Harp Seal		Unidentified Seal		Polar Bear	
	Initial	Closest	Initial	Closest	Initial	Closest	Initial	Closest	Initial	Closest	Initial	Closest
CPA—On Ice												
Mean	NA	NA	1445	**906**	1133	**683**	NA	NA	1550	**1,350**	2,300	**850**
Range	NA	NA	50-5,000	50-2,000	200-1,600	200-1,600	NA	NA	1,100-2,000	1,100-1,600	1,700-3,000	300-1,200
#Sightings	0		104		3		0		2		4	
CPA—In Water												
Mean	825	**760**	555	**446**	288	**275**	617	**524**	656	**504**	900	**900**
Range	500-1,200	400-1,200	50-2,400	12-2,000	50-500	50-500	100-1,500	100-1,200	50-1,500	30-1,250	900	900
#Sightings	5		259		4		9		8		1	
# Sightings	5		363		7		9		10		5	

Note: **Bold** indicates mean CPA for on-ice and in-water sightings by species.

The lowest mean CPA for all on-ice marine mammal observations was for bearded seal (683 m), followed by polar bear (850 m), ringed seal (906 m), and unidentified seal (1,350 m) (Table 15). The lowest mean CPA for in-water marine mammal observations was for bearded seal (275 m), followed by ringed seal (446 m), unidentified seal (504 m), harp seal (524 m), narwhal (760 m), and polar bear (900 m) (Table 15).

The lowest minimum CPA of all marine mammals observed on ice was for ringed seal (50 m), followed by bearded seal (200 m), polar bear (300 m), and unidentified seal (1,100 m) (Table 15). The lowest minimum CPA of all marine mammals observed in water was for ringed seal (12 m), followed by unidentified seal (30 m), bearded seal (50 m), harp seal (100 m), narwhal (400 m), and polar bear (900 m) (Table 15).

Initial sighting distances to narwhal ranged from 500–1,200 m (mean = 825 m), with a CPA for ranging from 400–1,200 m (mean = 760 m) (Table 15). A comparison of the mean of the initial sighting distance and CPA (825 m vs 760 m) and range of these two variables (500–1,200 m vs 400–1,200 m) suggests that narwhal neither moved toward or away from the vessel.

Ringed seal in-water initial sighting distances were lower (mean = 555 m, range 50–2,400 m) than those of ringed seal on ice (mean = 1,445 m, 50–5,000 m) (Table 15). This likely relates to increased detectability of ringed seals, and all seals species in general, at distance on ice due to the greater contrast between their dark body colouration and white ice vs darker water. The CPA for ringed seal in water (mean = 446 m, range 12–2,000 m) was also generally lower than the CPA for ringed seal on ice (mean = 906 m, range 50–2,000 m).

Initial sighting distances for bearded seal in water (mean = 288 m, range 50–500 m) were lower than initial sighting distances for bearded seal on ice (mean = 1,133 m, range 200–1,600 m). The mean CPA for bearded seal on ice (683 m, range 200–1,600 m) was higher than the mean CPA for bearded seal in water (275 m, range 50–500 m, Table 15). The small sample size (seven bearded seals) prevents from making any conclusions on these results.

The mean initial sighting distance for harp seal in water (617 m, range 100–1,500 m) was similar to the mean CPA for harp seal in water (524 m, range 100–1,200 m) (Table 15). Harp seal were not observed on ice during the 2023 SBO Program.

One polar bear was observed in the water during the 2023 SBO Program. Its initial sighting and CPA distances were both 900 m. The remaining polar bear sightings were observed on ice with a mean initial sighting distance of 2,300 m (range 1,700–3,000 m) and mean CPA of 850 m (range 300–1,200 m) (Table 15).

Overall, the CPA results support impact predictions that animals demonstrate localized avoidance of the ship. This provides further confidence that a vessel strike on a marine mammal is unlikely to occur based on current vessel speeds restriction within the RSA (9-knot speed restriction). These results also further support impact predictions made in the FEIS Addendum for the Early Revenue Phase (ERP), that the Project was unlikely to result in significant residual adverse effects on narwhal in the RSA, defined as effects that compromise the integrity of the population either through mortality (i.e., ship strikes) or via large-scale displacement or abandonment of the RSA.

2.2.3.5 Behavioural Responses

2.2.3.5.1 Response vs No Response

Marine mammal responses to vessel activities are presented by species in Table 16. Proportions of individuals who responded varied between species ranging from as low as 40% of sightings for narwhal to as high as 80% of sightings of polar bears. Due to the low number of sightings, further statistical analyses of response rates were not possible except for ringed seal sightings (Table 16). The number of responses presented in Table 16 considered all degrees of behavioural responses combined. A more detailed breakdown of responses is presented below for each species group.

Of the 399 sightings considered for the behavioural response analysis (within 2 km of the vessel), 133 (33.3%) demonstrated a behavioural response. Behavioural responses were observed in narwhal (20.0%), ringed seal (32.2%), bearded seal (28.6%), harp seal (55.6%), unidentified seal (40.0%) and polar bear (80.0%).

Table 16: Number of marine mammal sightings, inclusive of sightings on ice and in water, and percentage of groups showing behavioural response during the 2023 SBO Program. Numbers shown include sightings from both *Botnica* and *Fennica* with 2 km truncation.

Species	Number of sightings			
	Number of Sightings	Behavioural response not observed	Behavioural response observed	Percentage (%) of response
Narwhal	5	4	1	20.0
Ringed Seal	363	246	117	32.2
Bearded Seal	7	5	2	28.6
Harp Seal	9	4	5	55.6
Unidentified Seal	10	6	4	40.0
Polar Bear	5	1	4	80.0
Total	399	266	133	33.3

Note: On-ice responses that were observed included scan and flush for seal species and displaying vigilance, walking away, or running away for polar bear. In-water responses included scan, rapid dive/splash, and swim away for seal species and traveling slowly away for narwhal.

2.2.3.5.2 Seal and Walrus Behavioural Responses

Behavioural responses of seals that were recorded included “scan” (n=20), “flush” (n=42), “rapid dive/splash” (n=54), “swim away” (n=12), and “regular dive” (n=138) (Table 17). The remaining responses were recorded as either “no response” (n=67) or “unknown” (n=56). Descriptive summaries of bearded, harp, and unidentified seal behavioural responses are provided below. Due to small sample sizes, only a statistical analysis of response rates of ringed seals within 2 km of the vessels is presented.

Table 17: Type and number of behavioural responses by seal species as observed from the *Botnica* and *Fennica* in the RSA during the 2023 SBO Program.

Behavioural Response	Ringed Seal	Bearded Seal	Harp Seal	Unidentified Seal	Total
Scan	18	1	0	1	20
Flush	41	1[2]	0	0	42
Rapid dive/splash	47	0	4	3	54
Swim away	11	0	1	0	12
Regular dive	132	3	2	1	138
No response	62	1	1	3	67
Unknown	52	1	1	2	56
Total	**363**	**7**	**9**	**10**	**389**

Note: it is possible for >1 behavioural response to be recorded for each sighting.

[2] Only one bearded seal flush is recorded in Table 17 because the response behaviour of the on-ice bearded seal observation on the morning of 30 October was only included for the *Botnica*, the lead tandem icebreaker.

Bearded Seal

A total of eight bearded seal sightings were observed during the SBO Program; four were observed in water and three were observed on ice within 2 km of the vessel. Table 18 provides a summary of the behavioural responses of bearded seal. Of the four bearded seals observed in water within 2 km of the vessel, the first was observed resting with an unknown behavioural response (the observer did not observe or record a response, CPA = 450 m), the second was observed scanning and then did a regular dive while the vessel was transiting in open water (initial and CPA distance = 50 m), the third was observed doing a regular dive while the vessel was icebreaking (CPA = 500 m), and the fourth was observed traveling and then did a regular dive (CPA = 100 m) when the vessel was transiting open water.

Of the three bearded seal observed on ice within 2 km of the vessel, the first seal responded with a flush (CPA = 200 m). The second seal displayed no response (CPA = 1,600 m). In both these cases, the vessel was transiting in open water. The third bearded seal was observed by both vessels on the morning of 30 October as the vessels were icebreaking and entering Milne Port. The *Botnica*, which was the lead vessel, observed the young bearded seal resting on ice and then scanning toward the vessel. The initial sighting distance to the seal was 1,600 m (CPA = 250 m). The only response behaviour recorded by the *Botnica* MWOs was scan. The *Botnica* MWOs alerted the *Fennica* team of the sighting and a few minutes later, the *Fennica* MWOs observed the bearded seal resting (initial distance = 800 m). The seal flushed as the *Fennica* passed at a CPA distance of 275 m (Table 18).

One on-ice bearded seal was observed at >2 km from the vessel (initial distance = 2,500) when it was icebreaking with no response behaviour observed (CPA = 2,300 m) (Table 18).

Table 18: Behavioural responses of bearded seal as observed from the *Botnica* and *Fennica* in the RSA during the 2023 SBO Program.

Initial Behaviour	Group Size	Location	Initial Sighting Distance (m)	Vessel Activity	Behavioural Response	CPA (m)
Resting	1	On ice	2,500	Icebreaking	No response	2,300
	1	On ice	200	Transiting open water	Flush	200
	1	On ice	1,600	Transiting open water	No response	1,600
	1	In Water	450	Icebreaking	Unknown	450
	1	On ice[3]	1,600/800	Icebreaking	Scan/Flush	250/275
Scanning	1	In Water	50	Transiting open water	Regular dive	50
Regular Dive	1	In Water	500	Icebreaking	Regular dive	500
Traveling	1	In Water	150	Transiting open water	Regular dive	100

[3] This bearded seal was observed by both vessels. Response behaviour recorded by the *Botnica* MWOs was scan. The *Fennica* MWOs later observed the same seal flushing.

Harp Seal

All nine harp seal sightings were in water and within 2 km of the vessel. The initial behaviours of the harp seal sightings included resting (n=2), scanning (n=1), and traveling (n=6) (Table 19). Of the two resting harp seal sightings, one group of two individuals was observed doing a rapid dive with a splash (CPA=170 m) when the vessel was transiting in open water. The other single seal was observed swimming away from the vessel (CPA = 800 m) when the vessel was icebreaking.

Of the six sightings of traveling harp seal, three sightings consisted of groups of one, three, and 15 individuals that responded with a rapid dive and splash with CPA distances of 600 m, 225 m, and 900 m, respectively. All these observations occurred when the vessel was icebreaking. One sighting of eight traveling individuals was observed doing a regular dive (CPA = 1,200 m) when the vessel was icebreaking. For the remaining two sightings of traveling harp seal, one group of 15 individuals did not respond (CPA = 100 m) and the response was unknown for the remaining group of six individuals (CPA = 500 m). The vessel was transiting in open water during both observations. Finally, the group of five seals that were initially observed scanning (initial distance = 250 m) subsequently did a regular dive (CPA = 225 m) when the vessel was transiting in open water (Table 19).

Table 19: Behavioural responses of harp seal as observed from the *Botnica* and *Fennica* in the RSA during the 2023 SBO Program.

Initial Behaviour	Group Size	Location	Initial Sighting Distance (m)	Vessel Activity	Behavioural Response	CPA (m)
Resting	2	In Water	200	Transiting open water	Rapid dive/splash	170
	1	In Water	1,000	Icebreaking	Swim away	800
Scanning	5	In Water	250	Transiting open water	Regular dive	225
Traveling	15	In Water	100	Transiting open water	No response	100
	6	In Water	500	Transiting open water	Unknown	500
	8	In Water	1,500	Icebreaking	Regular dive	1,200
	3	In Water	300	Icebreaking	Rapid dive/splash	225
	15	In Water	1,100	Icebreaking	Rapid dive/splash	900
	1	In Water	600	Icebreaking	Rapid dive/splash	600

Unidentified Seal

There was a total of 14 unidentified seal sightings, of which 10 were observed within 2 km of the vessel. Of these 10 sightings, eight were of unidentified seals in water and two were of unidentified seals on ice. Of the eight unidentified seals in water within 2 km of the vessel, the initial behaviours were recorded as resting (n=4), diving (n=2), scanning (n=1), and traveling (n=1). The four resting in-water seal sightings were observed to either not respond, when the vessel was transiting open water, or did a rapid dive/splash, when the vessel was icebreaking (Table 20). The first in water resting seal sighting that did not respond occurred when the vessel was transiting in open water and consisted of a group of two seals (CPA = 400 m). The second sighting of a seal resting in water was a single seal (CPA = 350 m) that was observed 'bottling', or floating with its snout out of the water, and then sank underwater, when the vessel was transiting in open water. The third sighting of a seal resting in water (CPA = 30 m) was of one individual that responded with rapid dive/splash when the vessel was icebreaking. The fourth sighting of seals resting in water consisted of one group of five individuals that were observed scanning the ship while doing repeated regular and rapid dives throughout the sighting (CPA = 300 m) while the vessel was icebreaking.

Of the two sightings of seals in water that were initially observed diving, one sighting was of a single seal diving at 1,250 m (both initial and CPA distance) when the vessel was drifting and was not observed again. The response was recorded as unknown. The second sighting of a seal in water and diving was of one seal observed surfacing and then quickly diving with a splash (CPA = 100 m) when the vessel was icebreaking.

One seal in water was initially observed scanning 1,000 m from the vessel during icebreaking. The MWOs noted that it was not clear whether the seal was scanning towards the vessel, therefore, behavioural response was recorded as unknown. Finally, one seal in water was initially observed to be traveling and then did a regular dive immediately after it was first detected (initial distance and CPA = 600 m), while the vessel was icebreaking.

Of the two sightings of unidentified seals on ice and within 2 km of the vessel, both were single animals that were initially resting at distances of 1,100 m and 2,000 m. The first resting seal did not respond (CPA = 1,100 m) when the vessel was transiting in open water and the second resting seal was observed scanning (CPA = 1,600 m) when the vessel was icebreaking. There were three additional sightings of unidentified seal, all were >2 km from the vessel. Due to the distances to these sightings (initial and CPA sighting distances = 2,300m, 4,000 m, and 3,000 m) all responses were recorded as No response (2,300 m) or Unknown (4,000 m and 3,000 m).

Table 20: Behavioural responses of unidentified seal as observed from the *Botnica* and *Fennica* in the RSA during the 2023 SBO Program.

Initial Behaviour	Group Size	Location	Initial Sighting Distance (m)	Vessel Activity	Behavioural Response	CPA (m)
Resting	2	On Ice	2,300	Transiting open water	No response	2,300
	1	On Ice	1,100	Transiting open water	No response	1,100
	2	In Water	400	Transiting open water	No response	400
	1	In Water	350	Transiting open water	No response	350
	1	On Ice	4,000	Icebreaking	Unknown	4,000
	1	In Water	50	Icebreaking	Rapid dive/splash	30
	1	On Ice	3,000	Icebreaking	Unknown	3000
	1	On Ice	2,000	Icebreaking	Scan	1600
	5	In Water	1,500	Icebreaking	Rapid dive/splash	300
Scanning	1	In Water	1,000	Icebreaking	Unknown	1,000
Traveling	1	In Water	600	Icebreaking	Regular dive	600
Diving	1	In Water	1,250	Drifting	Unknown	1,250
	1	In Water	100	Icebreaking	Rapid dive/splash	100

Ringed Seal

To accommodate for uncertainty of sightings (e.g., species identification and distance measurement) and limited sightings numbers, behavioural responses of ringed seal were analysed using data within two kilometres of the vessel and during times when vessels were transiting open water or icebreaking (including transiting broken ice track). Animals with an “unknown” response type were also excluded from the analysis. There was a total of 389 ringed seal sightings during the 2023 SBO Program, of which 301 were observed within 2 km of the vessel, occurred when the vessel was either transiting open water or icebreaking, and a behavioural response was recorded. Of these 301 sightings, 221 were sightings of ringed seal in water and 80 were sightings of ringed seals on ice (Table 21).

Table 21: Number of ringed seals and proportion of individuals exhibiting behavioural responses and distances to the icebreaker during the 2023 SBO Program

		Distance from icebreaker (m)	
Behavioural Response	**Number (%)**	**Mean (SD)**	**Range**
On Ice			
Scan	10 (12.5%)	822 (450)	125–1,600
Flush response	40 (50%)	686 (487)	100–2,000
No response	30 (37.5%)	1,103 (582)	50–2,000
Total	**80**		
In Water			
Scan	7 (3.1%)	291 (241)	60–700
Rapid dive/splash	47 (21.2%)	346 (334)	50–1600
Swim Away	11 (4.9%)	350 (326)	50–1200
Regular Dive	131 (59.2%)	431 (386)	25–2000
No response	25 (11.3%)	507 (376)	75–1600
Total	**221**		

Of the 80 ringed seals hauled out on ice, 10 (12.5 %) exhibited a scan response, 40 (50%) exhibited a flush response, and the remaining 30 (37.5%) exhibited no response (Table 21). Scans were observed at a mean distance of 822 m (range = 125 to 1,600 m) and flush responses were observed at a mean distance of 686 m (range = 100 to 2,000 m) (Table 21). For the 221 ringed seals observed in water, 7 (3.1%) exhibited a scan response, 47 (21.2%) exhibited a rapid dive/splash, and 11 (4.9%) swam away. The remaining behaviours were non responsive with 131 seals demonstrating regular dives (59.2%) and 25 seals (11.3%) demonstrating no response. Scans were observed at a mean distance of 291 m (range = 60 to 700 m), rapid dive/spash responses were observed at a mean distance of 346 m (range = 50 to 1,600 m), and seals swimming away were observed at a mean distance of 350 m (range = 50 to 1,200 m) (Table 21, Figure 34).

Ringed seal responses on ice and in water, respectively, across the truncated 2 km distance can been seen in Figure 34. Relative proportions of responses, over 500-m binned distances, are presented in Figure 35. Distances were binned using 500-m distances to ensure a sufficient number of observations in each bin. For both on-ice and in-water sightings, the number of sightings increased with decreasing distance from the vessel. A higher relative proportion of ringed seals on ice were observed between 1–2 km compared to ringed seals in water, however it should also be noted that more ringed seals were sighted in-water more frequently than on ice by a factor of almost three.

When looking at the relative proportions of seal responses across distance, there is a visible relationship for seals on ice where flush and scan responses become more likely with decreasing distance from vessels (Figure 35). At distances <1 km, 50% or more of the seals exhibited a flush response (Figure 35). Ringed seals in water did not show a visible trend in reponse relative to changes in distance from vessels. It should be noted that sample sizes at distances >1 km were very low.

Figure 34: Ringed seal sightings on ice (top) and in water (bottom) across distance from vessel in 100-m bins during the 2023 SBO Program.

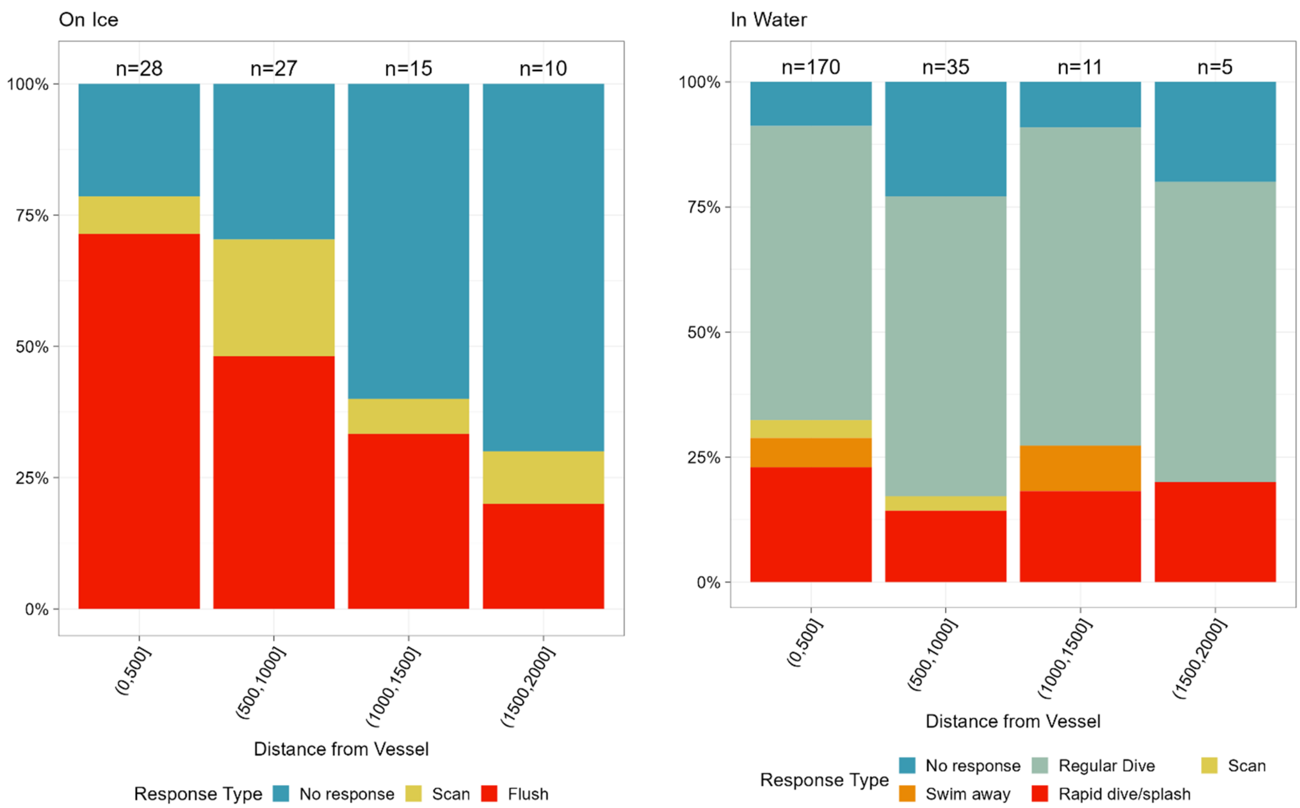


Figure 35: Proportion of behavioural responses exhibited by ringed seals relative to the distance from vessel in 500-m bins for seals on-ice (left) and seals in-water (right) during the 2023 SBO Program.

The best fitting ordinal logistic regression model included vessel activity and distance from the vessel as predictor variables for ringed seal responses on ice. The analysis of deviance found a significant effect of distance ($p < 0.005$) and vessel activity ($p < 0.001$) on seal behaviour. The plots on the left side in Figures 36 and 37 indicate observed frequency and predicted probability of responses in 500-m binned distances from the vessel for seals on ice and in water, respectively. The plots on the right in Figures 36 and 37 indicate the observed frequency and predicted probability of behavioural responses based on vessel activity at the time of the observation.

Figure 36 (left) indicates that the probability of flush response increases with decreasing distance to the vessel for seals on ice while the probability of no response increases with increasing distance from the vessel. Seals were predicted to exceed a 50% probability of flushing at distances up to 1,000 m (Figure 36, left). Figure 37 (right) indicates that open water transits had a lower likelihood of eliciting a response, with the mean predicted value slightly below 50%, compared to when the vessel was icebreaking (Figure 36, right). This suggests that seals on ice may respond more strongly to the vessels during active icebreaking than when transiting open water.

For ringed seals in water, based on the AIC comparing candidate models the model which included distance and vessel activity was selected, neither distance nor vessel activity had a significant effect on ringed seal responses ($p < 0.09$ for distance, and $p > 0.5$ for vessel activity). Figure 37 shows no clear trend across vessel distance or different vessel activities. Caution is advised in the interpretation of this result due to uncertainty related to undetected subsurface responses.

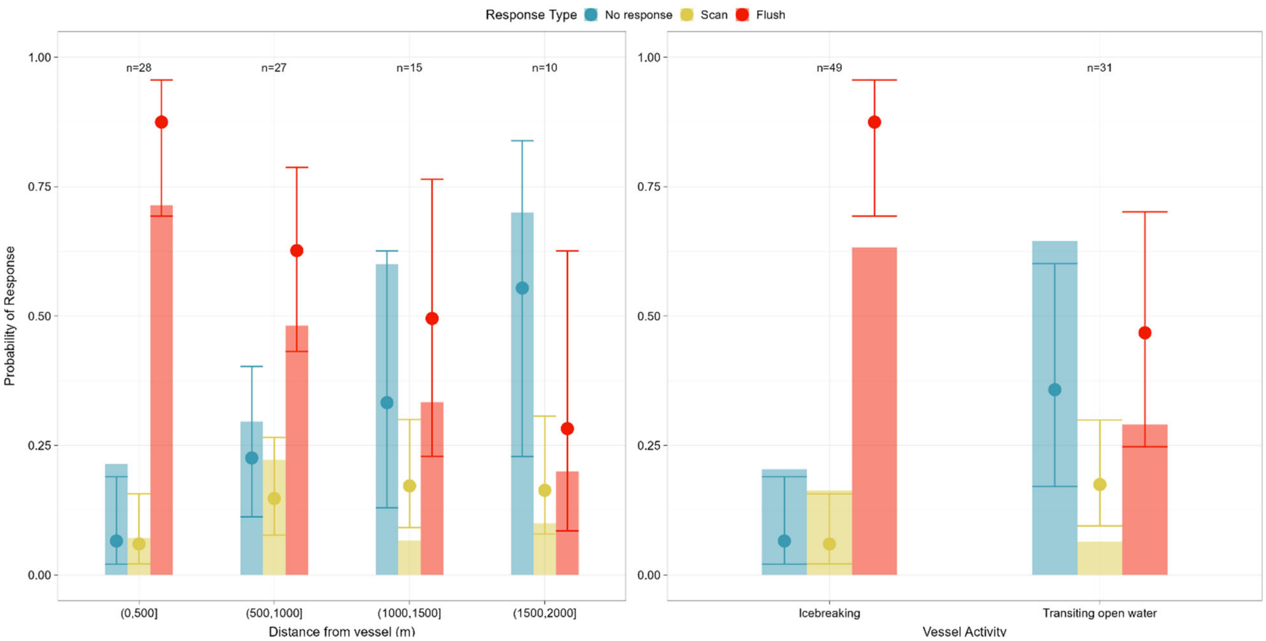


Figure 36: Predicted probabilities (+/- 95% CIs) of ringed seal behavioural response types on ice as predicted by the selected OLR model shown in the point and error bars, with bar graphs showing observed response frequency.

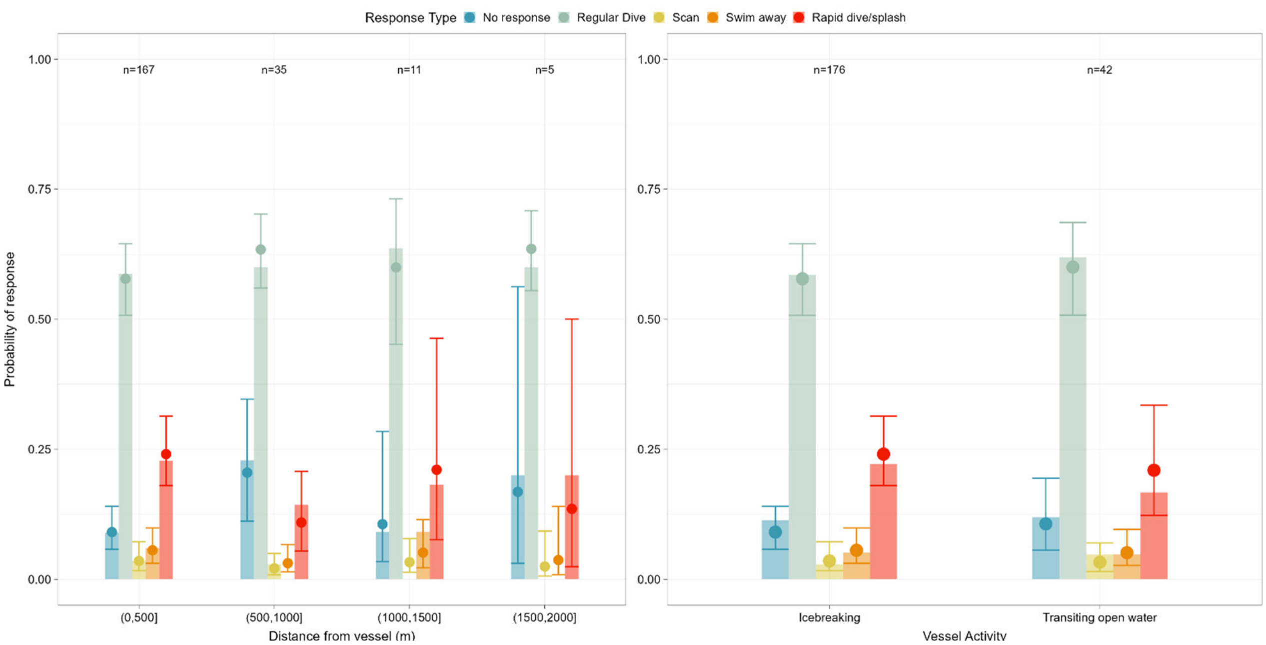


Figure 37: Predicted probabilities (+/- 95% CIs) of ringed seal behavioural response types in water as predicted by the selected OLR model shown in the point and error bars, with bar graphs showing observed response frequency.

Seal Behavioural Responses to Icebreaking

Behavioural responses of ringed, bearded, harp and unidentified seal during the 2023 SBO Program were similar to findings in other similar studies of seal responses to icebreaking and vessels. On ice, seals either demonstrate no response or response can progress from hauled out and resting to scanning and then flushing off the ice (Lomac-MacNair, Andrade and Esteves 2019, Jansen 2006). Flush responses of ringed seals hauled out on ice have also been observed in other studies to increase at closer distances to vessels (Kanik et al. 1980, Brueggeman et al. 1992, Richardson et al. 1995, Lomac-MacNair, Andrade and Esteves 2019). The majority of seal responses occurred within 1,000 m of vessels and reported response distances included 100 m (90% of harbour seals flushing in response to cruise ships, Jansen et al. 2010), 200 m (75% of harbour seals flush in response to cruise ships, Jansen et al. 2006), 400 to 800 m (flee behaviour, Richardson et al. 1995), ~700 m (on-ice ringed, harp, hooded, and bearded seals flushing in response to icebreakers, Lomac-MacNair, Andrade and Esteves 2019), and ~1,000 m (ringed and bearded seal flush response, Brueggeman et al. 1992). Kanik et al. (1980) reported that ringed and harp seal remained on ice when an icebreaker was 1–2 km away, often diving into the water as the vessel approached at closer distances.

The results of the 2023 SBO Program ringed seal behavioural response analysis also demonstrated that the majority of seals on-ice will flush within 1 km of the survey vessel (mean flush response distance was 686 m) and that predicted probability of response declined at farther distances from the vessel. Lomac-MacNair, Andrade and Esteves's (2019) study found that mean ringed seal flush response distance was 437.5 m. They also found that 50% of seals would elicit a flush response at 709.4 m. This distance was 1,000 m for the ringed seal behavioural response analyses presented here. Lomac-MacNair, Andrade and Esteves (2019) also reported no flush responses beyond 800 m, however flush responses were observed across the 2 km observation distance utilised for the 2023 SBO Program behavioural response analyses. Bearded seal flush responses occurred at closer distances than ringed seal during both the 2023 SBO Program and Lomac-MacNair, Andrade and Esteves (2019). During the 2023 SBO Program, bearded seal were observed flushing at distances of 200 and 275 m from the vessel which is closer than the mean flush response distance of 410.1 m reported by Lomac-MacNair, Andrade and Esteves (2019). However, it must be noted this data should be interpreted with caution given that there were only seven sightings of bearded seal during the 2023 SBO Program, with two flush responses.

In water, seal behavioural responses to icebreaking may include no response, scan, swim away, or rapid dive/splash (Lomac-MacNair, Andrade and Esteves 2019). Ringed seals observed in water during the 2023 SBO Program did not show a visible trend in relative to changes in distance from vessels and there are no previous studies that discuss any trends related to behavioural responses of seals in water. Previous studies focussed on the behavioural response of seals on ice to vessels or icebreakers and were specifically focussed on flushing.

During the 2023 SBO Program, open water transits had a lower likelihood of eliciting a response, with the mean predicted value of a flush response being slightly below 50%. This also suggests that seals on ice may responded more strongly to the vessels during active icebreaking than when transiting open water. Brueggeman et al. (1992) also reported that ringed and bearded seal were less responsive when the icebreaker was transiting in open water.

2.2.3.5.3 Narwhal

All five narwhal sightings were observed on 28 October within 2 km of the vessels; four from the lead vessel, the *Fennica*, and one from the following vessel, the *Botnica*. The initial behaviour observed for these sightings included traveling (three sightings of groups of six, five and three individuals), resting (one sighting of a group of five individuals), and regular dive (one sighting of a single individual) (Table 22).

Of the three sightings of traveling narwhal, the groups of six and five narwhal were recorded to show no response with CPAs of 1,000 m and 700 m, respectively. The group of three traveling narwhal was observed traveling slowly away from the vessel (CPA = 1,200 m). There was one group of five narwhal initially observed resting and moving slowly at the surface in a patch of open water before diving under the ice as they reached the ice edge (CPA = 400 m). Finally, there was one sighting of a single narwhal initially observed doing a regular dive with no other response (CPA = 500 m). All narwhal sightings occurred when the vessel was icebreaking (Table 22).

Table 22: Behavioural responses of narwhal as observed from the Botnica and Fennica in the RSA during the 2023 SBO Program

Initial Behaviour	Group Size	Initial Sighting Distance (m)	Vessel Activity	Behavioural Response	CPA (m)
Traveling	6	1,000	Icebreaking	No response	1,000
	5	800	Icebreaking	No response	700
	3	1,200	Icebreaking	Traveling slowly away	1,200
Resting	5	625	Icebreaking	Regular dive	400
Regular dive	1	500	Icebreaking	No response	500

Previous studies have demonstrated that narwhal responses to icebreaking activities may include a ‘freeze’ response (lying motionless or swimming slowly away), huddling in groups, ceasing sound production, leaving the area, and attraction to open leads in the ice caused by an icebreaker transit and doing short-lived, “exploratory” dives in the rubble-filled ship track (Finley et al. 1990, Mansfield 1983). It has also been noted that narwhal avoid using leads in the ice during icebreaker transits (Arctic Bay Public Meeting, Koono, pers. comm.).

2.2.3.5.4 Polar Bear

There were seven polar bear sightings between 22 and 29 October, five of which were within 2 km of the vessel. The initial behaviour observed for these sightings included resting (one sighting of an individual bear, initial distance = 1,700 m), walking (three sightings of individual bears, initial distances = 3,000 m, 2,800 m, and 1,700 m), and swimming (one sighting of an individual bear, initial distance = 900 m) (Table 23).

On 22 October, a single bear was observed 1,700 m ahead of the ship off the starboard side and resting on a piece of cake ice (<20m across) covered in blood, indicating it had been recently feeding (Table 23). The *Botnica* maintained its course as it was not deemed to be on course to approach within 300 m of the bear based on the vessel travel direction and the angle and distance to the bear off the starboard side. As the vessel continued on its course it soon became apparent the bear and vessel distance was decreasing, possibly due to the ice drifting and current, and the MWO lead recommended the officer on watch alter course to port to avoid getting too close to the bear. The vessel also reduced its speed as it got closer to the bear very slowly passing the bear at a CPA of

300 m. The bear did not move and remained seated on the ice displaying vigilance and yawning a few times as the vessel passed. The vessel was in Baffin Bay transiting in open water (Table 23).

On the morning of 24 October, there were two sightings of individual polar bears walking on ice within a few minutes of each other while the vessel was icebreaking. The first bear was observed at an initial sighting distance of 3,000 m and the second bear was observed in the vicinity of the first bear, but more than 10 body lengths away, at an initial sighting distance of 2,800 m (Table 23). The first bear was observed walking and the rolling around on the ice and appeared to be occasionally breaking through ice and swimming and then walking on the ice as it moved away from the vessel (CPA = 900 m). The second bear was observed alternating between walking and running away from the vessel. It was also observed lying down on an ice floe where the view from the observers to the bear was obstructed by ice and the bear remained there for the rest of the sighting (CPA = 1,200 m) (Table 23).

On 25 October, there was one sighting of a polar bear in the water swimming at 900 m from the vessel when it was transiting. The bear appeared to be swimming in the same direction as the vessel, between ice floes. As a result of the low profile of the bear in the water and the distance to the sighting, it was unclear whether the bear was swimming away from the vessel. The response was recorded as unknown (CPA = 900 m) (Table 23).

The last sighting of a polar bear within 2 km of the vessel occurred on 29 October when a single polar bear was observed walking 1,700 m away from the *Botnica*, which was following the lead vessel, the *Fennica*. Shortly after the bear was initially sighted, the bear was observed running away from the vessel stopping to look back at the vessels (CPA = 1,200 m). It continued running or walking quickly away from the vessels and was approximately 3,000 m away from the vessels when it was last observed (Table 23).

There were two additional sightings of polar bear at distances >2 km from the vessels. On 28 October the MWOs on the *Fennica* observed one polar bear on ice at an initial distance of 3,000 m and informed the MWOs on the *Botnica* who also observed it. The initial behaviour was recorded as feeding because the bear could be observed through the Big Eye binoculars hunched over bloody ice and surrounded by ravens (CPA = 2,500 m). The second sighting of a polar bear >2 km away was initially observed by the MWOs on the *Fennica*, who informed the MWOs on the *Botnica*, on 29 October, of one polar bear at an initial sighting distance of 2,200 m. This polar bear was also observed on the ice, feeding with ravens in its vicinity with no response behaviour (CPA = 2,100 m). Both of these sightings occurred when icebreaking occurred. (Table 23).

Table 23: Type and number of behavioural responses of polar bear as observed from the Botnica and Fennica in the RSA during the 2023 SBO Program.

Initial Behaviour	Group Size	Initial Sighting Distance (m)	Vessel Activity	Behavioural Response	CPA (m)
Resting	1	1,700	Transiting open water	Displaying vigilance	300
Walking	1	3,000	Icebreaking	Walking away	900
	1	2,800	Icebreaking	Running away	1,000
	1	1,700	Icebreaking	Running away	1,200
Swimming	1	900	Icebreaking	Unknown	900
Feeding/foraging	1	3,000	Icebreaking	No response	2,500
	1	2,200	Icebreaking	No response	2,100

The results of observations of polar bear during the 2023 SBO Program align with findings from previous studies of polar bear behaviour near icebreaker operations that demonstrated that polar bear actively avoid icebreakers before a risk of collision can occur and these reactions involve either vigilance or walking or running away (Smultea et al. 2016; Golder 2019).

3.0 SEABIRD MONITORING

Seabird surveys were completed according to the Canadian Wildlife Service (CWS)/ECSAS protocols for moving platforms (Gjerdrum et al. 2012). The objective of the seabird survey was to document seabird species, abundance, and distribution. Similar to marine mammal surveying methodology, environmental variables such as weather, ice condition, sea state, visibility, and ship speed and direction were recorded. All observations were entered into an ECSAS database and format provided by CWS. Seabird sightings data were provided by Baffinland to the CWS for integration into a long-term seabird sightings database for the Arctic region. This data is used by the CWS to examine linkages between seabirds and marine habitats (OBIS 2019).

During the 2023 SBO Program, an experienced seabird observer conducted seabird surveys.

3.1 Materials and Methods

3.1.1 Field Methodology

Sightings data were collected from the bridge of the *Botnica* during dedicated survey periods that were scheduled intermittently throughout the day (lasting one to two hours each). The total daily watch period for seabirds was variable depending on sighting conditions and vessel activity, ranging from 0.5 to 4.5 h. Systematic data collection on seabird sightings and environmental conditions were entered into an electronic database. Surveying was performed with the naked eye and using 10x50 binoculars. At the beginning of each watch period, a GPS track file was initiated to record the path and speed of the survey vessel and to record sighting locations. Database entries underwent daily quality assurance and quality control procedures by the seabird observer.

3.1.2 Surveys from Moving Platforms

ECSAS seabird surveys consist of a series of one minute “snapshot” counts of birds within an estimated 300 m perpendicular distance from the ship’s port side and extending forward of that perpendicular point an estimated 300 m thus defining the functional survey box. All seabird surveys were conducted from inside the bridge of the *Botnica*. Given the *Botnica*’s typical travel speed of seven to nine knots (13–17 kilometres per hour [kph]), the ship travelled approximately 300 m in one minute thus defining the spatial extent of the survey box. The *Botnica* occasionally slowed down to speeds between five and seven knots (9–13 kph) during icebreaking activities, extending the time to travel 300 m to 1.5–2.0 minutes. A transect was defined as five, back-to-back, one-minute snapshots. ECSAS protocol suggests that each series of transects should be between one and two hours in duration (i.e., a survey). The ECSAS protocol considered a survey to be applicable regardless of whether birds were present or not. The seabird surveys conducted during the 2023 SBO Program attempted to provide consistent coverage throughout the day. During the 2023 SBO Program, a one to two-hour survey each in the morning and afternoon were generally achieved. Weather, sea state, and other factors affected that schedule only to a limited extent.

According to the ECSAS protocol, bird surveys were best completed when the platform was travelling at a minimum speed of 4 knots (7.4 kph). Surveys could be done when the ship was travelling less than 4 knots, but birds are often attracted to slow moving or stationary vessels. If birds were clearly gathering around the vessel and settling on the water when the ship was moving slowly, surveys were ceased. As vessel speeds were typically between seven and nine knots, the potential for making repeat sightings of individual birds was considered negligible.

During each five-minute observation period, a 300 m wide rectangular area of ocean from 270˚ to 0˚ was surveyed from the vessel's port side (Figure 38). All birds observed on the water surface were recorded throughout each five-minute period and their perpendicular distance from the observer estimated. ECSAS protocol prescribed that counts be recorded in distance bins of 0 to 50 m, 51 to 100 m, 101 to 200 m, and 201 to 300 m (Figure 38).

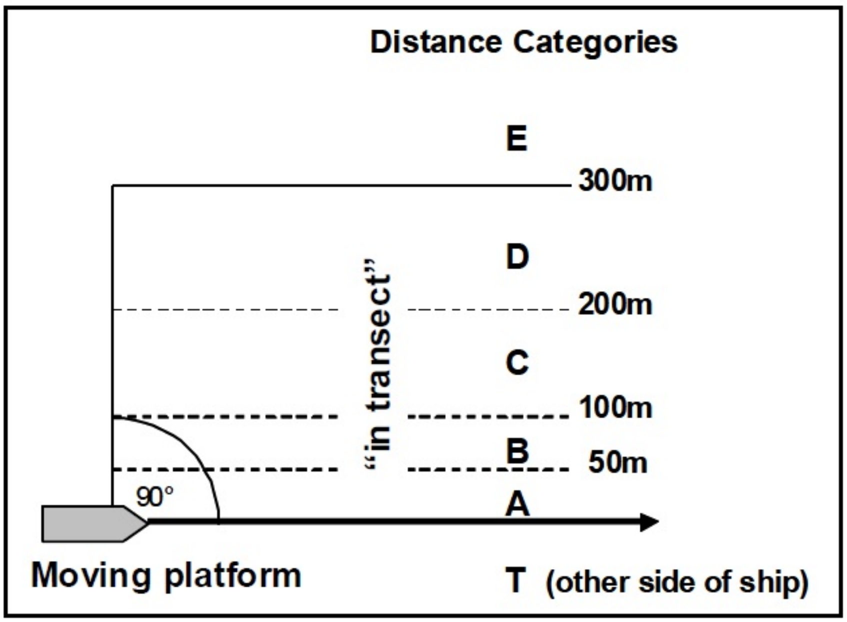


Figure 38: Moving Platform Sampling Area for Eastern Canada Seabirds at Sea Monitoring (from Gjerdrum, Fifield, and Wilhelm 2012)

Birds in Flight

More birds fly through a survey area than are present in that area at a single instant in time. Flying birds were recorded using a series of five instantaneous (i.e., one-minute) snapshots. The distance covered during each snapshot depended on the speed of the ship but given the ship's chosen typical travelling speed between 7.0 and 9.0 knots (13–17 kph), it would travel approximately 300 m in one minute (thus defining a survey box). According to ECSAS protocol, during each snapshot, flying birds were recorded as in transect only if they were within 300 m to the side and 300 m ahead of the vessel (i.e., within the estimated box).

Lines of Flying Birds

Some bird species fly in long lines. At each snapshot, the number of birds in the flock was counted and the distance class assigned according to the location of the flock centre. All birds were recorded as in transect if the centre of the flock was within the 300 m transect.

3.1.3 Surveys from Stationary Platforms

Seabird surveys from a stationary vessel are best completed from a position outdoors. Ideally, these surveys are conducted from a position near the edge of the observation platform because it can increase the detection rate of birds, especially for birds that use the water at the base of the platform. Given the temperature and weather, i.e., the cold and icy conditions during the 2023 SBO Program, conducting seabird surveys from a location outside the bridge and near the edge of the vessel was considered a safety risk therefore these surveys were conducted from inside the bridge.

Stationary surveys were done by scanning a 180˚ arc around the vessel, giving priority to birds within a 300 m semi-circle (Figure 39). The observation area was visually swept once per scan, from one side to the other, and all birds on the water and in flight were systematically recorded at that time. The distance to birds from the observer was measured using a distance gauge and recorded for all birds.

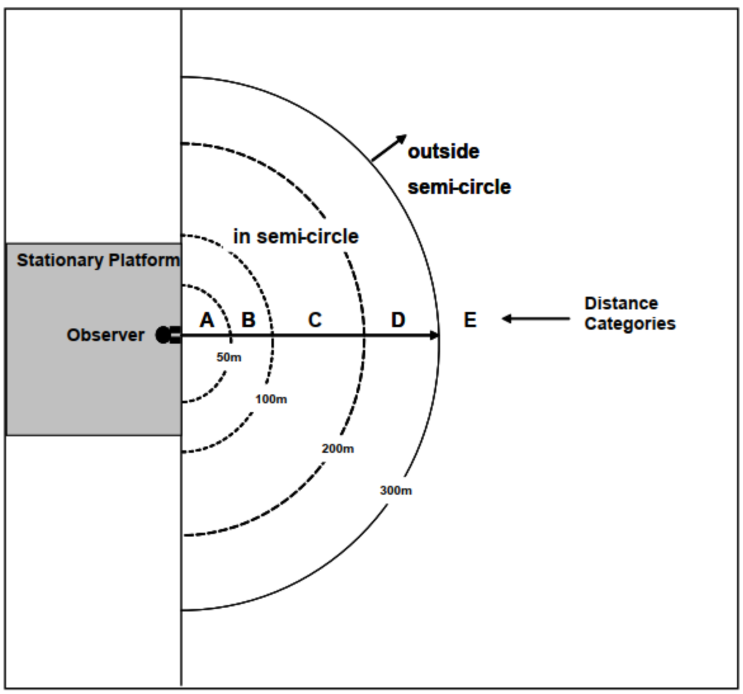


Figure 39: Stationary Platform Sampling Area for Eastern Canada Seabirds at Sea Monitoring (from Gjerdrum, Fifield, and Wilhelm 2012).

3.1.4 Data Analysis

Species Relative Abundance and Species Richness

Species relative abundance and species richness were calculated for the 2023 SBO Program. Species relative abundance is the sum of all individuals observed per species per survey period. Species richness is the number of different species recorded during the survey period, e.g., the 2023 SBO Program.

Species Density and Probability of Detection

Sightings data from a moving vessel are analogous to line-transect sampling and can be used to estimate the density of seabirds. When distances to seabirds are recorded, the density estimate can be corrected for seabirds that are farther away from the ship and harder to detect (i.e., not observed or missed). This correction is employed through use of a distance-based detection function as outlined in Buckland et al. (2001).

The standard analysis method of transect surveys assumes 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). Because the locations of the transect lines are considered random with respect to the location of seabirds, the average density of seabirds is considered to be the same irrespective of distance from the transect line. Thus, any observed change in seabird sightings with increasing distance from the transect line is considered a change in the probability of detection, rather than a true change in bird density. The change in detection probability with respect to sighting distance from the transect line is measured to provide an estimate of the average probability of detection of a bird, which is, in turn, used to estimate the density of seabirds in the survey area. Sample size for modelling the detection function should generally be at least 60 to 80 sightings, although for some purposes, as few as 40 sightings may be adequate (Buckland et al. 2001). Due to the low number of seabird sightings during the 2023 SBO Program (34 sightings), densities were not calculated for the 2023 seabird data (Buckland et al. 2001).

3.2 Survey Results

The total daily watch period for seabirds was variable depending on sighting conditions and vessel activity, ranging from 0.5 h to 4.5 h. Only a cursory assessment of the seabird data recorded as part of the 2023 SBO Program is presented in this report. The complete 2023 seabird sightings database has been provided to CWS.

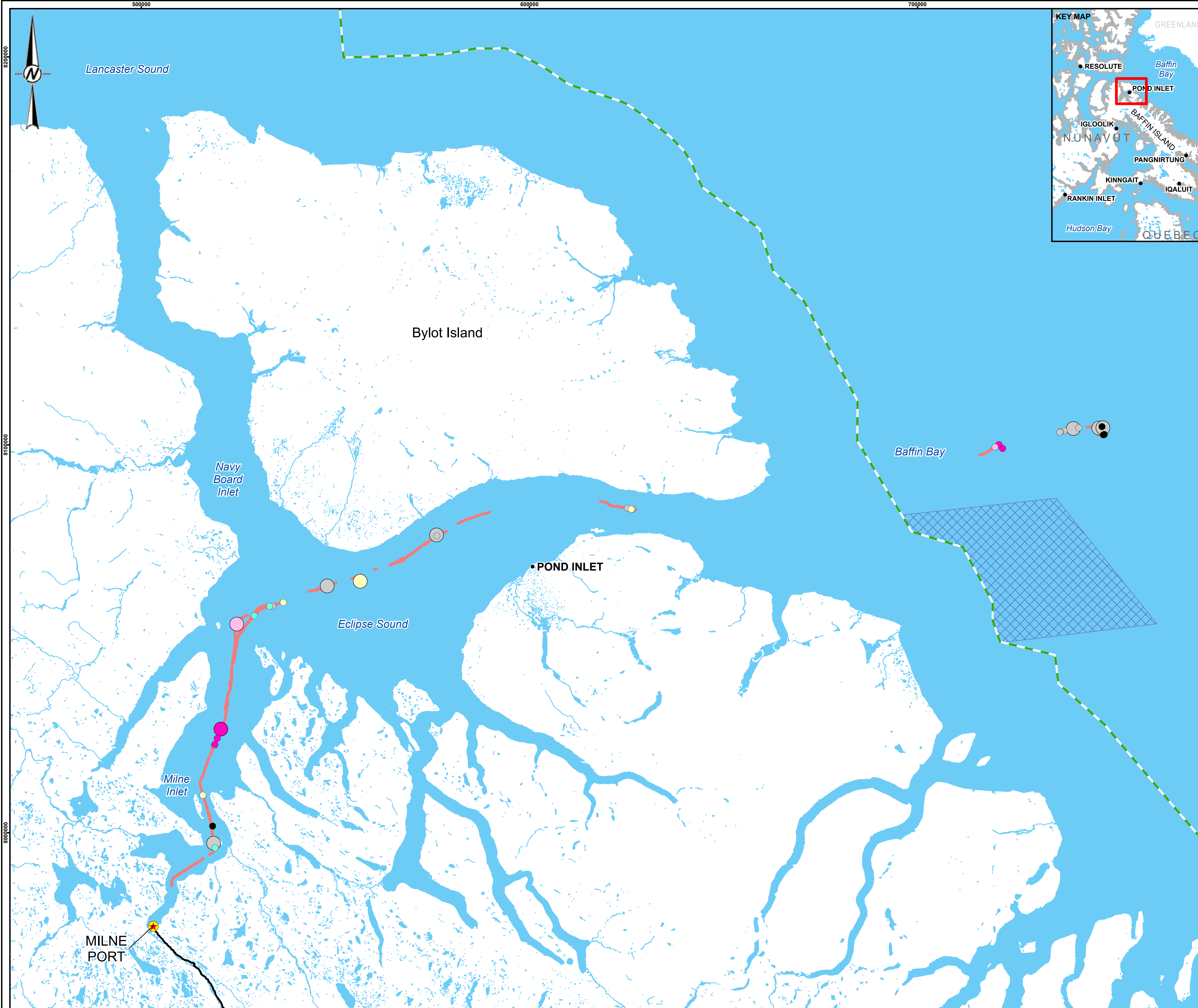
3.2.1 Relative Abundance and Species Richness

Total monitoring effort for seabirds was 15.5 h, consisting of 188 5-min moving platform surveys and four instantaneous stationary platform surveys, covering 206.5 km. A total of six species were identified (34 confirmed sightings comprising 47 individuals), with Glaucous gull (*Larus hyperboreus*) being the most common species (Table 24; Figure 40).

Table 24: Seabird Sightings Recorded During the 2023 Ship-based Observer Program

Common Name	Scientific Name	No. of Individuals	No. of Counts (moving and stationary)	Relative Abundance (# individuals / hr)
Black guillemot	*Cepphus grille*	6	5	0.38
Black-legged kittiwake	*Rissa Tridactyla*	4	4	0.26
Common raven	*Corvus corax*	5	4	0.32
Glaucous gull	*Larus hyperboreus*	23	15	**1.47**
Northern fulmar	*Fulmarus glacialis*	4	4	0.26
Thick-billed murre	*Uria lomvia*	5	2[1]	0.32
Total		**47**	**34**	**3.00**

1. One black guillemot was observed during an instantaneous stationary platform survey.
2. **Bold** = most abundant species



LEGEND

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

SHIP TRACK EFFORT STATUS

- PORT

SEABIRD SIGHTINGS (GROUP SIZE)

BLACK GUILLEMOT
- 1
- 2-10

BLACK-LEGGED KITTIWAKE
- 1

COMMON RAVEN
- 1
- 2-10

GLAUCOUS GULL
- 1
- 2-10

NORTHERN FULMAR
- 1

THICK-BILLED MURRE
- 1
- 2-10

0 25 50
1:1,000,000 KILOMETRES

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. 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
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
SEABIRD SIGHTINGS DURING THE 2023 SBO SURVEY (21 – 30 OCTOBER)

CONSULTANT

YYYY-MM-DD	2024-03-13
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	40

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

3.2.2 Comparison to 2018 and 2019 SBO Programs

There was no Leg 1 SBO (summer) survey in 2023. More species were recorded during Leg 2 (fall) surveys in 2019 than during Leg 2 in 2018 or 2023 (12 vs.7 and 6 species, respectively) (Table 25). This is likely in the range of natural variation for presence and abundance of species between years and the difference in length of program between years (19 days in 2018, 23 days in 2019, 9 days in 2023) and number of observation periods (Table 25). During the fall surveys in 2019, two species were identified that were not observed in 2018, ivory gull and long tailed duck. During the fall surveys in 2019 and 2023, another species, the Common Raven, that was not observed in 2018 was observed.

The relative abundance (number of individuals per hour of observation) of all seabirds observed during the 2018, 2019, and 2023 fall SBO programs can be seen in Table 25 and Figure 41. The relative abundance of seabirds was highest in fall 2018 (16.31 individuals/h) followed by fall 2019 (5.13 individuals/h) and fall 2023 (3.00 individuals/h).

Glaucous Gull was the most abundant species observed in 2018 (9.91 individuals/h) and 2023 (1.47 individuals/h) while Northern Fulmar were the most abundant species observed 2019 (2.15 individuals/h). Black-legged kittiwake was much more commonly observed in 2018 than in 2019 and 2023 (3.85 individuals/h in 2018 vs. 0.4 individuals/h in 2019 and 0.26 individuals/h in 2023). The next most observed species in 2018, in order of highest relative abundance, included Black-legged Kittiwake (3.86 individuals/h), Northern Fulmar (1.22 individuals/h), and Black Guillemot (0.95 individuals/h). Other species observed in 2018 included unidentified gulls and Pomarine Jaegar. The next most abundant species observed in 2019, in order of highest relative abundance, included Glaucous Gull (2.04 individuals/h), Black-legged Kittiwake (0.4 individuals/h), and Black Guillemot (0.2 individuals/h) while other species that were observed included Common raven, King Eider, Ivory Gull (a Schedule 1 Endangered listed species), Thick-billed Murre, Gyrfalcon, Iceland Gull, Long-tailed duck, and Snowy Owl. The next three most abundant species observed in 2023, in order of relative abundance, were Black Guillemot (0.38 individuals/h), Common Raven and Thick-billed Murre (0.32 individuals/h each), and Black-legged Kittiwake and Northern Fulmar (0.26 individuals/h each) (Table 25, Figure 41).

The most commonly observed species across all survey years included Glaucous Gull, Northern Fulmar, Black-legged Kittiwake, and Black Guillemot (Table 25, Figure 41).

Table 25: Number of Seabirds Recorded During Leg 2 (Fall) of the 2018, 2019 and 2023 Ship-Based Observer Program

Common Name	Scientific Name	2018 (529 5-minute snapshots)		2019 (1008 5-minute snapshots)		2023 (188 5-minute snapshots)	
		No. of Individuals	No. of individuals/ h (44.1 h)	No. of Individuals	No. of individuals/ h (84.0 h)	No. of Individuals	No. of individuals/ h (15.7 h)
Black guillemot	*Cepphus grille*	42	0.95	17	0.20	6	0.38
Black-legged kittiwake	*Rissa Tridactyla*	170	3.86	34	0.40	4	0.26
Common raven	*Corvus corax*	0	0.00	9	0.11	5	0.32
Glaucous gull	*Larus hyperboreus*	437	**9.91**	171	2.04	23	**1.47**
Gyrfalcon	*Falco rusticolus*	0	0.00	1	0.01	0	0.00
Iceland gull	*Larus glaucoides*	0	0.00	1	0.01	0	0.00
Ivory gull	***Pagophila eburnean***	**0**	0.00	4	0.05	0	0.00
King eider	*Somateria spectabilis*	0	0.00	8	0.10	0	0.00
Long-tailed duck	*Clangula hyemalis*	0	0.00	1	0.01	0	0.00
Northern fulmar	*Fulmarus glacialis*	54	1.22	181	**2.15**	4	0.26
Pomarine jaegar	*Stercorarius pomarinus*	1	0.02	0	0.00	0	0.00
Snowy owl	*Bubo scandiacus*	0	0.00	1	0.01	0	0.00
Thick-billed murre	*Uria lomvia*	0	0.00	3	0.04	5	0.32
Unidentified gull, tern, noddy, or skimmer	*NA*	14	0.32	0	0.00	0	0.00
Unidentified gull	*Larinae sp.*	1	0.02	0	0.00	0	0.00
Total		**719**	**16.31**	**431**	**5.13**	**47**	**3.00**

Bolded species = most observed species by year. ***Bolded and italicized*** – federally-listed species (Schedule 1 Endangered, SARA 2019)

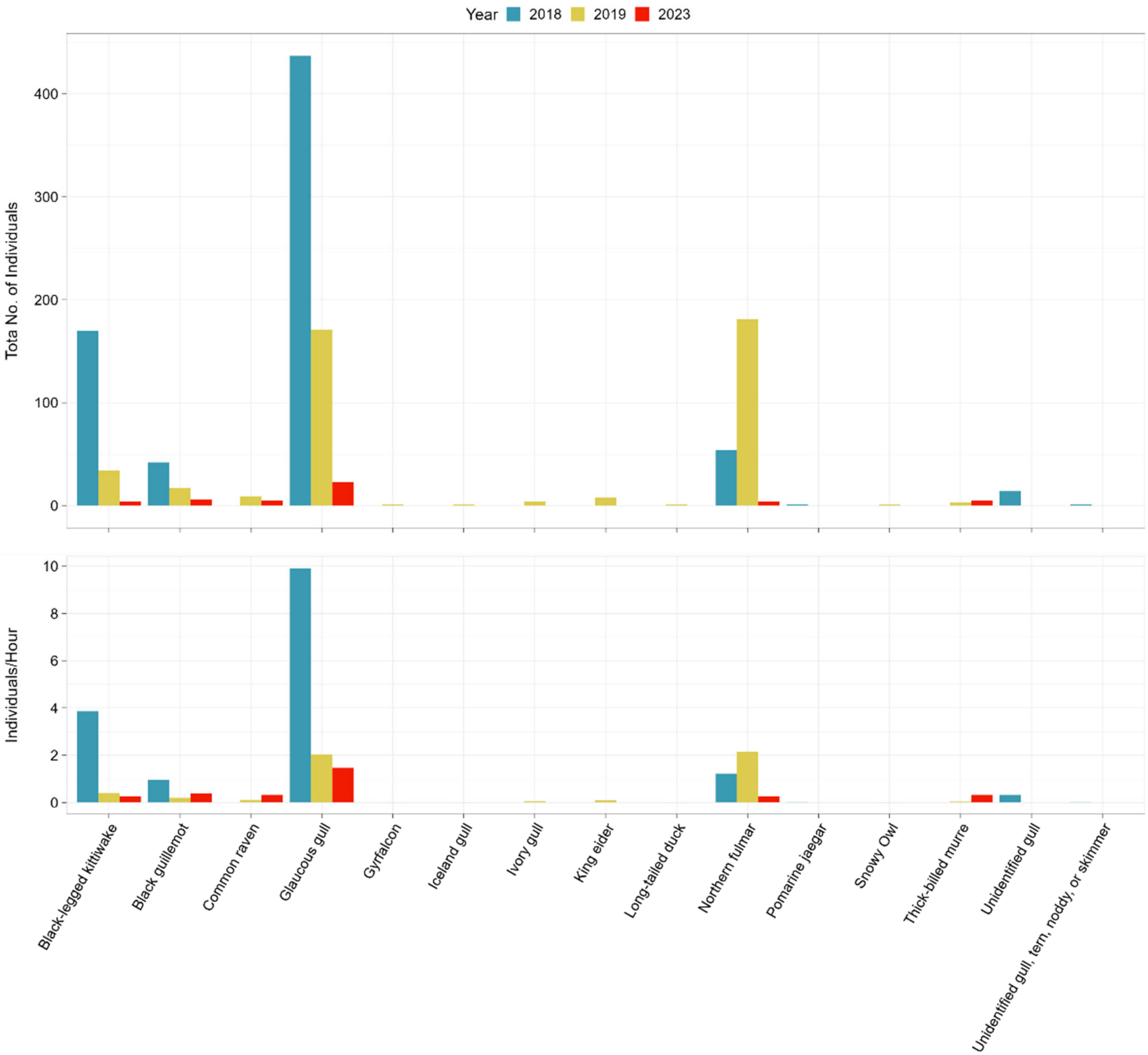


Figure 41: Comparison of Relative Abundances of Seabirds in 2018, 2019 and 2023

4.0 SUMMARY

The 2023 SBO Program was conducted onboard icebreakers *Botnica* and *Fennica* during the fall shoulder seasons (21 to 30 October) of 2023. The SBO Program was designed to meet Conditions No. 99, 101, 106, 108, 123 and 126 of Project Certificate No. 005. The primary objective of the SBO Program was to monitor for potential ship strikes on marine mammals and seabirds in the RSA. The second objective of the SBO program was to collect observational data on the presence, relative abundance and distribution of marine mammals and seabirds, as well as behavioural responses within the boundaries of the RSA relative to Project vessel operations.

Data collection methodology for the 2023 SBO Program was similar to the 2018 and 2019 SBO Programs with slight adjustments in protocol to address recommendations provided by the MEWG. In addition to marine mammal observations, seabird sightings were recorded using the CWS ECSAS survey protocol. Marine mammal sightings were recorded over a daily monitoring period extending up to 9 h depending on available daylight hours. Seabird sightings were recorded during dedicated seabird surveys conducted periodically throughout the day (lasting one to two hours each). The total daily watch period for seabirds was variable depending on sighting conditions, ranging from 0.5 to 4.5 h.

Marine Mammals

Most survey effort was from the *Botnica* from 21 to 27 October (52.2 h covering 675.1 km) with a dedicated observation team on each side of the vessel for 98% of the total survey period. From 28 to 30 October, observations were conducted from both the *Botnica* (18.4 h covering 248.7 km) and the *Fennica* (18.7 h covering 255.8 km). Total monitoring effort for the Botnica from 21-27 October and considering the lead vessel only from 28-30 October was 70.7 hours covering 949.9 km.

Five different marine mammal species were observed during the 2023 SBO Program including narwhal, ringed seal, harp seal, bearded seal, and polar bear. Beluga, bowhead whale, killer whale, and walrus were not observed in the RSA during the 2023 SBO Program; however, these species are known to occur in the region. A total of 431 marine mammal sightings comprising 562 individuals were recorded during the 2023 SBO Program.

The relative abundance of marine mammals in the RSA during the 2023 SBO Program, expressed as the animal detection rate (no. of individuals relative to survey effort in km) was 0.503 individuals/km (0.382 sightings/km). Ringed seal had the highest detection rate at 0.401 individuals/km (0.350 sightings/km), followed by harp seal (0.058 individuals/km), narwhal (0.018 individuals/km), unidentified seal (0.015 individuals/km), bearded seal (0.007 individuals/km), and polar bear (0.004 individuals/km).

The relative abundance of marine mammals in the RSA was similar in fall of 2023 (0.503 individuals/km) to that observed in fall 2018 (0.530 individuals/km). Fall 2018 and 2023 had higher relative abundance rates compared to fall 2019 (0.16 individuals/km). Harp seal was the species with highest relative abundance rates in 2018 (0.225 individuals/km) and 2019 (0.059 individuals/km), while ringed seal was the species with the highest relative abundance rate in 2023 (0.403 individuals/km). Species observed with higher relative abundance in fall 2023 than previous years included ringed seal, bearded seal, and polar bear.

The observed decrease in narwhal relative abundance in from 2018 to 2023 may be a reflection of the difference in the time of year and ice cover conditions between the SBO Programs. In 2018, the SBO Program occurred earlier in the year (28 September to 17 October) than the 2019 SBO Program (5 to 28 October) and the 2023 SBO Program (21 to 30 October). It is possible that there were more narwhal remaining in the RSA in 2018 and 2019, compared to 2023. Additionally, there was less ice during both of the 2018 and 2019 late shoulder season

SBO Program, with the majority of observation effort occurring in open water, compared to the 2023 SBO Program where most observation effort occurred in ice conditions. These heavier ice conditions may have impacted the observer's ability to detect narwhal and/or influence narwhal habitat use in the RSA.

The lowest mean CPA for all on-ice marine mammal observations was for bearded seal, followed by polar bear, ringed seal, and unidentified seal. The lowest mean CPA for in-water marine mammal observations was for bearded seal, followed by ringed seal, unidentified seal, harp seal, narwhal, and polar bear. The lowest minimum CPA of all marine mammals observed on ice was for ringed seal, followed by bearded seal, polar bear, and unidentified seal. The lowest minimum CPA of all marine mammals observed in water was for ringed seal, followed by unidentified seal, bearded seal, harp seal, narwhal, and polar bear.

Overall, the CPA results support impact predictions that animals demonstrate localized avoidance of the ship. This provides further confidence that a vessel strike on a marine mammal is unlikely to occur based on current vessel speeds restriction within the RSA (9-knot speed restriction). These results also further support impact predictions made in the FEIS Addendum for the Early Revenue Phase (ERP), that the Project was unlikely to result in significant residual adverse effects on narwhal in the RSA, defined as effects that compromise the integrity of the population either through mortality (i.e., ship strikes) or via large-scale displacement or abandonment of the RSA.

Behavioural responses recorded for seals on-ice included scan and flush and behavioural response recorded for seals in-water included swim away and rapid dive/splash. The only species for which flush activity was observed were ringed seal and bearded seal on ice while rapid dive/splash responses were observed for ringed seal, harp seal, and unidentified seal. Of the 399 sightings considered for the behavioural response analysis (within 2 km of the vessel), one third demonstrated a behavioural response. Behavioural responses were observed in all species with the highest proportion of sightings with responses for polar bear followed by harp seal, unidentified seal, ringed seal, and narwhal.

Due to small sample sizes for most species, only a statistical analysis of response rates of ringed seals within 2 km of the vessels is presented. The best fitting ordinal logistic regression model included vessel activity and distance of the vessel to the sighting as predictor variables for ringed seal responses on ice. The model predicted that the probability of flush response increases with decreasing distance from the vessel and the probability of no response increases with increasing distance from the vessel. Model results suggested that ringed seals responded more strongly to the vessels during active icebreaking than when transiting open water. For ringed seals in water, based on the AIC comparing candidate models the model which included distance and vessel activity was selected, neither distance nor vessel activity had a significant effect on ringed seal responses. The analysis of deviance found neither distance nor vessel activity had a significant effect on in water ringed seal responses ($p < 0.09$ for distance, and $p > 0.5$ for vessel activity).

Only two bearded seals were reported to flush, one during icebreaking and one while the vessel was transiting open water (CPA = 200 m and 275 m respectively). The remaining bearded seals on ice did not respond and bearded seal in water responded with regular dives which are not considered as energetically costly as the other 'response' behaviours. Due to the limited sample sizes of bearded and harp seals at distances beyond 1,000 m, further studies would be needed to validate the potential sensitivities of these species.

All five narwhal sightings occurred when the vessel was icebreaking and the only behavioural response observed was by one group of 3 narwhal that were observed traveling slowly away from the vessel at 1,200 m. Of the seven sightings of individual polar bears, one displayed vigilance at a CPA of 300 m, two ran away at CPAs of 1,000 m and 1,200 m and one walked away at a CPA of 900 m. There was no behavioural response observed noted during the other three observations. All polar bear sightings occurred when the vessel was icebreaking except for the one bear that was observed resting and then displaying vigilance at 300 m.

Similar to previous years, no ship strikes on marine mammals (or near misses) were recorded during the active monitoring periods on the *Botnica* or *Fennica* during 2023. Overall, the distances maintained by marine mammals from the survey vessel in 2023 (i.e., CPA results) lend confidence to existing environmental assessment predictions, in that marine mammals in the RSA are likely to demonstrate localized avoidance of Project vessels, and that vessel strikes on marine mammals are unlikely to occur based on current vessel speeds in the RSA (9 knot speed restriction).

Collectively, the 2023 SBO monitoring results support the impact predictions and significance determination in the FEIS Addendum for the Early Revenue Phase (ERP) in that the Project is unlikely to result in significant residual adverse effects on marine mammals in the RSA, defined as effects that compromise the integrity of marine mammal populations in the region either through mortality (i.e., ship strikes) or via large-scale displacement or abandonment of the RSA.

Seabirds

Total monitoring effort for seabirds during the 2023 SBO Program was 15.7 h consisting of 188 5-min moving platform surveys and four instantaneous stationary platform surveys over 206.5 km. A total of six species were identified (34 confirmed sightings comprising 47 individuals), with Glaucous gull (*Larus hyperboreus*) being the most common species.

Glaucous Gull was the most abundant species observed in 2023 (1.47 individuals/h) followed by Black Guillemot (0.38 individuals/h), Common Raven and Thick-billed Murre (0.32 individuals/h each), and Black-legged Kittiwake and Northern Fulmar (0.26 individuals/h each). The relative abundance of seabirds was highest in fall 2018 (16.31 individuals/h) followed by fall 2019 (5.13 individuals/h) and fall 2023 (3.00 individuals/h). Glaucous Gull was the most abundant species observed in 2018 (9.91 individuals/h) and 2023 (1.47 individuals/h) while Northern Fulmar were the most abundant species observed 2019 (2.15 individuals/h). Black-legged kittiwake were much more commonly observed in 2018 than in 2019 and 2023 (3.85 individuals/h in 2018 vs. 0.4 individuals/h in 2019 and 0.26 individuals/h in 2023). Species observed across all survey years included Glaucous Gull, Northern Fulmar, Black- legged Kittiwake, and Black Guillemot.

Recommendations

Continuation of the SBO Program is recommended for 2024 in accordance with NIRB Project Certificate No. 005 Terms and Conditions. Ongoing annual monitoring will allow for additional data comparison between monitoring years, which will serve to identify whether any additional adaptive management measures during the shoulder seasons are required.

5.0 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.

WSP Canada Inc.

Kyla Graham, BSc, MRes
Marine Biologist

Patrick Abgrall
Senior Marine Biologist

KG/PA/asd

https://golderassociates.sharepoint.com/sites/11206g/deliverables (do not use)/issued to client_for wp/400-499/1663724-497-r-rev0-74000/1663724-497-r-rev0-74000 2023 sbo report 15mar_24.docx

6.0 REFERENCES

Allen, A.S. 2014. The development of ship'' routeing measures in the Bering Strait: Lessons learned from the North Atlantic right whale to protect local whale populations. Marine Policy 50:215-226.

Baffinland Iron Mines Corporation (Baffinland). 2018. Production Increase Proposal. NIRB File No. 08MN053. Project certificate No. 005. June 19, 2018.

Baffinland. 2020. Production Increase Proposal Extension Application.

Baffinland. 2022. Production Increase Proposal Renewal. May 20, 2022.

Baffinland. 2023. Sustaining Operations Proposal. April 2023.

Beckett, J., D. Chiperzak, B. Wheeler, T. Hills, D. Ebner, and M. Setterington. 2008. Nunavut Wildlife Resource and Habitat Values. Final Report. Prepared by Nuami Jacques Whitford Ltd., Yellowknife, NWT for Nunavut Planning Commission, Cambridge Bay, Nunavut. 238 p.

Brewer, K. D., M. L. Gallagher, P.R. Regos, P.E. Isert, and J.D. Hall. 1993. ARCO Alaska, Inc. Kuvlum #1 exploration prospect/Site specific monitoring program final report. Rep. from Coastal & Offshore Pacific Corp., Walnut Creek, CA, for ARCO Alaska Inc., Anchorage, AK. 80 p.

Brueggeman, J. J., G. A. Green, R. A. Grotefendt, M. A. Smultea, D. P. Volsen, R. A. Rowlett, C. C. Swanson, C. I. Malme, R. Mlawski, and J. J. Burns. 1992. 1991 marine mammal monitoring program (walrus and polar bear) Crackerjack and Diamond prospects Chukchi Sea. Rep. from EBASCO Environmental, Bellevue, WA, for Shell Western E & P Inc. and Chevron U.S.A. Inc.

Canarctic and Roche. 1993. Impact and risk assessment of shipping in Deception Bay. Rep. By Canarctic Shipping Company Ltd. and Roche Ltd., Ottawa, ON, for Raglan Project, Falconbridge Nickel Ltd., Toronto, ON. 139 p.

Constantine, R., M. Johnson, L. Riekkola, S. Jervis, L. Kozmian-Ledward, T. Dennis, L.G. Torres, and N. Aguilar de Soto. 2015. Mitigation of vessel-strike mortality of endangered Bryde's whales in the Hauraki Gulf, New Zealand. Biological Conservation 186:149-157.

Cosens, S.E. and L.P Dueck. 1988. Response of migrating narwhal and beluga to icebreaker traffic at the Admiralty Inlet ice-edge, N.W.T. in 1986. p. 39-54 In: W.M. Sackinger et al. (eds.), Port and ocean engineering under arctic conditions. Vol II. Geophysical Institute, Univ. Alaska, Fairbanks. 111 p.

Dolman, S., V. Williams-Grey, R. Asmutis-Silvia and S. Isaac. 2006. Vessel collisions and cetaceans: What happens when they don't miss the boat. Whale and Dolphin Conservation Society Science Report. 25pGjerdrum, C., Fifield, D.A., and Wilhelm, S.I. 2012.

Erbe, C. and D.M. Farmer. 2000. Zones of impact around icebreakers affecting beluga whales in the Beaufort Sea. The Journal of Acoustical Society of America 108(3):1332-1340

Finley, K.J., G.W. Miller, R.A. Davis, and C.R. Greene. 1984. Responses of narwhals (*Monodon monoceros*) and belugas (*Delphinapterus leucas*) to ice-breaking ships in Lancaster Sound – 1983. In LGL Limited. 1986. Reactions of beluga whales and narwhals to ship traffic and ice-breaking along ice edges in the eastern Canadian Arctic. Canada Department of Indian and Northern Affairs, Environmental Studies No. 37: xi + 117 p.

Finley, K.J., G. W. Miller, R. A. Davis, and C. R. Greene. 1990. Reactions of belugas, *Delphinapterus leucas*, and narwhals, *Monodon monoceros*, to ice-breaking ships in the Canadian high arctic. Canadian Bulletin of Fisheries and Aquatic Sciences. 224:97-117.

Gjerdrum, C., Fifield, D. A., and S. I. Wilhelm. 2012. Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms. Canadian Wildlife Service Technical Report Series No. 515. Atlantic Region. 37 p.

Goldbogen, J.A., J. Calambokidis, R.E. Shadwick, E.M. Oleson, M.A. McDonald and J.A. Hildebrand. 2006. Kinematics of foraging dives and lunge-feeding in fin whales. The Journal of Experimental Biology 209:1231-1244.

Golder. 2019. 2018 Ship-based Observer Program – Technical Data Report. Prepared by Golder Associates Ltd. For Baffinland Iron Mines Corporation. Report No. 1663724-088-R-Rev0-20000. 30 May 2019. 48 p. + appendices.

Golder. 2020. 2019 Ship-based Observer Program – Technical Data Report. Prepared by Golder Associates Ltd. For Baffinland Iron Mines Corporation. Report No. 1663724-185-R-Rev0-31000. 24 July 2020. 64 p. appendices.

Harding, K. C., M. Fukiwara, Y. Axberg, and T. Härkönen. 2005. Mass-dependent energetics and survival of harbour seal pups. Functional Ecology 19:129–135.

Jansen, J. K., Bengtson, J. L. Boveng, P. L. Dahle, S. P. and J. Ver Hoef. 2006. Disturbance of harbor seals by cruise ships in Disenchantment Bay, Alaska: an investigation at three spatial and temporal scales. AFSC Processed Report 2006-02, 75 p. Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, Seattle, Washington, USA.

Jansen, J. K., Boveng, P. L., Dahle, S. P. and J. L. Bengtso. 2010. Reaction of harbor seals to cruise ships. Journal of Wildlife Management 74:1186–1194.

Jensen, A.S. and G.K. Silber. 2003. Large whale ship strike database. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/OPR 25. 37pp.

Jason Prno Consulting Services Ltd (JPCS). 2017. Technical supporting Document (TSD) No. 03: Results of Community Workshops Conducted for Baffinland Iron Mines Corporation's – Phase 2 Proposal. Report submitted to Baffinland Iron Mines Corporation. January 2017.

Kanik, B., M. Winsby, and R. Tanasichuk. 1980. Observations of marine mammal and sea bird interaction with icebreaking activities in the High Arctic/July 2–- 12, 1980. Rep. from Hatfield Consultants Ltd., West Vancouver, B.C., for Petro-Canada, Calgary, AB. 53 p.

Kelly, J., R. Power, L. Noble, J. Meade, J. Kelly, K. Reid, S. Kuehnemund, C. Carley, C. Grant, M. Roberge, E. Lee, and M. Teasdale. 2010. A system for characterizing and quantifying coastal marine habitat in Newfoundland and Labrador. Fisheries and Oceans Canada, Marine Environment and Habitat Management, St. John's NL. v + 81 pp

Kite-Powell H.L., A Knowlton and M. Brown. 2007. Modelling the Effect of Vessel Speed on Right Whale Ship Strike Risk. NA04NMF47202395. National Oceanic and Atmospheric Administration and National Marine Fisheries Service. 8 p.

Knowlton, A.R. and S.D. Kraus. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. Journal of Cetacean Research Management (Special Issue 2), 193–208.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions Between Ships and Whales. Marine Mammal Science 17(1):35-75.

Lawson, J.W. and V. Lesage. 2013. A draft framework to quantify and cumulate risks of impacts from large development projects for marine mammal populations: A case study using shipping associated with the Mary River Iron Mine project. DFO Canadian Science Advisory Secretariat Research Document. 2012/154 iv+22p.

LGL and Greeneridge. 1986. Reactions of beluga whales and narwhals to ship traffic and ice-breaking along ice edges in the eastern Canadian High Arctic: 1982-1984. Environ. Stud. 37. Indian & Northern EDAffairs Canada, Ottawa, ON. 301 p.

Lomac-Macnair, K., Andrade, J.P., and E. Esteves. 2019. Seal and polar bear behavioural response to an icebreaker vessel in northwest Greenland. 13(2), p. 277-289.

Lydersen, C. 1988. Status and biology of ringed seals (*Phoca hispida*) in Svalbard. NAMMCO Scientific Publications: 1:46-62

Mansfield, A.W. 1983. The effects of vessel traffic in the arctic on marine mammals and recommendations for future research. Canadian Technical Report of Fisheries Aquatic Science 1186: x +97 p.

Neilson, J.L., C.M. Gabriele, A.S. Jensen, K. Jackson, and J.M. Straley. 2012. Summary of Reported Whale-Vessel Collisions in Alaskan Waters. Journal of Marine Biology 2012:1-18

Nichol, L.M., B.M. Wright, P. O'Hara, and J.K.B. Ford. 2017. Risk of lethal vessel strikes to humpback and fin whales off the west coast of Vancouver Island, Canada. Endangered Species Research 32:373-390

Nichols O.C., H.L. Kite-Powell, R.D. Kenney, and M.W. Brown. 2005. A simple two-dimensional model of ship encounter risk for right whales in Cape Cod Bay: Final results and management implications. Collaborative works of the Center for Coastal Studies, PO Box 1036, Provincetown, USA, Marine Policy Center, Woods Hole Oceanographic Institution, Woods Hole, USA, Graduate School of Oceanography, University of Rhode Island, Narragansett, USA and the New England Aquarium, Central Wharf, Boston, USA.

Nowacek, D.P., M.P. Johnson, and P.L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London 271:227–231.

OBIS (Ocean Biogeographic Information System). 2019. CWS-EC Eastern Canada Seabirds at Sea (ECSAS). Available at: https://obis.org/dataset/51391fb1-ae4d-44d8-9178-a06f95545604. Accessed: March 19, 2020

Parry, S. 2020. Ordinal logistic regression models and statistical software: what you need to know. Cornell Statistical Consulting Unit (CSCU). Statnews #91. Available at: https://cscu.cornell.edu/resources/handoutstutorials/. Accessed: March 10, 2024

Paterson, W, C.E. Sparling, D. Thompson, P.P. Pomeroy, J.J. Currie, D.J. McCafferty. 2012. Seals like it hot: changes in surface temperature of harbour seals (*Phoca vitulina*) from late pregnancy to moult. Journal of Thermal Biology 37:454-461.Reeves, R., C. Rosa, J.C. George, G. Sheffield and M. Moore. 2012. Implications of Arctic industrial growth and strategies to mitigate future vessel and fishing gear impacts on bowhead whales. Marine Policy 36(2):454-462

Richardson, W.J., D.H. Thomson, C.R. Green Jr. and C.I. Malme. 1995. Marine mammals and Noise. Academic Press, Inc., San Diego, CA.

RStudio Team. 2023. RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/.

SEM (Sikumiut Environmental Management Ltd.). 2014. 2013 Ship-Based Observer Pilot Program: Marine Mammal and Seabird Observations. Prepared by Sikumiut Environmental Management Ltd., St. John's, NL for Baffinland Iron Mines Corporation, Oakville, Ontario. 20 p. + appendices.

SEM. 2015. 2014 Ship-Based Observer Pilot Program. Prepared by Sikumiut Environmental Management Ltd., St. John's, NL for Baffinland Iron Mines Corporation, Oakville, Ontario. 17 p. + appendices.

SEM. 2016. 2015 Ship-Based Observer Program. Prepared by Sikumiut Environmental Management Ltd., St. John's, NL for Baffinland Iron Mines Corporation, Oakville, Ontario. 14 p. + appendices.

Silber, G.K., J. Slutsky and S. Bettridge. 2010. Hydrodynamics of a ship/whale collision. Journal of Experimental Marine Biology and Ecology 391:10–19.

Smith, H.R., Brandon, J.R., Abgrall, P., Fitzgerald, M., Elliott, R.E. and V.D. Moulton. 2015. Shore- Based Monitoring of Narwhals and Vessels at Bruce Head, Milne Inlet, 30 July – 8 September 2014. Final LGL. LGL Report No. FA0013-2. Prepared by LGL Limited, King City, ON for Baffinland Iron Mines Corporation, Oakville, Ontario. 73 p. + appendices.

Smith, H.R., S. Raborn, M. Fitzgerald and V.D. Moulton. 2016. Shore- Based Monitoring of Narwhals and Vessels at Bruce Head, Milne Inlet, 29 July – 5 September 2015. LGL Report No. FA0044-1. Prepared by LGL Limited, King City, ON for Baffinland Iron Mines Corporation, Oakville, ON. 73 p.

Smith, H.R., V.D. Moulton, S. Raborn, P. Abgrall, R.E. Elliott and M. Fitzgerald. 2017. Shore-based monitoring of narwhals and vessels at Bruce Head, Milne Inlet, 2017. LGL Report No. FA0089-1. Prepared by LGL Limited, King City, Ontario for Baffinland Iron Mines Corporation, Oakville, Ontario. 87 p. + appendices

Smultea, M.A., Brueggeman, J., Robertson, F., Fertl, D., Bacon, C., Rowlett, A., and G.A. Green. 2016. Polar Bear (*Usus maritimus*) behaviour near icebreaker operations in the Chukchi Sea, 1991. Arctic 69(2): 177-184.

Stirling, I. 2005. Reproductive rates of ringed seals and survival of pups in Northwestern Hudson Bay, Canada, 1991-2000. Polar Biology 28(5):381-387.

Vanderlaan A.S.M. and C.T. Taggart. 2007. Vessel Collisions with whales: The probability of lethal injury based on vessel speed. Society for Marine Mammalogy 23(1):144-156.

Vanderlaan, A.S.M., C.T. Taggart, A.R. Serdynska, R.D. Kenney, and M. W. Brown. 2008. Reducing the risk of lethal encounters: vessels and right whales in the Bay of Fundy and on the Scotian Shelf. Endangered Species Research 4:283-297.

Van Waerebeek K, A.N. Baker, F. Félix, J. Gedamke, M. Iñiguez, G.P. Sanino. 2007. Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment. Latin American Journal of Aquatic Mammals 6:43-69.

Wells RS, M.D. Scott. 1997. Seasonal incidence of boat strikes on bottlenose dolphins near Sarasota, Florida. Marine Mammal Science 13:475–480.

Wilson, S.C., I. Trukhanova, L. Dmitrieva, E. Dolgova, I. Crawford, M. Baimukanov, T. Baimukanov, B. Ismagambetov, M. Pazylbekob, M. Jüssi, S.J. Goodman. 2017. Assessment of impacts and potential mitigation for icebreaking vessels transiting pupping areas of an ice-breeding seal. Biological Conservation 214:213-222.

WSP Canada Inc (WSP). 2024. 2023 Ship-Based Observer Program: Training Manual. WSP Report No. 166372402-069-R-Rev0. 36 p. + appendices.

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

APPENDIX A

MWO Training Manual

REPORT

2023 Ship-Based Observer Program

Training Manual

Submitted to:

Submitted by:

WSP Canada Inc.

301 - 3600 Uptown Boulevard, Victoria, British Columbia, V8Z 0B9, Canada

+1 604 296 4200

1663724-496-R-Rev0

15 March 2024

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

The Ship-Based Observer (SBO) Program represents one of several programs that were developed to support the Mary River Project (the Project). The SBO Program is part of the Marine Mammals component of the Marine Monitoring Plan (MMP), in accordance with Project Certificate (PC) terms and conditions issued for the Project. This manual was developed by experienced marine wildlife observers (MWOs) to help train other biologists and non-biologists who may or may not have ship-based wildlife observation experience.

An MWO is a person with training in marine mammal and seabird survey techniques. These techniques include spotting and identifying marine mammals and seabirds, estimating distances to sightings, determining relative location of sightings and their movement with respect to the vessel, and recording environmental variables. This training may also serve as a refresher course for experienced MWOs.

This SBO Program manual will cover:

- objectives of the SBO Program
- health and safety and life at sea
- field program overview
- marine mammal surveys and protocol
- seabird surveys
- data collection, management, and backup

2.0 OBJECTIVES OF THE SHIP-BASED OBSERVER (SBO) PROGRAM

The 2023 SBO Program is proposed to occur over a 14-day window in October during final shipping operations. The primary objective of the SBO Program is to monitor for potential ship strikes on marine mammals and seabirds in the Regional Study Area (RSA). The secondary objective of the SBO Program is to collect data on the presence, relative abundance and distribution of marine mammals and seabirds within the boundaries of the RSA.

The main role of the MWOs during the SBO Program will be to continuously scan the water around the vessel and actively look for marine mammals and seabirds.

- To document all marine mammal and seabird observations while onboard the vessel.
- To document any marine mammal and seabird vessel interactions or incidents of concern related to vessel activities.

3.0 LIFE AT SEA

Working at sea for long periods of time is an exciting adventure, but it can also be challenging. Your experience on the vessel will depend a lot on your attitude and what you make of it. It is usually a great opportunity to explore areas not often seen by others, or to view a familiar area through a different point of view, and to develop relationships in the close community on board a vessel.

Since a ship is a confined environment with limited space shared by several people, some rules and procedures are often needed. The following section will introduce you to the conditions of working at sea.

3.1 Vessel

The MWO team will be working and living on the MSV *Botnica* which is a multipurpose offshore support vessel and icebreaker built by Aker Finnyards in Rauma, Finland, in 1998 (Figure 1). The vessel was the newest and technically most advanced state-owned icebreaker in Finland until 2012, when it was sold to the Port of Tallinn (Estonia). The *Botnica* is 96.80 m (317.3 ft) by 2.04 m (78.7 ft) and can accommodate up to 72 personnel.

In 2023, Baffinland hired a second icebreaker, the MSV *Fennica* which is another larger offshore support vessel and icebreaker built by Aker Finnyards, in 1993 (Figure 1). The *Fennica* is 116.0 m (380.6 ft) by 26.0 m (85.3 ft) and can accommodate up to 77 personnel. Depending on ice and operating conditions during the 2023 fall shipping season, the MWO team may be split into two teams working from the *Botnica* and *Fennica*.

The *Botnica and Fennica*'s crew are Transport Canada certified to meet government safety requirements. This includes:

- Transport Canada safety inspections.
- marine safety equipment available onboard.
- marine emergency procedures (e.g., man overboard), and evacuation procedures.
- crew certified in vessel operation, Marine First Aid, and Marine Emergency Duties.

Figure 1: MSV *Botnica* (left) and MSV *Fennica* (right)

3.2 Health and Safety

MWOs are expected to attend daily toolboxes and vessel safety orientations and meetings and be familiar with the location of safety equipment on-board the MSV *Botnica* and *MSV Fennica*. In addition to vessel safety, all MWOs must read and understand the SBO Program-specific Project Risk Assessment and Safety Plan (PRASP) which will be reviewed prior to the start of the SBO Program. A major component of the PRASP is the identification of potential health and safety hazards associated with the SBO Program including environmental conditions and MWO activities and the implementation of the controls necessary to minimize the risk to people. The program specific PRASP is based on the assessment of previous worksites and similar activities and is a dynamic document that can be modified if things change during the SBO Program. The PRASP will typically cover the following information:

- general project information.
- project site description (mine and vessel).
- personnel contact information.
- emergency contact information.
- task risks and controls.
- safe work practices and procedures.
- toolbox meetings (to be completed at the start of every day).
- incident reporting.

Vessel specific health and safety to consider while onboard the vessel will be covered once you board the vessel. This will include:

- emergency equipment and supplies.
- emergency drills (e.g., man overboard, fire, abandon ship).
- location of medic/nurse station.
- restricted areas.
- smoking areas and non-smoking areas.
- drug and alcohol policies.
- areas where specific personal protective equipment (PPE) is required.
- how and when to use an immersion suit and SOLAS life vest (provided by the vessel).
- all survey crew will partake in a vessel safety orientation at the beginning of the survey.

While working at sea there is the potential to become seasick. This can affect your ability to continue to observe for marine mammals and seabirds. It is recommended that if you are unsure about whether you will get seasick that you plan to bring enough seasickness medication to last you the entire program.

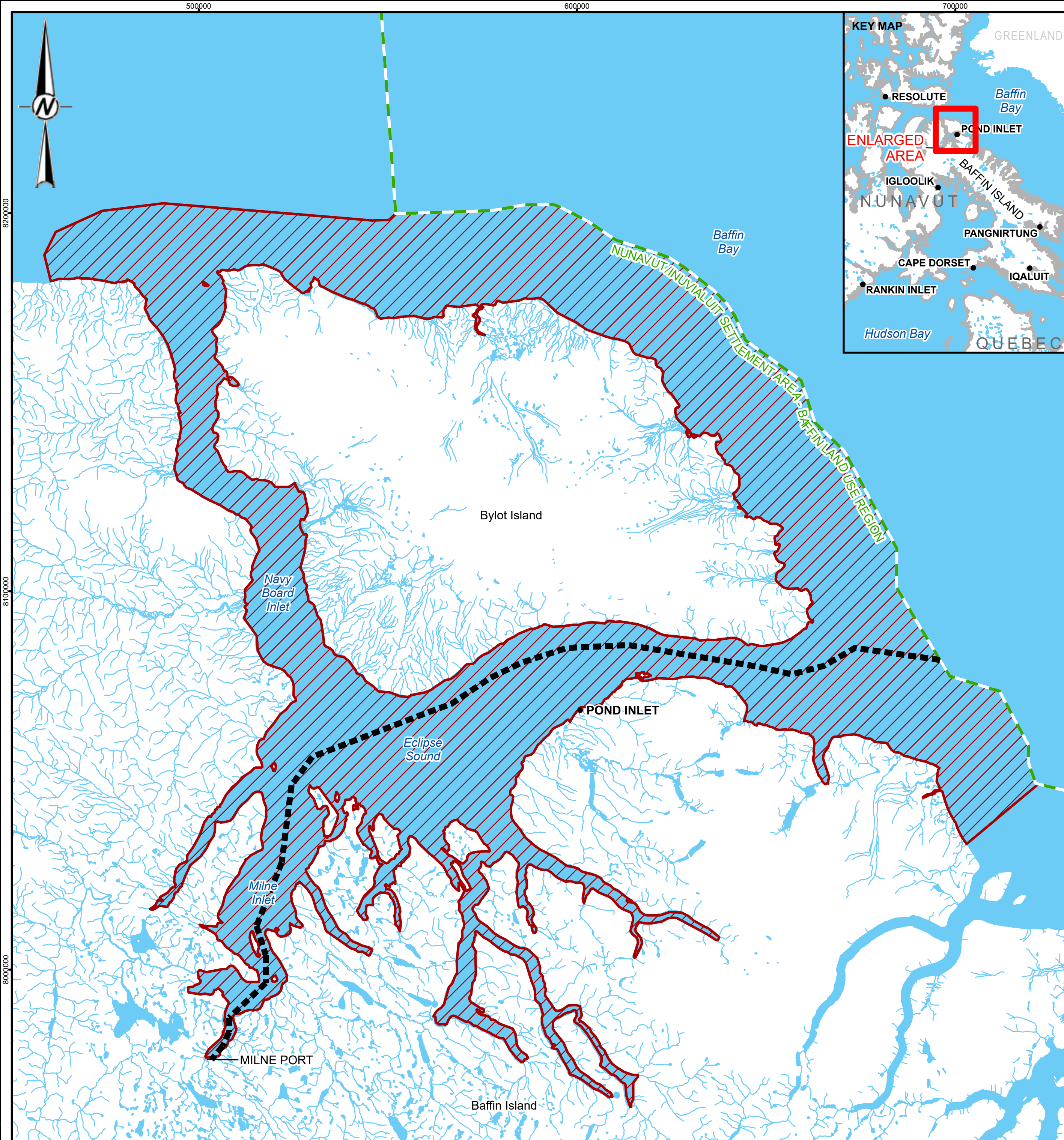
3.3 What to Bring

Remember to bring copies of all your important documents and certificates. You are required to bring:

- Valid photo identification and other important documents and certificates.
- Important medication (i.e., Epipen, seasickness tablets, etc.). If you take regular medications, bring enough to last the entire trip with enough to last an extra week, just in case.
- Personal toiletries.
- Bath towel (provided on vessel, not provided at port site).
- Outdoor clothing and footwear to wear on deck. You will be required to bring an insulated winter coat (rated to -25C or colder), insulated winter footwear (rated to -25C or colder, steel toed), winter headwear, and lined mittens or gloves (cold weather rated).
- Indoor footwear to wear inside the vessel where you will spend most of your time.
- Flip-flops for wearing in the shower.
- Camera (optional). There will be a project camera, but you may want your own.
- Binoculars (optional). We will be providing binoculars for use during watches however you may want to have a personal pair to use.
- Sunglasses (polarized are better).
- Hat.
- Sunscreen.
- Water bottle and/or coffee mug (optional).
- Universal plug adapter. The vessel has European plug outlets so it is recommended you bring at least one universal plug adapter so you can charge your computer, phones, etc.
- Noise cancelling headphones/earbuds (optional). There are earplugs available on site and on the vessel. It will be noisy during icebreaking!
- Personal entertainment. Since entertainment can be limited, it is strongly recommended that you bring items such as books, music, cards, games, or other hobbies to keep yourself busy during your spare time. This can go a long way towards keeping you happy during your stay.
- Don’t count on cell phone service or internet. There will be a satellite phone to use for emergencies.

4.0 FIELD PROGRAM

The *Botnica* and *Fennica* will act as Ice Management Vessels (IMV), providing clear safe passage for Project Ore carriers through the Northern Shipping Route (Figure 2) which traverses Baffin Bay, Pond Inlet, Eclipse Sound, and Milne Inlet. MWOs will be stationed on the bridge of the Botnica or *Fennica* while observing for marine mammals and seabirds. The primary objective of the SBO Program is to monitor for potential ship strikes on marine mammals and seabirds in the RSA. The secondary objective of the SBO Program is to collect data on the presence, relative abundance and distribution of marine mammals and seabirds within the boundaries of the RSA.



LEGEND

- COMMUNITY
- SHIPPING ROUTE (APPROXIMATE)
- WATERCOURSE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- MARINE MAMMAL REGIONAL STUDY AREA
- 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.
PROJECTED COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
MARINE MAMMAL REGIONAL STUDY AREA

CONSULTANT

YYYY-MM-DD	2023-10-06
DESIGNED	KG
PREPARED	AA
REVIEWED	KG
APPROVED	PR

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000	0	2

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

5.0 TRAINING GOALS

From this manual you will learn:

- For Marine Mammal Surveys:
  - field schedule and what is expected of you.
  - position on the vessel while observing.
  - observation techniques.
  - how to use the equipment.
  - how to estimate distances.
  - how to record data.
  - how to spot and identify a marine mammal.
- For Seabirds:
  - survey methods from a moving platform.
  - survey methods from a stationary platform.
  - how to record data.

6.0 MARINE MAMMAL SURVEY

6.1 Field Schedule

The 2023 SBO team will consist of seven observers, including one WSP team lead and one seabird observer. Watch periods will occur in two-hour watches with four MWOs on watch at a time. To ensure adequate coverage on both sides of the vessel there will be a port team and a starboard team with one observer and one data recorder working together on each side of the vessel (single-vessel schedule). Port and starboard team members will rotate every hour between observer and data recorder positions. At each hourly rotation the MWOs who were on break will take over as visual observers, the visual observers will shift to data recorders, and the data recorders will go for a break. If the MWO team is split into two teams, one on the *Fennica* and one on the *Botnica*, there will be one team of 4 MWOs (including the seabird observer) and one team of 3 MWOs. The SBO teams will then switch to the two-vessel schedule with one observer covering both sides of the vessel and one observer assisting and recording data while the third/fourth observers (team of 3 and team of 4, respectively) is on break or conducting seabird watches (team of 4). Table 1 and Table 2 are proposed MWO watch schedules for the 2023 Program. Table 1 shows MWO watches for a full team with an MWO and data recorder on each side of the vessel, while Table 2 shows MWO watches for a reduced team where an MWO and data recorder cover the full MWO observation area ahead of the vessel. MWOs will rotate through MWO1 to MWO3 schedules on three-day rotations during the program.

At times when mitigation is required, there are many sightings, or on-watch MWOs are feeling fatigued and unable to observe and collect data accurately, the off-shift MWOs can help collect data. The WSP crew lead will alternate between teams to mentor the MWOs during active watch periods, help with data recording, and review data quality. Watch times will start at sunrise (~8:30 am early October, ~9:45 am late October) and end at sunset (~5:15 pm early October, ~4:00 pm late October).

Each morning at 7:15 am before breakfast, the SBO team will meet on the bridge of the *Botnica* for a daily toolbox session where the team will review Baffinland's daily health and safety updates and discuss the daily plan and any health and safety issues that have come up for the team.

Table 1: Proposed MWO Schedules – Single vessel (one visual observer and one data recorder per side)

Three-Day Rotating Schedule	Survey Day 1	Survey Day 2	Survey Day 3	Survey Day 1	Survey Day 2	Survey Day 3	Seabird Observer	Team Lead (6th MWO)
	Port	Port	Port	Starboard	Starboard	Starboard		
07:00-07:30	7:15 Toolbox	7:15 Toolbox	7:15 Toolbox	7:15 Toolbox	7:15 Toolbox	7:15 Toolbox	7:15 Toolbox	Ensure databases are open with GPS's connected (logging data), 7:15 Toolbox
07:30-08:00	07:30 breakfast	07:30 breakfast	07:30 breakfast	07:30 breakfast	07:30 breakfast	07:30 breakfast	07:30 breakfast	07:30 breakfast
08:00-09:00	MWO1, MWO2	MWO4, MWO5	MWO2, MWO3, BirdObs	MWO5, MWO6	MWO3, MWO1	MWO6, MWO4	Bird Obs to conduct bird surveys and support MWO team/Team lead when needed	MWO, check-in @ 0900, QAQC and reporting
09:00-10:00	MWO3, MWO1	MWO6, MWO4, BirdObs	MWO1, MWO2	MWO4, MWO5	MWO2, MWO3	MWO5, MWO6		
10:00-11:00	MWO2, MWO3	MWO5, MWO6	MWO3, MWO1	MWO6, MWO4, BirdObs	MWO1, MWO2	MWO4, MWO5		QAQC and reporting
11:00-12:00	MWO1, MWO2	MWO4, MWO5	MWO2, MWO3, BirdObs	MWO5, MWO6	MWO3, MWO1	MWO6, MWO4		
12:00-12:30	**LUNCH - Team 1 and Team 2 MWOs to ensure ongoing observation coverage**							
12:30-1:00	MWO3, MWO1	MWO6, MWO4, BirdObs	MWO1, MWO2	MWO4, MWO5	MWO2, MWO3	MWO5, MWO6		
12:00-1:00	MWO2, MWO3	MWO5, MWO6	MWO3, MWO1	MWO6, MWO4, BirdObs	MWO1, MWO2	MWO4, MWO5		
1:00-2:00	MWO1, MWO2	MWO4, MWO5	MWO2, MWO3, BirdObs	MWO5, MWO6	MWO3, MWO1	MWO6, MWO4		
2:00-3:00	MWO3, MWO1	MWO6, MWO4, BirdObs	MWO1, MWO2	MWO4, MWO5	MWO2, MWO3	MWO5, MWO6		
3:00-4:00	MWO2, MWO3	MWO5, MWO6	MWO3, MWO1	MWO6, MWO4, BirdObs	MWO1, MWO2	MWO4, MWO5		
4:00-5:30	MWO1, MWO2	MWO4, MWO5	MWO2, MWO3, BirdObs	MWO5, MWO6	MWO3, MWO1	MWO6, MWO4		
								QAQC and reporting, back up data, check-in @ 1830, daily report submission

MWO Team	Day 1 - MWO Hours	Day 2 - MWO Hours	Day 3 - MWO Hours	Day 4 - MWO Hours	Day 4 - MWO Hours	Day 5 - MWO Hours	3-Day Total MWO Hours
Team 1							
MWO1	7:00		6:00		7:00		**20:00**
MWO2	7:00		6:00		6:00		**19:00**
MWO3	6:00		7:00		7:00		**20:00**
Team 2							
MWO5		7:00		7:00		6:00	**20:00**
MWO4		7:00		6:00		7:00	**20:00**
MWO6		6:00		7:00		6:00	**19:00**
Seabird Observer							
BirdObs		3:00	4:00	3:00			**10:00**

Table 2: Proposed MWO Schedules – two-vessel (one visual observer, one data recorder)

24 Hr clock (EDT)	12 Hr clock (EDT)	Ship-based Observer			Golder Crew Lead MWO watches according to schedule (3rd MWO)
		MWO1	MWO2	MWO3	
07:00-07:30	07:00-07:30	7:15 Toolbox	7:15 Toolbox	7:15 Toolbox	Ensure databases are open with GPS's connected (logging data), 7:15 Toolbox
07:30-08:00	07:30-08:00	07:30 breakfast	07:30 breakfast	07:30 breakfast	07:30 breakfast
08:00-08:30	08:00-08:30	Watch 1 (Both)	Watch 1 (Data)		check-in @ 0900, QAQC and reporting around WMO watches
08:30-09:00	08:30-09:00	Watch 1 (Both)	Watch 1 (Data)		
09:00-09:30	09:00-09:30	Watch 2 (Data)		Watch 2 (Both)	
09:30-10:00	09:30-10:00	Watch 2 (Data)		Watch 2 (Both)	
10:00-10:30	10:00-10:30		Watch 3 (Both)	Watch 3 (Data)	QAQC and reporting around MWO watches
10:30-11:00	10:30-11:00		Watch 3 (Both)	Watch 3 (Data)	
11:00-11:30	11:00-11:30	Watch 4 (Both)	Watch 4 (Data)		
11:30-12:00	11:30-12:00	Watch 4 (Both)	Watch 4 (Data)	11:30 lunch	11:30 lunch or QAQC and reporting around MWO watches
12:00-12:30	12:00-12:30	Lunch then Watch 5 (Data)	Cover MWO3 (Both) for lunch	Watch 5 (Both)	QAQC and reporting or 12:00 lunch
12:30-13:00	12:30-13:00	Watch 5 (Data)		Watch 5 (Both)	
13:00-13:30	1:00 - 1:30		Watch 6 (Both)	Watch 6 (Data)	
13:30-14:00	1:30 - 2:00		Watch 6 (Both)	Watch 6 (Data)	
14:00-14:30	2:00 - 2:30	Watch 7 (Both)	Watch 7 (Data)		QAQC and reporting around MWO watches
14:30-15:00	2:30 - 3:00	Watch 7 (Both)	Watch 7 (Data)		
15:00-15:30	3:00 - 3:30	Watch 8 (Data)		Watch 8 (Both)	
15:30-16:00	3:30 - 4:00	Watch 8 (Data)		Watch 8 (Both)	
16:00-16:30	4:00 - 4:30		Watch 9 (Both)	Watch 9 (Data)	QAQC and reporting around MWO watches
16:30-17:00	4:30 - 5:00		Watch 9 (Both)	Watch 9 (Data)	
17:00-17:30	5:00 - 5:30	Watch 10 (Both)	Watch 10 (Data)		
17:30-18:00	5:30 - 6:00	Watch 10 (Both)	Watch 10 (Data)		
18:00-18:30	6:00 - 6:30	18:00 Dinner	18:00 Dinner	18:00 Dinner	QAQC and reporting, back up data, check-in @ 1830, daily report submission
Total hours		7:00	7:30	6:00	

6.2 Observer Position

MWOs will rotate between starboard, port or full view observer and data recorder positions. Observers on visual watch will each focus their survey efforts to their side of the vessel with some overlap at the bow (~10°) to ensure proper coverage where the two observation areas meet. When the vessel is in-transit, marine mammal observations will consist of scanning the water from the bow (0°) to the stern (180°), focusing on the water ahead and to the side(s) of the moving vessel (from 350° on port to 120° on starboard or 10° on starboard to 240° on port; Figure 4 and Figure 8). When the vessel is stationary, MWOs should regularly move around the bridge changing their visual search area to cover the entire area around the vessel (Figure 5). The port and starboard data recorders will be responsible for entering observer data, e.g., environmental data, vessel activity data, and sightings data, as visual observers provide them information.

Figure 3: MWO port side and seabird observer workstation on the Botnica

If there is only one MWO present on the bridge, they will be responsible for surveying the entire area around the vessel (360°) from the middle of the bridge. When the vessel is in-transit, the observer will scan from the bow (0°) to the stern (180°), focusing on the water ahead and to the side(s) of the moving vessel (from 0° to 120° on the starboard side and 0° to 240° on the port side, Figure 6). When the vessel is stationary, the MWO should regularly change their search area to cover the entire area around the vessel (Figure 7). If there is only one observer on visual effort, the MWO will have to ensure they move from the starboard side to the port side of the vessel to cover both sides of the vessel.

The bridge on the *Botnica* is 20 m above sea level (ASL) and the bridge of the *Fennica* is 27 m ASL allowing for good visibility around both vessels.

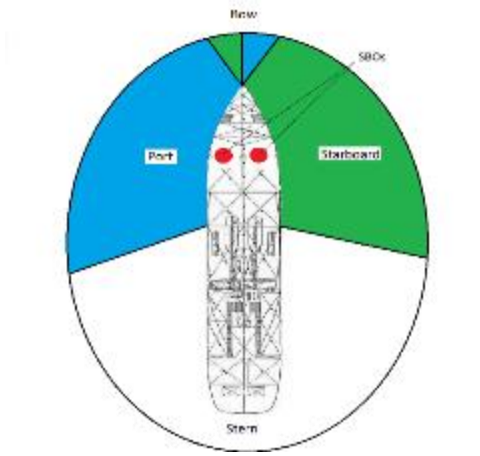


Figure 4: MWO locations (two MWOs) and Field of Observation when Vessel is Moving

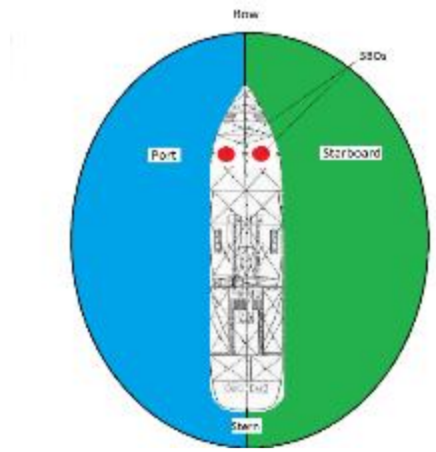


Figure 5: MWO location (two MWOs) and Field of Observation when Vessel is Stationary

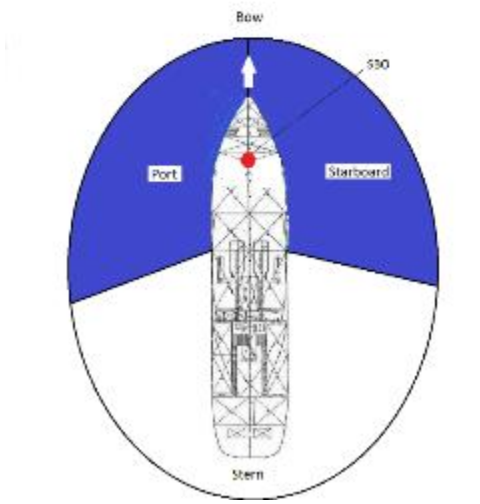


Figure 6: MWO location (one MWO) and Field of Observation when Vessel is Moving

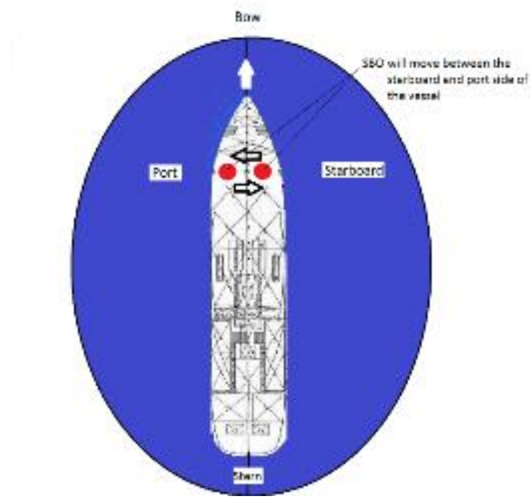


Figure 7: MWO location (one MWO) and Field of Observation when Vessel is Stationary

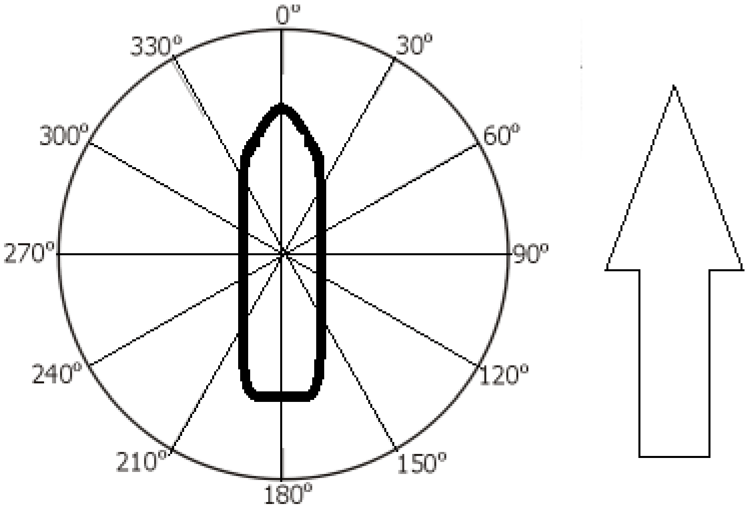


Figure 8: Degrees in Relation to the Vessel

Figure 9: The *Botnica* Bridge – view to the port side (left) and starboard side (right)

Figure 10: The *Fennica* Bridge as viewed from the port side

6.3 Equipment

Binoculars

Typical binoculars increase objects 7 to 10 times (i.e., 7x or 10x).

Three types of binoculars are used during visual watches:

- 7x50 reticle binoculars - typically used for scanning and estimating distances.
- 8x42 and 10x42 - for higher magnification of marine mammal observations, i.e., for species identification.
- 40x100 Big Eye binoculars - for higher magnification of marine mammal observations at distance, e.g., for species identification, group size, and behaviour observation purposes.

Team members should regularly clean the binocular eye pieces with an alcohol based antiseptic cloth when sharing binoculars with other individuals. This prevents the spread of eye infections which are usually highly contagious. Don't use the antiseptic cloth to clean lenses. If the binoculars contact ocean water, rinse them with fresh water and let them dry. Use a soft cloth to clean the lenses as they are prone to scratches, and some have protective coats that can wear out. There will be wipes that can be used on the binoculars as part of the SBO kit.

7x50 Reticle Binoculars

Reticle binoculars have a scale built inside the lenses, called a reticle, which is used to estimate distances of objects. This will be discussed in greater detail below.

8x42 or 10x42 Binoculars

8 and 10x42 binoculars will also be used. They will have slightly greater magnification to use for identification.

40x100 Big Eye binoculars

Big Eye binoculars (40 x 100) will be used for verifying species, group sizes and spatial distribution, e.g., clusters of seal on ice, and behaviours.

Additional Distance Measurement Equipment

Clinometer

Depression angle from the horizon to the sighting is determined using a clinometer. Use only one clinometer reading for the center of a group (no angle ranges). These are typically used during aerial surveys and will be used experimentally for practicing and calibrating distance estimation between observers in 2023.

Bearing Measurement

Pelorus

Relative bearings to sightings (measured against ship's ahead) will be taken using a pelorus. Two peloruses will be mounted on the bridge accounting for the best location for an all-around view of the observation area. One pelorus will be mounted on the port side and one on the starboard side of the bridge. Use only one bearing reading for the center of a group (don't record bearing ranges).

It is important to ensure that the ahead mark points exactly to the ship's ahead direction as any misalignment will cause an error in bearings. The WSP Biologists will work with the vessel officers ensure that the peloruses are aligned correctly depending on where they are mounted on the vessel.

Global Position Systems (GPSs)

Three different types of GPSs will be available to provide location data during the survey including the GLO2 GPS, SU-353 GPS, and Bad Elf GPS.

GLO2 GPS

The GLO2 GPS will be used to record vessel tracks to the MWO database during marine mammal surveys so that we can track effort and record latitude and longitude location when:

- a sighting is made (marine mammal, another vessel)
- the start of a visual survey effort watch period and when environmental observations and vessel activity is recorded.

The GPS should be turned on and paired with the tablet and *Survey 123* (MWO database) application at the start of the first watch. To turn on and pair the GPS:

- Hold the power button located on the top of the device. It may take a few minutes for the device to acquire satellites. The GPS has a built-in antenna to acquire a signal. When the GPS is flashing green, it is searching for satellites, when it is solid green, it has a fix on satellites.
- Turn on the Samsung tablet or iPad - hold middle button on right side of the Samsung tablet or the button on the top right of the iPad. Enable the Bluetooth in the Settings menu and then select the GPS by name, which will show up in the list of available devices. If you have trouble finding the correct GPS, try turning Bluetooth on and off again and the active GPS should pop up. Click on *Pair* when prompted and remember the ID of the GPS now connected.

- Open the *Survey 123* application and select the satellite symbol at the top right of the screen, then select the settings symbol at the top right of the next screen. Select the connected GPS by name from the list. Do not select *Integrated Provider* or the application will try to connect to satellites via the cell service provider which we will not have in most of the survey area. The application will tell you the sensor has been connected.
- You can now go back to the main *Survey 123* page and select *Aquatics Marine Mammal* to access the survey forms.

Survey 123 does not log track data. In addition to tracks being recorded by a Bad Elf GPS, another application, called *Field Maps* (discussed later), will record track data from the Glo2 GPS.

SU-353 GPS

An SU-353 GPS can be used to feed GPS data into both the MWO and seabird databases. The SU-353 GPS should be turned on and set up with the MWO or seabird databases at the start of watch.

You do not need to turn this GPS on like you do the Bad Elf, just plug it into a USB port on the computer and follow the instructions to connect it to the seabird database (see Appendix A).

Bad Elf GPS

The Bad Elf GPS will be used to record daily track data and as an alternate to the GLO2 or SU-353 GPSs for use with the *Survey 123* MWO or seabirds databases.

The Bad Elf GPS should be turned on at the start of the first watch. To turn on the Bad Elf GPS hold the “ON” button located on the top left of the device. It may take a few minutes for the device to acquire satellites. The GPS’s have built in antennae to acquire a signal. See Appendix A to connect the Bad Elf GPS if you’re working off the computer.

The Bad Elf GPS should be set to *log GPS track data continuously*. To turn on logging, press and hold the GPS button for 3 seconds and when it has started logging the LCD display will show a blinking icon along the bottom of the display. Check the GPS regularly during your shift to ensure that it has not lost signal and is working properly.

****IMPORTANT****

- Every time you turn the GPS on and off again make sure to RESTART LOGGING.
- Make sure to download the GPS tracks from the Bad Elf GPS daily so we don’t lose data when the GPS starts writing over older tracks.
- One glitch with the Bad Elf GPS is that files longer than 8 hours cannot be accessed. Download GPS tracks halfway through the survey day otherwise the track file will be too large if it is logging data longer than 8 hours.

Cameras

Two cameras will be available for collecting photographic data: a Canon EOS 5DS DSLR with a Canon 100-400 mm lens and one Nikon CoolPix P1000 Super-telephoto (3000mm zoom) camera.

Figure 11: Canon EOS 5DS DSLR (left) and Canon 100-400 mm lens (right)

Figure 12: Nikon Coolpix P1000

6.4 Observing Techniques

To ease the strain on the observers' eyes, two types of scanning techniques are used to detect marine mammals: U and S scans (Figure 13). S-scan method consist of scanning the water parallel to the horizon (in an s-shaped pattern) and U-scans consist of scanning the water perpendicular to the horizon (shaped like the letter u). These scanning techniques should be used every 20 seconds to avoid observer fatigue. These are some helpful hints to implement in your active scanning routine:

- Continuously scan the water with the naked eye using the S and U techniques.
- Use binoculars to occasionally scan the horizon and to focus in on possible sightings. Binoculars decrease your observing area by focusing your view on a small area, so it is best not to use them continuously to scan.

- Use higher magnification binoculars for sightings at far distances. It can be more difficult to focus binoculars with higher magnification in rough sea conditions.
- Be ready to observe the next sighting; keep your eyes moving and scanning the field of view as soon as possible after gathering all information about a sighting. Working with a data recorder will help minimise lost observation time.
- Regularly change the distance of your view, do not just look at the horizon or just at the water close to the vessel.
- Keeping your eyes moving and switching your field of view regularly helps keep you alert. You will be less likely to become ‘bored’ and forget that you are actively searching for cues of marine mammals and other wildlife.
- Watch for sighting cues (discussed in more detail below).

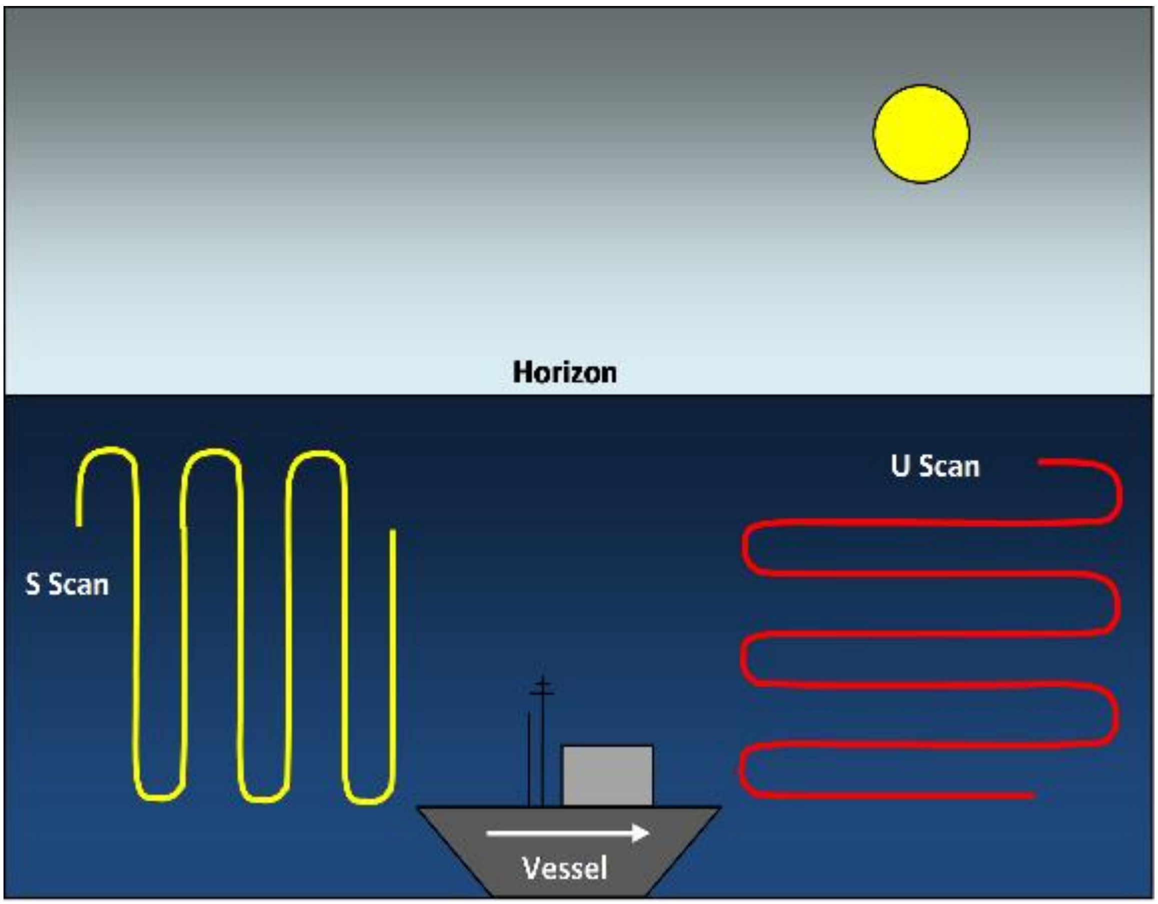


Figure 13: S and U Scanning Techniques to be used during Marine Mammal Observing

6.5 Estimating Distances

Accurately estimating distances is the most important MWO skill and is learned with regular practice. Some helpful resources when trying to estimate the distance to a sighting is:

- use known distance to shore (from nautical charts, vessel's radar, GPS plotters) as a reference.
- If you can see the horizon, use reticle binoculars.
- Clinometers can be used to collect data on the angle the sighting is from the vessel.
- Practice between sightings using references to known object on the radar and/or the clinometer.
- ask others on the bridge – the crew is a great resource.

Calculating Distance Using Reticle Binoculars

Reticle binoculars can be used to estimate the distance to a sighting if the following information is present/known:

- a horizon is present and is not obscured (by fog or land).
- the height above sea-level to the eye of the person sighting the marine mammal is known.

It is useful to generate a distance table (see Table 3) prior to the start of a field program once the MWOs have been identified (eye height is known) and the vessel platform has been decided (platform high above sea level).

Making a Distance Table

Estimating distances based on reticle readings depends on the distance to the horizon which is dependent on:

- the height of the observer eye above sea level in metres.
- radians per reticle mark for the type of binoculars you are using.

The milliradians (mils) per reticle mark for Fujinon 7X50 reticle binoculars is 5 (Fujinon 2006). We use this number to produce a distance table for each project and each person (if the height of individuals differs significantly) using the following equation:

Distance = (eye height + height above sea level in meters) x 1000 / # of mils or milliradians.

For the purposes of this manual, we have assumed that everyone is 1.8 m to eye level. We know that the height of the *Botnica*'s bridge is 20 m above sea level = total 21.8 m. With these assumptions we can generate the following table.

Table 3: Reticle Distance Table Example

Number of Reticles	# milliradians (mils)	Eye Height* + Height Above Sea Level	Distance in Metres to Sighting
1	5	21.8	4360
2	10	21.8	2180
3	15	21.8	1453
4	20	21.8	1090
5	25	21.8	872
6	30	21.8	727
7	35	21.8	623
8	40	21.8	545
9	45	21.8	484
10	50	21.8	436
11	55	21.8	396
12	60	21.8	363
13	65	21.8	335
14	70	21.8	311

Notes: Distance = (eye height + height above sea level in metres) x 1000 / # of mils (Fujinon 2006).
Assumptions: eye height = 1.8 m, height above sea level = 20 m (*Botnica*)
* Eye height will vary slightly between individuals
Each Reticle = 5 milliradians also called mils

How to use the Fujinon reticle binoculars:

1. Make sure your binoculars are in focus.
2. Line up the top reticle line with the horizon.
3. Count from the horizon (top reticle) down, how many lines there are to the marine mammal.
4. Use the number of lines counted and the distance calculation table to find out the distance to the marine mammal.

Example: Look at Figure 14 and estimate the distance to the marine mammal using Table 3 above.

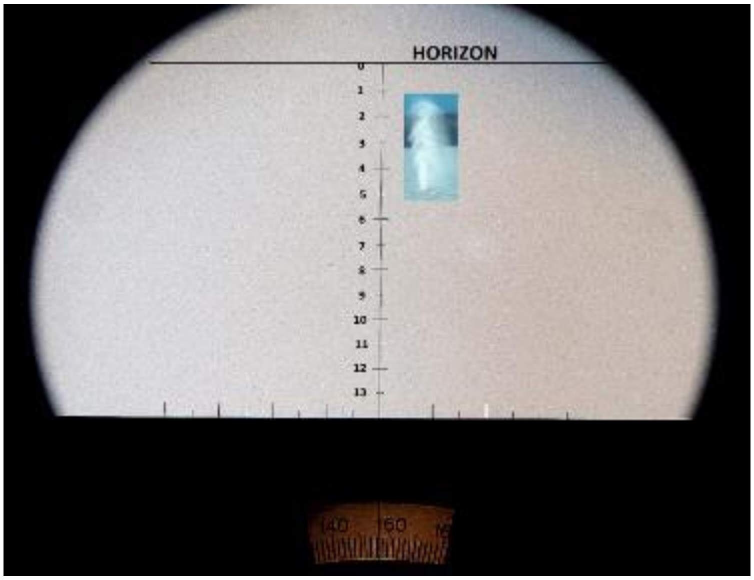
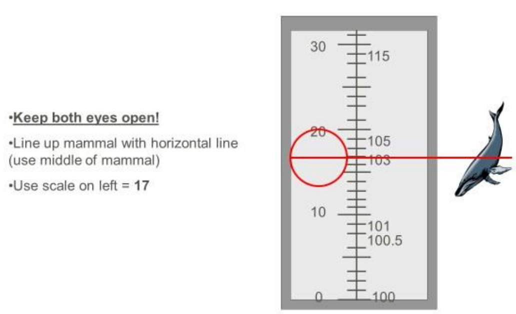


Figure 14: Calculate the Distance to the Marine Mammal

Calculating Distance Using a Clinometer

Clinometers:



- Keep both eyes open and, looking through the clinometer, line up the horizontal line with the centre portion of the animal.
- Record the number on the left that the horizontal line passes through.
- If a group of several animals is sighted, measure from the centre of the group.

Figure 15: Using a clinometer to measure distance

6.6 Detection Cues

Marine mammals spend most of their time underwater, therefore, MWOs can only spot them when they are at the surface which in most instances is for a very short amount of time. Detection cues are useful to know as they can mark the presence of marine mammals even when they have not fully surfaced. Below is a list of detection cues that will be useful to know when performing MWO duties.

Body

Often a marine mammal is first observed when you see its body, e.g., seals on ice, a whale's back or tail as it dives, etc.

Figure 16: Sighting cues - body

Splash

Splashes may be a sign that a marine mammal is present (Figure 17).

Figure 17: Sighting cues - splash

Footprints

Footprints occur when a marine mammal has just been on or near the surface of the water and the surface looks disturbed and different from the surrounding water (see Figure 18).

Figure 18: Sighting cue – footprint

Birds

Birds may be attracted to marine mammals when they are feeding. Keep an eye out for bird aggregations near the surface of the water and diving into the water (Figure 19).

Figure 19: Sighting cue - birds

Blows

Marine mammals breathe air requiring them to surface between dives, even if for a short time. When whales surface, they often expel a watery mist from their blowholes. Blows vary in size and can be seen from very far distances. This is the one of the most common detection cues. During calm conditions, blows may also be heard.

Baleen whales (bowhead whales) and toothed whales (narwhals, belugas, and killer whales) have different blows.

Toothed whale blow (narwhals, belugas, killer whales, sperm whales)

Toothed whales have only one single blow hole and, because they are smaller animals than the baleen whales we might observe, e.g., bowhead whales, that their blows are shorter and wider than baleen whale blows (Figure 20). Blows of toothed whales are not often seen from far distances, and at times, not seen at all.

Baleen whale blow (bowhead whales)

Because baleen whales have two blowholes; their blows are wider apart and sometimes V-shaped or heart-shape (Figure 20). Baleen whale blows are also much higher than toothed whale blows at times and can be observed from greater than one kilometre away.

Figure 20: Baleen whale blow (left) versus toothed whale blow (right)

6.7 Species Identification

Identifying the species of a marine mammal you have observed is a task that is learned through training and experience. If you are local to the area, you likely already know more than we do!

If you are unsure about what species you have spotted you can ask other team members on the bridge to help you identify the animal, including another MWO and the WSP lead. It is also a good idea to take a photo as soon as you see the sighting. Photos can be useful to confirm species identification. Marine mammal cues can sometimes look different from an elevated surface like that of the bridge of a large vessel compared to viewing from smaller vessels at the water surface. It may take a few sightings to get used to cues from a different observation platform. If you are not 100% confident but fairly confident of the species identification, record the sighting as a 'possible' species identification otherwise record it as an *unidentified* species.

Marine mammals that could potentially occur in the area include:

- narwhal
- beluga whale
- killer whale
- bowhead whale
- sperm whale
- ringed seal
- harp seal
- hooded seal
- bearded seal
- walrus
- polar bear

Here are some helpful hints to distinguish between the common marine mammals you will likely see in the area.

6.7.1 Whales

If you spot what you think is a whale, the first questions to ask are:

- what is the shape of the blow?
- what is the size of the whale?
- what is the colour?
- do you see a tusk?

Here are some quick tips, keeping in mind that windy conditions can change the shape or angle of a blow:

- If it is a large whale with a V-shaped blow, then it is likely a **bowhead whale**.
- If it is a large whale with a low, bushy blow angled to the side (their single nostril exhales forward and left), then it is likely a **sperm whale**.
- If it is smaller with a lower, bushy blow and white body then it is likely a **beluga whale**.
- If it is smaller with a lower bushy blow and a dark body, then it is likely a **narwhal.**
- If it is smaller with a lower bushy blow and a large dorsal fin, then it is likely a **killer whale.**

Narwhal

Figure 21: Narwhal

Adult male narwhals are easily recognizable by their long, spiraled tusk that can extend up to nine feet. Narwhals do not have functional teeth inside the mouth, but males (and some females) continuously grow one of two upper jaw teeth through their lips. The narwhal is a relatively small whale (4.7 m) with a sleek grey and white spotted body. Their head is blunt, lacking a beak, and they lack a dorsal fin. The pectoral flippers are small and rounded, and their fluke is noticeably convex at the terminal end. They occasionally lift their flukes while diving. Narwhals follow the receding Arctic ice in the summers deep into non-frozen waters of bays and fjords and migrate out to sea as winter ice grows. Light colored females and young adults can sometimes be mistaken for belugas, but generally a few individuals in a group of narwhals will display identifiable characteristics. Large congregations of hundreds of animals occur in the summer months.

Beluga Whale

Figure 22: Beluga whale

As the only marine mammal that is completely white, the beluga whale is easily recognizable. Its skin can at times have a yellowish tint. Belugas have a relatively small body size (as with the narwhal) of between 2.7 to 4.2 m long. The head is blunt, containing a protruding melon. Their fins are small, and they have a narrow ridge instead of a dorsal fin. They rarely raise their flukes when diving. Belugas are very social, often found in groups of 5 to 15 individuals and even aggregations of thousands in some estuarine areas and bays. They display a strong site fidelity to their natal bays. They can sometimes be mistaken for young harp seals, ice, or white birds.

Killer Whale

Killer whales will be the only whale you may see with a prominent dorsal fin. They are mid-sized whales (larger than narwhals and belugas) and can reach up to 9 m in length. Their other distinguishing feature is their dark black bodies with white eye and saddle patches. It should be easy to spot and identify killer whales during the program.

Figure 23: Killer whales

Bowhead Whale

Figure 24: Bowhead whale

The bowhead has a black robust body lacking a dorsal fin, a massive head, and a highly arched jaw line. Distinguishing features are a white lower chin patch and a hump anterior of the blowholes followed by a depression. The immense head can break through ice 1.8 meters thick. Their blows are also V-shaped when seen from the front or from behind and they often raise their fluke when diving. They are closely associated with sea ice and follow the receding ice in the northern hemisphere summers.

Sperm Whale

Sperm whales are not common in the RSA however they are occasionally observed in the vicinity of Pond Inlet, in Eclipse Sound. Sperm whales have very long (up to 18.3 m), log-like and usually finless bodies. There is a distinct triangular or rounded hump 2/3 of the way along their back. They have dusky grey-brown wrinkled skin which can appear black or paler brown depending on the lighting. Sperm whales have huge box-like heads (rarely seen) with a blunt snout and a slit-like blowhole on the side at the front of the rostrum. They have broad, triangular-shaped, dark tail flukes that are deeply notched and often have a ragged trailing edge. Sperm whales dive with a deep arching roll, with tailstock and flukes raised vertically as they sink.

Figure 25: Sperm whale

6.7.2 Seals and Walruses

Ringed Seal

Ringed seals are the smallest and most common species of seal in the Arctic. They are the most important prey species for polar bears. Ringed seals have plump bodies and small heads with short snouts. They are generally dark dorsally with irregular ring patterns and lighter on the ventral side. Pups are born white and shed this coat at 6 to 8 weeks of age after which they are uniformly dark until their first molt. Like the bearded seal, they are also closely associated with sea ice. Ringed seals are also often observed alone and do not often aggregate in large groups. Ringed seal moult in June and July when they haul-out on the sea ice.


Figure 26: Ringed seal

Harp Seal

Harp seals are distinguishable from ringed seals in their horseshoe-shaped dark saddle patch on their backs. Pups are born with white fluffy coats until 3 to 4 weeks of age when the white coat is replaced with a silver coat with some scattered spots. Adult harp seals have robust bodies and small heads with broad flat narrow snouts. They have light gray coats with black faces and a black saddle patch. Younger individuals may appear spotted as their saddle patch develops with each moult. Aggregations are observed during breeding (February to March) and in spring when moulting. Groups may also form during feeding and migrating activities.


Figure 27: Harp seal

Bearded Seal

Bearded seals are one of the largest seals in the Arctic. Its distinguishing characteristic is a dense “beard” of whiskers on its upper lip. Its large body is offset by its small blunt head with large cheeks. The square fore flippers are small relative to the body making it appear stockier and more robust than other seals. Adults are gray or dark brown with some spots or rings visible. Pups are also brown to bluish. Bearded seals are generally associated with drifting sea ice in shallow-water areas. They are more commonly observed alone, however, aggregations may occur when drifting sea ice becomes concentrated. During the months of April to August bearded seals will spend more time hauled out for molting.

Figure 28: Bearded seal

Hooded Seal

The hooded seal is a large seal named after their distinctive nasal cavities that can be inflated by males during the mating season. Males are larger than females. They have silver-gray fur with black spots of various shapes and sizes. Hooded seal pups, also called blue-backs, have blue-gray fur on their backs and white fur on their bellies and they shed this coat when they’re about 14 months old. Hooded seals are not very social and are usually seen alone or in small groups.

Figure 29: Hooded seals

Walrus

Walruses are easily distinguished from other seals by their large bodies and tusks. They have a thick bunch of whiskers on their cheeks. Adult males are usually much larger than females. Skin colour varies and can appear pale beige to bright pink. Newborns have greyish-brown hair. In the summer, walruses haul-out on pebble and sandy beaches in large aggregations to moult and rest.

Figure 30: Walrus

6.7.3 Polar Bear

Polar bears are easily distinguishable from other marine mammals. On the ice, polar bears appear to have a yellow tint. Keep in mind that you may observe a polar bear swimming in the ocean. Its pointed snout should allow you to distinguish it from seals.

Figure 31: Polar Bear

In addition to recording the number of bears in a group of polar bears (classified as bears within 10 adult bear body lengths of each other, Smultea et al. 2016), we will record the age class of each bear in a group which can be classified visually by size and relative size (see Section 6.11.1.5).

6.8 Behaviours

Behaviours will need to be recognized and recorded during the survey. Behaviours will be classed according to species classes: seal and walrus, polar bear, and whales. We will be recording behavior in two separate instances when there is a sighting; what the animals were doing upon initial sighting and any changes in behaviour that could indicate a response to the presence and/or activity of the icebreaker. The following is a list of behaviours you may see while observing marine mammals by Species Group:

6.8.1 Whales

Traveling – When a whale is swimming with a definite heading.

Traveling (Traveling Slowly Away) – When a whale is swimming at a slow or normal with a definite heading. If you the vessel is close enough to observe it, there will be a barely visible trail or small amount of white water trailing behind.

Figure 32: Narwhal traveling

Traveling (Traveling Fast Away) – When a marine mammal is swimming rapidly through the water. Fast swimming is often associated with splashes in the water from the animal moving quickly through it.

If a whale or group of whale's behaviour changes in response to the vessel's presence or activities, e.g., there is obvious movement away from the vessel at a fast swim speed, creating whitewater (fleeing), record in the Behaviour in Response to Vessel section.

Figure 33: Whale traveling fast

Blow – When a whale releases air from its lungs at the surface of the water. Blows can be visible from far distances and are observed as clouds moist air at the surface of the water

Figure 34: Whale blows

Resting – When a whale or group of whales are traveling very slowly and not making much forward progress.

Figure 35: Resting whale

Milling – When a whale or whales swim slowly in a limited area with no travel direction. Swimming in circles is an example of milling.

Figure 36: Milling whales

Feeding – When a whale is obviously feeding or foraging, e.g., mouth is open, prey can be seen.

Figure 37: Feeding whales

Porpoising - When whales are traveling at high speeds they will jump in and out of the water rapidly.

Figure 38: Porpoising whale

Dive (Normal or Rapid Dive/Splash) - When a marine mammal dives beneath the surface. A whale can dive with or without lifting its fluke.

If a whale's behaviour changes in response to the vessel's presence or activities, e.g., the whale dives suddenly with a splash with or without lifting its fluke, record in the Behaviour in Response to Vessel section.

Figure 39: Diving whale

Breach – When a whale leaps with its entire body out of the water and lands on the surface.

Figure 40: Breaching whale

Lobtail – When a whale slaps the water surface with its tail fluke, sometimes repeatedly.

Figure 41: Lobtail

Logging - Logging can be a form of resting when a whale or whales lie quietly at the surface. As they float motionless, part of the head, dorsal fin or other parts of the back are exposed.

Figure 42: Logging

Spyhopping – When a whale raises its head vertically out of the water so that its eyes are clear of the surface.

Figure 43: Spyhop

Approaching – Whale or whales observed moving towards the vessel.

Change Direction – Whale or whales observed changing their travel direction.

No Reaction - No whale behavioral response observed.

Unknown – It is unknown whether the whale responsed, e.g., the sighting was lost, the group disappeared but the response behaviour was not observed.

6.8.2 Seal and Walrus

Resting - Seals and walrus will haul-out onto ice and land to rest, often in large aggregations. They can also sleep in the water by either ‘logging’ (sleeping horizontally without moving) or ‘bottling’ (sleeping vertically in the water, with their nose pointed above the surface to breathe) (Figure 44).

Figure 44: Resting seal and walrus

Traveling – When an individual or group of seals are traveling steadily in one direction. When recording behavioural responses (if they occur) we will note if seal or walrus are traveling slowly or quickly toward or away from the vessel.

Figure 45: Traveling ringed (top) and harp (bottom) seals

Porpoising – When seals are traveling at high speeds they will jump in and out of the water rapidly. This is like the porpoising behaviour of whales and dolphins (Figure 46).

Figure 46: Porpoising seals

Figure 47: Scanning seal

Scan – When a seal is in an upright position with its head out of the water (not traveling) and looks at a vessel. Can occur both in water and when hauled-out on land or ice. Whales are more likely to exhibit 'spyhopping' than scanning.

Figure 48: Scanning seal

Diving – When a seal observed at the surface dives underwater. Can be a normal dive, i.e., the seal rolls slowly or moderately into a dive from the surface, or a rapid dive, i.e., the seal dives underwater rapidly often with a splash. Sometimes all you see is the disturbance of the water at the surface and a ‘footprint’ left behind after the seal dives (Figure 49).

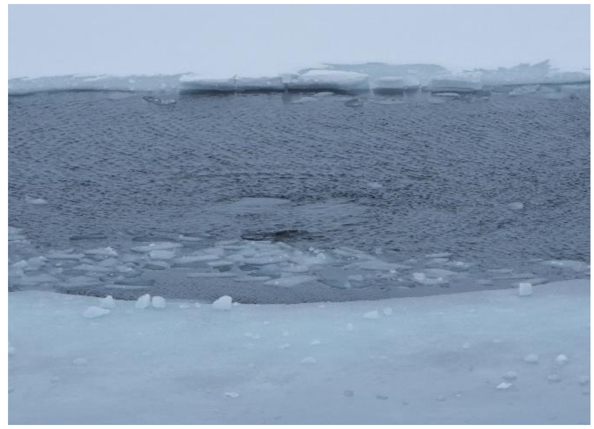


Figure 49: Seal footprint after diving

Flush - Seal behaviour that began as hauled out resting on ice or land progressing to the seal being alert and scanning, to moving from its location on ice or land into the water (i.e., changing from a resting behavior out of water to in water; Jansen et al. 2010).

An example of flushing behavior exhibited by a bearded seal is depicted in the photo sequence (Lomac-MacNair, Andrade, and Esteves 2019).

The bearded seal transitions from resting behavior on ice to in water. The seal progressed from resting (Figure 50; A) to alert (B and C), to flushing into the water (D–F) (Lomac-MacNair, Andrade and Esteves 2019).

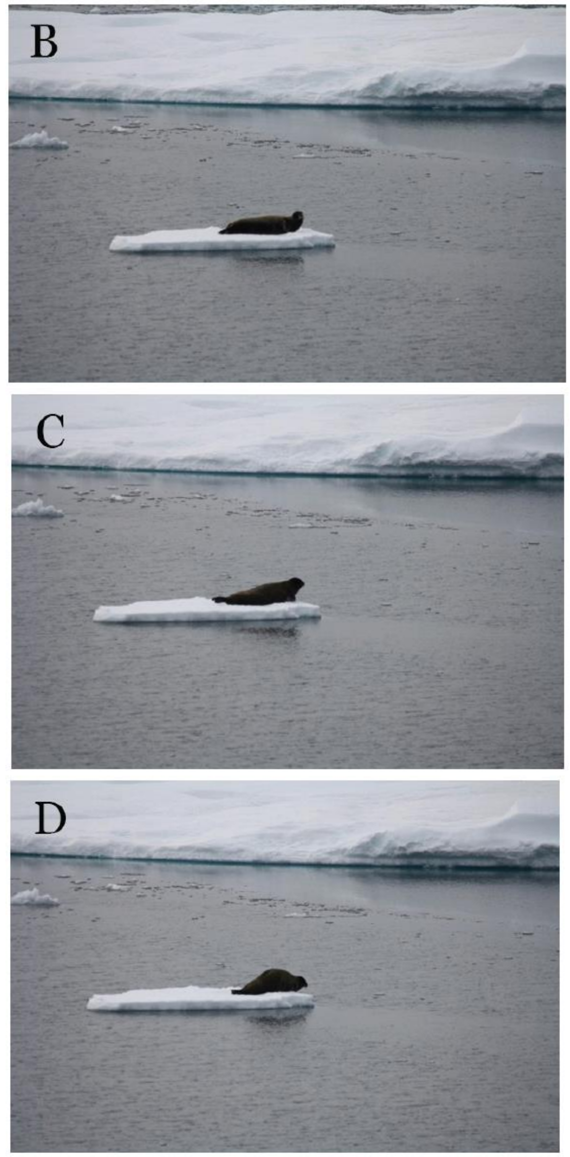

B
C
D

Figure 50: Seal flush sequence (A-F)

No Response - No seal behavioral response observed.

Unknown – It is unknown whether the seal group responded, e.g., the sighting was lost, the group disappeared, or the response behaviour was not observed.

6.8.3 Polar Bear Behaviour

Walking (Walking away) – Polar bear or bears observed walking on ice or land at a slow gait.

If the polar bear's behaviour changes in response to the vessel's presence or activities, e.g., there is obvious movement away from the vessel at a slow pace (walk or slow swim speed), record in the Behaviour in Response to Vessel section.

Figure 51: Walking polar bear

Running (Running away) – Polar bear or bears observed running on ice or land at a fast gait.

If the polar bear's behaviour changes in response to the vessel's presence or activities, e.g., there is obvious movement away from the vessel at run speed or at fast swim speed, creating whitewater (fleeing), record in the Behaviour in Response to Vessel section.

Figure 52: Running polar bear

Swimming – Polar bear or bears observed swimming through water. Distinguishable from seals when observed swimming with its pointed snout.

Figure 53: Swimming polar bear

Resting – Polar bear or bears sitting or lying prone in the same spot with head on the ground or paws, with legs sprawled out or front legs tucked under the body, with flank and hindquarters on the ground, or curled up, often sleeping with eyes closed (Øritsland, 1970).

Figure 54: Resting polar bear

Feeding/Foraging – Polar bear or bears observed eating prey (seal, walrus, or whale carcass). Also includes apparent hunting or foraging without moving (e.g., staring for long periods at a breathing hole in the ice, Smultea et al. 2016).

Figure 55: Feeding (top) and foraging (bottom) polar bears

Social – Polar bears interacting with each other, e.g., cubs at play, mother and cub interactions, fighting, etc.

Figure 56: Socialising polar bears

Displaying Vigilance - A head lift interrupting ongoing bear activity, involving visual scanning of the surroundings beyond the immediate vicinity (Dyck and Baydack, 2004). This includes watching the vessel or sniffing the air, usually with the nose elevated above the ears.

Figure 57: Polar bear displaying vigilance

Approaching – Polar bear or bears observed moving towards the vessel.

No Reaction - No seal behavioral response observed.

Unknown – It is unknown whether the bear responded, e.g., it is unclear whether there was a response or response behaviour cannot be recorded.

6.9 Other Important Information to Record

Re-sightings – It is important not to double count marine mammal sightings. If you see the same animal, or group of marine mammals, multiple times, it is ok to add a new sighting into the database if you mark each duplicate as a re-sighting. This is provided as an option in the database for each sighting you record.

Location upon first sighting – Record whether the marine mammal group was on ice, land, or in the water (for seals and walrus and polar bear sightings) or in water (for whales).

Distance upon first sighting and closest point of approach (CPA) – Distance upon first sighting is important to record upon first sighting the marine mammals. The closest point of approach or CPA is also important because we will be analysing this data to assess if and at what distance marine mammals are potentially responding to the vessel presence and activity.

Bearing from bow – In order to record the location of marine mammal sightings we need each sighting to include a bearing from bow. Figure 58 shows how to estimate the bearing from bow for a whale sighting.

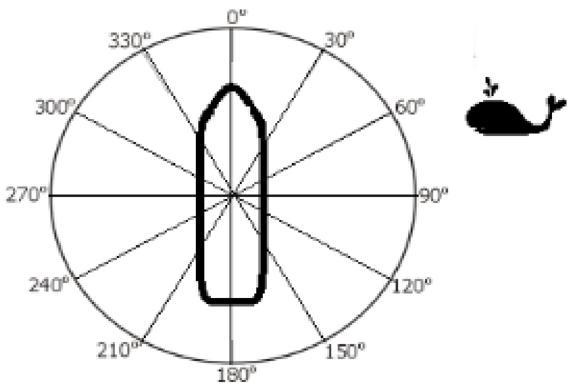


Figure 58: The Whale Sighting is Observed at Approximately 70 degrees

Distance estimation method – It is important to note how the distance to a sighting was measured or estimated. Ideally, distances are measured using reticle binoculars or a clinometer because they are more accurate than estimating using the naked eye. It is important to regularly practice estimating distance either estimating the distance to a known object and then measuring it using the reticle binoculars or clinometer or, if it's not possible to measure the distance, i.e., there is no horizon, you can practice by referencing to a known distance. For example, using the ship's radar to estimate distance to icebergs or other vessels in the area.

For additional information on the data to be collected during the 2023 SBO Program, refer to Section 6.11.

6.10 Environmental Variables

Environmental variables that are important to record during observation periods are:

- Sun Glare
- Ice Cover
- Beaufort Wind Force
- Wind Direction
- Beaufort Sea State
- Weather
- Visibility
- Sightability

Environmental variables are important to record because they can alter the ability to spot and identify marine mammals as well as influence the distribution of marine mammals. This information is used during reporting to analyse the MWO effort and marine mammal distribution.

Environmental variables should be recorded in several instances:

- at the beginning of each MWO watch or observer rotation.
- every 30 minutes.
- if environmental variables or vessel travel direction or activity changes during a watch; and

The *Survey 123* database collection forms are programmed in such a way that you will be prompted to record important information.

Sun Glare

Sun glare can affect a MWO's ability to spot and identify marine mammals. Sun glare is recorded in the environmental observation form.

Table 4 outlines what each sun glare category represents. The percent the sun glare is taking up in your field of view (FOV) is also recorded, as well as the where the sun glare starts and ends in the FOV (the relative position of the glare is recorded either in degrees).

Table 4: Sun Glare

Sun Glare Description	Picture of Description
No Glare	
Weak Glare – When animals were likely detected in center of reflection angle. Example of weak glare with 30% coverage.	
Moderate Glare - When animals were likely missed in the center of reflection angle. Example of moderate glare with ~50% coverage.	

Sun Glare Description	Picture of Description
Strong Glare - When animals were certainly missed in the center of reflection angle. Top photo: Strong glare and 100% coverage Bottom photo: Strong glare and ~40% coverage.	 
Variable Glare – when glare changes regularly, e.g., every couple of minutes, and it's not reasonable to update the Environmental Observations every time it changes.	

Ice Cover

There will likely be ice present during the program. As the presence of ice can affect the distribution of marine mammals it is an important condition to record. Ice cover will be recorded as a percentage of ice cover in the immediate vicinity of the vessel (within 100 m, Near Field Ice Cover) and a percentage of ice cover of your field of view (beyond 100 m, Far Field Ice Cover). Please record any additional comments you may have about ice cover in the *Comments* section in the *Environmental Observations* form.

Beaufort Wind Force

Wind is the main environmental condition affecting wave height and shape. In general, stronger winds produce larger and rougher waves. High winds cause rough sea states which can make it very difficult to spot and identify marine mammals. The Beaufort wind force scale is an international scale that ranks wind speeds into 12 categories (0 to 11). Wind speed is recorded in knots and is usually monitored by a dedicated instrument on the vessel called an anemometer. When you first board the vessel and before you start your first watch, ask a crew member where to obtain readings on wind speed and direction. Table 5 describes the main Beaufort wind force categories. You can also estimate wind speed based on the sea state observed. Table 5 also describes the type of sea conditions that correspond to the Beaufort wind force categories. We will also record the Beaufort sea state conditions during the survey. Keep in mind that Beaufort sea state can be slightly different to Beaufort wind force, e.g., it can take time for the sea state to change as the wind increases or decreases.

Table 5: Beaufort Scale for Wind Force

Beaufort Wind Force Chart

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

Wind Direction

Wind Direction is also noted in the database as North, Northeast, East, Southeast, South, Southwest, West or Northwest. Once we've joined the vessel, we will ask the bridge officers where we can find the instruments with this information on the bridge. If unsure when you're on your watch, ask one of the officers on watch.

Beaufort Sea State

Sea state greatly affects MWOs abilities to spot and identify marine mammals. Like Beaufort wind force, Beaufort Sea state is measured in categories. Beaufort sea state is based on sea state description in 11 categories, numbered 0 to 12 (See Table 6 showing up to Beaufort 7). It is a good idea to carry a copy of the Beaufort Sea State table with you on the MWO program and have it visible where you are performing your duties.

Table 6: Beaufort Sea State Categories and Corresponding Descriptions

Beaufort Number	Wave Height (m)	Sea State Description	Wind Speed (kts)	Picture of Sea Condition
0	0	Glassy, like a mirror	<1	
1	0.1 m	Ripples without crests, appearance of scaling, no foam crests	1-3	

Beaufort Number	Wave Height (m)	Sea State Description	Wind Speed (kts)	Picture of Sea Condition
2	0.2-0.3	Small wavelets, crests of glassy appearance, not breaking	4-6	
3	0.6-1.0	Large wavelets, crests begin to break, scattered whitecaps	7-10	
4	1.0-1.5	Small waves becoming longer, numerous whitecaps	11-16	

Beaufort Number	Wave Height (m)	Sea State Description	Wind Speed (kts)	Picture of Sea Condition
5	2.0-2.5	Moderate waves, taking longer form, many whitecaps, some spray	17-21	
6	3.0-4.0	Larger waves forming, whitecaps everywhere, more spray	22-27	
7	4.0-5.5	Sea heaps up, white foam from breaking waves begins to be blown in streaks along direction of wind	28-33	

Notes: Photos from https://digitalcommons.cwu.edu/government_posters/59/

Weather

Marine mammal observing is largely dependent on local weather conditions, as the ability to see a marine mammal is greatly reduced in conditions of increased cloud cover (affecting lighting), fog, and heavy rain or snow. Weather conditions are continuously recorded throughout a marine mammal survey to account for any changes in the ability to detect animals.

Visibility

Visibility is the distance you can see out from the vessel. In the database your options range from >10,000 m, which is considered Excellent visibility down to 500 – 1,000 m, which is considered Poor visibility.

Sightability

Sightability is an objective measure based on the combination of environmental variables (Sunglare, Beaufort Sea State, Visibility and Weather). This factor plays a major role in your ability to spot and accurately identify marine mammals, particularly at a distance. Sightability can be Poor, Fair, Good, or Excellent. Below is a guideline to the categories of Sightability:

- **Poor** – The observation area is highly obscured and ***marine mammals would most definitely be missed.*** For example, environmental conditions could consist of one or a combination of some or all the following: Sunglare might be Strong and obscuring most of the observation area, Beaufort Sea State > 4, Visibility is Poor (<1,000m), rain or snow are Heavy, or fog is Thick.
- **Fair** – The observation area is somewhat obscured and ***marine mammals would most likely be missed.*** For example, Sunglare might be Moderate and obscuring most of the observation area, Beaufort Sea State is 3-4, Visibility is Moderate, rain or snow is Light or Moderate, or fog is Patchy.
- **Good** – Almost all the observation area can be seen, and ***most marine mammals would be detected.*** For example, Sunglare may be weak to moderate obscuring only a very small proportion of the viewing area, Beaufort Sea State is 1-2, Visibility is Good or Very Good, there is no rain, snow, or fog.
- **Excellent** – All of the observation can be seen, and ***all marine mammals would be detected***. For example, there is no or weak Sunglare, Beaufort Sea State is 0, Visibility is Excellent, and there is no rain, snow, or fog.

6.11 Recording Data

One of the most important aspects of your job will be to carefully enter information on all sightings/observations during your watch. This information is critical to the success of the SBO Program. A lot of time and mentorship will be spent on training to record information properly, efficiently, and consistently.

MWOs will use specially designed electronic database forms using ESRI's *Survey 123* application on a Samsung tablet or an iPad. An *MS Access* database will also be available in case of technical issues with the new *Survey 123* database.

The *Survey 123* and *Access* database include the following forms/sections, respectively:

- **Project Info:** Record project information (project number, project name, client), survey date, survey start location and time, and any relevant comments.
- **Observers:** Record on-watch observers (port, starboard and data recorder), side of vessel (port or starboard watch or both) watch start time and location and any relevant comments.
- **Environmental Observations:** Record environmental variables that may affect marine mammal detection during the watch.
- **Vessel activity:** Record activities of the survey vessel (Botnica/Fennica) and any other vessels in the vicinity.
- **Marine Mammal Sightings:** Record marine mammal sighting data including time and location and behaviour upon initial sighting and whether there was a behavioural response to the vessel.
- **Transect Break/Resume/End:** Record break and resume times when one or both observers is off watch and when the survey day has ended.

The *Survey 123* forms include "drop-down" lists and pre-defined selections to make data recording faster and ensure data entry consistency for later analysis. The forms automatically import GPS location data from the GPS (start and stop locations and tracks of watch periods, marine mammal sighting locations).

The most important thing is to ensure that data has been entered in all relevant fields when an observation is made.

Starting the Samsung Tablet

To start the Samsung Tablet at the start of the day, press and hold down middle side button at the same time. The home screen will come up and prompt you to enter the Tablet's pin number (1478). Once it's open you can open the Survey 123 app.

To shut down the Samsung Tablet at the end of the day, press and hold middle button. The tablet will then show the Power Off and Restart buttons. If you don't want to shut down tap on the screen and you'll go back to the home screen.

If you would like to take a screenshot of the tablet, e.g., to take a screenshot of the map at the end of the day,

Starting the iPad

To start the iPad at the start of the day, press and hold down the button on the top right of the iPad and enter the iPad's pin number (379595).

Saving Data Forms

Survey 123

Always save forms immediately after entering data. You can do this by clicking on the *X* at the top left of the form to close it. A window will pop up with three options:

- *Close and Lose Changes* – don't select this option unless you're sure you don't want to keep it, e.g., you accidentally started a new survey form.
- *Continue This Survey* - select this option if you accidentally clicked on the *X* at the top left of the form but you want to continue entering data or editing the form.
- *Save in Drafts* - select this option if you want to save and close the form until you make another entry. Recommend doing this after each entry to avoid losing data.

You can also *Save in Outbox* in the app. To *Save to Outbox* select the checkmark at the bottom right of the forms and you will see the following three options:

- *Send now* – disregard this option. This will be done by the WSP team lead once the data has been QA/QC'd and when the vessel has good wifi.
- *Continue this survey* – select this option if you accidentally clicked on the check mark and want to continue entering data or editing the form.
- *Save in Outbox* – select this option if you want to save and close the form until you need to make another entry.

NOTE: If required data fields are not entered there will be an error message prompting you to enter the missing data. Whether the form is saved in *Drafts* or the *Outbox* you can still go back and edit if needed.

MS Access

The *Access* database automatically saves, so you do not have to worry about saving until the end of the day.

6.11.1 *Survey 123* Data Entry

The first screen you will see when you open the app is in Figure 59 (left). Click on the *Aquatics Marine Mammal* icon to open the project forms. You will then see the following options (Figure 59, right):

- *Collect* – select this option at the start of a new survey day.
- *Inbox/Outbox* – If the vessel's internet is good enough, a WSP team will submit forms at the end of a survey day once they have been QA/QC'd. You may notice some surveys saved there if the option to save to inbox/outbox was selected (see following sections).
- *Drafts* – unless you're starting a new survey, previous/active surveys will be saved here.
- *Overview* - The *Overview* folder is useful when you want to view all survey records in a single map or list.

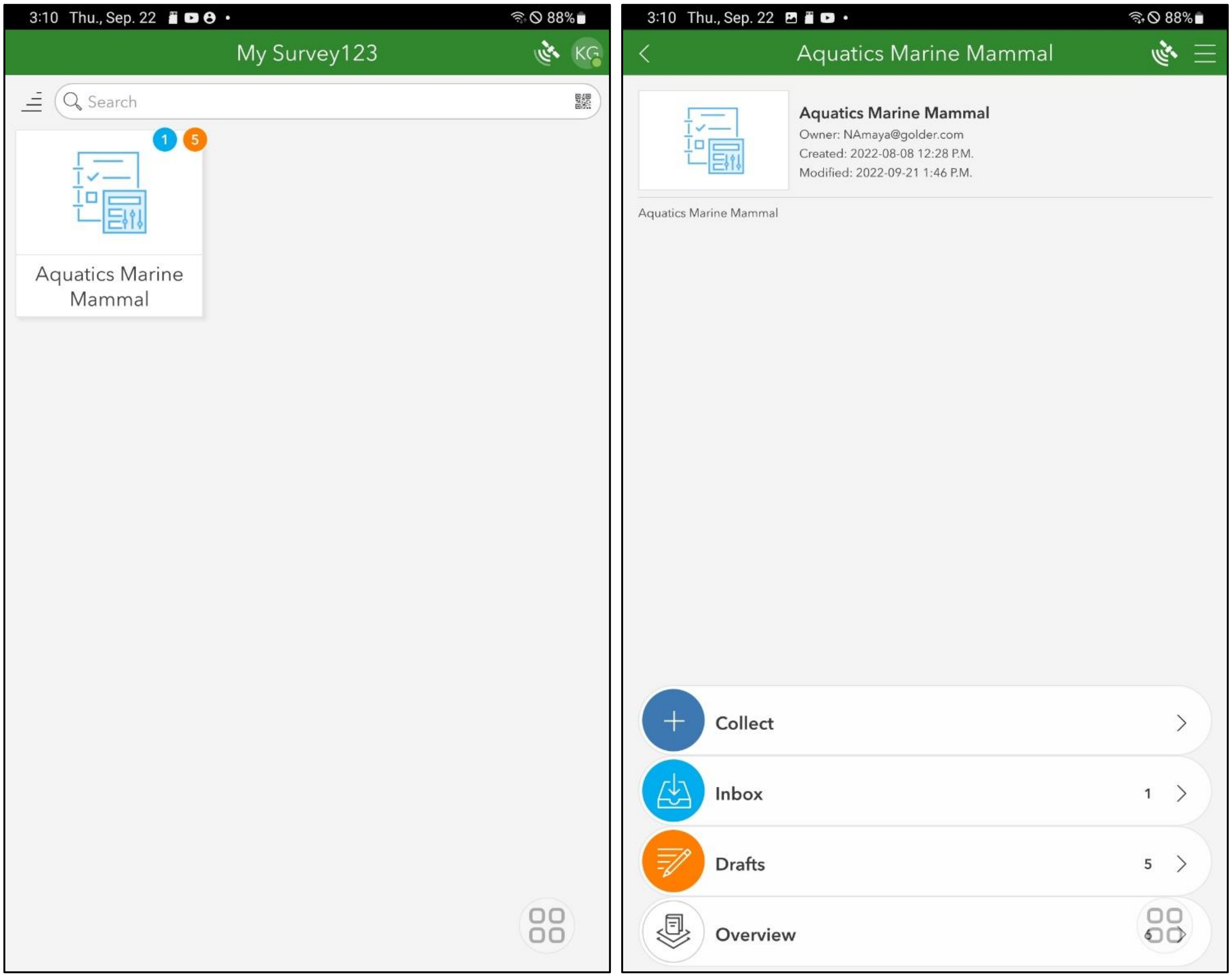


Figure 59: Aquatics Marine Mammal forms folder (left) and Folder Overview (right) in *Survey 123*

To start a new survey at the beginning of each survey day select *Collect* (Figure 59 right) and the first of the forms, *Project Info*, we will be using for data entry will open (Figure 60).

6.11.1.1 Project Info Form

The first team on watch will fill out the *Project Info* fields. If you click on the three horizontal bars at the top right of the form, a menu will pop out where you can select *Paste Answers from Favorite* to populate the *Project Info* section with the same information each time.

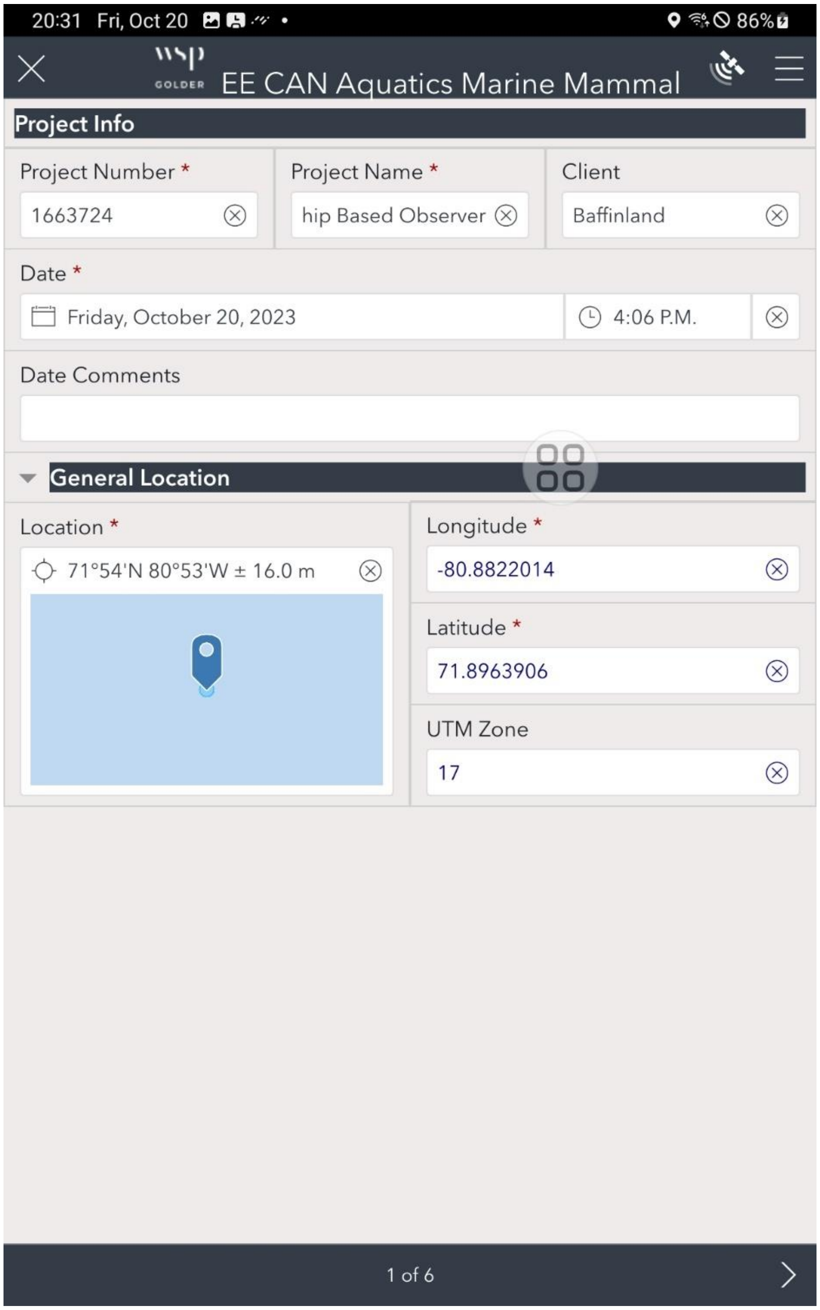


Figure 60: Project Info Fields

Select the date by tapping in the space below *Date* and the date and time will auto-fill. You can select a different date from the calendar if needed. You only need to enter info in this section at the start of each new survey day. To add location data at the start of each survey day, click on the *Location* icon and latitude and longitude data will be entered in the cells and a point will appear on the map (Figure 60).

6.11.1.2 Observers Form

This form should be completed at the beginning of every observer watch or role rotation, every 30 minutes, and when conditions change, e.g., vessel changes course or activity (Figure 61). It's important to note that a new *Observers* form should be filled out at the start of EACH WATCH.

NOTE: Every time you start a new *Observers* entry make sure you click on the + sign at the bottom right of the form to start a new *Observer* form. Otherwise, you will be entering over data entered in the form previously. You can scroll between the different forms by clicking on the left and right arrows next to the + sign at the bottom of the form.

- *Observer Port*, *Observer Starboard, Data Recorder*: select the observer and data recorder's names from the drop-down list. If you are observing the full observation area, enter your name for both port and starboard sides.
- *Tablet:* Select whether the tablet is being used to record data on the port or starboard side of the vessel. There is also an option to enter Both when you are observing both the port and starboard sides, e.g., you're the only observer on watch.
- For *Date/Time* and *Location* data enter the data in the same manner as you did in the *Project Info* and *General Location* sections by tapping on the Date field. If you need to re-do location data, you can click on the *Location* icon icon in the top left corner of the location map and update the location.
- *Waypoint*: No need to enter data here unless we're using a handheld GPS and have taken a waypoint on it. If you have taken a waypoint using a handheld GPS enter the waypoint number.
- *Comments*: Add any additional relevant information.

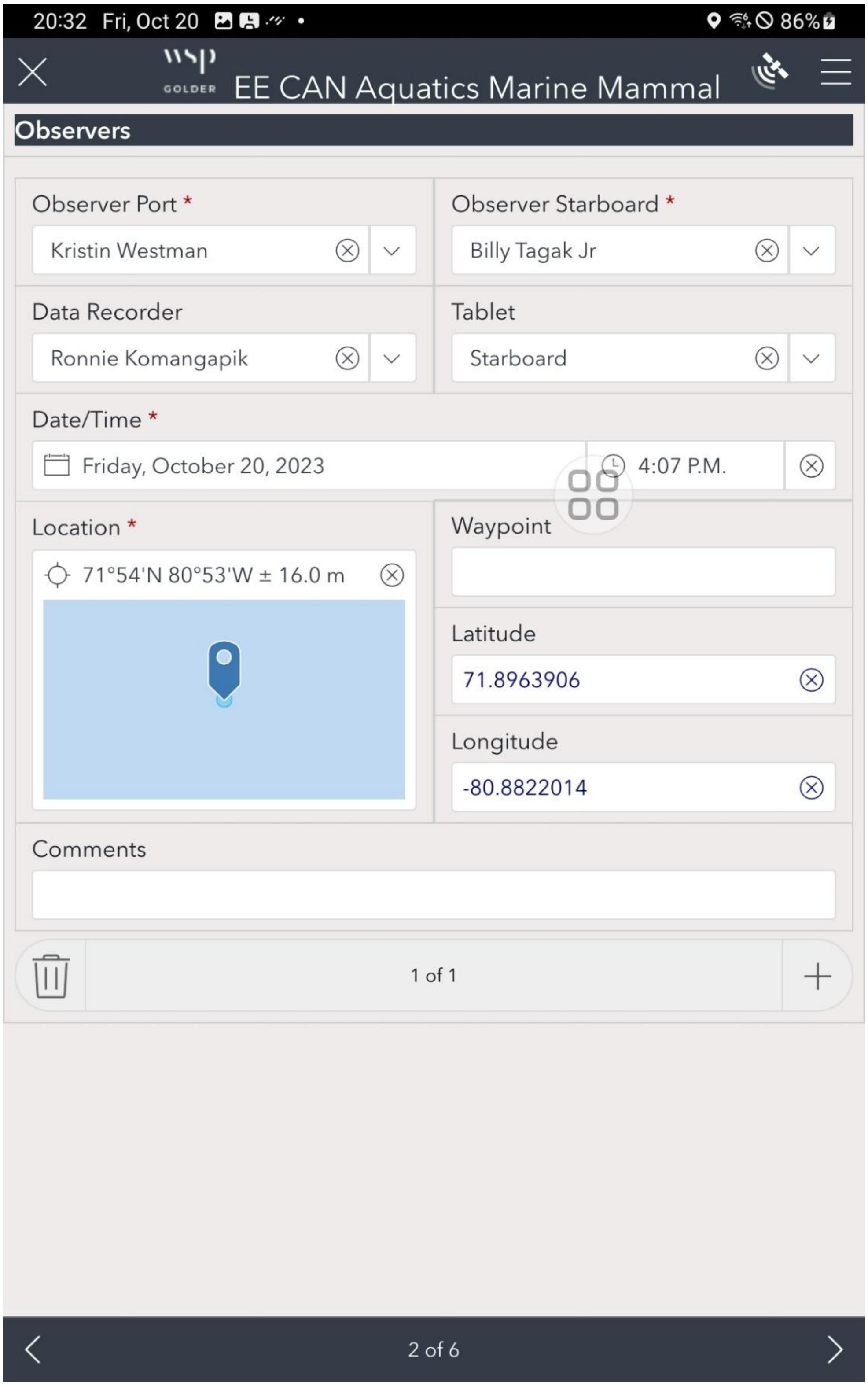


Figure 61: Observers form

6.11.1.3 Environmental Observations Form

This form should be completed at the beginning of every observer watch or role rotation, every 30 minutes, and when conditions change, e.g., vessel changes course or activity (Figure 62). See Section 6.10 Environmental Variables for descriptions of these environmental variables.

NOTE: Every time you start a new *Environmental Observations* form make sure you click on the + sign at the bottom right of the form to start a new *Environmental Observations* form. Otherwise, you will be entering over data entered in the form earlier. You can scroll between forms by clicking on the left and right arrows next to the + sign at the bottom of the form.

- *Observer Port, Observer Starboard*: select port and starboard observer's names from the drop-down list.
- *Photo number*: add a photo number or range of photos if a photo or photos was taken to capture the environmental variable. It is good practice to take at least one photo of each environmental variable to capture the interpretation of these factors in the field.

Location Info

- For *Observation Date/Time* and *Location* data enter the data as described in the *Project Info* and *General Location* sections by tapping on the Date field. If you need to re-do or update location data, you can click on the *Location* icon in the top left corner of the location map and update the location information.

Sun Glare

- *Sun Glare Descriptive*: Select the most accurate sun glare category from the drop-down list (see Section 6.10)
- *Sun Glare FOV: Select the proportion of sun glare covering the field of view of your observation area from the drop*-down list.
- *Sun Glare From*: Enter the angle in degrees where sun glare starts in your field of view (see Figure 58).
- *Sun Glare To*: Enter the angle in degrees where sun glare ends in your field of view (see Figure 58).

Ice and Weather

- *Ice cover <100m* and *Ice cover viewing area*: Select the most accurate ice cover descriptor for the proportion of ice cover within 100 m (Near Field) of the observation area around the vessel and over the entire field of view (Far Field), from the drop-down list.
- *Beaufort Wind Force* (Table 5), *Wind Direction*, *Beaufort Sea State* (Table 6), *Weather, Visibility, Sightability*: Select the most accurate descriptor for these weather variables from the drop-down list.
- *Comments*: Add any additional relevant information.

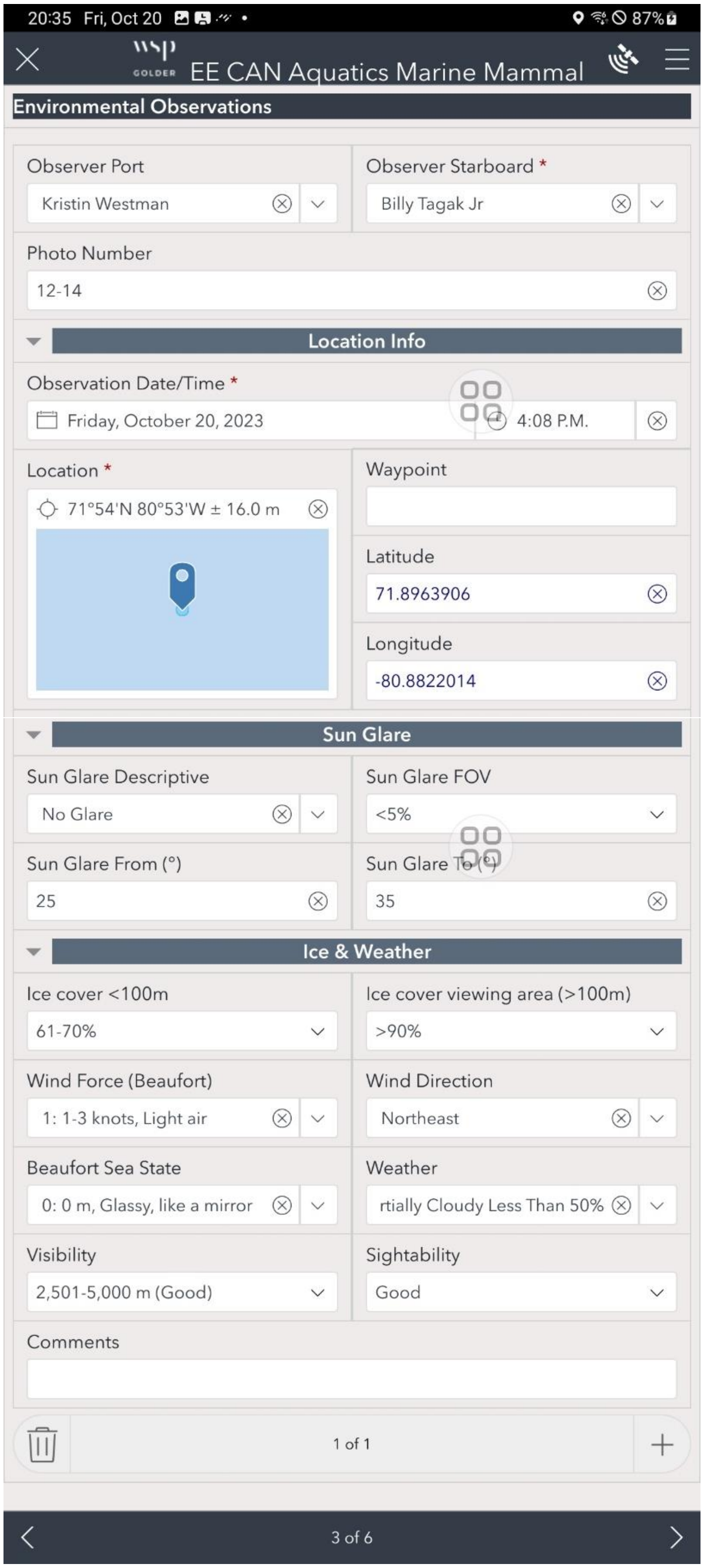


Figure 62: Environmental Observations Form

6.11.1.4 Vessel Activity Form

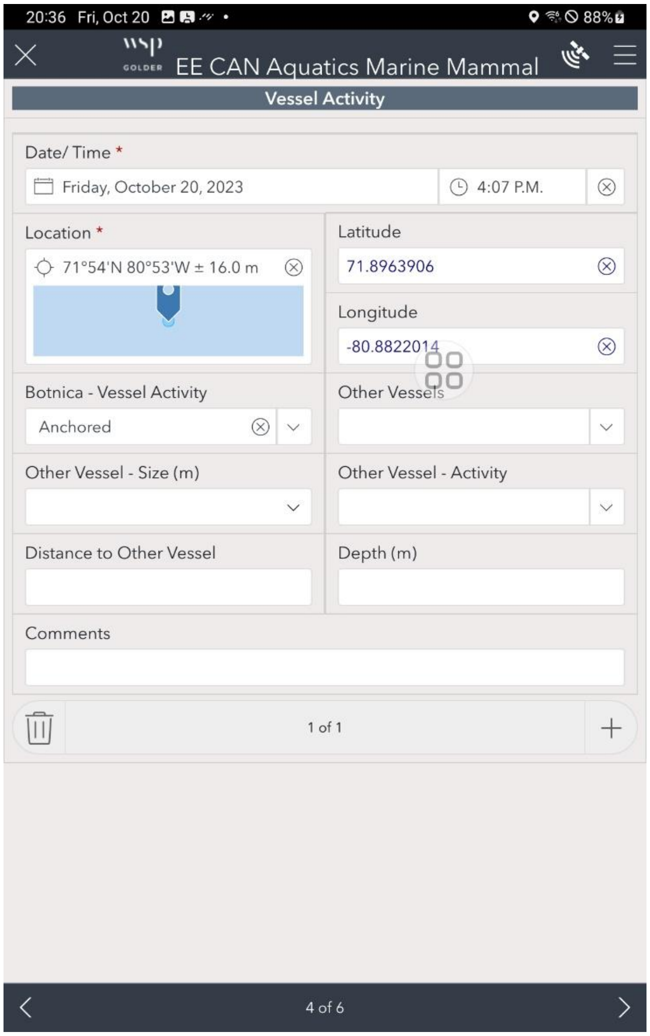
The *Botnica/Fennica* and other vessel activities will be recorded on this form (Figure 60). This form should be completed at the beginning of every observer watch or role rotation, every 30 minutes, and when conditions change, e.g., vessel changes course or activity. For the *Botnica/Fennica* we will record location, vessel activity and depth.

For vessel activity we'll be recording whether the *Botnica/Fennica* is transiting in open water, maneuvering, drifting, icebreaking (including transiting a broken ice track), ice management (pushing ice but not breaking) or anchored.

For other vessels we'll record the type of vessel, e.g., icebreaker, hunter, research/fisheries, passenger, sea lift, private, and ore carrier, and vessel size and vessel activity. If there are multiple vessels observed complete a new form for each vessel.

NOTE: Every time you start a new *Vessel Activity* form make sure you click on the + sign at the bottom right of the form to start a new form. Otherwise, you will be entering over data entered in the form earlier. You can scroll between forms by clicking on the left and right arrows next to the + sign at the bottom of the form.

- For *Date/Time* and *Location* data enter the data as described in the *Project Info* and *General Location* sections by tapping on the Date field. If you need to re-do or update location data, you can click on the *Location* icon icon in the top left corner of the Location map and update the location information.
- *Botnica - Vessel Activity (*also for *Fennica*), *Other Vessels*, *Other Vessel – Activity:* select the most accurate descriptor for each category, from the drop-down list. Complete the form at the same time you do environmental updates (for whichever vessel you're on, *Botnica* or *Fennica*) or whenever you see another vessel.
- *Distance to Other Vessel* - manually enter the distance other vessels are from the Botnica. You can obtain this from instruments on the bridge or ask the bridge crew if you are unsure.
- *Water depth (metres)*: manually enter the depth data in metres. You can obtain this from instruments/chart data on the bridge or ask the bridge crew if you are unsure.
- *Comments*: Add any additional relevant information.



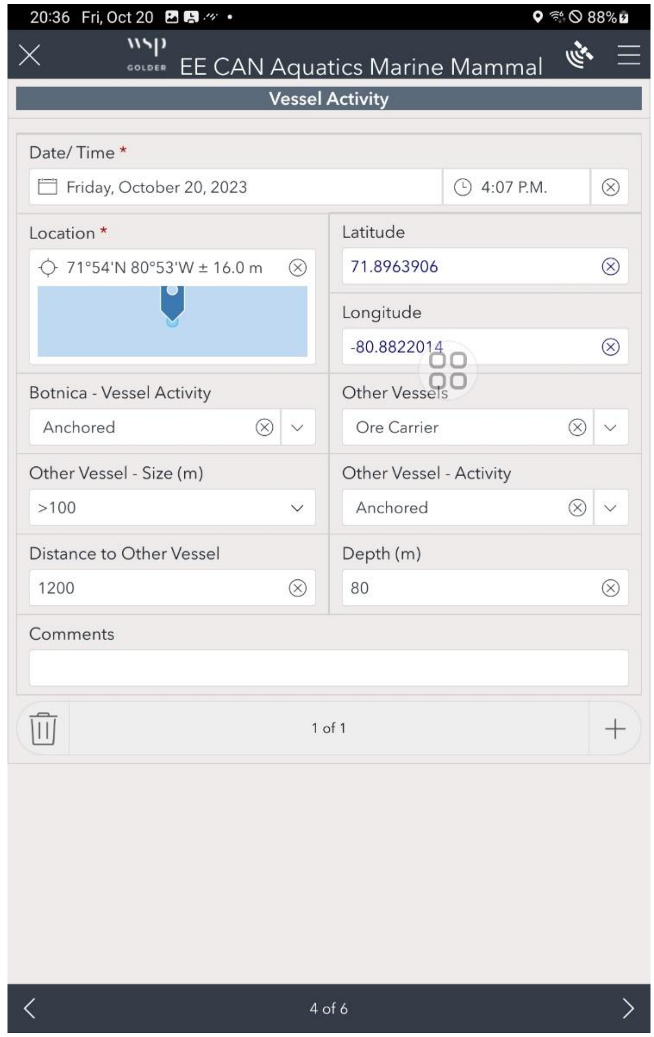


Figure 63: Vessel Activity: Botnica (left) and Botnica with Other Vessels (right)

6.11.1.5 Marine Mammal Sightings Form

Enter marine mammal sightings data in this form (Figure 64 to Figure 69).

NOTE: Every time you start a new *Marine Mammal* entry make sure you click on the + sign at the bottom right of the form to start a new form. Otherwise, you will be entering over data entered in the form earlier. You can scroll between forms by clicking on the left and right arrows next to the + sign at the bottom of the form.

- *Observer Name*: Enter your name or, if the observer was not you, the person who saw the marine mammal group. If a crew member observes the sighting, select *Other – See Comments* and record who observed it in the Comments section at the bottom of the form.
- *Species Group:* Select which species group you are observing. Depending on the species group, e.g., Seals and Walrus, Polar Bear, and Walrus, the form automatically pulls up a sighting sub form with data fields specific to that species group.
- *Re-sighting*: If you are sure that you are seeing a group of marine mammals observed and recorded earlier, enter *Yes*, otherwise enter *No*. If you would like to record additional information for a sighting you could start another form and mark it as a re-sighting then note in the comments that it is a continuation of the previous sighting.

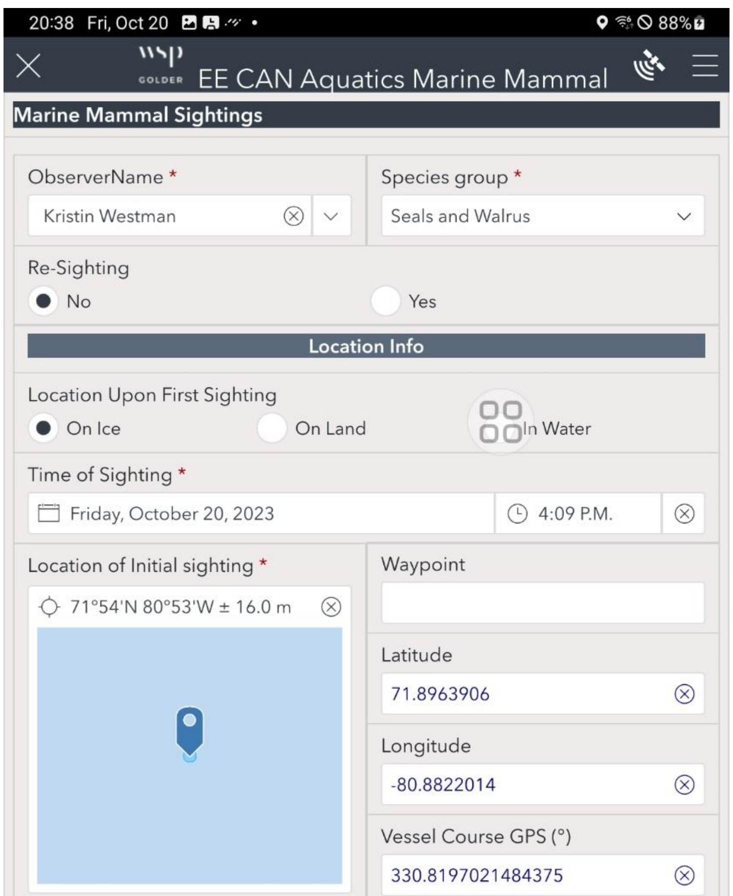


Figure 64: Marine Mammal Sightings: Observer and Location and Time Info

Location Info

- *Location Upon First Sighting:* Select whether the animals observed are On Ice, On Land, or In Water.
- *Time of Sighting* and *Location of Initial Sighting*: Enter the data as described in the *Project Info* and *General Location* sections by tapping on the Date field. If you need to re-do or update location data, you can click on the circle icon in the top left corner of the location map and update the location information.
- *Waypoint*: No need to enter data here unless we're using a handheld GPS and have taken a waypoint. If you have taken a waypoint using a handheld GPS, enter the waypoint number.

Sighting Info

- *Named Location:* This is an optional field. If you know the local name for the location you can enter this data or ask one of the Inuit observers who are familiar with the area, otherwise, leave it blank.
- *Species*: select the species from the drop-down list. You will only be able to enter species that fall within the Species Group you identified at the start of the form. If you can't find the species in the list or the list is blank, check that you have selected a Species Group, or it is the correct group. If you're not sure of species ID enter *Unidentified Seal* or *Unidentified Whale*. It is better to enter the species as unidentified rather than guess the species ID.
- *Certainty of ID:* If you are confident in the species ID enter *Definite*, if you are pretty sure but not 100% confident then enter *Possible*. In the comments you can add additional information on the characteristics of the species that my help confirm ID. If you can take a photo (recommended) we can also check in the photo later to confirm.
- *Distance Upon First Sighting (m)*: manually enter the distance of the sighting when you first spotted the animal/s. (see Section 6.5 Estimating Distances). It is important to get this information at the very start of the sighting.
- *Bearing Upon First Sighting (degrees)*: manually enter the bearing in degrees from the bow to the observation (see Figure 8). It is important to get this information at the very start of the sighting.
- *CPA (m):* Enter the Closest Point of Approach, the closest distance the sighting was from the *Botnica/Fennica*, during the sighting. This will likely be later than the Distance Upon First Sighting and may or may not be the same as *Distance (m) When Response Observed*.
- *Distance Estimation Method:* Select which method you used to estimate or measure the distance to the sighting. It is best to measure distance using reticle binoculars or a clinometer first. If this is not possible then use a reference to a known distance, e.g., based on the ship's radar to an iceberg or other vessel. Finally, use naked eye to estimate distance. It is a good idea to practice estimating distance with the naked eye when you can compare you estimates to measured distances using the reticle binoculars, clinometer or based on reference to a known distance.
- *Minimum Group Size/Best Estimate of Group Size*: manually enter your minimum and best estimate of the number of individuals observed during the sighting. Seals that are >5 body lengths from each other and polar bear >10 body lengths from each other will be treated as separate groups or sightings (Smultea et al. 2016).
- *Behaviour Upon Initial Sighting*: select the most appropriate behaviour relevant to the Species Group from the drop-down list (See section 6.8 for description of behaviours by Species Group).

Behavioural Data for Seals and Walrus

- *Behaviour Response to Icebreaker*: select the most appropriate behaviour for Seals and Walrus from the drop-down list (See section 6.8 for description of potential response behaviours by Species Group). Following are the Behavioural response options for Seals and Walrus (Lomac-McNair et al. 2019) and whether they are on ice or not :
  - Seal and Walrus on ice: No Response, Scan, Flush, Regular Dive, None Observed. Record None Observed when you are not confident whether there was or was not a response.
  - Seal and Walrus in water: No Response, Scan, Rapid Dive/Splash, Swim Away, Regular Dive, None Observed. Record None Observed when you are not confident whether there was or was not a response, e.g., the seal disappeared while you were collecting bearing info from the pelorus or providing information to the data recorder.
- *Distance and Bearing When Response Observed:* Manually enter the distance (see Section 6.5 Estimating Distances) and bearing (Figure 58) of the sighting when you observed a behavioural response.

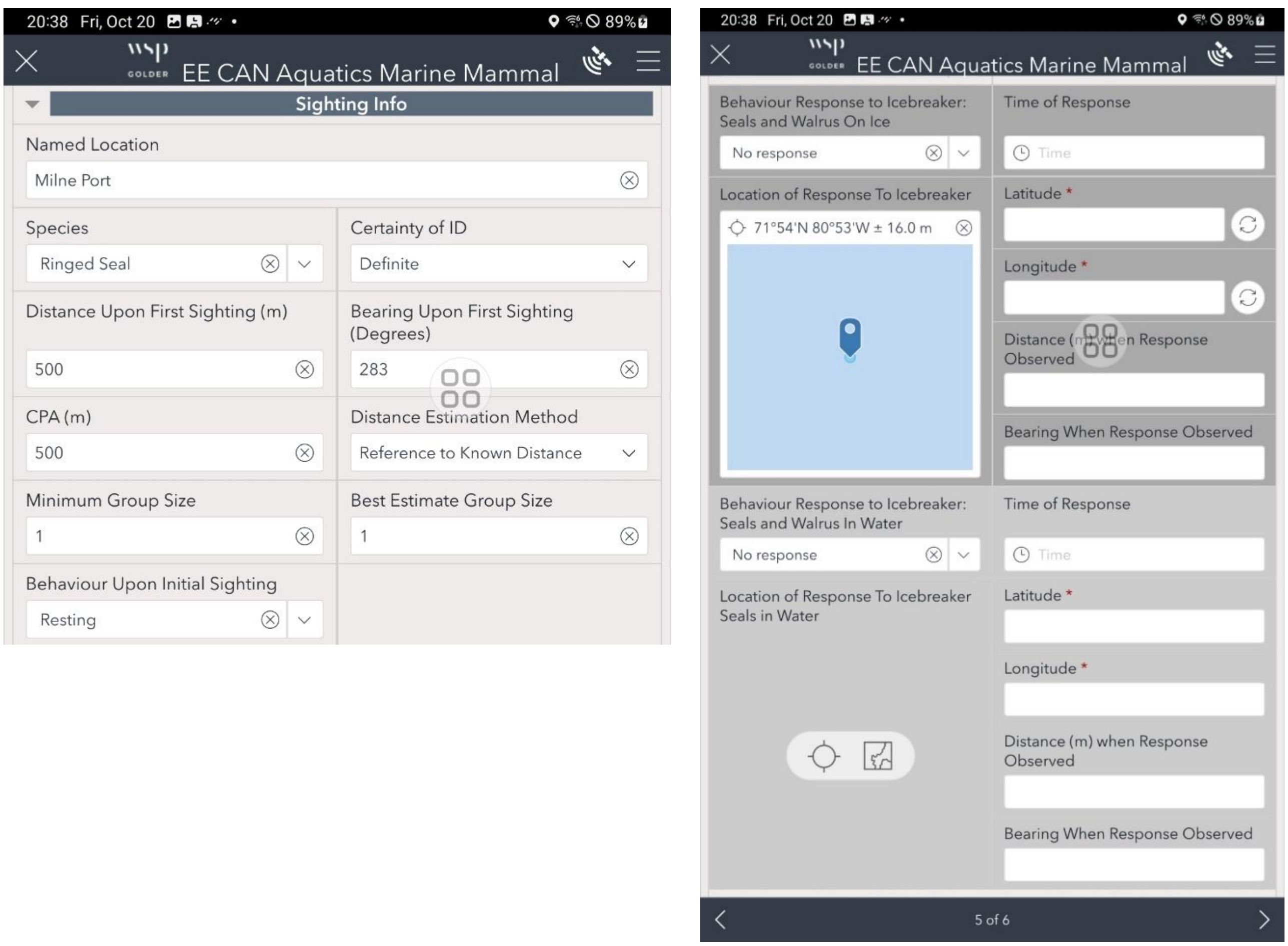


Figure 65 Behavioural Data Form: Seal and Walrus

Behavioural Data for Polar Bear

- *#Cubs/Juveniles:* Enter the number of Cubs and/or Juveniles in the group. Table 7 provides definitions of polar bear age classes (Smultea et al. 2016).

Table 7: Definitions of Polar Bear Age Classes (Smultea et al. 2016)

Age Class	Age (Years)	Body Size
Adult	>5	Full sized bear
Sub-Adult	2.5 – 5	Approximately two-thirds the size of an adult. Could be determined only if a larger adult bear was nearby.
Yearling	1 – 2.5	Approximately one-half the size of the closely accompanying adult presumed to be the mother.
Cub of Year (COY)	<1	Approximately one-third (or less) the size of the closely accompanying adult presumed to be the mother.
Undetermined	Unknown Year	

- *Age Class of Bear #1, Age Class of Bear #2, Etc.:* Select the age class of each individual bear in the group.
- *Behaviour Response to Icebreaker*: select the most appropriate behaviour relevant to the Species Group from the drop-down list (See section 6.8 for a description of potential response behaviours by Species Group). Following are the Behavioural response options by Species Group for polar bear (Smultea et al. 2016) and whether they're on ice or not:
  - Polar Bear: No response, Walking Away, Running Away, Approaching, Displaying Vigilance, None Observed. Record None Observed when you are not confident whether there was or was not a response, e.g., you lost track of the bear/s.
- *Distance and Bearing When Response Observed:* Manually enter the distance (see Section 6.5 Estimating Distances) and bearing (Figure 58) of the sighting when you observed a behavioural response.

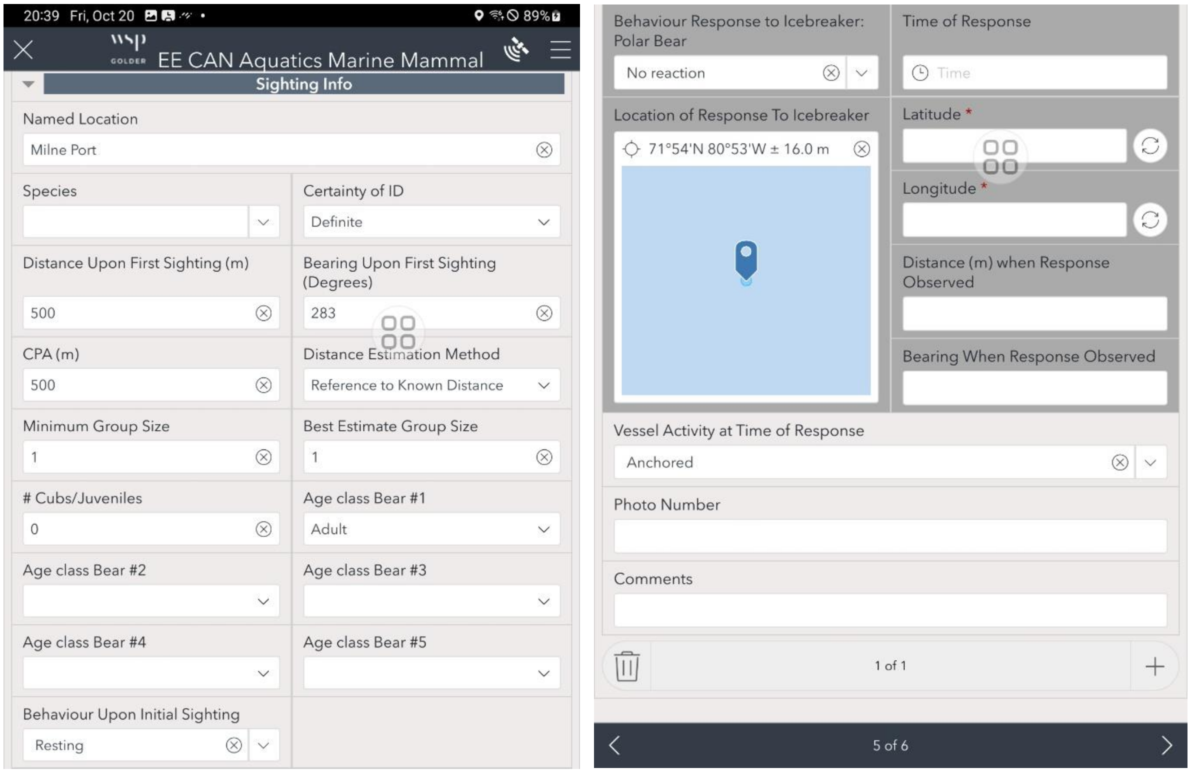


Figure 66 Behavioural Data Form: Polar Bear

Behavioural Data for Whales

- *Cue:* Select the cue that alerted you to the presence of the whale or whales.
- *#Calves/Juveniles:* If the group is close enough to identify the presence of calves or juveniles, enter the number in this field. Table 8 includes descriptions of narwhal age classes:

Table 8: Definitions of Narwhal Classes

Age Class	Description
Adults	Large whitish animals should be assumed to be adults. Dark animals that are 85% or larger than the length of whitish adults should be assumed to be adults.
Juveniles	Dark in color and 15% smaller than adult. May have short tusk present
Calves	Whitish to grey in appearance and slightly less than half of the length of the adult female.

- *Direction of Travel:* Using clock time, record the direction the whale/s are traveling relative to the *Botnica/Fennica,* e.g., 12 = same direction, 6 = opposite direction.
- *Behaviour Response to Icebreaker*: select the most appropriate behaviour relevant to the Species Group from the drop-down list (Figure 67, See section 6.8 for description of potential response behaviours by Species Group). Following are the Behavioural response options by Species Group for Whales:
  - Whales: No Response, Traveling Slowly Away, Traveling Quickly Away (including porpoising), Approaching, Change Direction, Rapid Dive/Splash, Breach, Lobtail, None Observed. Record None Observed when you are not confident whether there was or was not a response, e.g., you lost track of the whales.

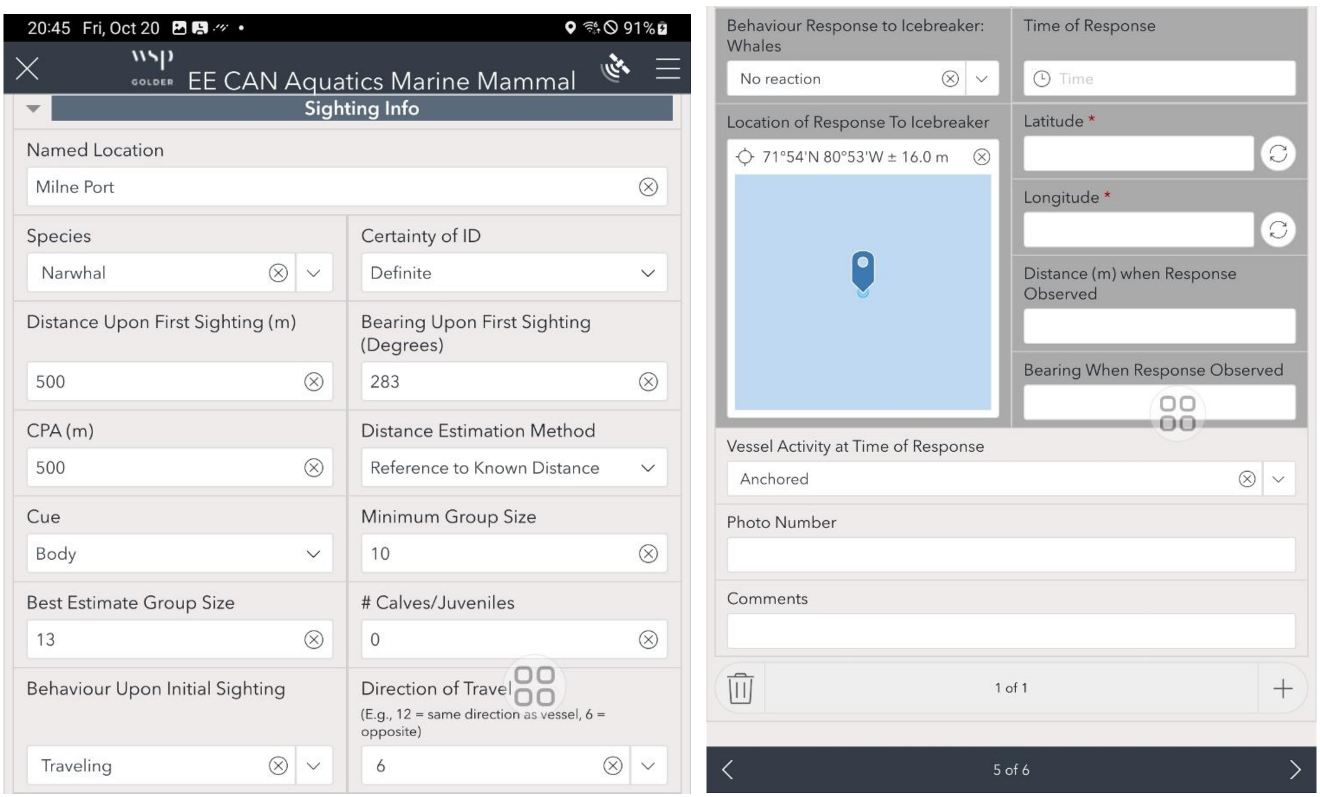


Figure 67 Behavioural Data Form: Whales

Behavioural Response: Vessel Activity, Photo Number, and Comments

- *Vessel Activity at Time of Response:* select the most accurate descriptor of the *Botnica/Fennica*'s activity at the time of the response from the drop-down list.
- *Photo Number:* it is a good idea to photograph sightings for an additional record of the sighting and to help confirm species ID and behaviour if needed. Enter the relevant photo numbers here.
- *Comments:* Enter any additional comments or information about the marine mammal sighting here.

6.11.1.6 Transect Break/Resume/End Form

This form is filled out whenever an observer/s must stop observing, e.g., to go to the washroom, during vessel drills. If you need to break your observations during your watch at any point, please fill out the *Transect Break* form (

Figure 68). This allows us to track the observer effort and to record when an MWO stops watching and/or nobody is on the bridge observing for marine mammals.

- *Both Observers Stopped*: if nobody is observing enter *Yes*.
- *Port Observer, Starboard Observer:* Enter the name of whichever observer is still on watch or if another observer covers for you. For example, you're on port and need to break your watch briefly while the other observer continues their observations. In this instance the observer remaining on watch should enter their name in both port and starboard observer field and monitor the full field of view until you return. If only one side has an observer enter N/A on the side without an observer, or if you're both stopping your observations, enter N/A in both Port and Starboard Observer fields.
- *Break/Resume/End:* Indicate whether it's a transect break when you're stopping observations, transect resume when you're resuming observations, or whether it's the end of the survey day. If both observers are coming back on watch after a break, then remember to complete the Environmental Observations and Vessel Activity forms again.
- *Time of Transect Break and Location*: enter the data as described in the *Project Info* and *General Location* section when you take a break (
- Figure 68, left) and when you resume your watch (Figure 68, right).
- *Waypoint*: No need to enter data here unless we're using a handheld GPS and have taken a waypoint. If you have taken a waypoint using a handheld GPS enter the waypoint number.

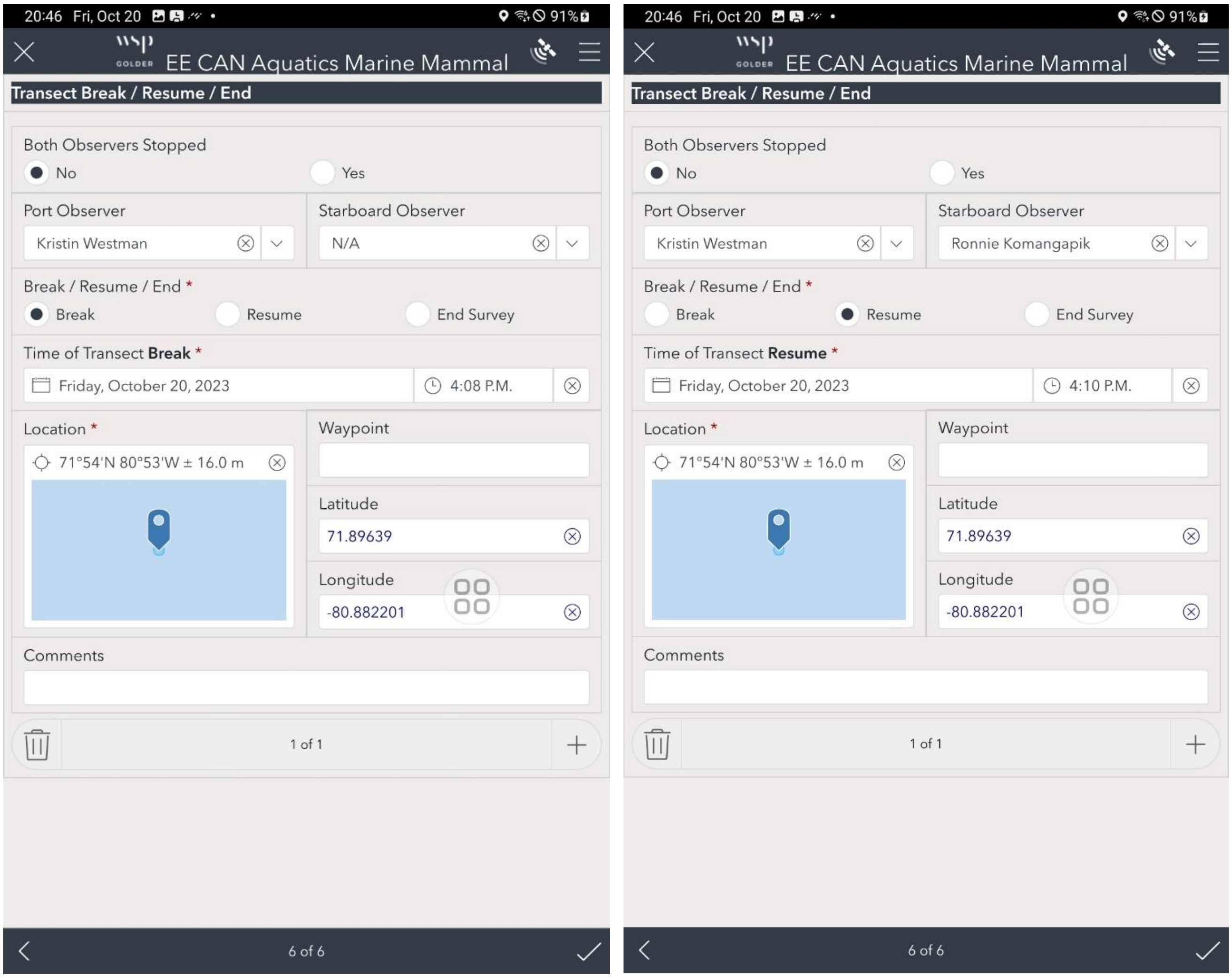


Figure 68: Transect Break: Break Transect (left – Ronnie has left watch, and nobody is observing the port side for 2 minutes) and Resume Transect (right)

End Survey

At the end of each survey period, enter one final record of the time and location to indicate where and when effort ended during that survey period and at the end of the survey day (

Figure 69).

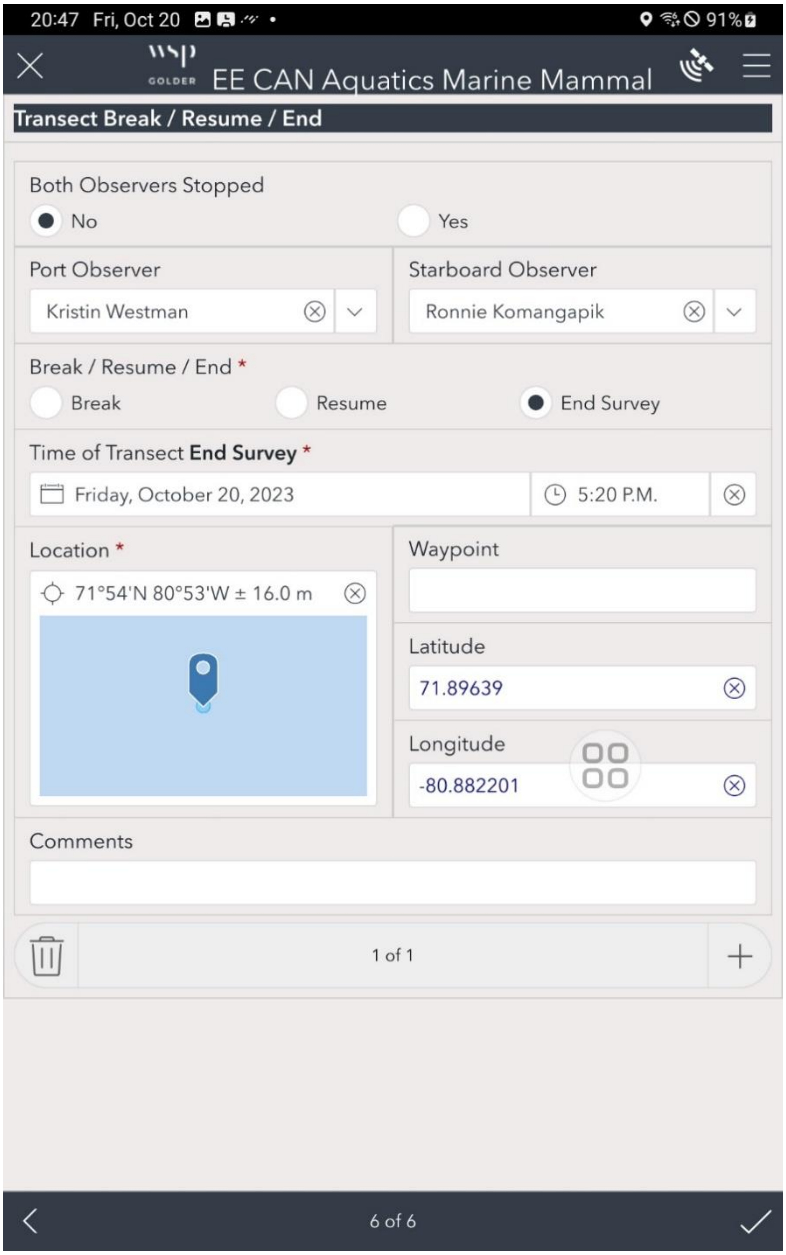


Figure 69: End Survey Day

- For *Time of Sighting* and *Location* data enter the data as described in the *Project Info* and *General Location* sections.

6.11.2 Data Quality Assurance / Quality Control and Back Up

Throughout and at the end of the day, a QA/QC on the data will be done to verify that no records/fields are missing. Once completed at the end of each day, the MWO database will be submitted by the WSP lead via the ship's internet to WSP's internal platform for web mapping, GIS, and field data collection in the cloud.

6.11.3 Field Maps

To capture survey effort, the Field Maps app will be used to collect GPS track data during all MWO activities. Click on the Field Maps app logo on the home screen of the tablet to open the app.

- When you open Field Maps you will see an option to select the program folder (Figure 70, left). Select *Aquatics Marine Mammal* to access base maps (Figure 70, right).

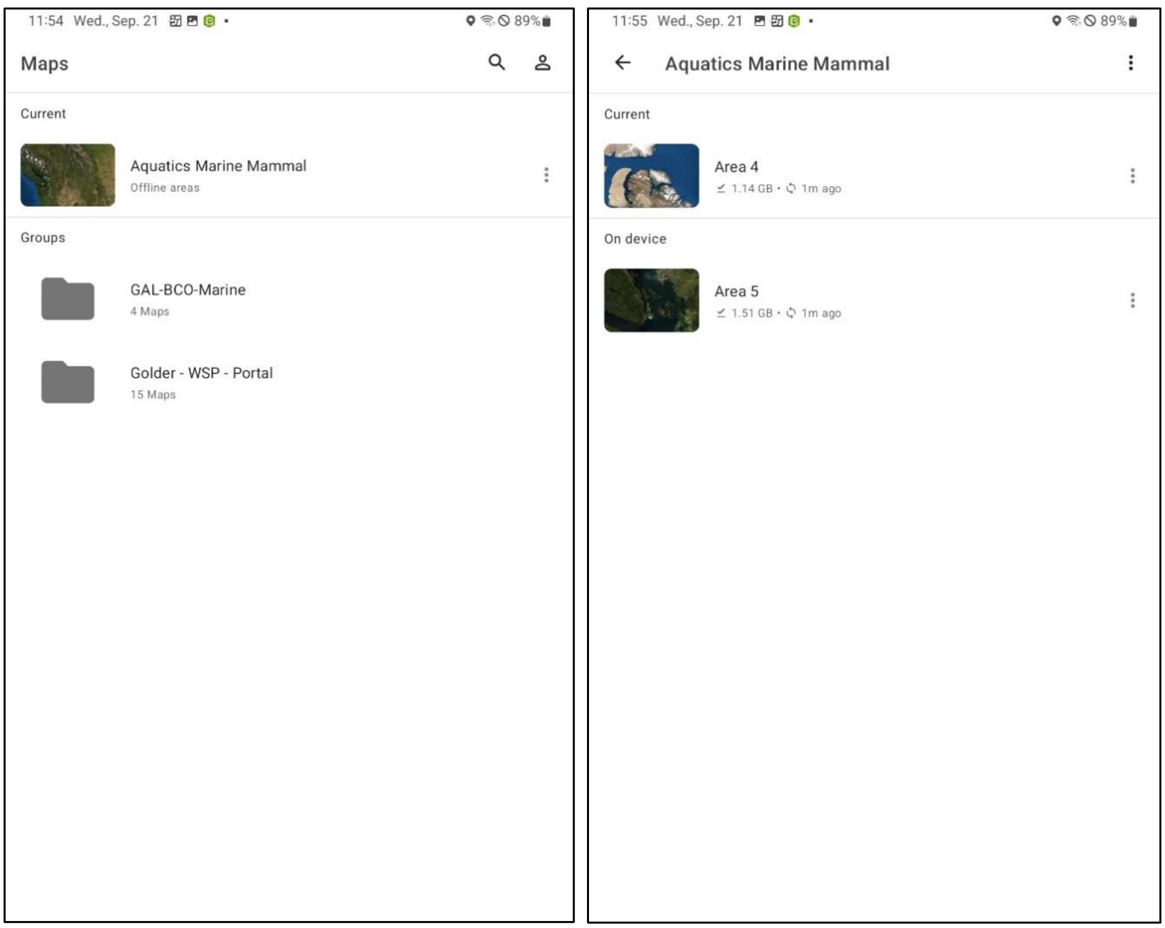


Figure 70: Navigating to Aquatics Marine Mammal Basemaps

- Area 5 base map is used in this example and Area 4 (SBO Program survey area) will be used during the program (Figure 71).

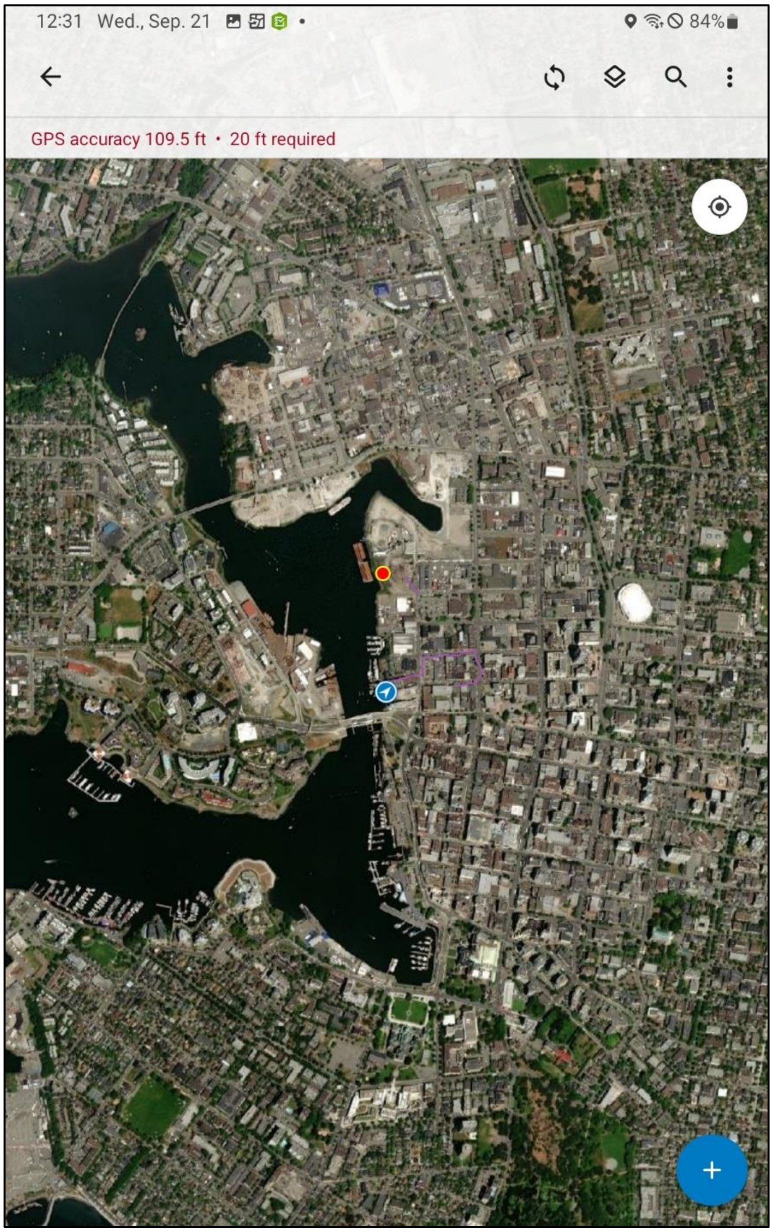


Figure 71: Opening a Base Map Layer in Field Maps

- The selected area will be shown. Click on the blue + in the bottom right of the screen.

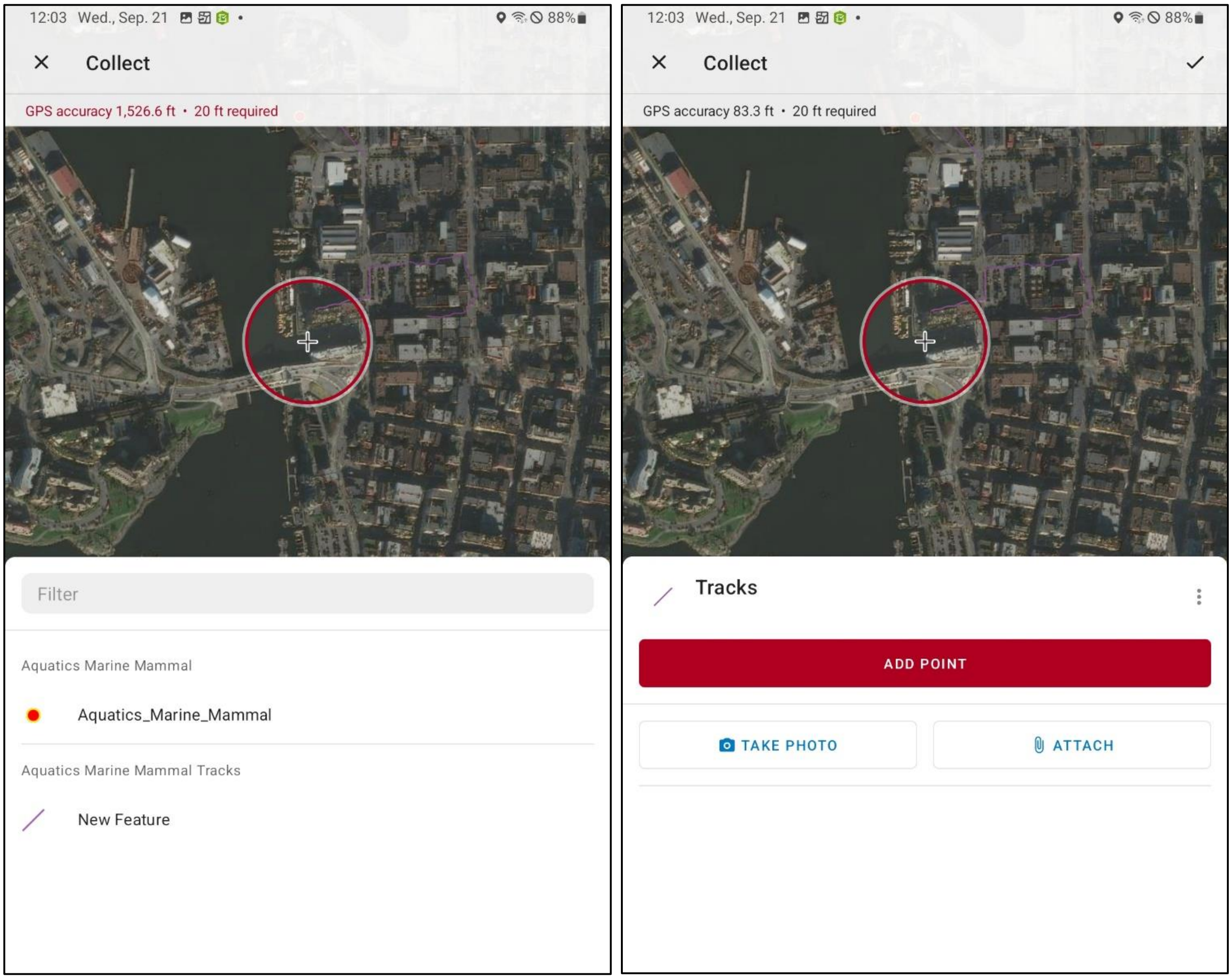


Figure 72: Adding a Track Layer Field Maps

- Select *New Feature* (Figure 72, left) and the *Tracks* layer will then open (Figure 72, right).

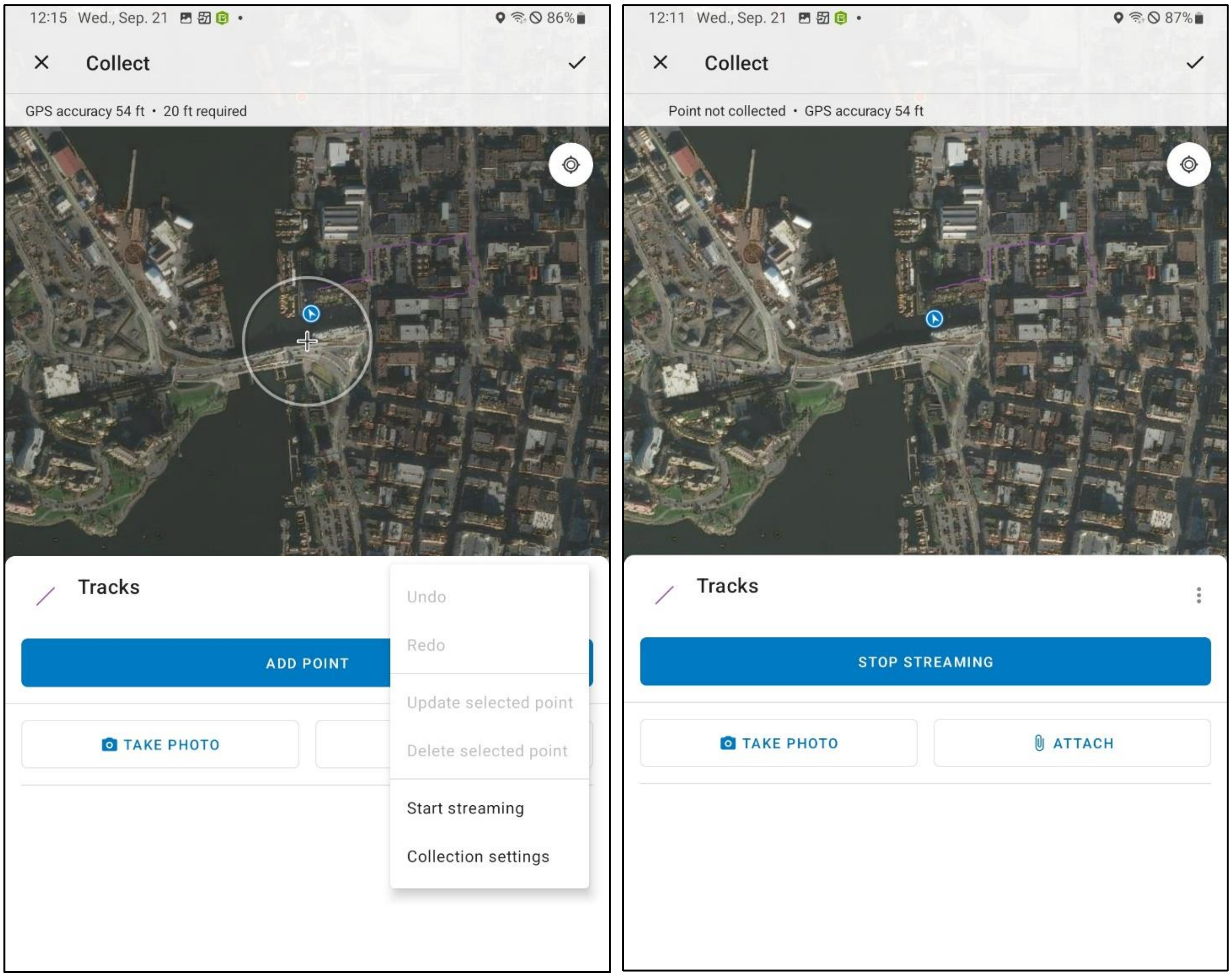


Figure 73: Record GPS Track data in Field Maps

- Select the three dots in the top right corner of the menu and select *Start Streaming* (Figure 73, left).
- When the app has started recording the GPS track data, the *Add Point* button will be replaced with *Stop Streaming* (Figure 73, right). Select *Stop Streaming* at the end of the survey period or survey day.

7.0 SEABIRD SURVEY

Seabird surveys will be completed by the seabird observer and/or qualified field lead according to the Canadian Wildlife Service's (CWS) Eastern Canada Seabirds at Sea (ECSAS) Protocols (Gjerdrum et al. 2012). During periods of low marine mammal activity, MWO's will be trained and participate in seabird surveys. The objective of the seabird survey is to document seabird species abundance and distribution. Like the marine mammal surveys, the seabird surveys also record the distances to bird observations. A summary of the survey methodology is provided here. A full outline of the methodology is provided in Gjerdrum et al. (2012).

7.1 Surveys from Moving Platforms

A survey consists of a series of 5-minute observation periods, which are exclusively dedicated to detecting birds. The goal is to complete six to ten 5-minute observation periods during a dedicated seabird survey period, regardless of whether birds are present or not. Seabird surveys should be conducted throughout the day to provide consistent coverage. The transition between observation periods may take a minute or two depending on seabird activity, to record the vessel's position and any conditions that may have changed since the last 5-minute observation period. A series of surveys will not exceed a total of two hours to avoid observer fatigue.

Surveys are best completed when the platform is travelling at a minimum speed of 4 knots (7.4 km/h). Surveys can be done when the ship is travelling less than 4 knots, but birds are often attracted to slow moving or stationary vessels. If birds are clearly gathering around the vessel and settling on the water when the ship is moving at decreased speeds (i.e., less than 2 knots), surveys will cease.

During a 5-minute observation period, a 300 m wide rectangular area of ocean will be covered (from 0˚ to 90˚). All birds observed on the sea surface are continuously recorded throughout the 5-minute period and their perpendicular distance from the observer is estimated. Bird counts are associated with distance "bins" and include 0 to 50 m, 51 to 100 m, 101 to 200 m, and 201 to 300 m. The distance gauge using an ordinary ruler will be used to approximate distance categories.

7.1.1 Birds in Flight

More birds will fly through the survey area than were present in that area at a single instant in time. Flying birds are recorded using a series of instantaneous counts, or snapshots, at regular intervals along the transect and during the 5-minute survey period (Table 9). The time interval between snapshots depends on the speed of the ship and is chosen so that the ship moves roughly 300 m between snapshots. During each snapshot, flying birds are recorded as in transect only if they are within 300 m to the side and 300 m ahead of the vessel.

Table 9: Snapshot Interval Frequency

Platform Speed (knots)	Interval Between Counts (minutes)
0.1 to 4.5	2.5
4.6 to 5.5	2
5.6 to 8.5	1.5
8.6 to 12.5	1
12.6 to 19	0.5

7.1.1.1 *Lines of Flying Birds*

Some bird species fly in long lines. At the time of the snapshot, the number of birds in the flock is counted and the distance class is assigned according to the location of the flock centre. All birds are recorded as in transect if the centre of the flock is within the 300 m transect.

7.2 Surveys from Stationary Platforms

Survey from stationary ships or platforms will be completed using snapshots methods occurring at regular intervals throughout the day. Surveys are completed from a position outdoors whenever possible, as close to the edge of the platform as permitted. A position near the edge will increase the detection rates of birds, especially for birds that use the waters at the base of the platform. Surveys are completed by scanning a 180° arc, giving priority to birds within a 300 m semi-circle. The same distance bins are used as with Moving Platform methods (Section 7.1).

7.3 Data Quality Assurance / Quality Control and Back Up

Throughout and at the end of the day, a QA/QC on the data will be done to verify that no records/fields are missing. Once completed, the database must be backed up on an external hard drive.

7.4 References

Gjerdrum, C., D.A. Fifield, and S.I. Wilhelm. 2012. Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms. Canadian Wildlife Service Technical Report Series No. 515. Atlantic Region. vi + 37 pp

Jansen, J. K., Boveng, P. L., Dahle, S. P. and J. L. Bengtso. 2010. Reaction of harbor seals to cruise ships. Journal of Wildlife Management 74:1186–1194.

Lerczak, J.A., and Hobbs, R.C. 1998. Calculating sighting distances from angular readings during shipboard, aerial, and shore-based marine mammal surveys. Marine Mammal Science 14(3):590 – 599.

Lomac-Macnair, K., Andrade, J.P., and E. Esteves. 2019. Seal and polar bear behavioral response to an icebreaker vessel in northwest Greenland. 13(2), p. 277-289. Jansen, J. K., P. L. Boveng, S. P. Dahle, and J. L. Bengtso. 2010. Reaction of harbor seals to cruise ships. Journal of Wildlife Management 74:1186–1194.

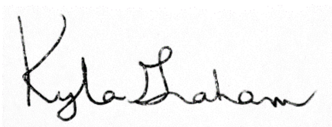
Øritsland, N.A. 1970. Temperature regulation of the polar bear (*Thalarctos maritimus*). Comparative Biochemistry and Physiology 37(2):225 – 233. http://dx.doi.org/10.1016/0010-406X(70)90547-5

Smultea, M.A., Brueggeman, J., Robertson, F., Fertl, D., Bacon, C., Rowlett, R.A. and G.A. Green. 2016. Polar Bear (Ursus maritimus) Behavior near Icebreaker Operations in the Chukchi Sea, 1991. 69(2): p. 177-184.

Dyck, M.G., and Baydack, R.K. 2004. Vigilance behaviour of polar bears (Ursus maritimus) in the context of wildlife-viewing activities at Churchill, Manitoba, Canada. Biological Conservation 116(3):343 – 350. http://dx.doi.org/10.1016/S0006-3207(03)00204-0

Signature Page

WSP Canada Inc.



Kyla Graham
Marine Biologist

Patrick Abgrall
Senior Marine Biologist

KG/PA/asd

https://golderassociates.sharepoint.com/sites/11206g/deliverables (do not use)/issued to client_for wp/400-499/1663724-496-r-rev0/1663724-496-r-rev0-74000 2023 sbo training manual 15mar_24.docx

APPENDIX A

How to connect GPSs to the Computer

How to set up SU-353 or Bad Elf GPS Connection to the computer:

1. Plug the SU-353 or Bad Elf GPS into a USB port on the computer.
2. Plug the device in and use the computer's 'Device Manager' to determine the Com port being used (Com ports may or may not change when devices or USB ports are switched) (Figure 1).

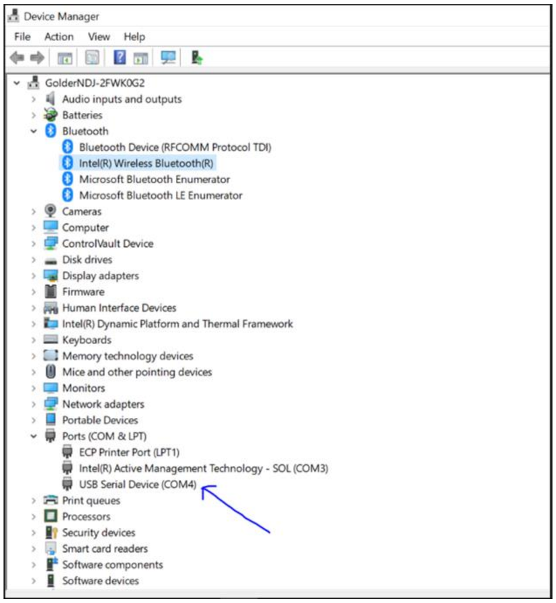


Figure 1: Using device manager to determine GPS com port

3. Check how well the GPS is working by opening 'VisualGPSView' (on the taskbar). You will have to go into settings and set the Com port and Baud Rate (4800 for SU-353, 9600 for Bad Elf) (Figure 2 and Figure 3). Note – only one thing can be connected to a Com port at a time, you will have to close this software before using the 'frmGPS' page in the ECSAS or Marine Mammals Access databases.

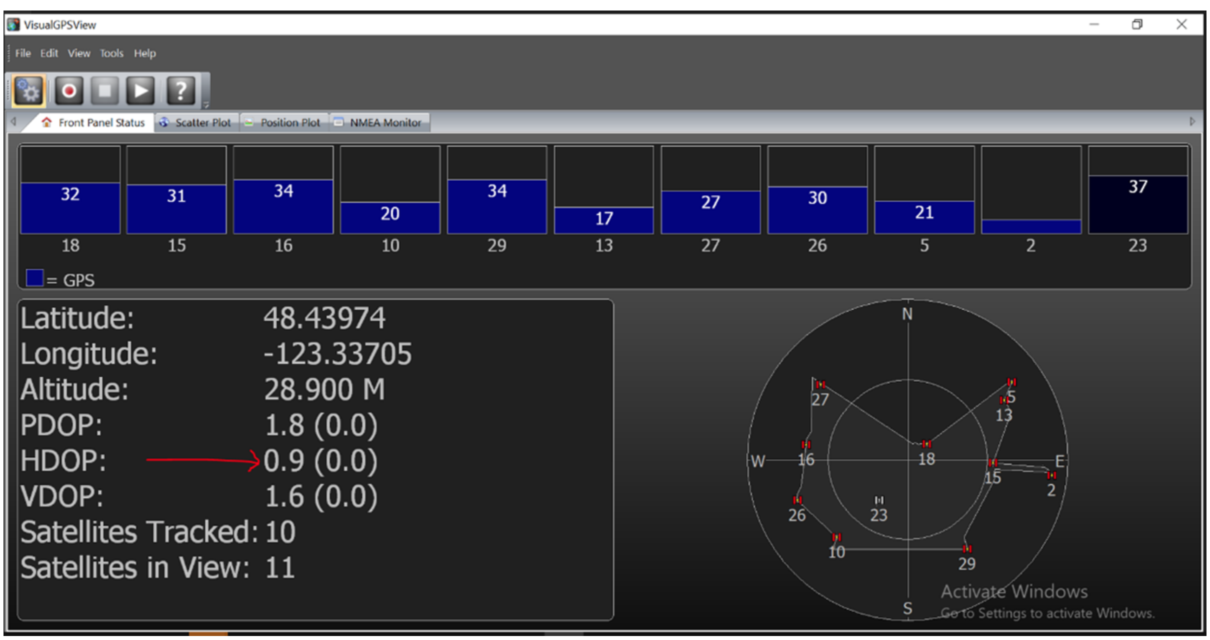


Figure 2: VisualGPSView window

DOP Value	Rating[5]	Description
<1	Ideal	Highest possible confidence level to be used for applications demanding the highest possible precision at all times.
1-2	Excellent	At this confidence level, positional measurements are considered accurate enough to meet all but the most sensitive applications.
2-5	Good	Represents a level that marks the minimum appropriate for making accurate decisions. Positional measurements could be used to make reliable in-route navigation suggestions to the user.
5-10	Moderate	Positional measurements could be used for calculations, but the fix quality could still be improved. A more open view of the sky is recommended.
10-20	Fair	Represents a low confidence level. Positional measurements should be discarded or used only to indicate a very rough estimate of the current location.
>20	Poor	At this level, measurements are inaccurate by as much as 300 meters with a 6-meter accurate device (50 DOP × 6 meters) and should be discarded.

Figure 3: DOP Rating Scale

4. To connect to the seabird database, configure the settings in the *ECSAS - Options* form (Figure 4):
   a. Select the Com port and Speed (4800 for SU-353, 9600 for BadElf)

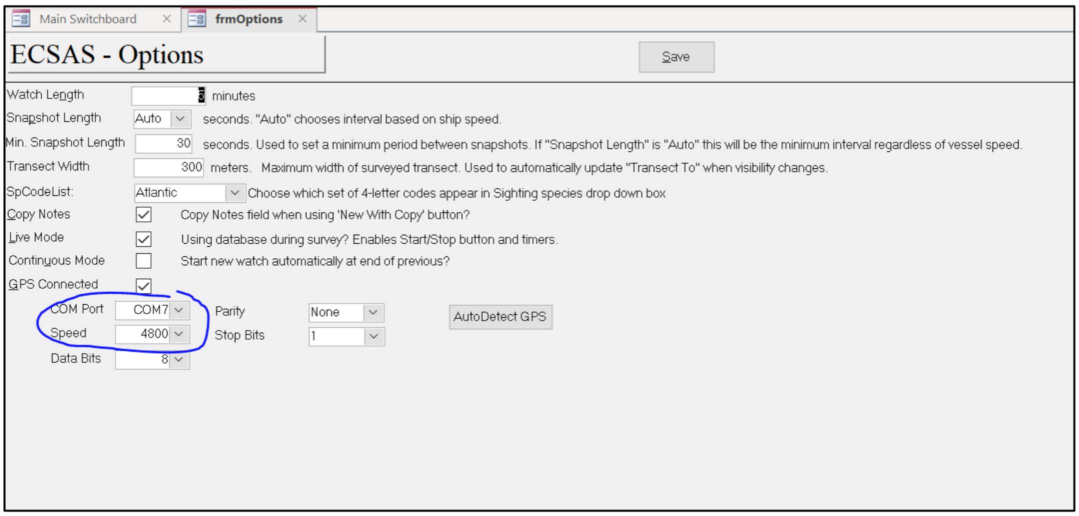


Figure 4: Configuring GPS settings in ECSAS

   b. Open Tools > GPS Data (**must stay open**) and then open the page for data entry. The 'Num Fix' value should grow – only reset to zero if connection to GPS lost (Figure 5).

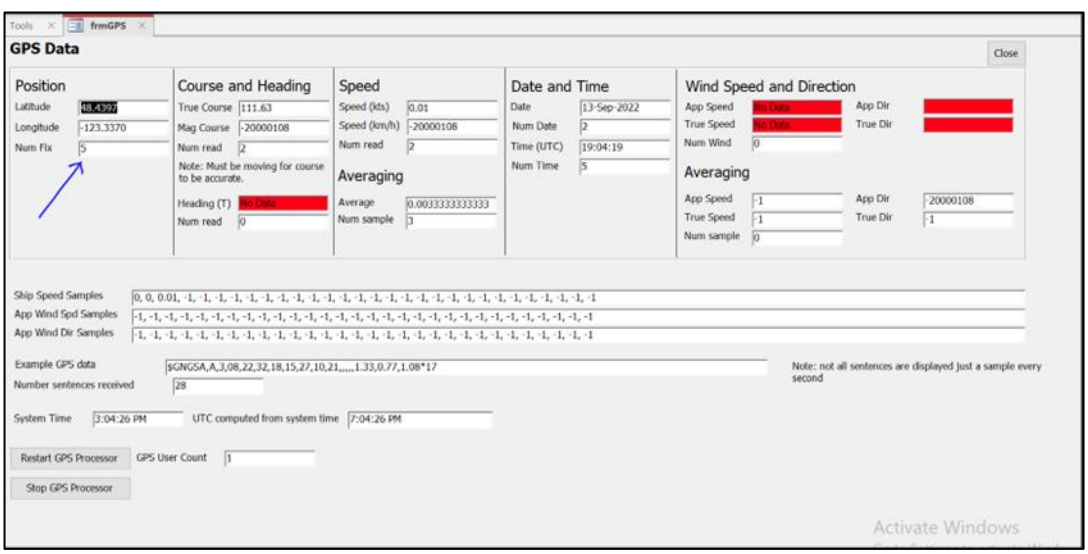


Figure 5: Check 'Num Fix' value

5. If you use another copy of the database, you will have to alter some of the code for the MGC/GPS connection to work.
    a. Open the list of database modules (1-3 blue arrows) (Figure 6):

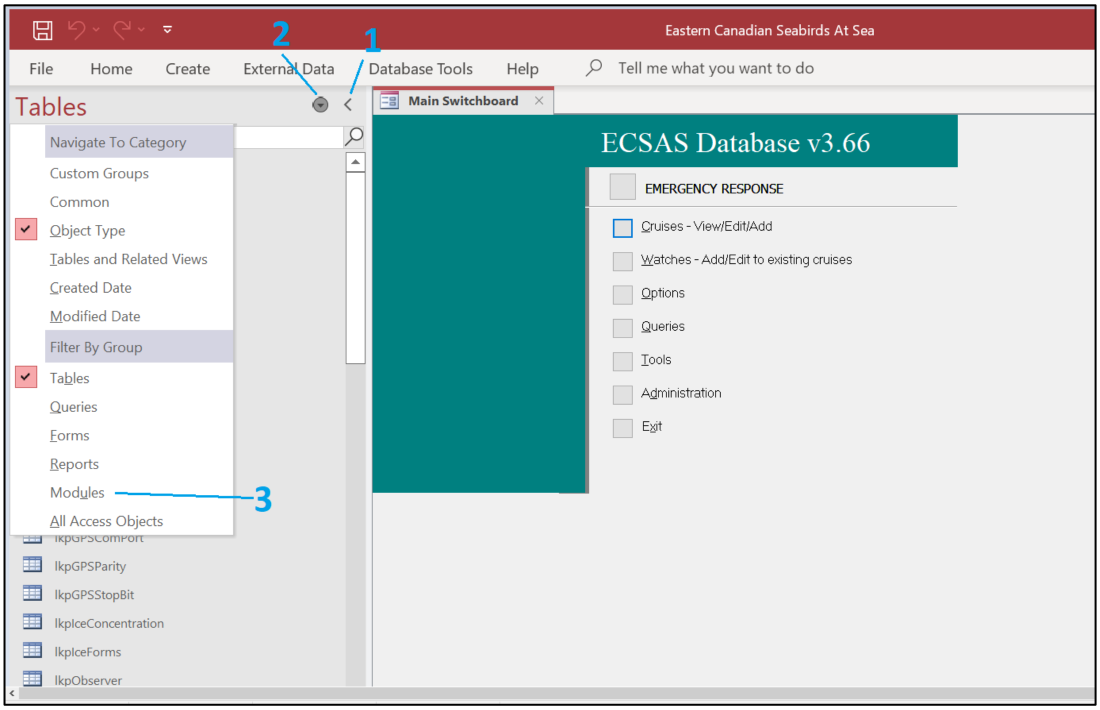


Figure 6: How to open database modules

    b. Double click on 'modGPS', scroll down to the 'initial globals' section and add the underlined to the text within the brackets (Figure 7) (this is the keycode that would've been provided with the MGC4VB software). Click on the save icon and close the module window. Minimize the module list and you are done!

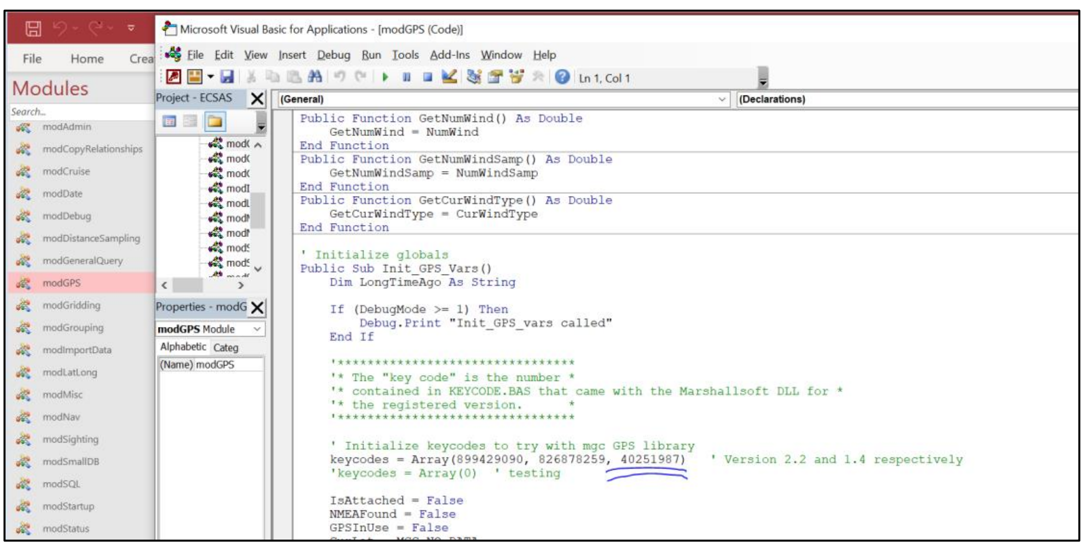
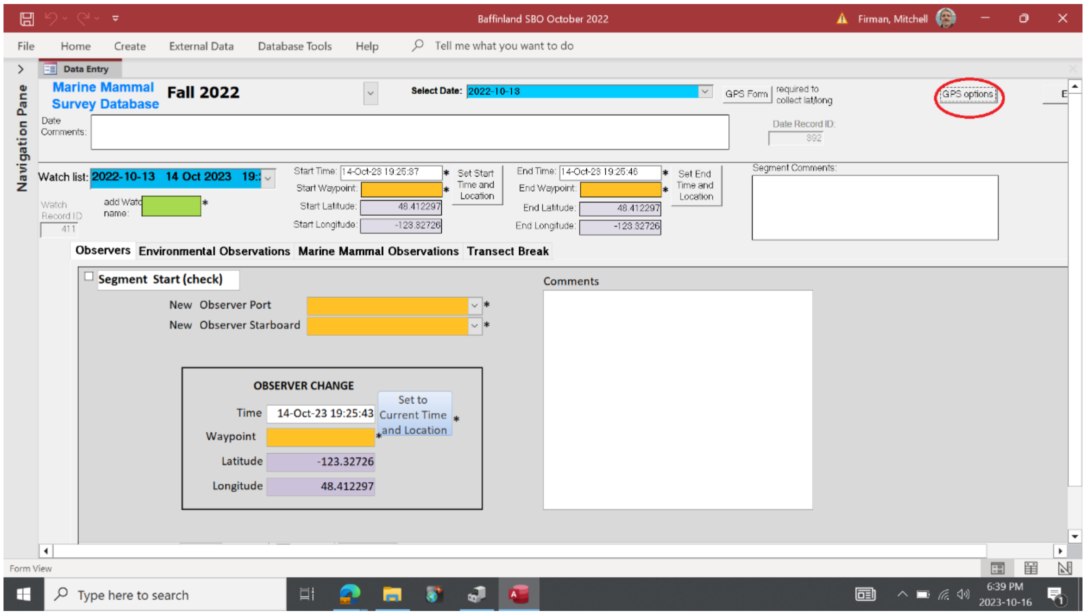
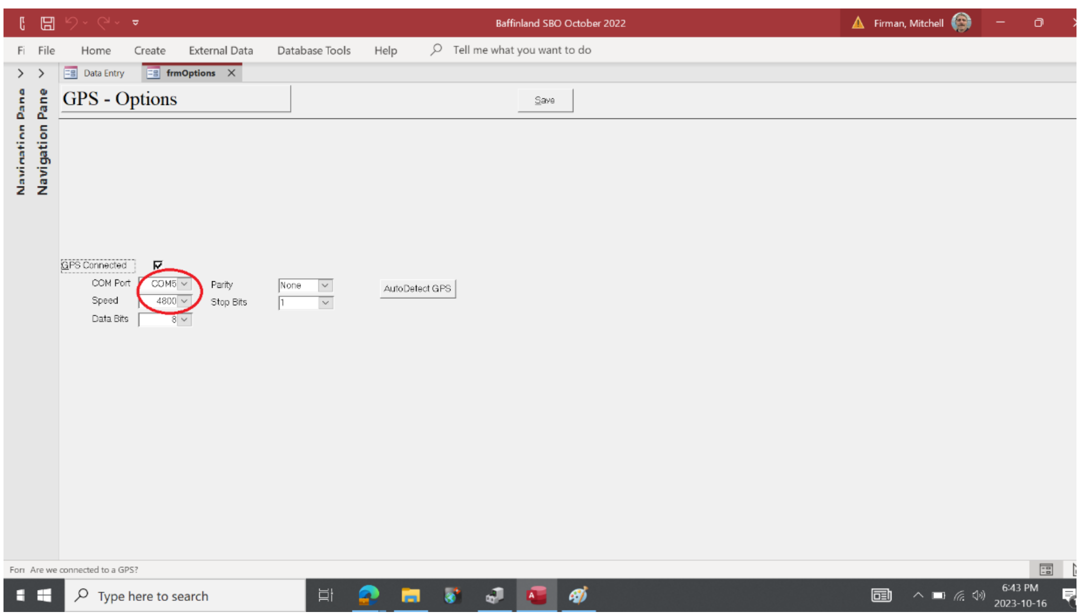


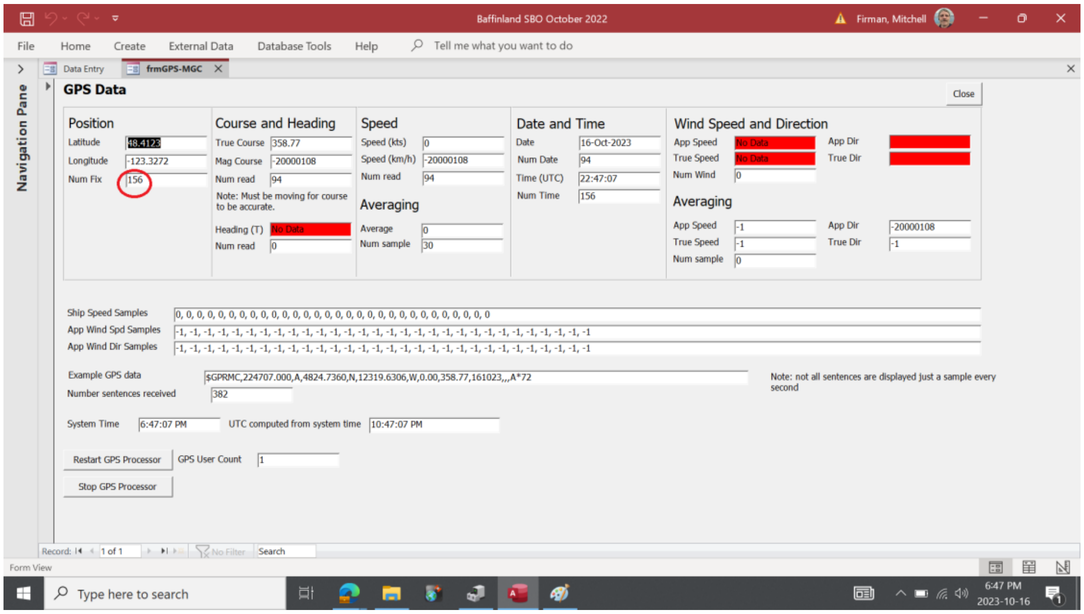
Figure 7: Altering the code for the MGC/GPS connection

6. To connect to the marine mammal database:
    a. Select the com port and speed (4800 for SU-353, 9600 for BadElf) from *GPS Options* (red circle) once you open the database.





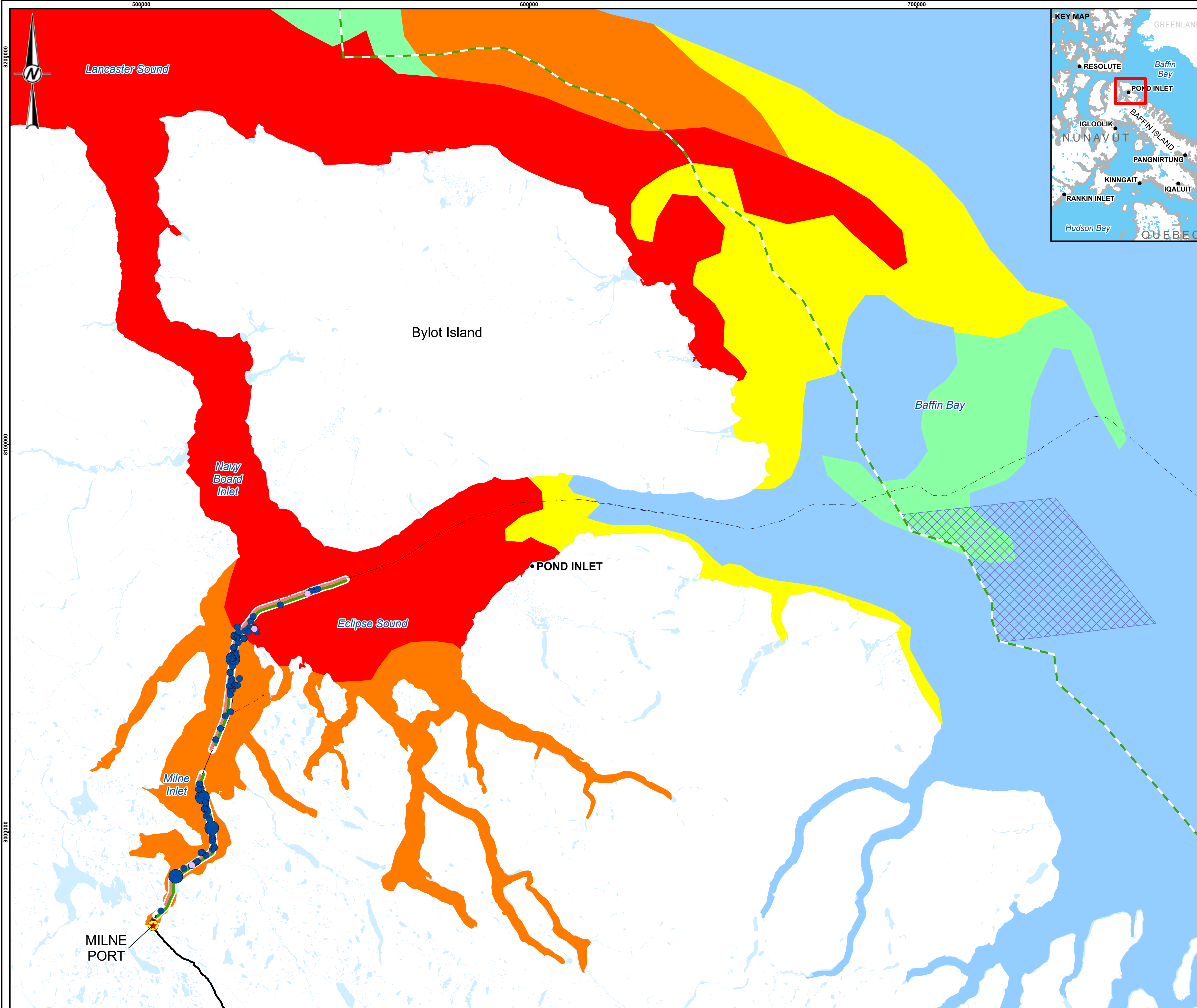
b. Open *GPS Form* (**must stay open**) and then open the page for data entry. The ‘Num Fix’ value should grow – only reset to zero if connection to GPS lost.



wsp.com

APPENDIX B

Daily Ice Charts



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL

- 1

RINGED SEAL

- 1
- 2-10

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

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

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

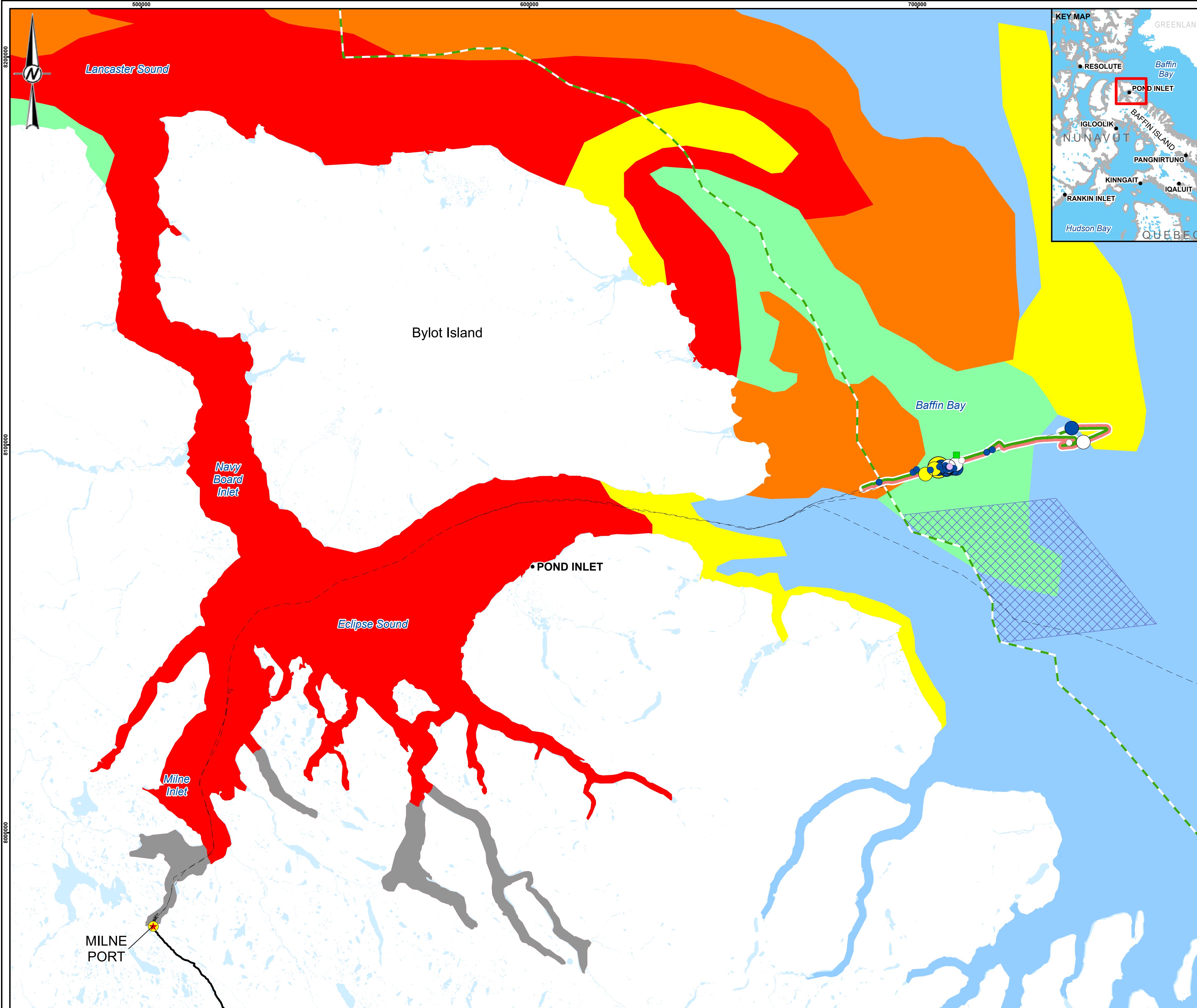
TITLE
SBO SURVEY - BOTNICA OCTOBER 21, 2023

CONSULTANT

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	1

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



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

HARP SEAL
- 2-10
- 10+

RINGED SEAL
- 1
- 2-10

UNIDENTIFIED SEAL
- 1
- 2-10

POLAR BEAR
- 1

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

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

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

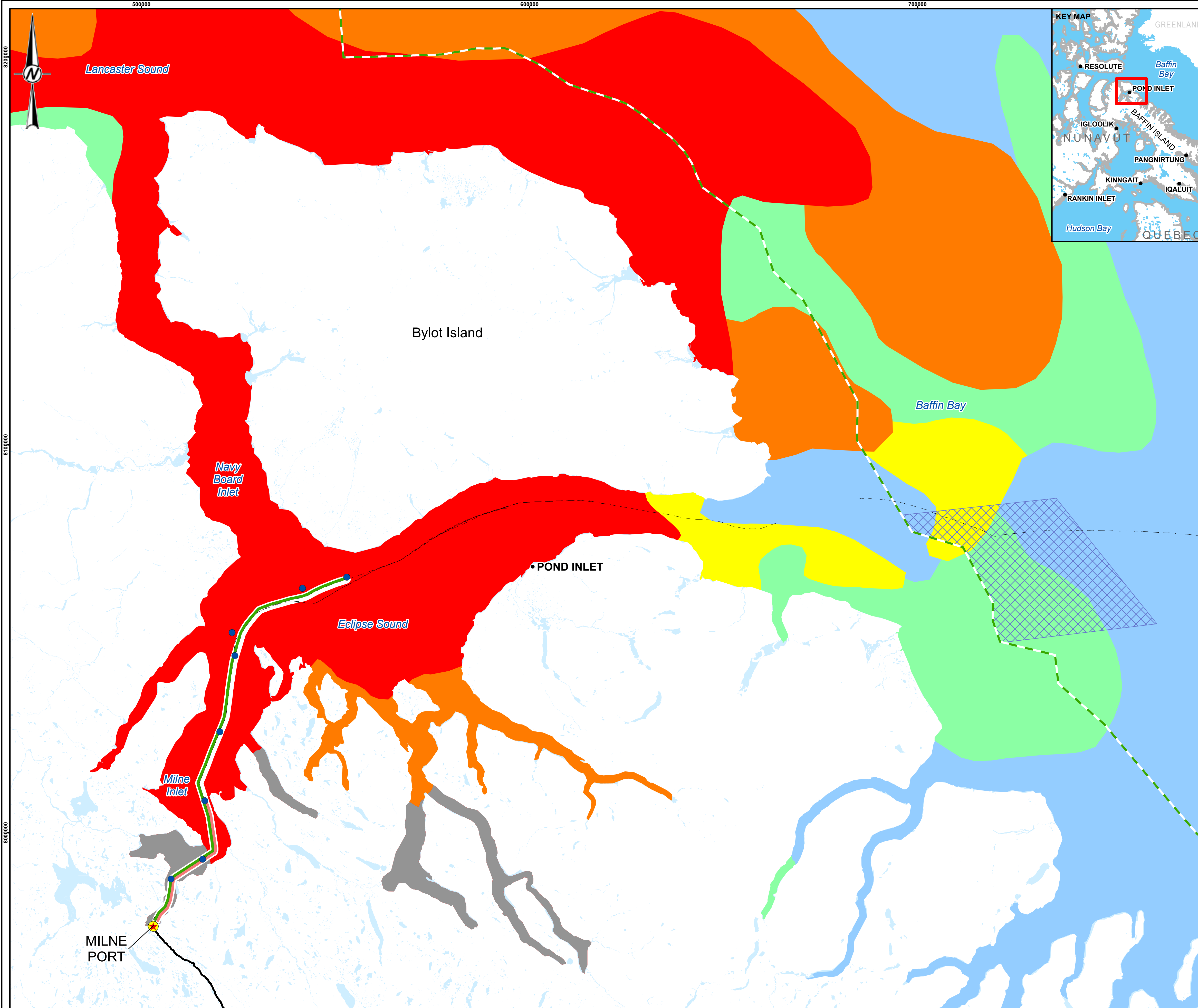
PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
SBO SURVEY - BOTNICA OCTOBER 22, 2023

CONSULTANT
wsp

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	2



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

RINGED SEAL

- 1

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

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

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

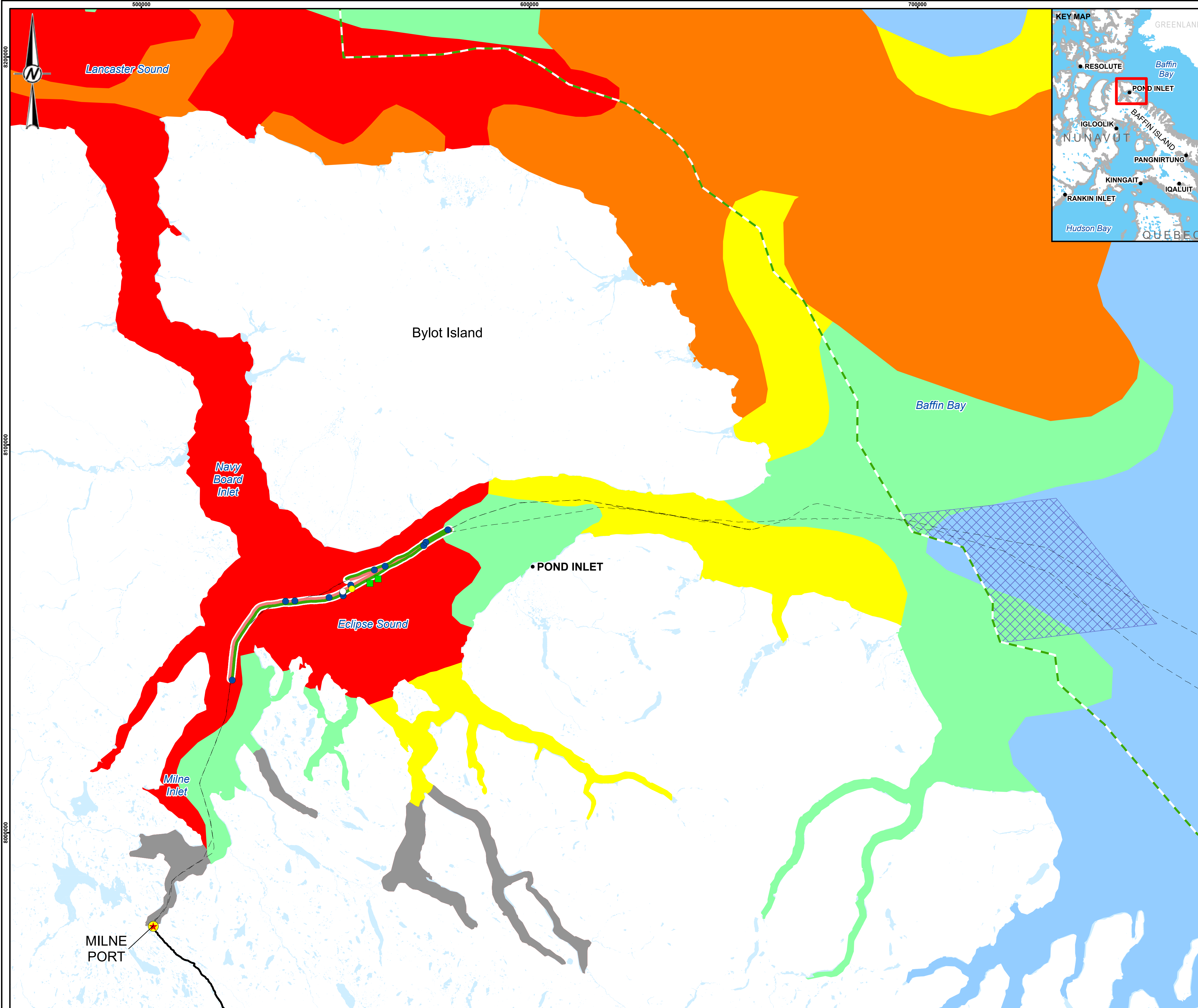
TITLE
SBO SURVEY - BOTNICA OCTOBER 23, 2023

CONSULTANT

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	3

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



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL

- 1

RINGED SEAL

- 1

UNIDENTIFIED SEAL

- 1

POLAR BEAR

- 1

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

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

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

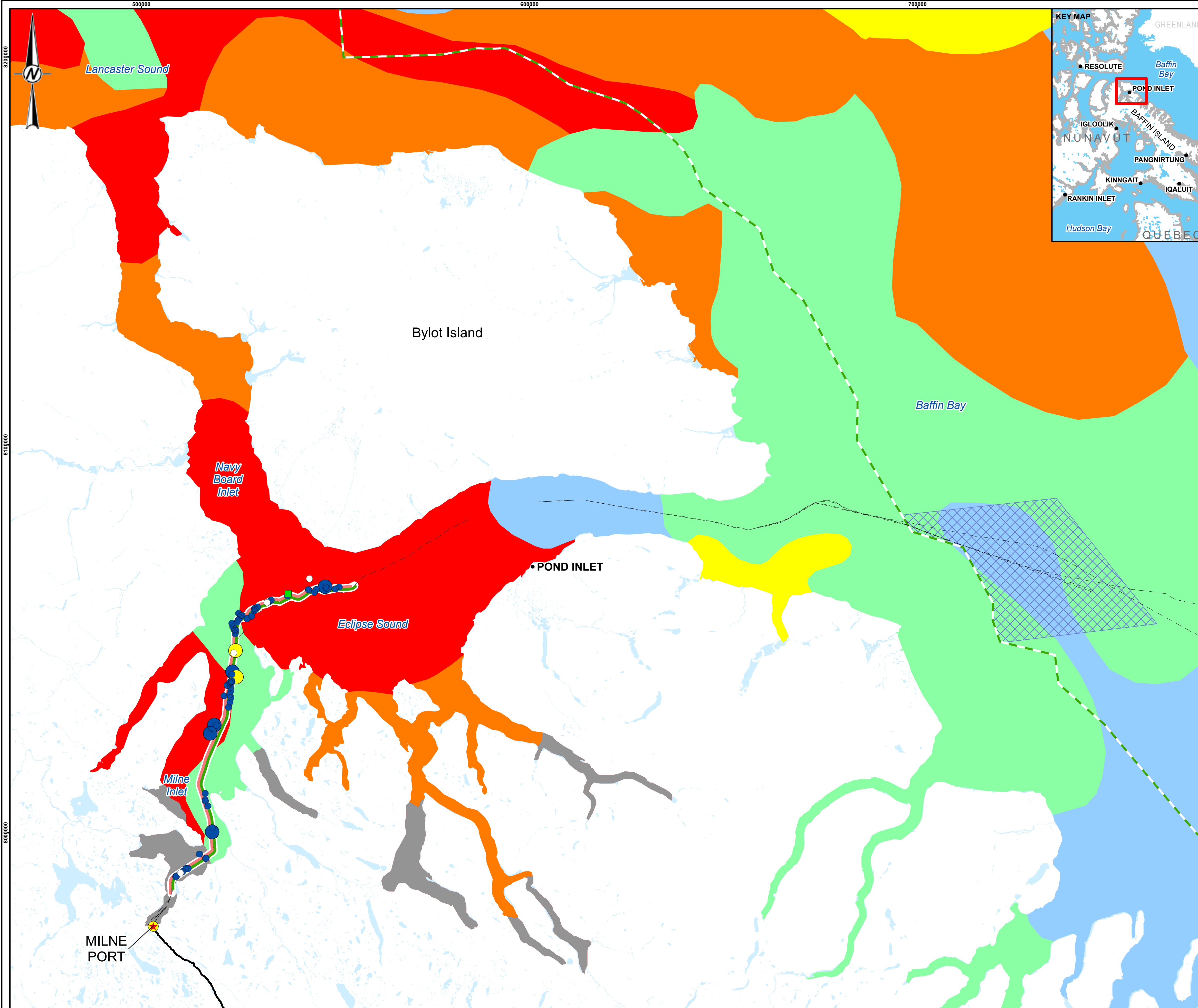
TITLE
SBO SURVEY - BOTNICA OCTOBER 24, 2023

CONSULTANT

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	4

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



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL

- 2-10

RINGED SEAL

- 1
- 2-10

UNIDENTIFIED SEAL

- 1

POLAR BEAR

- 1

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

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

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
SBO SURVEY - BOTNICA OCTOBER 25, 2023

CONSULTANT

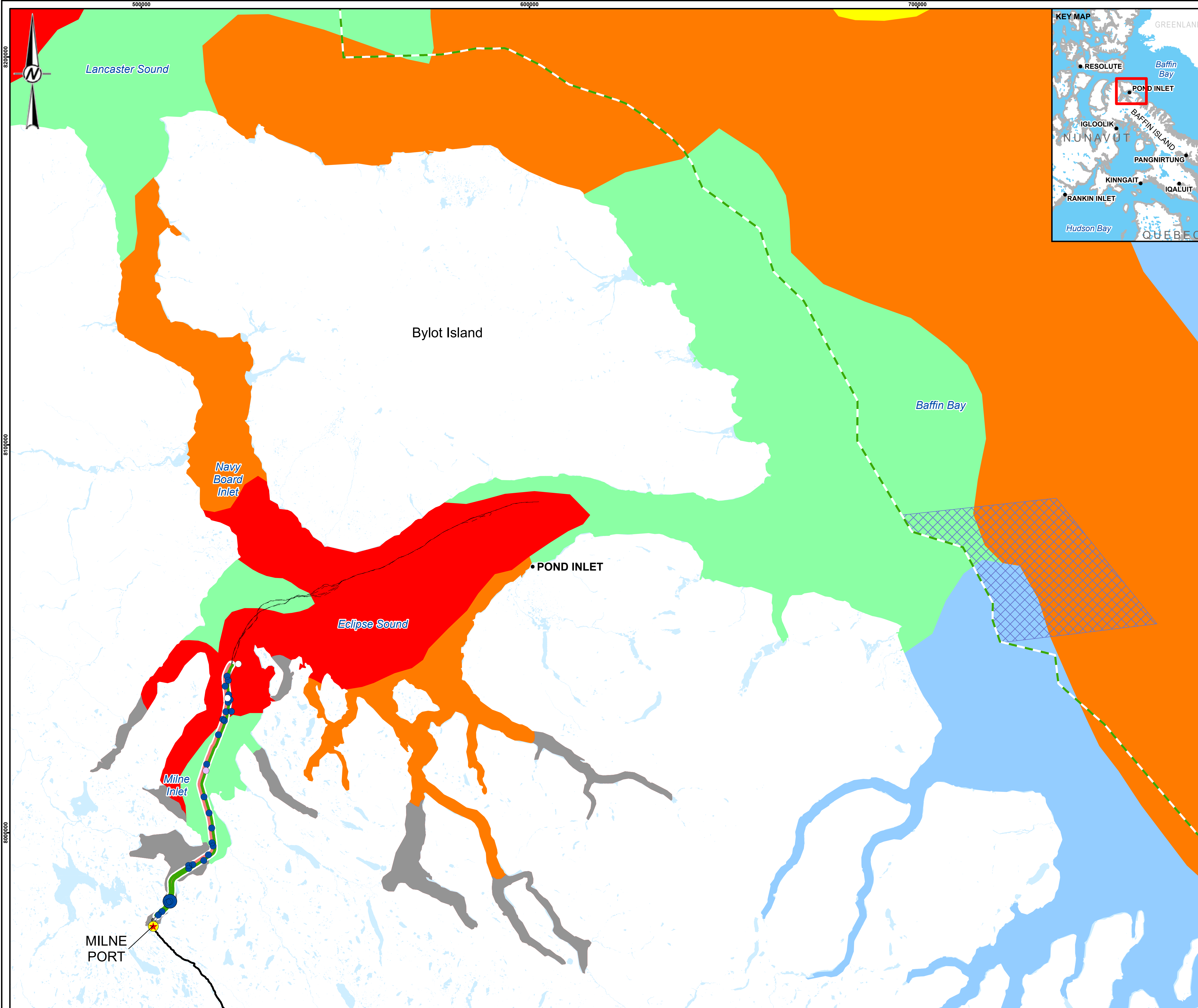
YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	5

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

25mm

PATH: I:\2016\166372402\Mapping\MXD\74000_2023_SBO\166372402_74000_Fig01to13_SBO_DailyEffort_Rev0.aprx PRINTED ON: AT: 6:43:04 PM



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL

- 1

RINGED SEAL

- 1
- 2-10

UNIDENTIFIED SEAL

- 1

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

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

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE

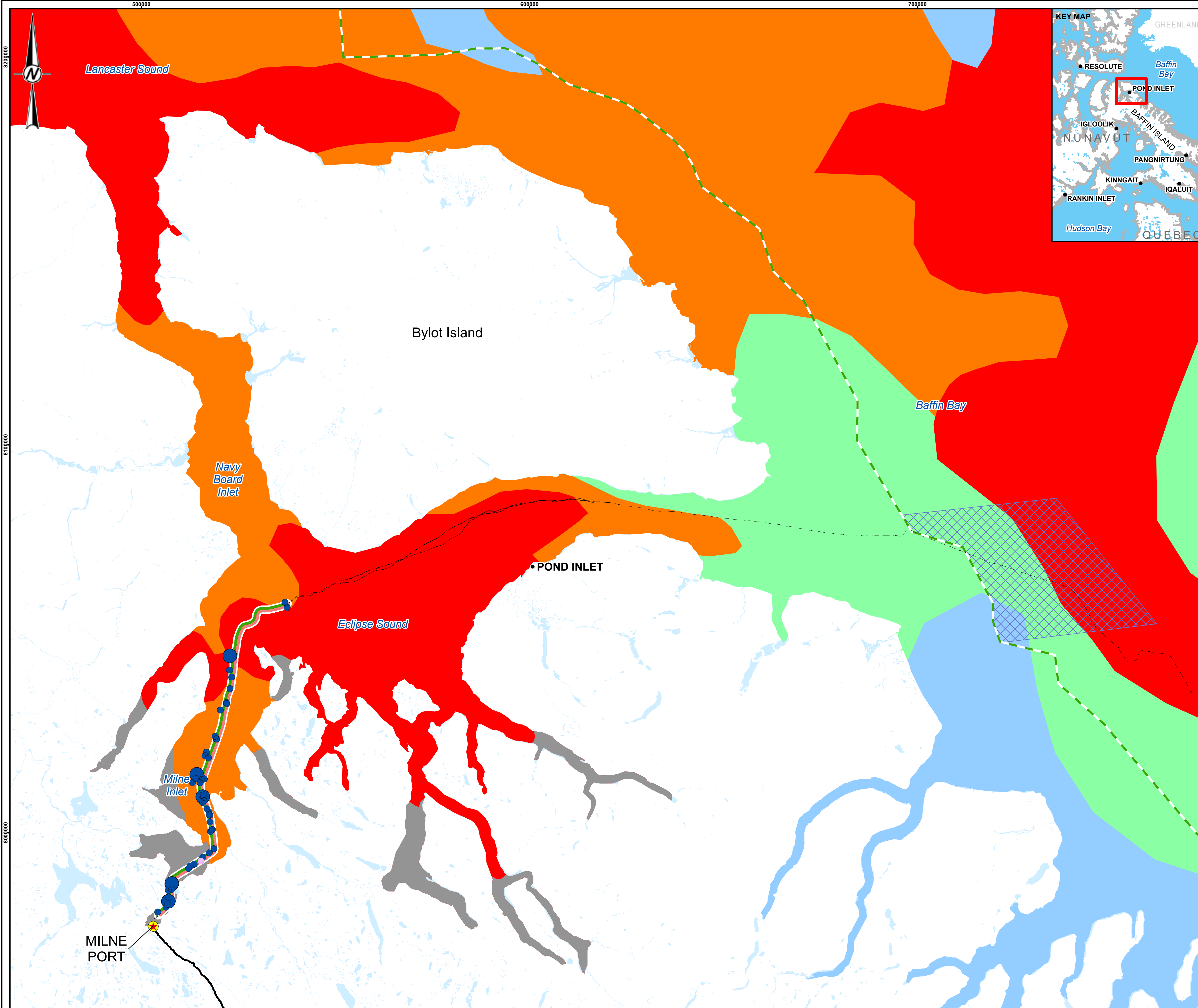
SBO SURVEY - BOTNICA OCTOBER 26, 2023

CONSULTANT

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	6

25mm



REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

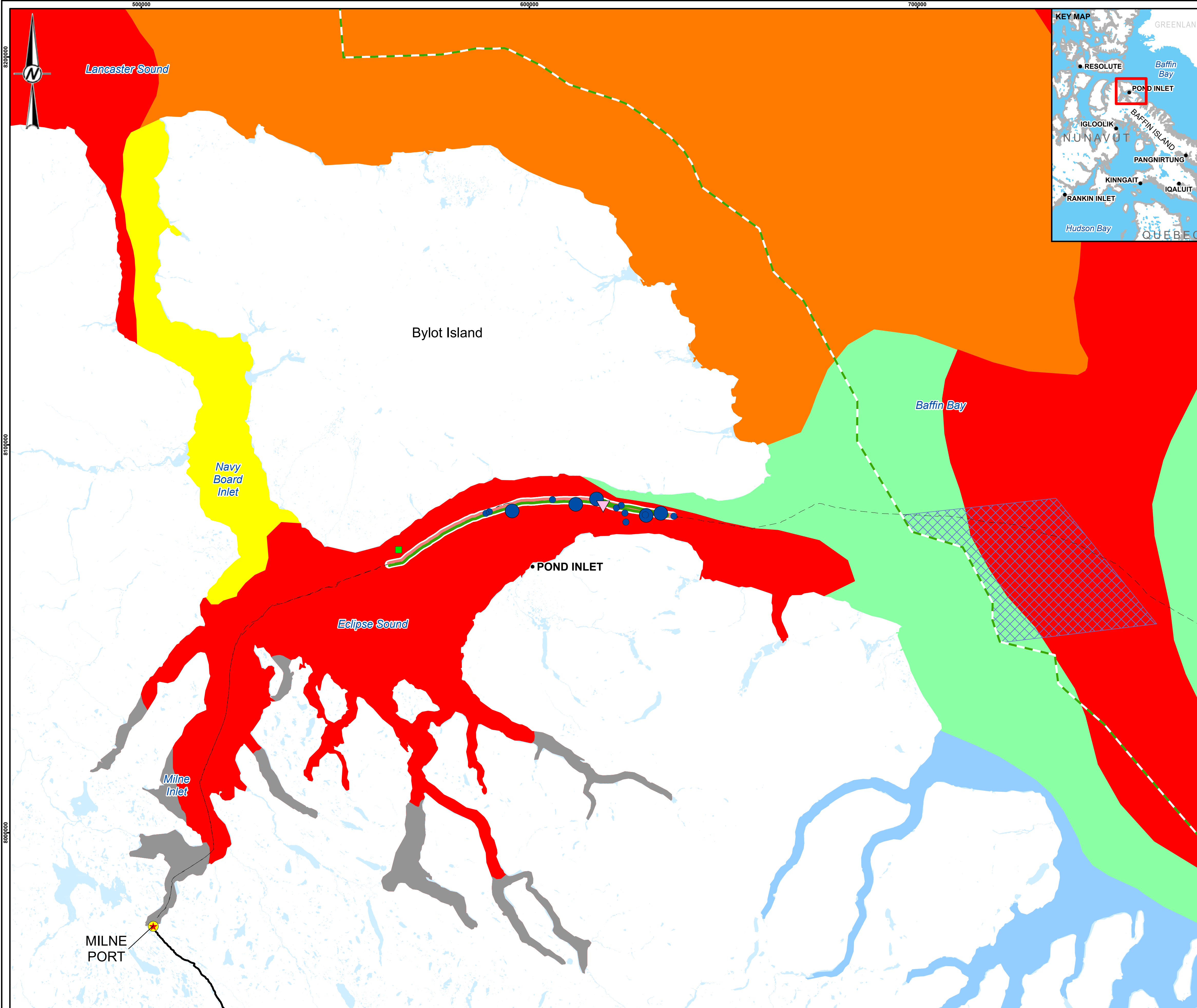
TITLE
SBO SURVEY - BOTNICA OCTOBER 27, 2023

CONSULTANT
wsp

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	7

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



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

RINGED SEAL

- 1
- 2-10

NARWHAL

- 2-10

POLAR BEAR

- 1

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

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

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE

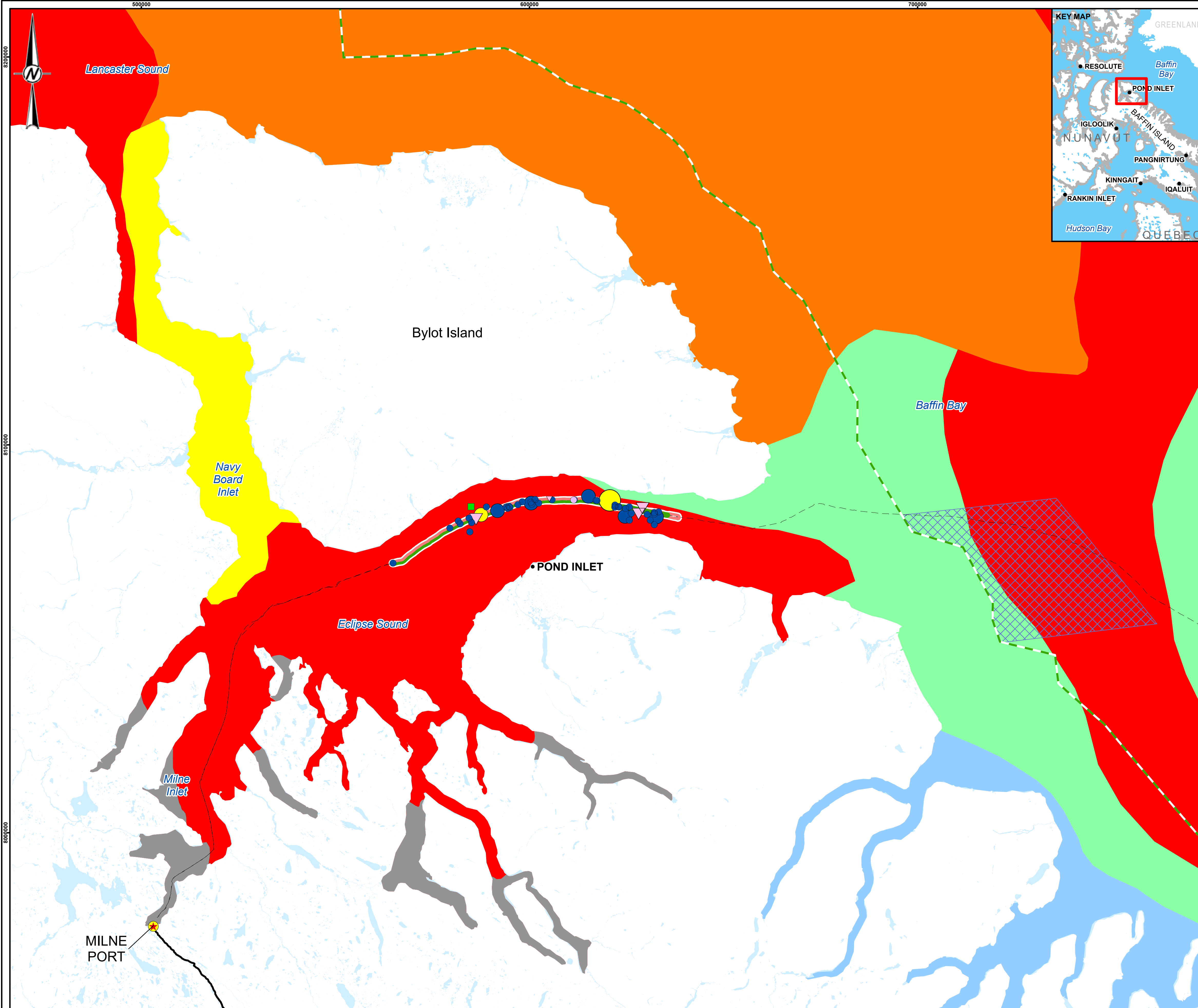
SBO SURVEY - BOTNICA OCTOBER 28, 2023

CONSULTANT

wsp

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	8



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL

- 1

HARP SEAL

- 2-10
- 10+

RINGED SEAL

- 1
- 2-10

NARWHAL

- 1
- 2-10

POLAR BEAR

- 1

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

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

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
SBO SURVEY - FENNICA OCTOBER 28, 2023

CONSULTANT

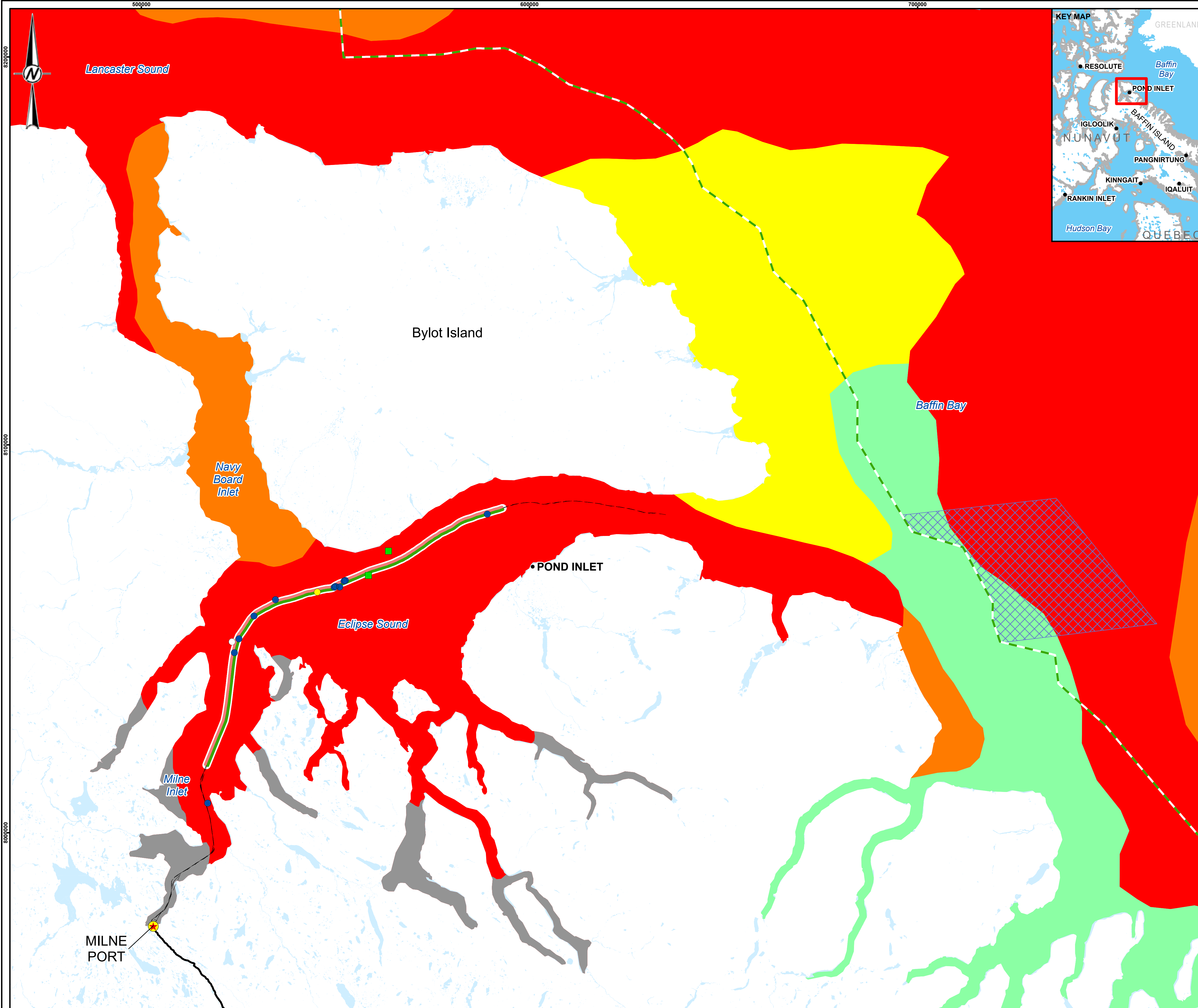
wsp

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	9

25mm

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



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

HARP SEAL
- 1

RINGED SEAL
- 1

UNIDENTIFIED SEAL
- 1

POLAR BEAR
- 1

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

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

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE

SBO SURVEY - BOTNICA OCTOBER 29, 2023

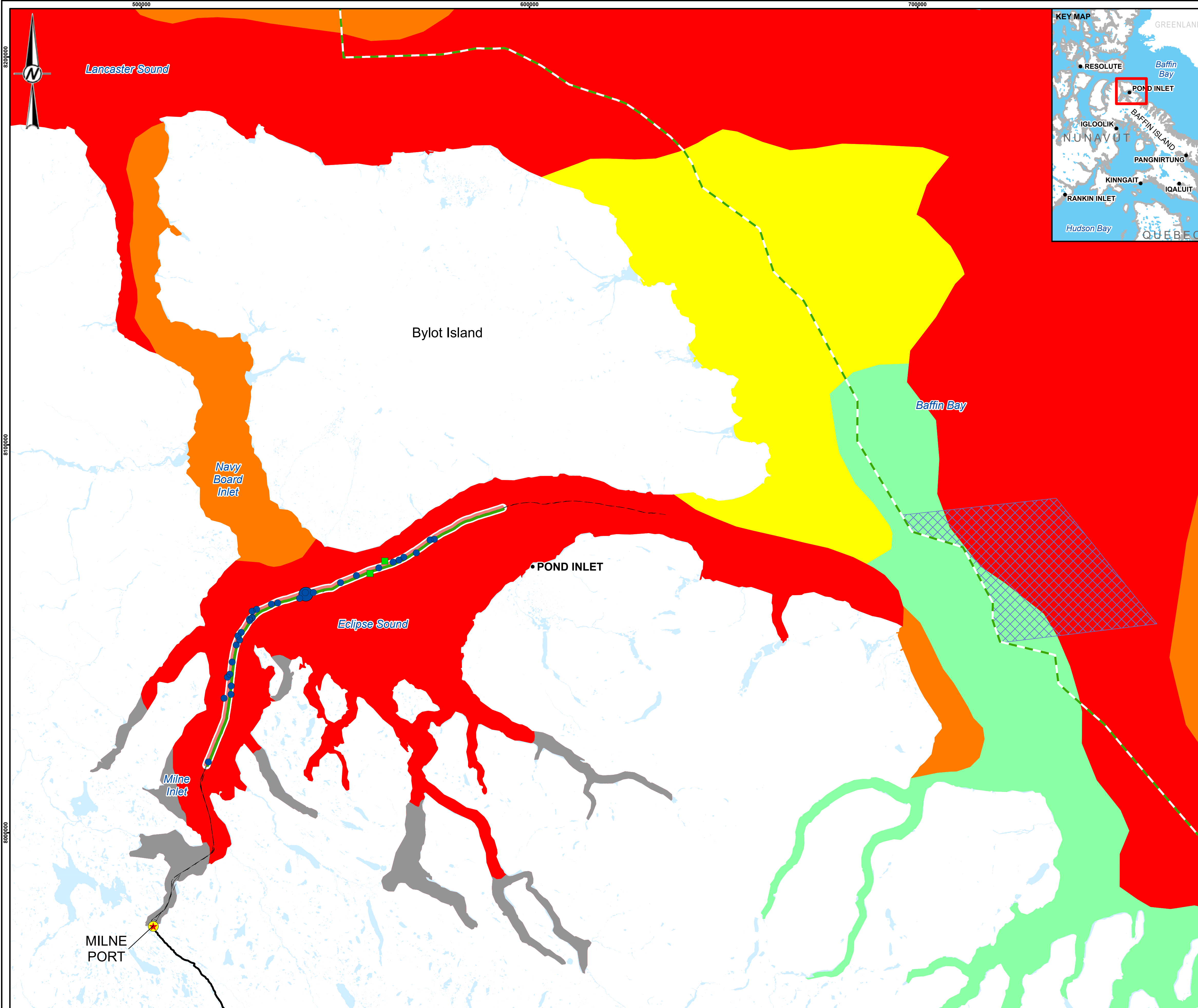
CONSULTANT

wsp

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	10

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



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

RINGED SEAL

- 1
- 2-10

POLAR BEAR

- 1

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

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

0 25 50
1:1,000,000 KILOMETRES

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

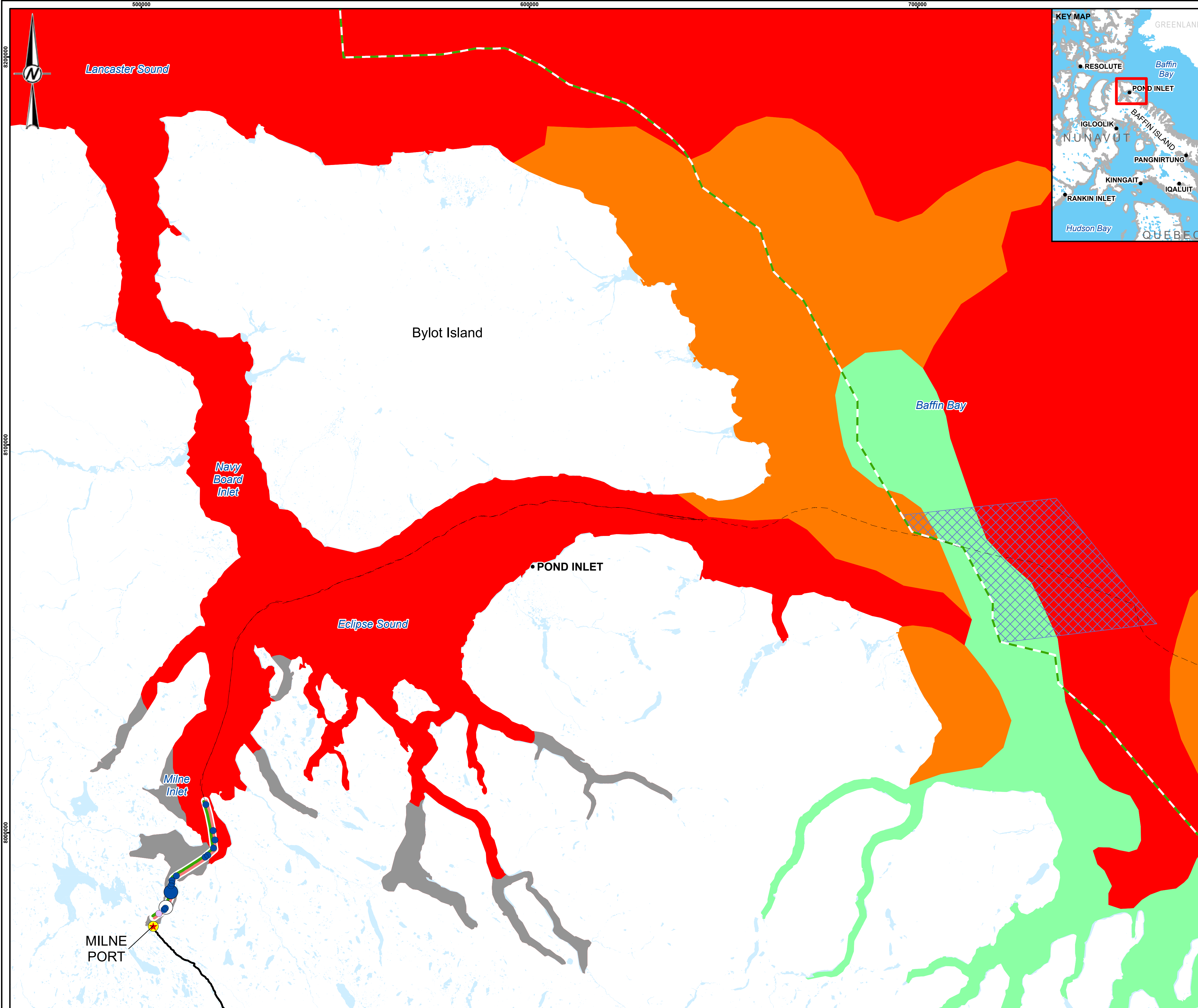
PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE
SBO SURVEY - FENNICA OCTOBER 29, 2023

CONSULTANT
wsp

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	11



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL

- 1

RINGED SEAL

- 1
- 2-10

UNIDENTIFIED SEAL

- 2-10

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

- 1-3/10
- 7-8/10
- 9-10/10
- LANDFAST ICE

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

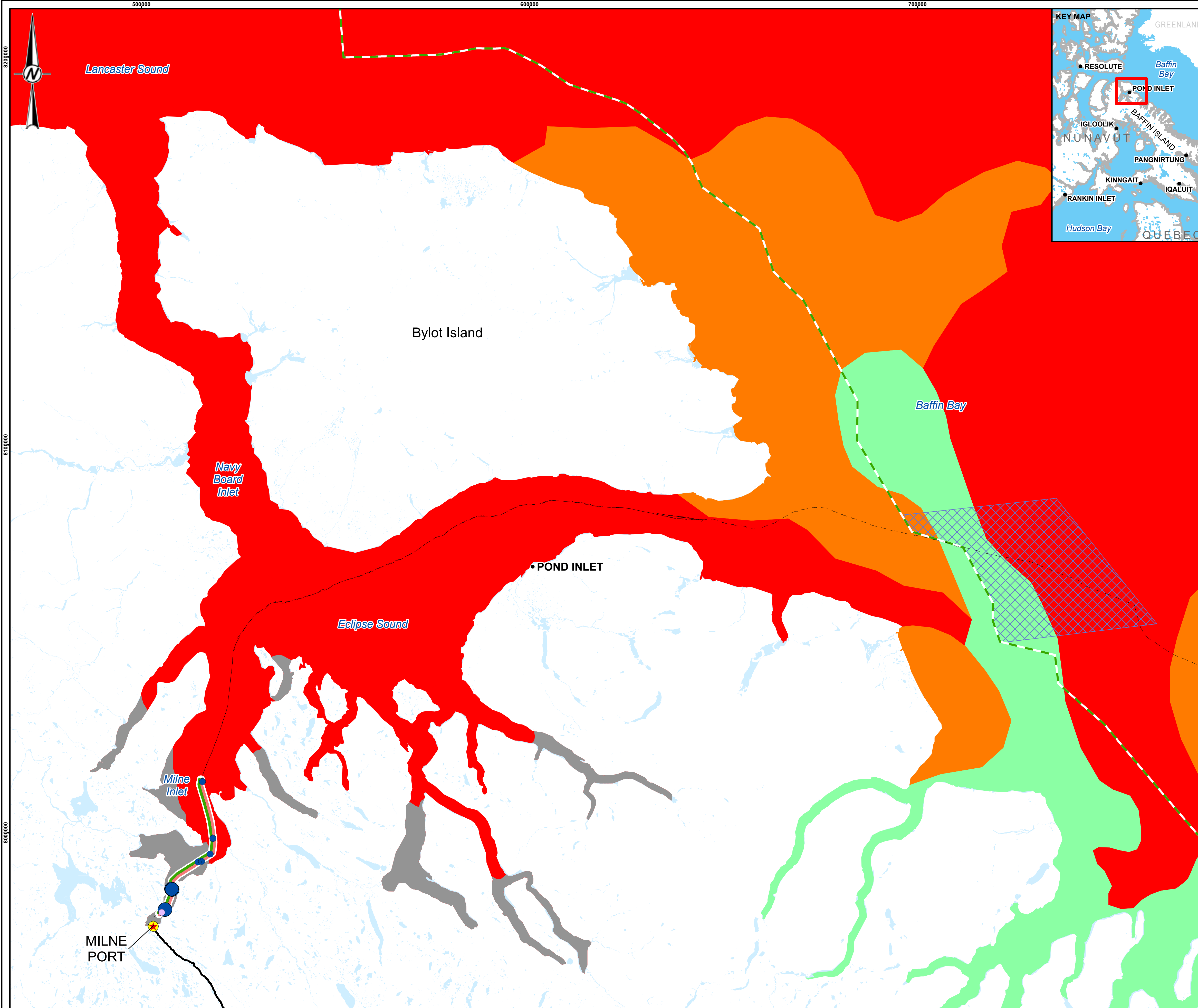
TITLE
SBO SURVEY - BOTNICA OCTOBER 30, 2023

CONSULTANT

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	12

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



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

SHIP TRACK EFFORT STATUS

- PORT
- STARBOARD

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL

- 1

RINGED SEAL

- 1
- 2-10

- MILNE INLET TOTE ROAD
- OTHER VESSEL TRACK
- 40 KM BUFFER ZONE
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY (NO ICE DATA)

ICE CONCENTRATION

- 1-3/10
- 7-8/10
- 9-10/10
- LANDFAST ICE

0 25 50

1:1,000,000 KILOMETRES

REFERENCE(S)

MILNE PORT INFRASTRUCTURE DATA BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – BAFFIN BAY AND APPROACHES TO RESOLUTE BAY. ACCESSED DECEMBER 11, 2023. HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT

BAFFINLAND IRON MINES CORPORATION

PROJECT

MARY RIVER PROJECT
2023 SHIP-BASED OBSERVER PROGRAM

TITLE

SBO SURVEY - FENNICA OCTOBER 30, 2023

CONSULTANT

wsp

YYYY-MM-DD	2024-03-21
DESIGNED	KG
PREPARED	AA
REVIEWED	PA
APPROVED	PA

PROJECT NO.	CONTROL	REV.	FIGURE
166372402	74000.05	0	13

APPENDIX C

R Code for Behavioural Response Analyses

SBO-Response Analysis

Jessica Garzke and Sam Sweeney

2024-02-14

#Load libraries

```
library(readxl)
library(tidyverse)

## ── Attaching core tidyverse packages ──────────────────────── tidyverse
2.0.0 ──
## ✓ dplyr     1.1.4     ✓ readr     2.1.4
## ✓ forcats   1.0.0     ✓ stringr   1.5.1
## ✓ ggplot2   3.4.4     ✓ tibble    3.2.1
## ✓ lubridate 1.9.3     ✓ tidyr     1.3.0
## ✓ purrr     1.0.2
## ── Conflicts ──────────────────────────────────────────
tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all
conflicts to become errors

library(foreign)
library(ggplot2)
library(MASS)

##
## Attaching package: 'MASS'
##
## The following object is masked from 'package:dplyr':
##
##     select

library(tidymodels)

## ── Attaching packages ────────────────────────────────────── tidymodels
1.1.1 ──
## ✓ broom        1.0.5     ✓ rsample      1.2.0
## ✓ dials        1.2.0     ✓ tune         1.1.2
## ✓ infer        1.0.5     ✓ workflows    1.1.3
## ✓ modeldata    1.2.0     ✓ workflowsets 1.0.1
## ✓ parsnip      1.1.1     ✓ yardstick    1.2.0
## ✓ recipes      1.0.9
## ── Conflicts ─────────────────────────────────────────
```

```
tidymodels_conflicts() ──
## ✖ scales::discard() masks purrr::discard()
## ✖ dplyr::filter()   masks stats::filter()
## ✖ recipes::fixed()  masks stringr::fixed()
## ✖ dplyr::lag()      masks stats::lag()
## ✖ MASS::select()    masks dplyr::select()
## ✖ yardstick::spec() masks readr::spec()
## ✖ recipes::step()   masks stats::step()
## • Learn how to get started at https://www.tidymodels.org/start/
```

```
library(rcompanion)
```

```
##
## Attaching package: 'rcompanion'
##
## The following object is masked from 'package:yardstick':
##
##     accuracy
```

```
library(generalhoslem)
```

```
## Loading required package: reshape
##
## Attaching package: 'reshape'
##
## The following object is masked from 'package:lubridate':
##
##     stamp
##
## The following object is masked from 'package:dplyr':
##
##     rename
##
## The following objects are masked from 'package:tidyr':
##
##     expand, smiths
```

```
library(gofcat)
library(forecast)
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
##
## Attaching package: 'forecast'
##
## The following object is masked from 'package:rcompanion':
##
##     accuracy
##
```

```
## The following object is masked from 'package:yardstick':
##
##     accuracy
```

```r
library(marginaleffects)
library(Hmisc)
```

```
##
## Attaching package: 'Hmisc'
##
## The following object is masked from 'package:parsnip':
##
##     translate
##
## The following objects are masked from 'package:dplyr':
##
##     src, summarize
##
## The following objects are masked from 'package:base':
##
##     format.pval, units
```

```r
library(reshape2)
```

```
##
## Attaching package: 'reshape2'
##
## The following objects are masked from 'package:reshape':
##
##     colsplit, melt, recast
##
## The following object is masked from 'package:tidyr':
##
##     smiths
```

```r
library(EnvStats)
```

```
## Registered S3 method overwritten by 'EnvStats':
##   method         from
##   print.estimate lava
##
## Attaching package: 'EnvStats'
##
## The following object is masked from 'package:Hmisc':
##
##     stripChart
##
## The following object is masked from 'package:MASS':
##
##     boxcox
##
```

```
## The following objects are masked from 'package:stats':
##
##     predict, predict.lm
```

```r
library(wesanderson)
```

```
## Registered S3 method overwritten by 'wesanderson':
##   method        from
##   print.palette DescTools
```

```r
library(ordinal)
```

```
##
## Attaching package: 'ordinal'
##
## The following object is masked from 'package:dplyr':
##
##     slice
```

```r
library(ggpubr)
```

```
##
## Attaching package: 'ggpubr'
##
## The following object is masked from 'package:forecast':
##
##     gghistogram
```

```r
library(compute.es)
library(rstatix)
```

```
##
## Attaching package: 'rstatix'
##
## The following objects are masked from 'package:infer':
##
##     chisq_test, prop_test, t_test
##
## The following object is masked from 'package:dials':
##
##     get_n
##
## The following object is masked from 'package:MASS':
##
##     select
##
## The following object is masked from 'package:stats':
##
##     filter
```

```r
library(emmeans)
library(multcomp)
```

```
## Loading required package: mvtnorm
## Loading required package: survival
##
## Attaching package: 'survival'
##
## The following object is masked from 'package:gofcat':
##
##     retinopathy
##
## Loading required package: TH.data
##
## Attaching package: 'TH.data'
##
## The following object is masked from 'package:MASS':
##
##     geyser
```

```
library(car)
```

```
## Loading required package: carData
##
## Attaching package: 'car'
##
## The following object is masked from 'package:EnvStats':
##
##     qqPlot
##
## The following object is masked from 'package:dplyr':
##
##     recode
##
## The following object is masked from 'package:purrr':
##
##     some
```

```
library(RVAideMemoire)
```

```
## *** Package RVAideMemoire v 0.9-83-7 ***
##
## Attaching package: 'RVAideMemoire'
##
## The following objects are masked from 'package:EnvStats':
##
##     cv, elogis
##
## The following object is masked from 'package:broom':
##
##     bootstrap
```

```r
library(ggalluvial)
library(pwr)
setwd("C:/Users/gld_ssweeney/Documents/SBOAnalysis")
```

#Load Data

```r
df <- read_csv("EE CAN SBO_Masterfile_166372402_11JAN2024.csv")

## Rows: 444 Columns: 79
## ── Column specification
────────────────────────────────────────────────────────
## Delimiter: ","
## chr  (41): globalid, project_name, client, survey_date_comments,
SurveyDate,...
## dbl  (30): ID#, objectid, project_number, gl_longitude, gl_latitude,
gl_east...
## lgl   (5): mmo_waypoint, mmo_age_class_bear_2, mmo_age_class_bear_3,
mmo_age...
## time  (3): mmo_bh_res_ib_datetime, mmo_bh_res_ibw_datetime,
VesselActivity_time
##
## ℹ Use `spec()` to retrieve the full column specification for this data.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.

head(df)

## # A tibble: 6 × 79
##   `ID#` objectid globalid        project_number project_name client
gl_longitude
##   <dbl>    <dbl> <chr>                    <dbl> <chr>        <chr>
<dbl>
## 1     5        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 2     6        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 3     7        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 4     9        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 5    10        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 6    11        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## # ℹ 72 more variables: gl_latitude <dbl>, gl_easting <dbl>, gl_northing
<dbl>,
## #   gl_utm_zone <dbl>, survey_date_comments <chr>, SurveyDate <chr>,
## #   objectid.1 <dbl>, globalid.1 <chr>, mmo_observer_name <chr>,
## #   mmo_species_group <chr>, mmo_re_sighting <chr>,
## #   mmo_location_first_sighting <chr>, `Sighting Datetime` <chr>,
## #   mmo_longitude <dbl>, mmo_latitude <dbl>, mmo_waypoint <lgl>,
```

```
## #   mmo_vessel_course_gps <chr>, mmo_named_location <chr>, mmo_species
<chr>, …
```

data carpentry

subset data to only work with ringed seal responses

```
Ringed_Sightings<- df %>%
  dplyr::filter(mmo_species=="Ringed Seal", mmo_re_sighting =="No")

head(Ringed_Sightings)

## # A tibble: 6 × 79
##   `ID#` objectid globalid        project_number project_name client
gl_longitude
##   <dbl>    <dbl> <chr>                    <dbl> <chr>        <chr>
<dbl>
## 1     5        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 2     7        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 3     9        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 4    10        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 5    11        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## 6    12        5 {3C8D423D-F9EC…      166372402 Ship Based … Baffi…
-80.8
## # ℹ 72 more variables: gl_latitude <dbl>, gl_easting <dbl>, gl_northing
<dbl>,
## #   gl_utm_zone <dbl>, survey_date_comments <chr>, SurveyDate <chr>,
## #   objectid.1 <dbl>, globalid.1 <chr>, mmo_observer_name <chr>,
## #   mmo_species_group <chr>, mmo_re_sighting <chr>,
## #   mmo_location_first_sighting <chr>, `Sighting Datetime` <chr>,
## #   mmo_longitude <dbl>, mmo_latitude <dbl>, mmo_waypoint <lgl>,
## #   mmo_vessel_course_gps <chr>, mmo_named_location <chr>, mmo_species
<chr>, …
```

#Set variables as numeric or factors

```
Ringed_Sightings$mmo_closest_distance_of_animal <-
as.numeric(Ringed_Sightings$mmo_closest_distance_of_animal)
Ringed_Sightings$mmo_bh_res_ib_distance<-
as.numeric(Ringed_Sightings$mmo_bh_res_ib_distance)
Ringed_Sightings$mmo_bh_res_ibw_distance<-
as.numeric(Ringed_Sightings$mmo_bh_res_ibw_distance)
Ringed_Sightings$mmo_bh_res_icebreak<-
as.factor(Ringed_Sightings$mmo_bh_res_icebreak)
Ringed_Sightings$mmo_bh_res_icebreak_water<-
```

```r
as.factor(Ringed_Sightings$mmo_bh_res_icebreak_water)

str(Ringed_Sightings)
```

```
## spc_tbl_ [389 × 79] (S3: spec_tbl_df/tbl_df/tbl/data.frame)
##  $ ID#                           : num [1:389] 5 7 9 10 11 12 13 15 16 17
...
##  $ objectid                      : num [1:389] 5 5 5 5 5 5 5 5 5 5 ...
##  $ globalid                      : chr [1:389] "{3C8D423D-F9EC-4BE5-BAFB-
FF1FB98E0E39}" "{3C8D423D-F9EC-4BE5-BAFB-FF1FB98E0E39}" "{3C8D423D-F9EC-4BE5-
BAFB-FF1FB98E0E39}" "{3C8D423D-F9EC-4BE5-BAFB-FF1FB98E0E39}" ...
##  $ project_number                : num [1:389] 1.66e+08 1.66e+08 1.66e+08
1.66e+08 1.66e+08 ...
##  $ project_name                  : chr [1:389] "Ship Based Observer" "Ship
Based Observer" "Ship Based Observer" "Ship Based Observer" ...
##  $ client                        : chr [1:389] "Baffinland" "Baffinland"
"Baffinland" "Baffinland" ...
##  $ gl_longitude                  : num [1:389] -80.8 -80.8 -80.8 -80.8 -
80.8 ...
##  $ gl_latitude                   : num [1:389] 71.9 71.9 71.9 71.9 71.9
...
##  $ gl_easting                    : num [1:389] 505429 505429 505429 505429
505429 ...
##  $ gl_northing                   : num [1:389] 7979947 7979947 7979947
7979947 7979947 ...
##  $ gl_utm_zone                   : num [1:389] 17 17 17 17 17 17 17 17 17
17 ...
##  $ survey_date_comments          : chr [1:389] "Day 1, woot-training" "Day
1, woot-training" "Day 1, woot-training" "Day 1, woot-training" ...
##  $ SurveyDate                    : chr [1:389] "2023-10-21 8:50" "2023-10-
21 8:50" "2023-10-21 8:50" "2023-10-21 8:50" ...
##  $ objectid.1                    : num [1:389] 48 50 52 53 54 55 56 58 59
60 ...
##  $ globalid.1                    : chr [1:389] "{DD5BD0F9-4C17-4920-90E1-
BB6312613731}" "{013CFACE-F15F-4140-A872-089811D38CEA}" "{DE25385F-034D-405A-
A563-CFB17D1317BC}" "{EE2C2D6D-298B-4AE3-A104-14E620A29C4D}" ...
##  $ mmo_observer_name             : chr [1:389] "Elisha Kasarnak" "Ronnie
Komangapik" "Ronnie Komangapik" "Ronnie Komangapik" ...
##  $ mmo_species_group             : chr [1:389] "Seals and Walrus" "Seals
and Walrus" "Seals and Walrus" "Seals and Walrus" ...
##  $ mmo_re_sighting               : chr [1:389] "No" "No" "No" "No" ...
##  $ mmo_location_first_sighting   : chr [1:389] "In Water" "In Water" "In
Water" "In Water" ...
##  $ Sighting Datetime             : chr [1:389] "2023-10-21 9:48" "2023-10-
21 10:15" "2023-10-21 10:45" "2023-10-21 10:54" ...
##  $ mmo_longitude                 : num [1:389] -80.8 -80.6 -80.5 -80.5 -
80.5 ...
##  $ mmo_latitude                  : num [1:389] 72 72 72.1 72.1 72.1 ...
##  $ mmo_waypoint                  : logi [1:389] NA NA NA NA NA NA ...
##  $ mmo_vessel_course_gps         : chr [1:389] "48.09" "58.48" "348.83"
```

```
"352.11" ...
##  $ mmo_named_location           : chr [1:389] NA "Near Bruce Head" NA NA
...
##  $ mmo_species                  : chr [1:389] "Ringed Seal" "Ringed Seal"
"Ringed Seal" "Ringed Seal" ...
##  $ mmo_certainty_of_id          : chr [1:389] "Definite" "Definite"
"Definite" "Definite" ...
##  $ mmo_dist_first_sighting      : num [1:389] 350 150 200 100 50 300 200
700 800 200 ...
##  $ mmo_bearing_first_sighting   : num [1:389] 35 10 20 5 45 320 12 3 1 0
...
##  $ mmo_closest_distance_of_animal: num [1:389] 100 150 165 100 50 100 200
700 800 150 ...
##  $ mmo_dist_est_method          : chr [1:389] "Naked eye" "Naked eye"
"Naked eye" "Naked eye" ...
##  $ mmo_cue                      : chr [1:389] NA NA NA NA ...
##  $ mmo_group_size_min           : num [1:389] 2 1 1 1 2 1 1 1 1 1 ...
##  $ mmo_group_size_best_e        : num [1:389] 2 1 1 1 2 1 1 1 1 1 ...
##  $ mmo_behaviour_init_sight     : chr [1:389] "Resting" "Resting"
"Scanning" "Resting" ...
##  $ mmo_num_juveniles            : num [1:389] NA NA NA NA NA NA NA NA NA
NA ...
##  $ mmo_age_class_bear_1         : chr [1:389] NA NA NA NA ...
##  $ mmo_age_class_bear_2         : logi [1:389] NA NA NA NA NA NA ...
##  $ mmo_age_class_bear_3         : logi [1:389] NA NA NA NA NA NA ...
##  $ mmo_age_class_bear_4         : logi [1:389] NA NA NA NA NA NA ...
##  $ mmo_age_class_bear_5         : logi [1:389] NA NA NA NA NA NA ...
##  $ mmo_dir_travel               : num [1:389] NA NA NA NA NA NA NA NA NA
NA ...
##  $ mmo_bh_res_icebreak          : Factor w/ 4 levels "Flush","No
response",..: NA NA NA NA NA 1 NA NA NA NA ...
##  $ mmo_bh_res_ib_datetime       : 'hms' num [1:389] NA NA NA NA ...
##   ..- attr(*, "units")= chr "secs"
##  $ mmo_bh_res_ib_longitude      : num [1:389] NA NA NA NA NA ...
##  $ mmo_bh_res_ib_latitude       : num [1:389] NA NA NA NA NA ...
##  $ mmo_bh_res_ib_distance       : num [1:389] NA NA NA NA NA 100 NA NA NA
NA ...
##  $ mmo_bh_res_ib_bearing        : chr [1:389] NA NA NA NA ...
##  $ mmo_bh_res_icebreak_water    : Factor w/ 6 levels "No response",..: 2
3 3 3 3 5 2 3 3 2 ...
##  $ mmo_bh_res_ibw_datetime      : 'hms' num [1:389] 09:50:00 NA NA
10:54:00 ...
##   ..- attr(*, "units")= chr "secs"
##  $ mmo_bh_res_ibw_longitude     : num [1:389] -80.6 -80.6 -80.5 -80.5 -
80.5 ...
##  $ mmo_bh_res_ibw_latitude      : num [1:389] 72 72 72.1 72.1 72.1 ...
##  $ mmo_bh_res_ibw_distance      : num [1:389] 100 150 165 100 50 100 200
NA NA 150 ...
##  $ mmo_bh_res_ibw_bearing       : num [1:389] 80 10 20 5 45 310 12 NA NA
0 ...
```

```
##  $ mmo_vessel_activity          : chr [1:389] "Transiting open water"
"Transiting open water" "Transiting open water" "Icebreaking (includes
transiting broken ice track)" ...
##  $ mmo_photo_number             : chr [1:389] NA NA NA NA ...
##  $ mmo_comments                 : chr [1:389] "No data in
mmo_certainty_of_id" "Normal dive, no splash. Post field comment: updated
Behavioural Response Water from Rapid dive/splash to Regular Dive. Tried to
"Regular dive, no splash. Post field comment: Tried to get behavioural
response datetime data from track data but no BadElf data "Regular dive, no
response. Post field comment: Used location from response section for initial
sighting and response location i ...
##  $ parentglobalid               : chr [1:389] "{3C8D423D-F9EC-4BE5-BAFB-
FF1FB98E0E39}" "{3C8D423D-F9EC-4BE5-BAFB-FF1FB98E0E39}" "{3C8D423D-F9EC-4BE5-
BAFB-FF1FB98E0E39}" "{3C8D423D-F9EC-4BE5-BAFB-FF1FB98E0E39}" ...
##  $ Port/Starboard               : chr [1:389] "Starboard" "Starboard"
"Starboard" "Starboard" ...
##  $ ENV_Obs_Time                 : chr [1:389] "2023-10-21 9:44" "2023-10-
21 10:05" "2023-10-21 10:33" "2023-10-21 10:52" ...
##  $ sg_descriptive               : chr [1:389] NA "Weak Glare" "Weak
Glare" "Weak Glare" ...
##  $ sg_fov                       : chr [1:389] NA NA NA NA ...
##  $ sg_from                      : num [1:389] NA NA NA NA NA NA 15 15 15
0 ...
##  $ sg_to                        : num [1:389] NA NA NA NA NA NA 30 30 30
0 ...
##  $ wi_ice_cover                 : chr [1:389] "21-30%" ">90%" "0%" "31-
40%" ...
##  $ wi_ice_cover_view_area       : chr [1:389] ">90%" ">90%" "11-20%" "51-
60%" ...
##  $ wi_visibility                : chr [1:389] "5,001-10,000 m (Very
Good)" "5,001-10,000 m (Very Good)" "5,001-10,000 m (Very Good)" "5,001-
10,000 m (Very Good)" ...
##  $ Beaufort                     : num [1:389] 1 1 2 2 0 0 1 1 1 2 ...
##  $ wi_wind                      : chr [1:389] "3: 7-10 knots, Gentle
breeze" "3: 7-10 knots, Gentle breeze" "1: 1-3 knots, Light air" "3: 7-10
knots, Gentle breeze" ...
##  $ wi_wind_dir                  : chr [1:389] "South" "West" "West"
"Southeast" ...
##  $ wi_sea_state                 : chr [1:389] "1 : <0.1 m, Ripples,
appearance of scaling" NA "0: 0 m, Glassy, like a mirror" NA ...
##  $ wi_sightability              : chr [1:389] "Good" "Good" "Good"
"Excellent" ...
##  $ wi_weather                   : chr [1:389] "Overcast 100% Cloud Cover"
"Overcast 100% Cloud Cover" "Light Snow" "Overcast 100% Cloud Cover" ...
##  $ VesselActivity_time          : 'hms' num [1:389] 09:45:00 10:10:00
10:33:00 10:52:00 ...
##   ..- attr(*, "units")= chr "secs"
##  $ va_vessel_activity           : chr [1:389] "Icebreaking (includes
transiting broken ice track)" "Icebreaking (includes transiting broken ice
track)" "Transiting open water" "Icebreaking (includes transiting broken ice
```

```
track)" ...
##  $ va_other_vessels             : chr [1:389] NA NA NA NA ...
##  $ va_dist_to_other_vessel      : num [1:389] NA NA NA NA NA NA NA NA NA
NA ...
##  $ va_depth                     : num [1:389] 154 186 289 NA NA NA 211
211 211 NA ...
##  $ va_comments                  : chr [1:389] NA NA NA NA ...
##  - attr(*, "spec")=
##   .. cols(
##   ..   `ID#` = col_double(),
##   ..   objectid = col_double(),
##   ..   globalid = col_character(),
##   ..   project_number = col_double(),
##   ..   project_name = col_character(),
##   ..   client = col_character(),
##   ..   gl_longitude = col_double(),
##   ..   gl_latitude = col_double(),
##   ..   gl_easting = col_double(),
##   ..   gl_northing = col_double(),
##   ..   gl_utm_zone = col_double(),
##   ..   survey_date_comments = col_character(),
##   ..   SurveyDate = col_character(),
##   ..   objectid.1 = col_double(),
##   ..   globalid.1 = col_character(),
##   ..   mmo_observer_name = col_character(),
##   ..   mmo_species_group = col_character(),
##   ..   mmo_re_sighting = col_character(),
##   ..   mmo_location_first_sighting = col_character(),
##   ..   `Sighting Datetime` = col_character(),
##   ..   mmo_longitude = col_double(),
##   ..   mmo_latitude = col_double(),
##   ..   mmo_waypoint = col_logical(),
##   ..   mmo_vessel_course_gps = col_character(),
##   ..   mmo_named_location = col_character(),
##   ..   mmo_species = col_character(),
##   ..   mmo_certainty_of_id = col_character(),
##   ..   mmo_dist_first_sighting = col_double(),
##   ..   mmo_bearing_first_sighting = col_double(),
##   ..   mmo_closest_distance_of_animal = col_double(),
##   ..   mmo_dist_est_method = col_character(),
##   ..   mmo_cue = col_character(),
##   ..   mmo_group_size_min = col_double(),
##   ..   mmo_group_size_best_e = col_double(),
##   ..   mmo_behaviour_init_sight = col_character(),
##   ..   mmo_num_juveniles = col_double(),
##   ..   mmo_age_class_bear_1 = col_character(),
##   ..   mmo_age_class_bear_2 = col_logical(),
##   ..   mmo_age_class_bear_3 = col_logical(),
##   ..   mmo_age_class_bear_4 = col_logical(),
##   ..   mmo_age_class_bear_5 = col_logical(),
```

```
##   ..   mmo_dir_travel = col_double(),
##   ..   mmo_bh_res_icebreak = col_character(),
##   ..   mmo_bh_res_ib_datetime = col_time(format = ""),
##   ..   mmo_bh_res_ib_longitude = col_double(),
##   ..   mmo_bh_res_ib_latitude = col_double(),
##   ..   mmo_bh_res_ib_distance = col_double(),
##   ..   mmo_bh_res_ib_bearing = col_character(),
##   ..   mmo_bh_res_icebreak_water = col_character(),
##   ..   mmo_bh_res_ibw_datetime = col_time(format = ""),
##   ..   mmo_bh_res_ibw_longitude = col_double(),
##   ..   mmo_bh_res_ibw_latitude = col_double(),
##   ..   mmo_bh_res_ibw_distance = col_double(),
##   ..   mmo_bh_res_ibw_bearing = col_double(),
##   ..   mmo_vessel_activity = col_character(),
##   ..   mmo_photo_number = col_character(),
##   ..   mmo_comments = col_character(),
##   ..   parentglobalid = col_character(),
##   ..   `Port/Starboard` = col_character(),
##   ..   ENV_Obs_Time = col_character(),
##   ..   sg_descriptive = col_character(),
##   ..   sg_fov = col_character(),
##   ..   sg_from = col_double(),
##   ..   sg_to = col_double(),
##   ..   wi_ice_cover = col_character(),
##   ..   wi_ice_cover_view_area = col_character(),
##   ..   wi_visibility = col_character(),
##   ..   Beaufort = col_double(),
##   ..   wi_wind = col_character(),
##   ..   wi_wind_dir = col_character(),
##   ..   wi_sea_state = col_character(),
##   ..   wi_sightability = col_character(),
##   ..   wi_weather = col_character(),
##   ..   VesselActivity_time = col_time(format = ""),
##   ..   va_vessel_activity = col_character(),
##   ..   va_other_vessels = col_character(),
##   ..   va_dist_to_other_vessel = col_double(),
##   ..   va_depth = col_double(),
##   ..   va_comments = col_character()
##   .. )
##  - attr(*, "problems")=<externalptr>
```

```
#remove exp for intervals
options(scipen =999)
```

#Create two data sets for seals either being on ice and in water for seperate analyses

```
# Ice
Ringed_Sightings_ice<-Ringed_Sightings%>%
  filter(mmo_location_first_sighting=="On Ice")%>%
```

```
dplyr::select(mmo_bh_res_icebreak,mmo_closest_distance_of_animal,mmo_behaviou
r_init_sight, va_vessel_activity,

mmo_bearing_first_sighting,mmo_dist_first_sighting,mmo_re_sighting,mmo_bh_res
_ib_distance)%>%

mutate(resp_dist=ifelse(is.na(mmo_bh_res_ib_distance),mmo_closest_distance_of
_animal,mmo_bh_res_ib_distance))%>%
  filter(mmo_bh_res_icebreak != "Unknown",resp_dist<=2000)%>%
  mutate(dist_bin=cut(resp_dist,breaks = c(0,500,1000,1500,2000), dig.lab =
5))

summary(Ringed_Sightings_ice)

##   mmo_bh_res_icebreak mmo_closest_distance_of_animal
mmo_behaviour_init_sight
##  Flush      :40       Min.   :  50.0                Length:80
##  No response:30       1st Qu.: 437.5                Class :character
##  Scan       :10       Median : 675.0                Mode  :character
##  Unknown    : 0       Mean   : 829.4
##                       3rd Qu.:1200.0
##                       Max.   :2000.0
##
##  va_vessel_activity mmo_bearing_first_sighting mmo_dist_first_sighting
##  Length:80          Min.   :  2.00             Min.   :  50
##  Class :character   1st Qu.: 25.75             1st Qu.: 800
##  Mode  :character   Median : 59.00             Median :1500
##                     Mean   :138.70             Mean   :1494
##                     3rd Qu.:291.50             3rd Qu.:1962
##                     Max.   :356.00             Max.   :5000
##                                                NA's   :2
##  mmo_re_sighting    mmo_bh_res_ib_distance   resp_dist
dist_bin
##  Length:80          Min.   : 100.0        Min.   :  50.0   (0,500]    :28
##  Class :character   1st Qu.: 387.5        1st Qu.: 450.0   (500,1000] :27
##  Mode  :character   Median : 600.0        Median : 725.0   (1000,1500]:15
##                     Mean   : 722.6        Mean   : 859.6   (1500,2000]:10
##                     3rd Qu.:1000.0        3rd Qu.:1200.0
##                     Max.   :2000.0        Max.   :2000.0
##                     NA's   :32

str(Ringed_Sightings_ice)

## tibble [80 × 10] (S3: tbl_df/tbl/data.frame)
##  $ mmo_bh_res_icebreak           : Factor w/ 4 levels "Flush","No
response",..: 1 2 1 2 2 2 1 1 2 2 ...
##  $ mmo_closest_distance_of_animal: num [1:80] 100 1200 1000 1200 1200 2000
500 800 500 1300 ...
##  $ mmo_behaviour_init_sight      : chr [1:80] "Scanning" "Resting"
"Resting" "Resting" ...
```

```
##  $ va_vessel_activity            : chr [1:80] "Transiting open water"
"Transiting open water" "Transiting open water" "Transiting open water" ...
##  $ mmo_bearing_first_sighting    : num [1:80] 320 50 28 88 85 110 4 11 74
58 ...
##  $ mmo_dist_first_sighting       : num [1:80] 300 1600 1100 1400 1400 2200
500 1800 650 1800 ...
##  $ mmo_re_sighting               : chr [1:80] "No" "No" "No" "No" ...
##  $ mmo_bh_res_ib_distance        : num [1:80] 100 NA 1000 NA NA NA 500 800
NA NA ...
##  $ resp_dist                     : num [1:80] 100 1200 1000 1200 1200 2000
500 800 500 1300 ...
##  $ dist_bin                      : Factor w/ 4 levels
"(0,500]","(500,1000]",..: 1 3 2 3 3 4 1 2 1 3 ...

# Water
Ringed_Sightings_water<-Ringed_Sightings%>%
  filter(mmo_location_first_sighting=="In Water")%>%

dplyr::select(mmo_bh_res_icebreak_water,mmo_closest_distance_of_animal,mmo_be
haviour_init_sight, va_vessel_activity,

mmo_bearing_first_sighting,mmo_dist_first_sighting,mmo_re_sighting,mmo_bh_res
_ibw_distance)%>%

mutate(resp_dist=ifelse(is.na(mmo_bh_res_ibw_distance),mmo_closest_distance_o
f_animal,mmo_bh_res_ibw_distance))%>%
  filter(mmo_bh_res_icebreak_water != "Unknown",resp_dist<=2000)%>%
  mutate(dist_bin=cut(resp_dist,breaks = c(0,500,1000,1500,2000), dig.lab =
5))

summary(Ringed_Sightings_water)

##      mmo_bh_res_icebreak_water mmo_closest_distance_of_animal
##  No response        : 25        Min.   :  12.0
##  Rapid dive/splash: 47          1st Qu.: 150.0
##  Regular Dive       :131        Median : 300.0
##  Scan               :  7        Mean   : 410.6
##  Swim away          : 11        3rd Qu.: 500.0
##  Unknown            :  0        Max.   :2000.0
##
##  mmo_behaviour_init_sight va_vessel_activity mmo_bearing_first_sighting
##  Length:221               Length:221         Min.   :  0.0
##  Class :character         Class :character   1st Qu.: 25.0
##  Mode  :character         Mode  :character   Median : 76.0
##                                              Mean   :166.9
##                                              3rd Qu.:330.0
##                                              Max.   :359.0
##                                              NA's   :1
##  mmo_dist_first_sighting mmo_re_sighting    mmo_bh_res_ibw_distance
##  Min.   :  50.0          Length:221         Min.   :  25.0
```

```
##  1st Qu.: 200.0          Class :character   1st Qu.: 150.0
##  Median : 400.0          Mode  :character   Median : 300.0
##  Mean   : 526.2                             Mean   : 402.1
##  3rd Qu.: 700.0                             3rd Qu.: 485.0
##  Max.   :2200.0                             Max.   :2000.0
##                                             NA's   :33
##    resp_dist             dist_bin
##  Min.   :  25.0   (0,500]    :170
##  1st Qu.: 150.0   (500,1000] : 35
##  Median : 300.0   (1000,1500]: 11
##  Mean   : 413.3   (1500,2000]:  5
##  3rd Qu.: 500.0
##  Max.   :2000.0
##
```

```
str(Ringed_Sightings_water)
```

```
## tibble [221 × 10] (S3: tbl_df/tbl/data.frame)
##  $ mmo_bh_res_icebreak_water     : Factor w/ 6 levels "No response",..: 2
3 3 3 3 2 3 3 2 2 ...
##  $ mmo_closest_distance_of_animal: num [1:221] 100 150 165 100 50 200 700
800 150 700 ...
##  $ mmo_behaviour_init_sight      : chr [1:221] "Resting" "Resting"
"Scanning" "Resting" ...
##  $ va_vessel_activity            : chr [1:221] "Icebreaking (includes
transiting broken ice track)" "Icebreaking (includes transiting broken ice
track)" "Transiting open water" "Icebreaking (includes transiting broken ice
track)" ...
##  $ mmo_bearing_first_sighting    : num [1:221] 35 10 20 5 45 12 3 1 0 30
...
##  $ mmo_dist_first_sighting       : num [1:221] 350 150 200 100 50 200 700
800 200 800 ...
##  $ mmo_re_sighting               : chr [1:221] "No" "No" "No" "No" ...
##  $ mmo_bh_res_ibw_distance       : num [1:221] 100 150 165 100 50 200 NA
NA 150 NA ...
##  $ resp_dist                     : num [1:221] 100 150 165 100 50 200 700
800 150 700 ...
##  $ dist_bin                      : Factor w/ 4 levels
"(0,500]","(500,1000]",..: 1 1 1 1 1 1 2 2 1 2 ...
```

#Set colours for figures

```
###fct relevel and colour coding

Ringed_Sightings_water$mmo_bh_res_icebreak_water<-
fct_relevel(Ringed_Sightings_water$mmo_bh_res_icebreak_water, "No
response","Regular Dive", "Scan", "Swim away","Rapid dive/splash")

Ringed_Sightings_ice$mmo_bh_res_icebreak<-
fct_relevel(Ringed_Sightings_ice$mmo_bh_res_icebreak, "No response","Scan",
"Flush")
```

```r
wes5<-scale_fill_manual(values = wes_palette("Zissou1",n=8, type =
"continuous"))
wes3<-scale_fill_manual(values = wes_palette("Zissou1",n=3, type =
"continuous"))
wes5<-scale_fill_manual(values = wes_palette("Zissou1",n=5, type =
"continuous"))
wes5col<-scale_color_manual(values = wes_palette("Zissou1",n=5, type =
"continuous"))
wes3col<-scale_color_manual(values = wes_palette("Zissou1",n=3, type =
"continuous"))
```

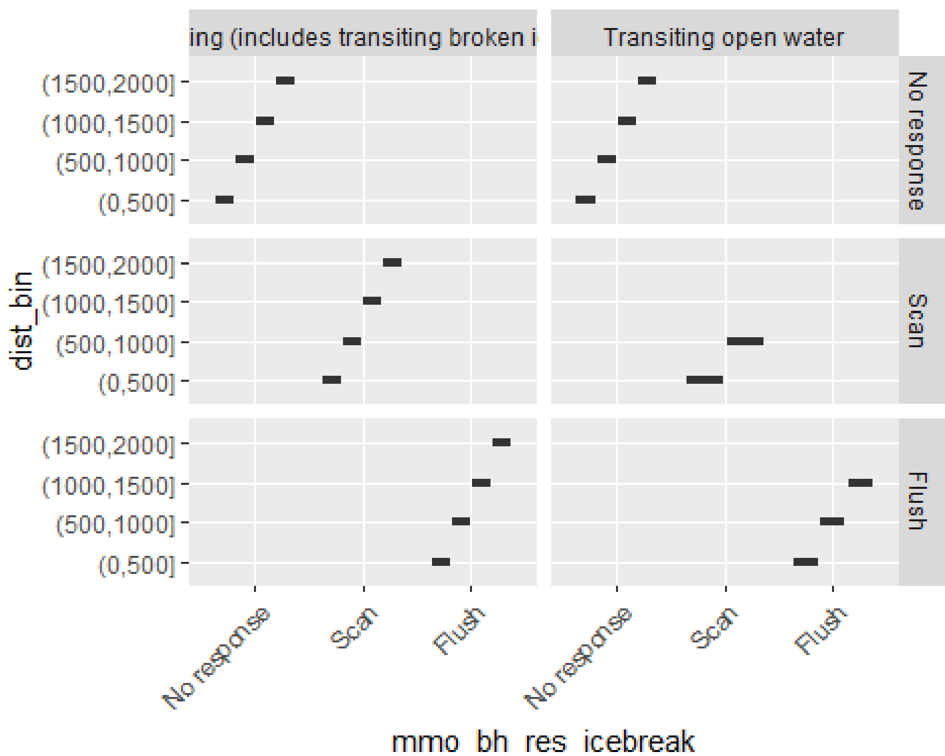
#Code-prep for figures

```r
theme_all <- theme_bw()  +
  theme(line = element_line(linewidth = 0.2, colour = "black"),
        rect = element_rect(linewidth = 0.2, colour = "black"),
        plot.margin = margin(0.1, 0.5, 0.1, 0.1, "lines"),
        panel.background = element_blank(),
        axis.title.x = element_text(colour = "black", angle = 0, size = 10,
hjust = 0.5, vjust = -0.5),
        axis.title.y = element_text(colour = "black", angle = 90, size = 10,
hjust = 0.5, vjust = 0.3,
                                    margin = margin(0.1, 1.1, 0.1, 0.1,
"lines")),
        axis.text.x = element_text(colour = "black", size = 9, angle = 0,
vjust = 0.5, hjust = 0.5),
        axis.text.y = element_text(colour = "black", size = 9),
        legend.text = element_text(size = 9),
        legend.title = element_text(size = 10),
        legend.key.size = unit(0.7, "lines"),
        legend.background = element_blank())
```

Distribution of data

On Ice

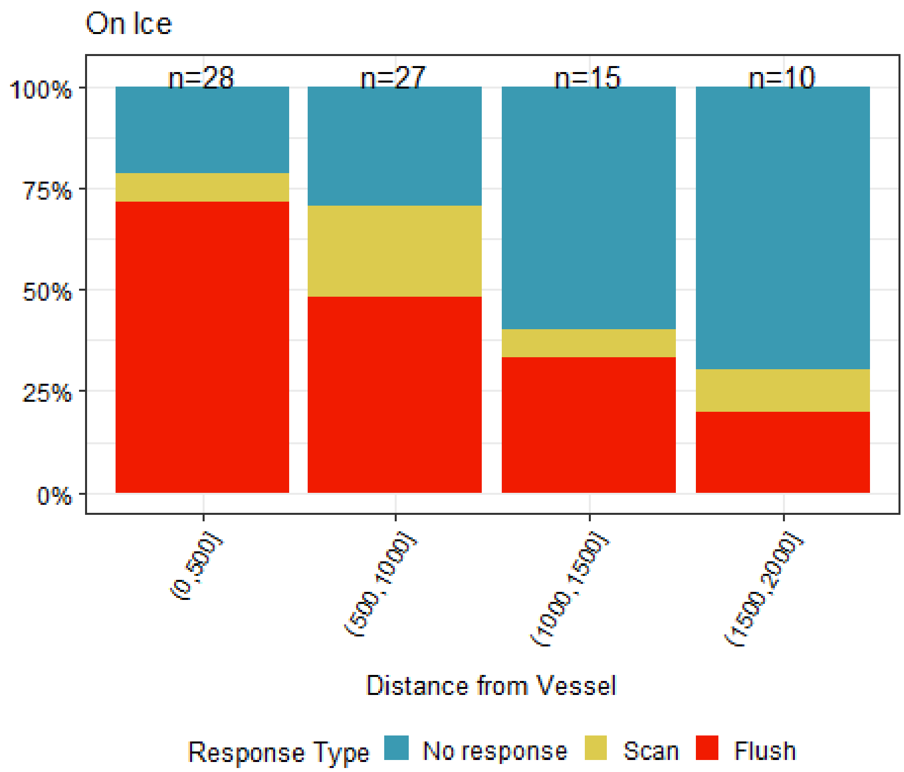
```r
ggplot(Ringed_Sightings_ice, aes(x = mmo_bh_res_icebreak, y = dist_bin)) +
geom_boxplot(size = .75) +   facet_grid(mmo_bh_res_icebreak ~
va_vessel_activity, margins = FALSE) +   theme(axis.text.x =
element_text(angle = 45, hjust = 1, vjust = 1))
```



boxtaxplots

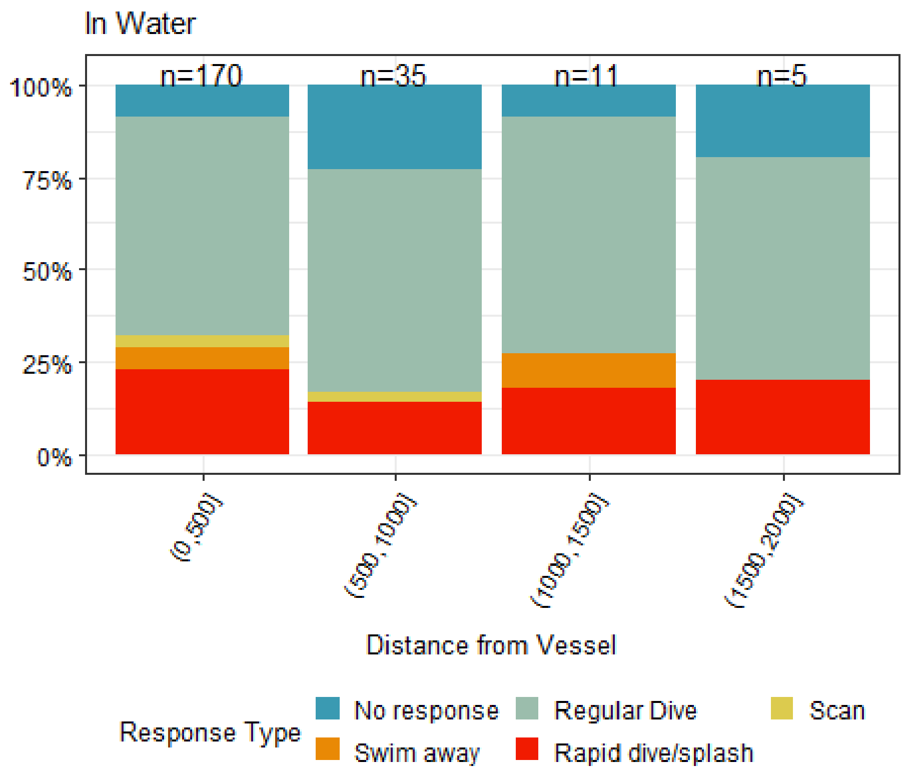
on ice

```
ice_stax<-ggplot(Ringed_Sightings_ice)+geom_bar(aes(x=dist_bin, fill =
mmo_bh_res_icebreak), position ="fill")+
  stat_n_text(aes(x=dist_bin,
y=1.03),size=4)+theme_all+scale_y_continuous(labels = scales::percent)+wes3+
  labs(subtitle = "On Ice", fill="Response Type")+theme(legend.position =
"left")+xlab("Distance from Vessel")+ylab("")+
  theme(axis.text.x = element_text(angle = 60, vjust = 1,
hjust=1))+theme(legend.position = "bottom")

ice_stax
```



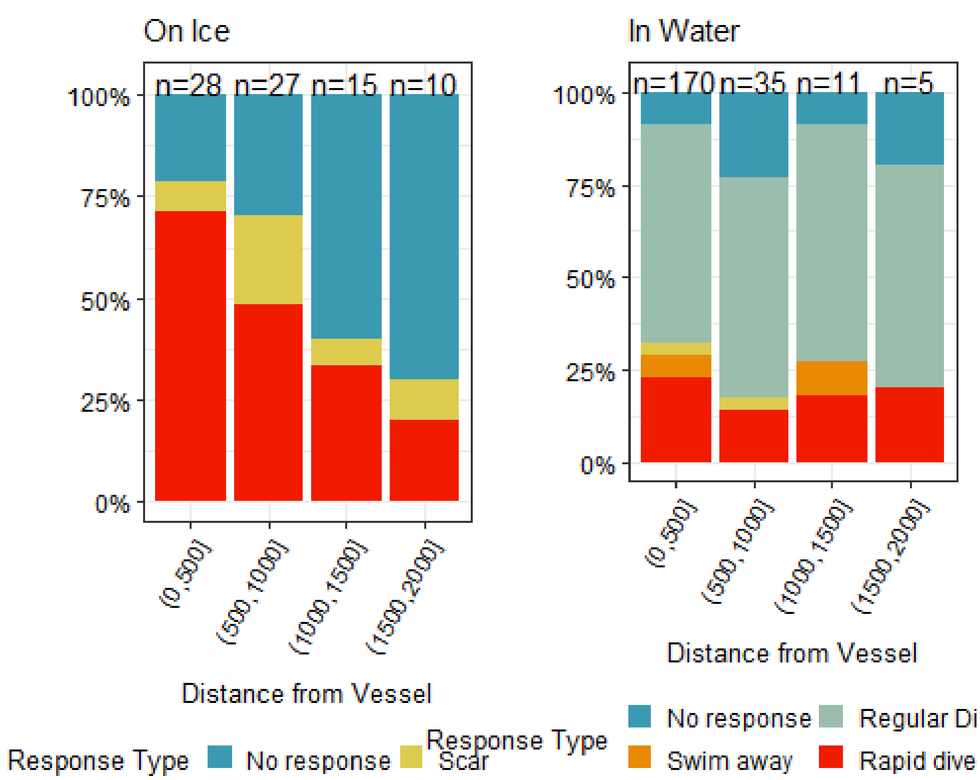
in water ; need to fig the order of colours as water and on ice have different # variables and is automatically ordered by alphabet

```
water_stax<-ggplot(Ringed_Sightings_water)+geom_bar(aes(x=dist_bin, fill =
mmo_bh_res_icebreak_water), position ="fill")+
  stat_n_text(aes(x=dist_bin,
y=1.03),size=4)+theme_all+scale_y_continuous(labels = scales::percent)+wes5+
  labs(subtitle = "In Water", fill="Response Type")+xlab("Distance from
Vessel")+ylab("")+
  theme(axis.text.x = element_text(angle = 60, vjust = 1,
hjust=1))+theme(legend.position =
"bottom")+guides(fill=guide_legend(nrow=2,byrow=TRUE))

water_stax
```



create a two panel figure

```
ggarrange(ice_stax,water_stax, ncol =2)+rremove("ylab")
```

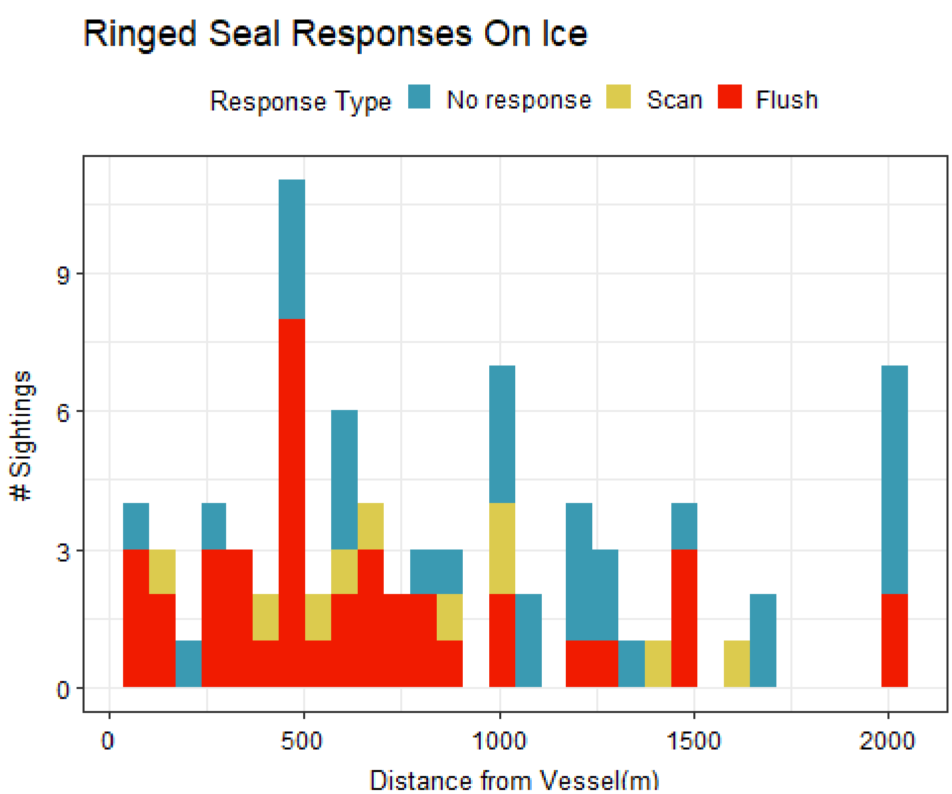


```
ggsave("ringed seal responses barstack.png", width = 3000, height = 1800,
units = "px")
```

histogram

on ice

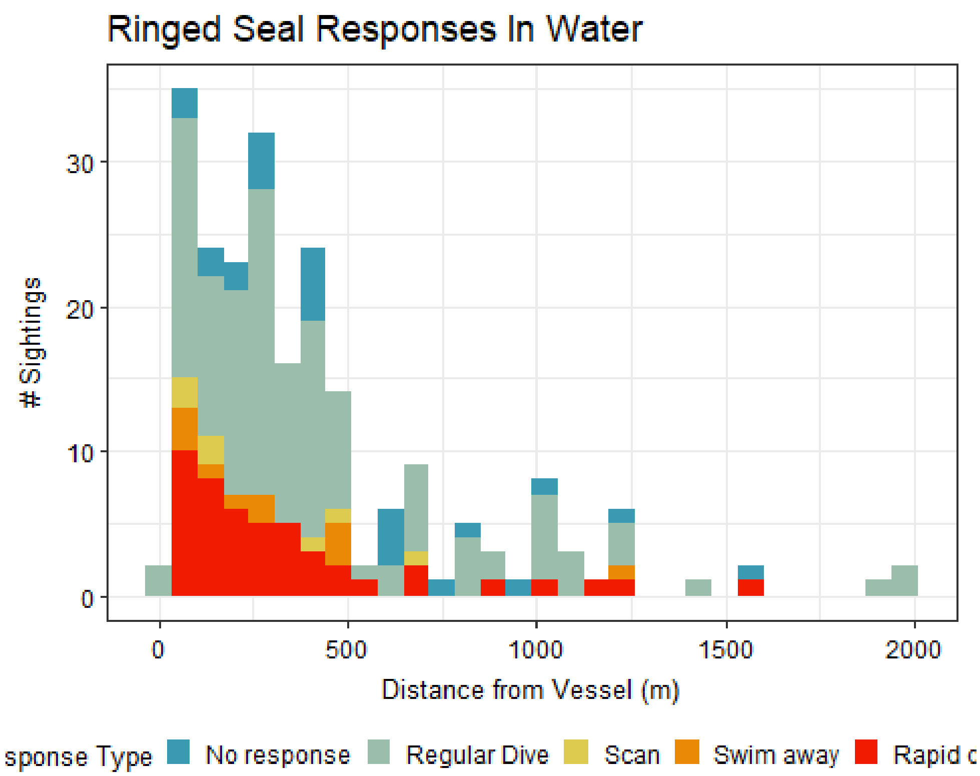
```
resp_ice<-ggplot(Ringed_Sightings_ice)+
  geom_histogram(aes(x=resp_dist, fill=mmo_bh_res_icebreak))+
  theme_all+labs(title="Ringed Seal Responses On Ice", fill= "Response
Type")+wes3+xlab("Distance from Vessel(m)")+ylab("#
Sightings")+theme(legend.position = "top")

resp_ice

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



in water

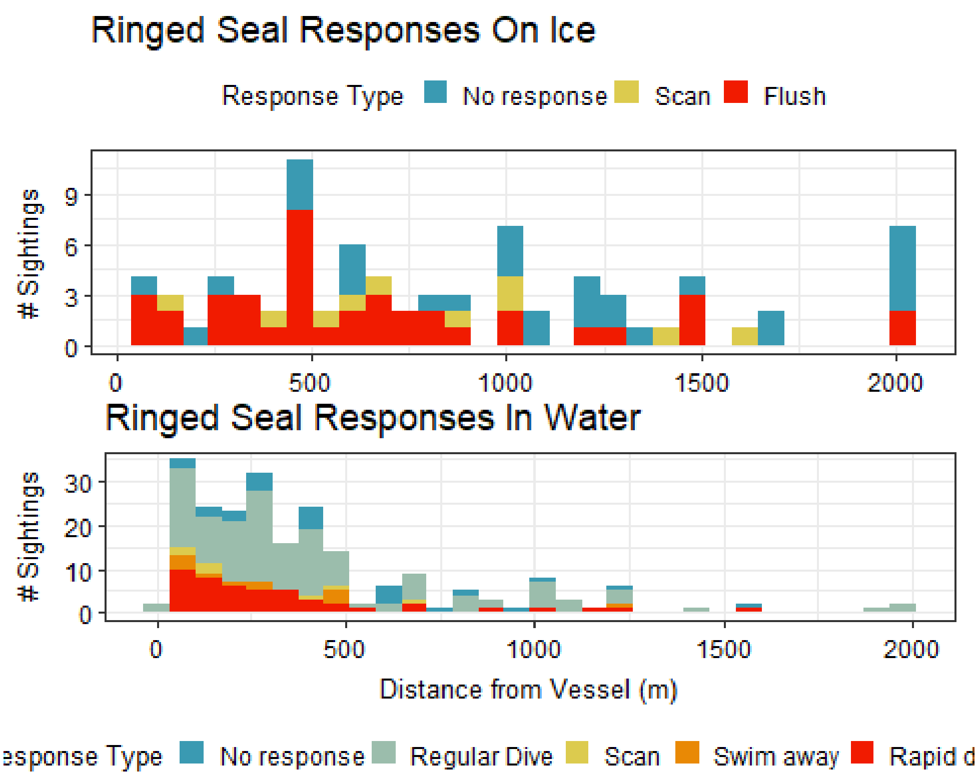
```
resp_water<-ggplot(Ringed_Sightings_water)+
  geom_histogram(aes(x=resp_dist, fill=mmo_bh_res_icebreak_water))+
  theme_all+labs(title="Ringed Seal Responses In Water", fill= "Response
Type")+wes5+xlab("Distance from Vessel (m)")+ylab("#
Sightings")+theme(legend.position = "bottom")


resp_water
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



create a two panel figure

```
ggarrange(resp_ice+rremove("xlab"), resp_water,ncol=1)

## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

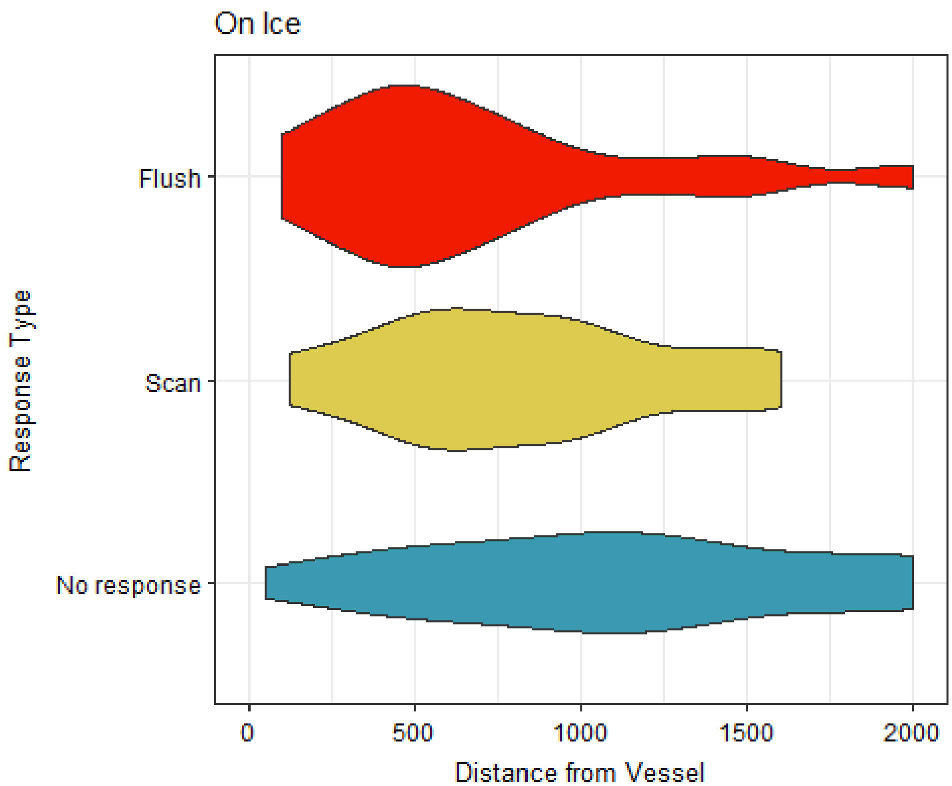



```
ggsave("ringed seal responses histogram.png", width = 2300, height = 2800,
units = "px")
```

Violin Plots to see sample and observation distribution

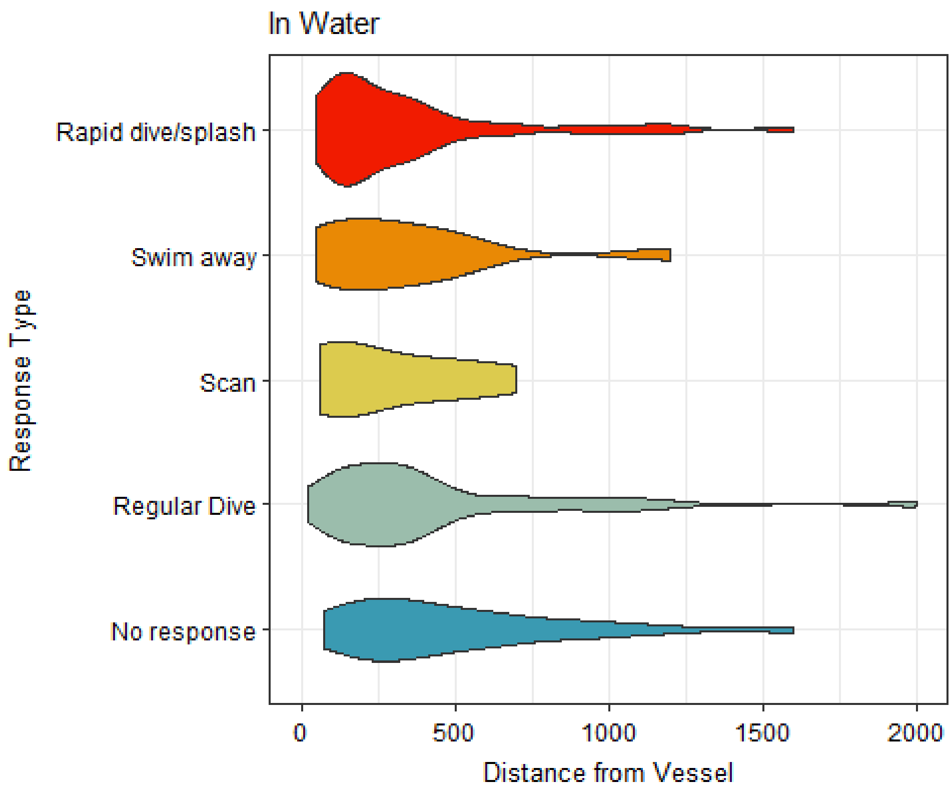
on ice

```
viol_ice=ggplot(Ringed_Sightings_ice)+geom_violin(aes(x=mmo_bh_res_icebreak,
y = resp_dist, fill= mmo_bh_res_icebreak))+
  coord_flip()+xlab("Response Type")+ylab("Distance from
Vessel")+labs(subtitle = "On Ice")+
  wes3+theme_all+theme(legend.position = "none")+ylim(0,2000)

viol_ice
```



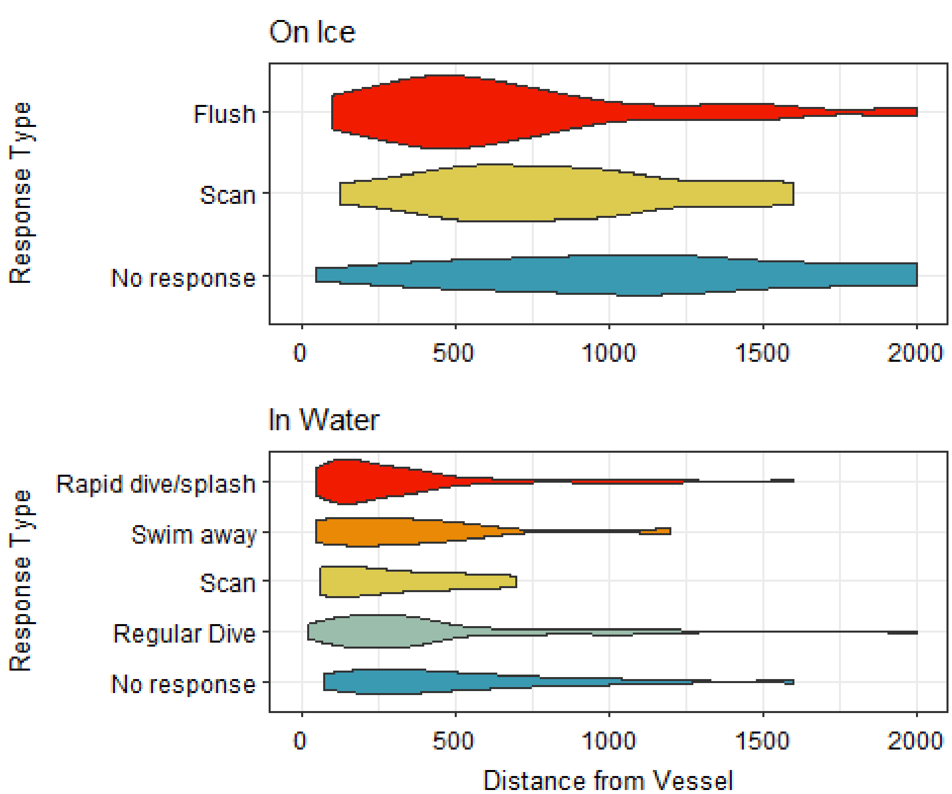
in water

```
viol_water=ggplot(Ringed_Sightings_water)+geom_violin(aes(x=mmo_bh_res_icebreak_water, y = resp_dist, fill= mmo_bh_res_icebreak_water))+
  coord_flip()+xlab("Response Type")+ylab("Distance from Vessel")+labs(subtitle = "In Water")+
  wes5+theme_all+theme(legend.position = "none")+ylim(0,2000)

viol_water
```



create a two panel figure

```
ggarrange(viol_ice+rremove("xlab")
         ,viol_water, ncol = 1, nrow = 2, align="hv")
```



```
ggsave("ringed seal responses violin.png", width = 2000, height = 3000, units
= "px")
```

Ice Data set

Ordinal Regression Model

Model selection

```
#ensure no unknowns are in the data, since they cant be placed in the ordinal
series
Ringed_Sightings_ice<-Ringed_Sightings_ice%>%
  filter(mmo_bh_res_icebreak != "Unknown")


model0 <- clm(as.factor(mmo_bh_res_icebreak) ~ 1, data =
Ringed_Sightings_ice)
model <- clm(as.factor(mmo_bh_res_icebreak) ~ resp_dist +
as.factor(va_vessel_activity), data = Ringed_Sightings_ice)
model1 <- clm(as.factor(mmo_bh_res_icebreak) ~ resp_dist *
as.factor(va_vessel_activity), data = Ringed_Sightings_ice)
model2<- clm(as.factor(mmo_bh_res_icebreak) ~ dist_bin +
as.factor(va_vessel_activity), data = Ringed_Sightings_ice)
model3<- clm(as.factor(mmo_bh_res_icebreak) ~ dist_bin *
as.factor(va_vessel_activity), data = Ringed_Sightings_ice)

## Warning: (1) Hessian is numerically singular: parameters are not uniquely
determined
## In addition: Absolute convergence criterion was met, but relative
criterion was not met

anova(model0, model, model1, model2, model3) # model has a lower AIC so it
fits better the data, BUT AIC are all very similar: going with dist_bin
instead of continuous resp_dist

## Likelihood ratio tests of cumulative link models:
##
##        formula:
## model0 as.factor(mmo_bh_res_icebreak) ~ 1
## model  as.factor(mmo_bh_res_icebreak) ~ resp_dist +
as.factor(va_vessel_activity)
## model1 as.factor(mmo_bh_res_icebreak) ~ resp_dist *
as.factor(va_vessel_activity)
## model2 as.factor(mmo_bh_res_icebreak) ~ dist_bin +
as.factor(va_vessel_activity)
## model3 as.factor(mmo_bh_res_icebreak) ~ dist_bin *
as.factor(va_vessel_activity)
##        link: threshold:
## model0 logit flexible
## model  logit flexible
```

```
## model1 logit flexible
## model2 logit flexible
## model3 logit flexible
##
##        no.par    AIC  logLik LR.stat df  Pr(>Chisq)
## model0      2 159.89 -77.945
## model       4 138.25 -65.124 25.6429  2 0.000002702 ***
## model1      5 139.41 -64.704  0.8388  1      0.3597
## model2      6 138.96 -63.480  2.4491  1      0.1176
## model3      9 142.78 -62.388  2.1844  3      0.5350
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(model2)
```

```
## formula:
## as.factor(mmo_bh_res_icebreak) ~ dist_bin + as.factor(va_vessel_activity)
## data:    Ringed_Sightings_ice
##
##  link  threshold nobs logLik AIC    niter max.grad cond.H
##  logit flexible  80   -63.48 138.96 7(0)  1.24e-10 8.0e+01
##
## Coefficients:
##                                                     Estimate Std. Error z
value
## dist_bin(500,1000]                                   -1.4253     0.6384  -
2.233
## dist_bin(1000,1500]                                  -1.9610     0.7427  -
2.641
## dist_bin(1500,2000]                                  -2.8738     0.8991  -
3.196
## as.factor(va_vessel_activity)Transiting open water  -2.0718     0.5555  -
3.730
##                                                     Pr(>|z|)
## dist_bin(500,1000]                                  0.025581 *
## dist_bin(1000,1500]                                 0.008277 **
## dist_bin(1500,2000]                                 0.001392 **
## as.factor(va_vessel_activity)Transiting open water 0.000192 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##                    Estimate Std. Error z value
## No response|Scan  -2.6569     0.6146  -4.323
## Scan|Flush        -1.9422     0.5752  -3.377
```

```
#Analysis of deviance analysis
Anova.clm(model2, type = "II") #significant effect of distance on seal
response (p<0.001) and vessel activity on seal behaviour (p<0.5)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: as.factor(mmo_bh_res_icebreak)
##                                 LR Chisq Df Pr(>Chisq)
## dist_bin                          15.140  3   0.001701 **
## as.factor(va_vessel_activity)   16.185  1 0.00005746 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#p-value for model and pseudo R-squared
nagelkerke(model2)
```

```
## $Models
##
## Model: "clm, as.factor(mmo_bh_res_icebreak) ~ dist_bin +
as.factor(va_vessel_activity), Ringed_Sightings_ice"
## Null:  "clm, as.factor(mmo_bh_res_icebreak) ~ 1, Ringed_Sightings_ice"
##
## $Pseudo.R.squared.for.model.vs.null
##                                 Pseudo.R.squared
## McFadden                                0.185584
## Cox and Snell (ML)                      0.303463
## Nagelkerke (Cragg and Uhler)            0.353880
##
## $Likelihood.ratio.test
##  Df.diff LogLik.diff  Chisq      p.value
##       -4     -14.465 28.931 0.0000080745
##
## $Number.of.observations
##
## Model: 80
## Null:  80
##
## $Messages
## [1] "Note: For models fit with REML, these statistics are based on
refitting with ML"
##
## $Warnings
## [1] "None"
```

```
### Postdoc Test
marginal = emmeans(model2,
                   ~ dist_bin + as.factor(va_vessel_activity))
marginal
```

```
##  dist_bin    va_vessel_activity                                 emmean
SE
##  (0,500]     Icebreaking (includes transiting broken ice track)  2.300
0.586
##  (500,1000]  Icebreaking (includes transiting broken ice track)  0.874
0.402
```

```
##  (1000,1500] Icebreaking (includes transiting broken ice track)  0.339
0.604
##  (1500,2000] Icebreaking (includes transiting broken ice track) -0.574
0.726
##  (0,500]     Transiting open water                               0.228
0.493
##  (500,1000]  Transiting open water                              -1.198
0.572
##  (1000,1500] Transiting open water                              -1.733
0.660
##  (1500,2000] Transiting open water                              -2.646
0.858
##   df asymp.LCL asymp.UCL
##  Inf    1.1519    3.4473
##  Inf    0.0867    1.6619
##  Inf   -0.8446    1.5217
##  Inf   -1.9976    0.8491
##  Inf   -0.7394    1.1948
##  Inf   -2.3186   -0.0765
##  Inf   -3.0263   -0.4403
##  Inf   -4.3283   -0.9639
##
## Results are given on the as.factor (not the response) scale.
## Confidence level used: 0.95
```

```
pairs(marginal,
      adjust="tukey")
```

```
##  contrast
##  (0,500] Icebreaking (includes transiting broken ice track) - (500,1000]
Icebreaking (includes transiting broken ice track)
##  (0,500] Icebreaking (includes transiting broken ice track) - (1000,1500]
Icebreaking (includes transiting broken ice track)
##  (0,500] Icebreaking (includes transiting broken ice track) - (1500,2000]
Icebreaking (includes transiting broken ice track)
##  (0,500] Icebreaking (includes transiting broken ice track) - (0,500]
Transiting open water
##  (0,500] Icebreaking (includes transiting broken ice track) - (500,1000]
Transiting open water
##  (0,500] Icebreaking (includes transiting broken ice track) - (1000,1500]
Transiting open water
##  (0,500] Icebreaking (includes transiting broken ice track) - (1500,2000]
Transiting open water
##  (500,1000] Icebreaking (includes transiting broken ice track) -
(1000,1500] Icebreaking (includes transiting broken ice track)
##  (500,1000] Icebreaking (includes transiting broken ice track) -
(1500,2000] Icebreaking (includes transiting broken ice track)
##  (500,1000] Icebreaking (includes transiting broken ice track) - (0,500]
Transiting open water
##  (500,1000] Icebreaking (includes transiting broken ice track) -
```

```
(500,1000] Transiting open water
##  (500,1000] Icebreaking (includes transiting broken ice track) - 
(1000,1500] Transiting open water
##  (500,1000] Icebreaking (includes transiting broken ice track) - 
(1500,2000] Transiting open water
##  (1000,1500] Icebreaking (includes transiting broken ice track) - 
(1500,2000] Icebreaking (includes transiting broken ice track)
##  (1000,1500] Icebreaking (includes transiting broken ice track) - (0,500] 
Transiting open water
##  (1000,1500] Icebreaking (includes transiting broken ice track) - 
(500,1000] Transiting open water
##  (1000,1500] Icebreaking (includes transiting broken ice track) - 
(1000,1500] Transiting open water
##  (1000,1500] Icebreaking (includes transiting broken ice track) - 
(1500,2000] Transiting open water
##  (1500,2000] Icebreaking (includes transiting broken ice track) - (0,500] 
Transiting open water
##  (1500,2000] Icebreaking (includes transiting broken ice track) - 
(500,1000] Transiting open water
##  (1500,2000] Icebreaking (includes transiting broken ice track) - 
(1000,1500] Transiting open water
##  (1500,2000] Icebreaking (includes transiting broken ice track) - 
(1500,2000] Transiting open water
##  (0,500] Transiting open water - (500,1000] Transiting open water
##  (0,500] Transiting open water - (1000,1500] Transiting open water
##  (0,500] Transiting open water - (1500,2000] Transiting open water
##  (500,1000] Transiting open water - (1000,1500] Transiting open water
##  (500,1000] Transiting open water - (1500,2000] Transiting open water
##  (1000,1500] Transiting open water - (1500,2000] Transiting open water
##  estimate    SE  df z.ratio p.value
##     1.425 0.638 Inf   2.233  0.3320
##     1.961 0.743 Inf   2.641  0.1415
##     2.874 0.899 Inf   3.196  0.0302
##     2.072 0.556 Inf   3.730  0.0047
##     3.497 0.991 Inf   3.530  0.0099
##     4.033 1.015 Inf   3.973  0.0018
##     4.946 1.194 Inf   4.142  0.0009
##     0.536 0.687 Inf   0.780  0.9941
##     1.449 0.817 Inf   1.773  0.6388
##     0.647 0.672 Inf   0.963  0.9795
##     2.072 0.556 Inf   3.730  0.0047
##     2.608 0.828 Inf   3.150  0.0349
##     3.520 1.010 Inf   3.486  0.0115
##     0.913 0.923 Inf   0.989  0.9762
##     0.111 0.831 Inf   0.133  1.0000
##     1.536 0.935 Inf   1.642  0.7246
##     2.072 0.556 Inf   3.730  0.0047
##     2.985 1.140 Inf   2.618  0.1492
##    -0.802 0.899 Inf  -0.892  0.9869
##     0.623 0.966 Inf   0.645  0.9982
```

```
##     1.159 1.011 Inf   1.146  0.9465
##     2.072 0.556 Inf   3.730  0.0047
##     1.425 0.638 Inf   2.233  0.3320
##     1.961 0.743 Inf   2.641  0.1415
##     2.874 0.899 Inf   3.196  0.0302
##     0.536 0.687 Inf   0.780  0.9941
##     1.449 0.817 Inf   1.773  0.6388
##     0.913 0.923 Inf   0.989  0.9762
##
## Note: contrasts are still on the as.factor scale
## P value adjustment: tukey method for comparing a family of 8 estimates
```

```
cld(marginal, Letters=letters)
```

```
##  dist_bin    va_vessel_activity                                 emmean
SE
##  (1500,2000] Transiting open water                              -2.646
0.858
##  (1000,1500] Transiting open water                              -1.733
0.660
##  (500,1000]  Transiting open water                              -1.198
0.572
##  (1500,2000] Icebreaking (includes transiting broken ice track) -0.574
0.726
##  (0,500]     Transiting open water                               0.228
0.493
##  (1000,1500] Icebreaking (includes transiting broken ice track)  0.339
0.604
##  (500,1000]  Icebreaking (includes transiting broken ice track)  0.874
0.402
##  (0,500]     Icebreaking (includes transiting broken ice track)  2.300
0.586
##   df asymp.LCL asymp.UCL .group
##  Inf   -4.3283   -0.9639  ab
##  Inf   -3.0263   -0.4403  a c
##  Inf   -2.3186   -0.0765  abcd
##  Inf   -1.9976    0.8491    cde
##  Inf   -0.7394    1.1948    cde
##  Inf   -0.8446    1.5217   b def
##  Inf    0.0867    1.6619      ef
##  Inf    1.1519    3.4473       f
##
## Results are given on the as.factor (not the response) scale.
## Confidence level used: 0.95
## Note: contrasts are still on the as.factor scale
## P value adjustment: tukey method for comparing a family of 8 estimates
## significance level used: alpha = 0.05
## NOTE: If two or more means share the same grouping symbol,
##       then we cannot show them to be different.
##       But we also did not show them to be the same.
```

```
### Check model assumptions
nominal_test(model2)

## Tests of nominal effects
##
## formula: as.factor(mmo_bh_res_icebreak) ~ dist_bin +
as.factor(va_vessel_activity)
##                               Df  logLik    AIC    LRT Pr(>Chi)
## <none>                           -63.480 138.96
## dist_bin                       3 -62.119 142.24 2.7225   0.4364
## as.factor(va_vessel_activity)

scale_test(model2)

## Tests of scale effects
##
## formula: as.factor(mmo_bh_res_icebreak) ~ dist_bin +
as.factor(va_vessel_activity)
##                               Df  logLik    AIC     LRT Pr(>Chi)
## <none>                           -63.480 138.96
## dist_bin                       3 -61.943 141.89 3.07330   0.3805
## as.factor(va_vessel_activity)  1 -63.472 140.94 0.01473   0.9034
```

The data indicate a significant difference in response depending on vessel activity types ($p < 0.01$), and a significant effect of distance on seal behaviour ($p < 0.05$). ###

using clm

```
tidy(model2, exponentiate = TRUE, conf.int = TRUE)

## # A tibble: 6 × 8
##   term         estimate std.error statistic p.value conf.low conf.high
coef.type
##   <chr>           <dbl>     <dbl>     <dbl>   <dbl>    <dbl>     <dbl>
<chr>
## 1 No response…   0.0702     0.615     -4.32 1.54e-5 NA           NA
intercept
## 2 Scan|Flush     0.143      0.575     -3.38 7.34e-4 NA           NA
intercept
## 3 dist_bin(50…   0.240      0.638     -2.23 2.56e-2  0.0636      0.799
location
## 4 dist_bin(10…   0.141      0.743     -2.64 8.28e-3  0.0302      0.574
location
## 5 dist_bin(15…   0.0565     0.899     -3.20 1.39e-3  0.00831     0.298
location
## 6 as.factor(v…   0.126      0.556     -3.73 1.92e-4  0.0394      0.356
location
```

The exponentiated coefficient (the odds ratio) related to distance is 0.999 which is less than 1: this means that distance is negatively related to no response values. But since no response is better than a scan which in turn is better than flush, then larger distance is positively related to having no response, which reads: The further the seals were away from the vessel tend to have no response (p < 0.05). Specifically, at 500-1000 meters there is 53.7% more odds (0.463 – 1 = -0.537, p=0.12) of having no response or scans. At 1000-1500 m there is (0.291 - 1 = -0.709, p < 0.05) there is 70.9% more odds of having no response or scan response in seals. At 1500 - 2000m there is 91% more odds (0.090 - 1 = -0.91, p<0.01) of having no response. When vessels were transiting water there is 68%)0.320 - 1 = -0.68) more odds of having no response in seals than when vessels are icebreaking (p< 0.05).

checking model fit

```
nagelkerke(model2) # (Nagelkerke’s R-squared: which is a number between 0 and 1 that measures the goodness of fit of a logistic regression model.)
```

```
## $Models
##
## Model: "clm, as.factor(mmo_bh_res_icebreak) ~ dist_bin +
as.factor(va_vessel_activity), Ringed_Sightings_ice"
## Null:  "clm, as.factor(mmo_bh_res_icebreak) ~ 1, Ringed_Sightings_ice"
##
## $Pseudo.R.squared.for.model.vs.null
##                              Pseudo.R.squared
## McFadden                             0.185584
## Cox and Snell (ML)                   0.303463
## Nagelkerke (Cragg and Uhler)         0.353880
##
## $Likelihood.ratio.test
##  Df.diff LogLik.diff  Chisq      p.value
##       -4     -14.465 28.931 0.0000080745
##
## $Number.of.observations
##
## Model: 80
## Null:  80
##
## $Messages
## [1] "Note: For models fit with REML, these statistics are based on
refitting with ML"
##
## $Warnings
## [1] "None"
```

The likelihood ratio test: which tests if the full model (the model with all the predictors included) fits the data better than the null model (the model with no variables). In our case, the LogLik.diff is -8.9805 with p < 0.01, which means that adding the predictors is better than the null model with no predictors.

###Lipsitz test to check the goodness of fit

```
#lipsitz.test(model2)
```

Since the null hypothesis is a good model fit, then the p = 0.6331 obtained means that we cannot reject that hypothesis — which is a good thing.

###Accuracy of the ordinal logistic regression model

```
#Step 1: Get the fitted values and save them in preds:
#preds <- augment(model2, type = "class")
#preds

#Step 2: Look at the confusion matrix
#conf_mat(preds, truth = mmo_bh_res_icebreak, estimate = .fitted)

#Step 3: Calculate the model accuracy:
#forecast::accuracy(preds, truth = mmo_bh_res_icebreak, estimate = .fitted)

#brant.test(model2) #null hypothesis is that the proportional odds assumption holds. The assumption is considered violated if p < 0.05 on the Omnibus test plus at least one of the variables [source: McNulty K. Handbook of Regression Modeling in People Analytics: With Examples in R and Python. 1st edition. Chapman and Hall/CRC; 2021.]

#plot_predictions(model2, condition = "mmo_bh_res_icebreak") + facet_wrap(~group)
```

using polr: one thought I had why to go with clm was: The polr package is used when the proportional odds assumption holds, which means that the effect of a predictor variable (vessel distance and activity) is the same across all levels of the response variable (seal behaviour). The clm package is used when the proportional odds assumption does not hold, which means that the effect of a predictor variable is different across different levels of the response variable 2.

```
model1<- polr(mmo_bh_res_icebreak ~ resp_dist +va_vessel_activity, method =
"logistic",  Hess = TRUE, data = Ringed_Sightings_ice)
summary(model1)

## Call:
## polr(formula = mmo_bh_res_icebreak ~ resp_dist + va_vessel_activity,
##     data = Ringed_Sightings_ice, Hess = TRUE, method = "logistic")
##
## Coefficients:
##                                             Value Std. Error t value
## resp_dist                               -0.001532  0.0005005  -3.061
## va_vessel_activityTransiting open water -1.897213  0.5107947  -3.714
##
## Intercepts:
##                   Value   Std. Error t value
## No response|Scan -2.6372  0.5761    -4.5774
## Scan|Flush       -1.9494  0.5369    -3.6306
## Flush|Unknown    15.1282  0.5370    28.1694
##
```

```
## Residual Deviance: 130.2475
## AIC: 140.2475
```

```r
model1$coefficients
```

```
##                                resp_dist va_vessel_activityTransiting open
water
##                             -0.001531655                             -
1.897213337
```

```r
## store table
(ctable <- coef(summary(model1)))
```

```
##                                                Value   Std. Error   t
value
## resp_dist                               -0.001531655 0.0005004583 -
3.060506
## va_vessel_activityTransiting open water -1.897213337 0.5107946810 -
3.714239
## No response|Scan                        -2.637246331 0.5761431540 -
4.577415
## Scan|Flush                              -1.949375869 0.5369318020 -
3.630584
## Flush|Unknown                           15.128158176 0.5370427190
28.169376
```

```r
## calculate and store p values
p <- pnorm(abs(ctable[, "t value"]), lower.tail = FALSE) * 2

## combined table
(ctable <- cbind(ctable, "p value" = p))
```

```
##                                                Value   Std. Error   t
value
## resp_dist                               -0.001531655 0.0005004583 -
3.060506
## va_vessel_activityTransiting open water -1.897213337 0.5107946810 -
3.714239
## No response|Scan                        -2.637246331 0.5761431540 -
4.577415
## Scan|Flush                              -1.949375869 0.5369318020 -
3.630584
## Flush|Unknown                           15.128158176 0.5370427190
28.169376
##
p value
## resp_dist
0.002209634320693618179248796096203477645758539438247680664062500000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000
## va_vessel_activityTransiting open water
```

```
0.00020381639838750793434704600137763463862938806414604187011718750000000000000
00000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000
## No response|Scan
0.00000470756910743773677703941094030426484096096828579902648925781250000000000
00000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000
## Scan|Flush
0.00028278093837185873165793181804872347129276022315025329589843750000000000000
00000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000
## Flush|Unknown
0.000000000000000000000000000000000000000000000000000000000000000000000000000
00000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000001387712
```

```
## get 95% Confidence Intervals
(ci <- confint(model1)) # default method gives profiled CIs
```

```
## Waiting for profiling to be done...
```

```
##                                                 2.5 %       97.5 %
## resp_dist                                -0.002511571 -0.000642977
## va_vessel_activityTransiting open water -2.950708830 -0.921426521
```

```
confint.default(model1) # CIs assuming normality
```

```
##                                                 2.5 %        97.5 %
## resp_dist                                -0.002512536 -0.0005507753
## va_vessel_activityTransiting open water -2.898352516 -0.8960741593
```

```
## odds ratios
exp(coef(model1))
```

```
##                                 resp_dist va_vessel_activityTransiting open
water
##                                 0.9984695
0.1499860
```

```
## OR (Odd Ratios) and CI (Confidence Intervals)
exp(cbind(OR = coef(model1), ci))
```

```
##                                                 OR      2.5 %    97.5 %
## resp_dist                                0.9984695 0.99749158 0.9993572
## va_vessel_activityTransiting open water 0.1499860 0.05230262 0.3979510
```

```
#step(model1, direction = "forward")
# looking at diff methods, AIC is lowest for "logistic"
# need to test assumption of proportional odds


# Proportional Odds Assumptions
```

```
sf <- function(y) {
  c('Y>=1' = qlogis(mean(y >= 1)),
    'Y>=2' = qlogis(mean(y >= 2)),
    'Y>=3' = qlogis(mean(y >= 3)))
}
#below displays the (linear) predicted values we would get if we regressed
our dependent variable on our predictor variables one at a time, without the
parallel slopes assumption
(s <- with(Ringed_Sightings_ice, summary(as.numeric(mmo_bh_res_icebreak)
~va_vessel_activity + resp_dist, fun=sf)))

## as.numeric(mmo_bh_res_icebreak)      N= 80
##
## +------------------+---------------------------------------------------+--
+----+-----------+----------+
## |                  |                                                   |
N|Y>=1|       Y>=2|      Y>=3|
## +------------------+---------------------------------------------------+--
+----+-----------+----------+
## |va_vessel_activity|Icebreaking (includes transiting broken ice track)|49|
Inf| 1.36097655| 0.5436154|
## |                  |                                Transiting open water|31|
Inf|-0.59783700|-0.8938179|
## +------------------+---------------------------------------------------+--
+----+-----------+----------+
## |         resp_dist|                                        [  50, 500)|22|
Inf| 1.50407740| 0.9808293|
## |                  |                                        [ 500, 750)|18|
Inf| 0.95551145| 0.2231436|
## |                  |                                        [ 750,1300)|21|
Inf| 0.09531018|-0.4855078|
## |                  |                                        [1300,2000]|19|
Inf|-0.31845373|-0.7731899|
## +------------------+---------------------------------------------------+--
+----+-----------+----------+
## |           Overall|                                                   |80|
Inf| 0.51082562| 0.0000000|
## +------------------+---------------------------------------------------+--
+----+-----------+----------+

#next  we evaluate the parallel slopes assumption by running a series of
binary logistic regressions with varying cutpoints on the dependent variable
and checking the equality of coefficients across cutpoints
glm(I(as.numeric(mmo_bh_res_icebreak) >= 2) ~ resp_dist, family="binomial",
data = Ringed_Sightings_ice)

##
## Call:  glm(formula = I(as.numeric(mmo_bh_res_icebreak) >= 2) ~ resp_dist,
##     family = "binomial", data = Ringed_Sightings_ice)
##
```

```
## Coefficients:
## (Intercept)    resp_dist
##    1.736456    -0.001369
##
## Degrees of Freedom: 79 Total (i.e. Null);  78 Residual
## Null Deviance:       105.9
## Residual Deviance: 96.21     AIC: 100.2
```

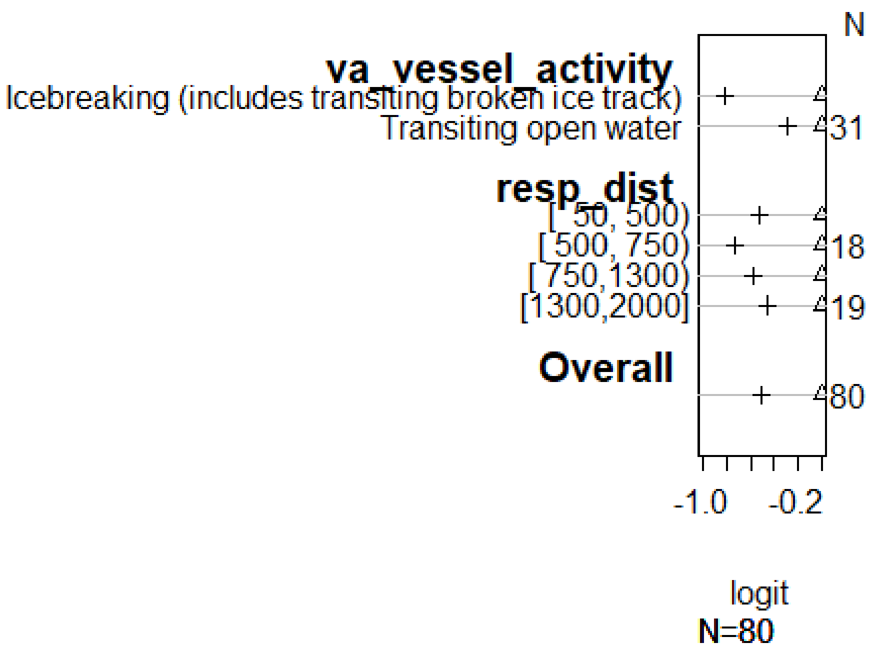
```
glm(I(as.numeric(mmo_bh_res_icebreak) >= 3) ~ resp_dist, family="binomial",
data = Ringed_Sightings_ice)
```

```
##
## Call:  glm(formula = I(as.numeric(mmo_bh_res_icebreak) >= 3) ~ resp_dist,
##     family = "binomial", data = Ringed_Sightings_ice)
##
## Coefficients:
## (Intercept)    resp_dist
##    1.075496    -0.001269
##
## Degrees of Freedom: 79 Total (i.e. Null);  78 Residual
## Null Deviance:       110.9
## Residual Deviance: 102.5     AIC: 106.5
```

```
#plotting these slops
s[, 4] <- s[, 4] - s[, 3]
s[, 3] <- s[, 3] - s[, 3]
s
```

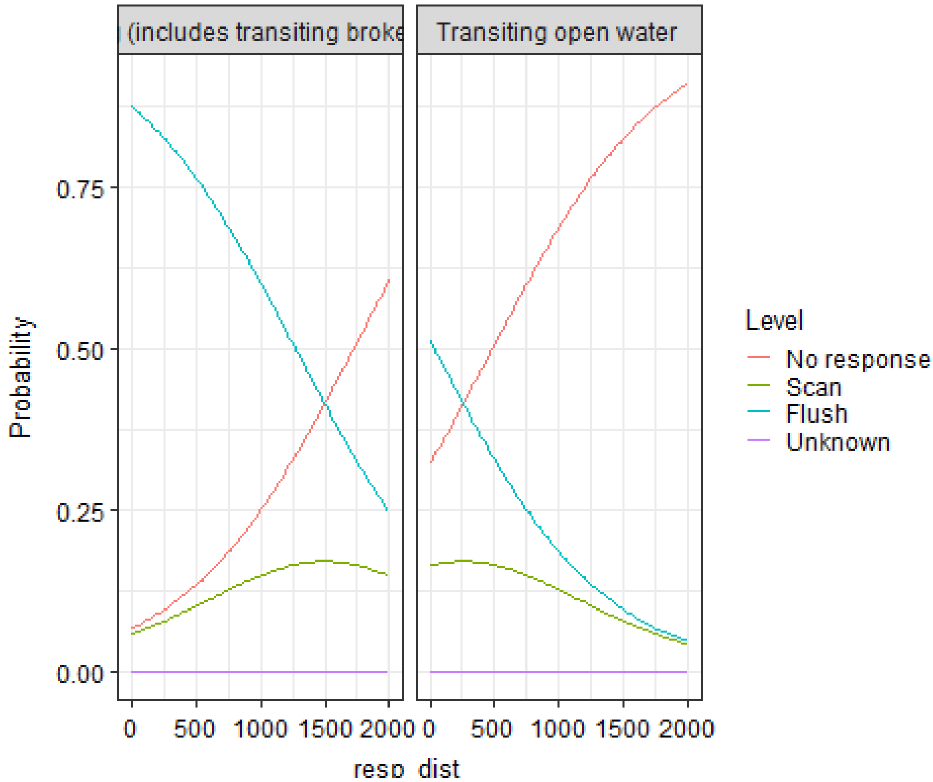
```
## as.numeric(mmo_bh_res_icebreak)      N= 80
##
## +-----------------+----------------------------------------------------+--
+----+----+----------+
## |                 |                                                    |
N|Y>=1|Y>=2|      Y>=3|
## +-----------------+----------------------------------------------------+--
+----+----+----------+
## |va_vessel_activity|Icebreaking (includes transiting broken ice track)|49|
Inf|   0|-0.8173611|
## |                 |                                Transiting open water|31|
Inf|   0|-0.2959809|
## +-----------------+----------------------------------------------------+--
+----+----+----------+
## |        resp_dist|                                          [  50, 500)|22|
Inf|   0|-0.5232481|
## |                 |                                          [ 500, 750)|18|
Inf|   0|-0.7323679|
## |                 |                                          [ 750,1300)|21|
Inf|   0|-0.5808180|
## |                 |                                          [1300,2000]|19|
Inf|   0|-0.4547362|
## +-----------------+----------------------------------------------------+--
```

```
+----+----+----------+
## |           Overall|                                                    |80|
Inf|   0|-0.5108256|
## +-----------------+--------------------------------------------------+--
+----+----+----------+

plot(s, which=1:3, pch=1:3, xlab='logit', main=' ', xlim=range(-1:0))
```




```
#setting up that one neat graph revisit later
newdat <- data.frame( va_vessel_activity = rep(c("Icebreaking (includes
transiting broken ice track)","Transiting open water"), each = 150),
  resp_dist = rep(seq(from = 0, to = 2000, length.out = 100), 3))

newdat <- cbind(newdat, predict(model1, newdat, type = "probs", interval =
'confidence'))
head(newdat)

##                                  va_vessel_activity resp_dist No response
## 1 Icebreaking (includes transiting broken ice track)   0.00000  0.06677944
## 2 Icebreaking (includes transiting broken ice track)  20.20202  0.06873382
## 3 Icebreaking (includes transiting broken ice track)  40.40404  0.07074106
## 4 Icebreaking (includes transiting broken ice track)  60.60606  0.07280234
## 5 Icebreaking (includes transiting broken ice track)  80.80808  0.07491883
## 6 Icebreaking (includes transiting broken ice track) 101.01010  0.07709174
##         Scan     Flush         Unknown
## 1 0.05784199 0.8753783 0.0000002691065
## 2 0.05930255 0.8719634 0.0000002609072
```

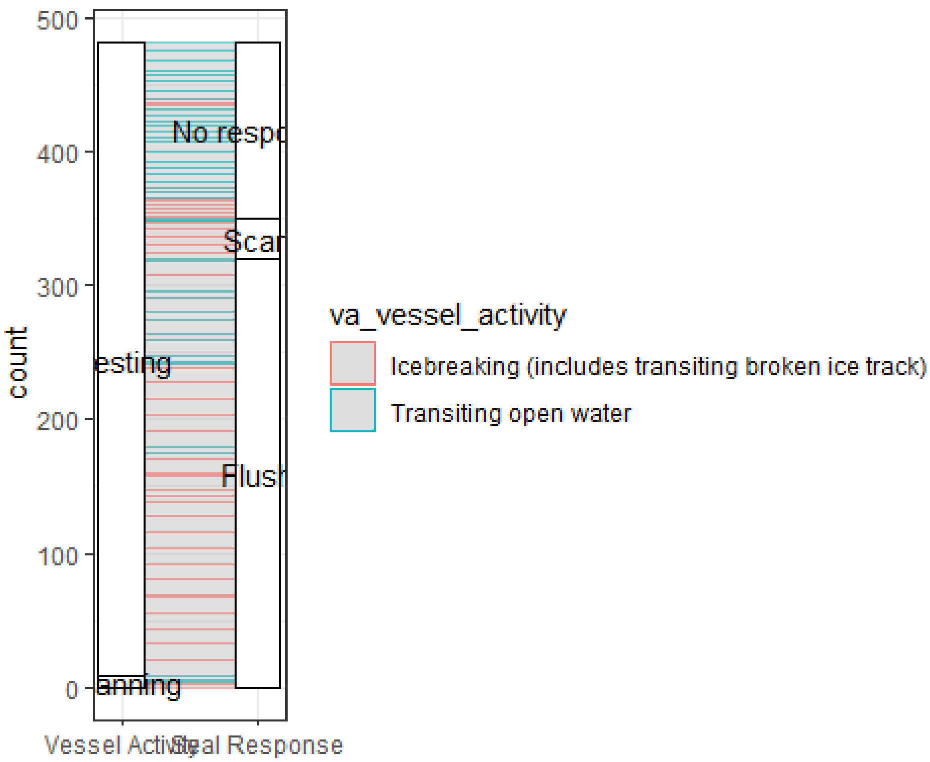
```
## 3 0.06078977 0.8684689 0.0000002529577
## 4 0.06230355 0.8648939 0.0000002452504
## 5 0.06384376 0.8612372 0.0000002377780
## 6 0.06541021 0.8574978 0.0000002305332

lnewdat <- melt(newdat, id.vars = c( "va_vessel_activity", "resp_dist"),
                variable.name = "Level", value.name= "Probability")
head(lnewdat)

##                                   va_vessel_activity resp_dist       Level
## 1 Icebreaking (includes transiting broken ice track)   0.00000 No response
## 2 Icebreaking (includes transiting broken ice track)  20.20202 No response
## 3 Icebreaking (includes transiting broken ice track)  40.40404 No response
## 4 Icebreaking (includes transiting broken ice track)  60.60606 No response
## 5 Icebreaking (includes transiting broken ice track)  80.80808 No response
## 6 Icebreaking (includes transiting broken ice track) 101.01010 No response
##   Probability
## 1  0.06677944
## 2  0.06873382
## 3  0.07074106
## 4  0.07280234
## 5  0.07491883
## 6  0.07709174

lnewdat<-lnewdat %>%
  filter("Level" != "NA")
head(lnewdat)

##                                   va_vessel_activity resp_dist       Level
## 1 Icebreaking (includes transiting broken ice track)   0.00000 No response
## 2 Icebreaking (includes transiting broken ice track)  20.20202 No response
## 3 Icebreaking (includes transiting broken ice track)  40.40404 No response
## 4 Icebreaking (includes transiting broken ice track)  60.60606 No response
## 5 Icebreaking (includes transiting broken ice track)  80.80808 No response
## 6 Icebreaking (includes transiting broken ice track) 101.01010 No response
##   Probability
## 1  0.06677944
## 2  0.06873382
## 3  0.07074106
## 4  0.07280234
## 5  0.07491883
## 6  0.07709174

ggplot(lnewdat, aes(x = resp_dist, y = Probability, colour = Level)) +
  geom_line()+facet_wrap(~va_vessel_activity, labeller
=labeller(mmo_behaviour_init_sight~va_vessel_activity))+theme_all
```



Flow Diagram

```
#rearrrange dataset; reduce to only ship activity, distance, and seal
behaviour
#ice
df <-
Ringed_Sightings_ice[c("mmo_behaviour_init_sight","mmo_bh_res_icebreak",
"dist_bin", "va_vessel_activity")]

#Summarize observations
df1 <- df %>%
  group_by(mmo_behaviour_init_sight, mmo_bh_res_icebreak, va_vessel_activity,
dist_bin) %>%
  mutate(count = n())


fluvial_OnIce <- ggplot(data = df1,
       aes(axis1 = mmo_behaviour_init_sight, axis2 = mmo_bh_res_icebreak, y =
count)) +
  geom_alluvium(aes(color=va_vessel_activity)) +
  geom_stratum() +
  geom_text(stat = "stratum",
            aes(label = after_stat(stratum))) +
  scale_x_discrete(limits = c("Vessel Activity", "Seal Response"),
                   expand = c(0.15, 0.05)) +
  scale_fill_viridis_d() +
```

```
  theme_bw()
fluvial_OnIce
```



Water

Ordinal Regression Model

Model selection

```
#ensure no unknowns are in the data, since they cant be placed in the ordinal series, also make sure the vessel activities with 1-2 entries are filteress for this case since they cause model convergence issues
Ringed_Sightings_water<-Ringed_Sightings_water%>%
  filter(mmo_bh_res_icebreak_water != "Unknown", va_vessel_activity != "Drifting",
                va_vessel_activity != "Maneuvering")
#Null model
model0 <- clm(as.factor(mmo_bh_res_icebreak_water) ~ 1, data = Ringed_Sightings_water)
model <- clm(as.factor(mmo_bh_res_icebreak_water) ~ resp_dist + as.factor(va_vessel_activity), data = Ringed_Sightings_water)
model1 <- clm(as.factor(mmo_bh_res_icebreak_water) ~ resp_dist * as.factor(va_vessel_activity), data = Ringed_Sightings_water)
model2<- clm(as.factor(mmo_bh_res_icebreak_water) ~ dist_bin + as.factor(va_vessel_activity), data = Ringed_Sightings_water)
model3<- clm(as.factor(mmo_bh_res_icebreak_water) ~ dist_bin *
```

```
as.factor(va_vessel_activity), data = Ringed_Sightings_water)
model4<-clm(as.factor(mmo_bh_res_icebreak_water) ~
as.factor(va_vessel_activity), data = Ringed_Sightings_water)

anova(model0, model, model1, model2, model3, model4) # model1 has lowest AIC,
narrowly beating out the null, Selected model is model2 inlcuding inned
distance (FOR EASIER INTERPRETATION) and vessel activity. AIC difference
between model0, model, and model2 is veyr samll.

## Likelihood ratio tests of cumulative link models:
##
##        formula:
## model0 as.factor(mmo_bh_res_icebreak_water) ~ 1
## model4 as.factor(mmo_bh_res_icebreak_water) ~
as.factor(va_vessel_activity)
## model  as.factor(mmo_bh_res_icebreak_water) ~ resp_dist +
as.factor(va_vessel_activity)
## model1 as.factor(mmo_bh_res_icebreak_water) ~ resp_dist *
as.factor(va_vessel_activity)
## model2 as.factor(mmo_bh_res_icebreak_water) ~ dist_bin +
as.factor(va_vessel_activity)
## model3 as.factor(mmo_bh_res_icebreak_water) ~ dist_bin *
as.factor(va_vessel_activity)
##        link: threshold:
## model0 logit flexible
## model4 logit flexible
## model  logit flexible
## model1 logit flexible
## model2 logit flexible
## model3 logit flexible
##
##        no.par    AIC  logLik LR.stat df Pr(>Chisq)
## model0      4 508.63 -250.32
## model4      5 510.34 -250.17  0.2891  1    0.59079
## model       6 507.95 -247.98  4.3890  1    0.03617 *
## model1      7 509.45 -247.73  0.5033  1    0.47803
## model2      8 509.85 -246.93  1.5982  1    0.20616
## model3     11 515.56 -246.78  0.2938  3    0.96119
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#Output of best fitting model
summary(model2)

## formula:
## as.factor(mmo_bh_res_icebreak_water) ~ dist_bin +
as.factor(va_vessel_activity)
## data:    Ringed_Sightings_water
##
##  link  threshold nobs logLik  AIC    niter max.grad cond.H
```

```
##  logit flexible  218  -246.93 509.85 8(1)  7.78e-13 5.7e+02
##
## Coefficients:
##                                                    Estimate Std. Error z
value
## dist_bin(500,1000]                                  -0.9503     0.3883  -
2.447
## dist_bin(1000,1500]                                 -0.1723     0.6063  -
0.284
## dist_bin(1500,2000]                                 -0.7060     0.9472  -
0.745
## as.factor(va_vessel_activity)Transiting open water  -0.1784     0.3373  -
0.529
##                                                    Pr(>|z|)
## dist_bin(500,1000]                                   0.0144 *
## dist_bin(1000,1500]                                  0.7763
## dist_bin(1500,2000]                                  0.4561
## as.factor(va_vessel_activity)Transiting open water   0.5969
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##                              Estimate Std. Error z value
## No response|Regular Dive     -2.3056     0.2506  -9.201
## Regular Dive|Scan             0.7013     0.1730   4.054
## Scan|Swim away                0.8648     0.1771   4.883
## Swim away|Rapid dive/splash   1.1495     0.1868   6.155
```

```
#Analysis of deviance analysis
Anova.clm(model2, type = "II")
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: as.factor(mmo_bh_res_icebreak_water)
##                                 LR Chisq Df Pr(>Chisq)
## dist_bin                          6.4905  3    0.09004 .
## as.factor(va_vessel_activity)     0.2809  1    0.59609
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#neither distance nor vessel activity are significant


#p-value for model and pseudo R-squared
nagelkerke(model4)
```

```
## $Models
##
## Model: "clm, as.factor(mmo_bh_res_icebreak_water) ~
as.factor(va_vessel_activity), Ringed_Sightings_water"
## Null:  "clm, as.factor(mmo_bh_res_icebreak_water) ~ 1,
```

```
Ringed_Sightings_water"
##
## $Pseudo.R.squared.for.model.vs.null
##                              Pseudo.R.squared
## McFadden                          0.000577484
## Cox and Snell (ML)                0.001325300
## Nagelkerke (Cragg and Uhler)      0.001473560
##
## $Likelihood.ratio.test
##  Df.diff LogLik.diff   Chisq p.value
##       -1    -0.14455 0.28911 0.59079
##
## $Number.of.observations
##
## Model: 218
## Null:  218
##
## $Messages
## [1] "Note: For models fit with REML, these statistics are based on
refitting with ML"
##
## $Warnings
## [1] "None"
```

```
### Postdoc Test
marginal = emmeans(model4,
                   ~ as.factor(va_vessel_activity))
marginal
```

```
##  va_vessel_activity                                emmean    SE  df
asymp.LCL
##  Icebreaking (includes transiting broken ice track) -0.263 0.149 Inf    -
0.554
##  Transiting open water                             -0.443 0.302 Inf    -
1.035
##  asymp.UCL
##     0.0289
##     0.1492
##
## Results are given on the as.factor (not the response) scale.
## Confidence level used: 0.95
```

```
pairs(marginal,
      adjust="tukey")
```

```
##  contrast
##  Icebreaking (includes transiting broken ice track) - Transiting open
water
##  estimate    SE  df z.ratio p.value
##      0.18 0.336 Inf   0.536  0.5917
```

```
##
## Note: contrasts are still on the as.factor scale
```

```
cld(marginal, Letters=letters)
```

```
##  va_vessel_activity                               emmean    SE  df
asymp.LCL
##  Transiting open water                            -0.443 0.302 Inf    -
1.035
##  Icebreaking (includes transiting broken ice track) -0.263 0.149 Inf    -
0.554
##  asymp.UCL .group
##     0.1492  a
##     0.0289  a
##
## Results are given on the as.factor (not the response) scale.
## Confidence level used: 0.95
## Note: contrasts are still on the as.factor scale
## significance level used: alpha = 0.05
## NOTE: If two or more means share the same grouping symbol,
##       then we cannot show them to be different.
##       But we also did not show them to be the same.
```

```
### Check model assumptions
nominal_test(model4)
```

```
## Tests of nominal effects
##
## formula: as.factor(mmo_bh_res_icebreak_water) ~
as.factor(va_vessel_activity)
##                               Df  logLik    AIC LRT Pr(>Chi)
## <none>                            -250.17 510.34
## as.factor(va_vessel_activity)
```

```
scale_test(model4)
```

```
## Tests of scale effects
##
## formula: as.factor(mmo_bh_res_icebreak_water) ~
as.factor(va_vessel_activity)
##                               Df  logLik    AIC     LRT Pr(>Chi)
## <none>                            -250.17 510.34
## as.factor(va_vessel_activity)  1 -250.06 512.13 0.21389   0.6437
```

using clm

```
tidy(model4, exponentiate = TRUE, conf.int = TRUE)
```

```
## # A tibble: 5 × 8
##   term        estimate std.error statistic  p.value conf.low conf.high
coef.type
##   <chr>          <dbl>     <dbl>     <dbl>    <dbl>    <dbl>     <dbl>
```

```
<chr>
## 1 No respons…    0.125     0.224    -9.28  1.69e-20   NA          NA
intercept
## 2 Regular Di…    2.32      0.162     5.22  1.83e- 7   NA          NA
intercept
## 3 Scan|Swim …    2.73      0.167     6.03  1.66e- 9   NA          NA
intercept
## 4 Swim away|…    3.61      0.177     7.25  4.20e-13   NA          NA
intercept
## 5 as.factor(…    0.835     0.336    -0.536 5.92e- 1    0.430       1.60
location
```

Response distance, icebreaking, manuevering, and transiting open water are not statistically significant ($p > 0.05$), which means these variables are not good predictors for seal response.

checking model fit

```
nagelkerke(model4) # (Nagelkerke’s R-squared: which is a number between 0 and
1 that measures the goodness of fit of a logistic regression model.)

## $Models
##
## Model: "clm, as.factor(mmo_bh_res_icebreak_water) ~
as.factor(va_vessel_activity), Ringed_Sightings_water"
## Null:  "clm, as.factor(mmo_bh_res_icebreak_water) ~ 1,
Ringed_Sightings_water"
##
## $Pseudo.R.squared.for.model.vs.null
##                              Pseudo.R.squared
## McFadden                          0.000577484
## Cox and Snell (ML)                0.001325300
## Nagelkerke (Cragg and Uhler)      0.001473560
##
## $Likelihood.ratio.test
##  Df.diff LogLik.diff   Chisq p.value
##       -1    -0.14455 0.28911 0.59079
##
## $Number.of.observations
##
## Model: 218
## Null:  218
##
## $Messages
## [1] "Note: For models fit with REML, these statistics are based on
refitting with ML"
##
## $Warnings
## [1] "None"
```

The likelihood ratio test: which tests if the full model (the model with all the predictors included) fits the data better than the null model (the model with no variables). In our case, the LogLik.diff is -0.23492 with p > 0.098, , it means that the model does not explain the data better than a null model. In other words, the predictors in your model are not doing better than chance, which is why none of your independent variables (IVs) are statistically significant. We have to accept the Nullhypothesis which means that seals in water are not affected by vessel activity.

###Lipsitz test to check the goodness of fit

```
#lipsitz.test(model4)
```

###Accuracy of the ordinal logistic regression model

```
#Step 1: Get the fitted values and save them in preds:
#preds <- augment(model4, type = "class")
#preds

#Step 2: Look at the confusion matrix
#conf_mat(preds, truth = mmo_bh_res_icebreak_water, estimate = .fitted)

#Step 3: Calculate the model accuracy:
#forecast::accuracy(preds, truth = mmo_bh_res_icebreak_water, estimate =
.fitted)

brant.test(model4) #null hypothesis is that the proportional odds assumption
holds. The assumption is considered violated if p < 0.05 on the Omnibus test
plus at least one of the variables [source: McNulty K. Handbook of Regression
Modeling in People Analytics: With Examples in R and Python. 1st edition.
Chapman and Hall/CRC; 2021.]

##
## Brant Test:
##                                                          chi-sq   df
pr(>chi)
## Omnibus                                                   0.529    3
0.91
## as.factor(va_vessel_activity)Transiting open water     0.529    3
0.91
##
## H0: Proportional odds assumption holds
```

using polr: one thought I had why to go with clm was: The polr package is used when the proportional odds assumption holds, which means that the effect of a predictor variable (vessel

The clm package is used when the proportional odds assumption does not hold, which means that the effect of a predictor variable is different across different levels of the response variable 2.

```r
model1<- polr(mmo_bh_res_icebreak_water ~ resp_dist +va_vessel_activity,
method = "logistic",  Hess = TRUE, data = Ringed_Sightings_water)
summary(model1)
```

```
## Call:
## polr(formula = mmo_bh_res_icebreak_water ~ resp_dist + va_vessel_activity,
##     data = Ringed_Sightings_water, Hess = TRUE, method = "logistic")
##
## Coefficients:
##                                             Value Std. Error t value
## resp_dist                              -0.0007671  0.0003693 -2.0774
## va_vessel_activityTransiting open water -0.2236102  0.3373521 -0.6628
##
## Intercepts:
##                              Value   Std. Error t value
## No response|Regular Dive    -2.4426  0.2901    -8.4202
## Regular Dive|Scan            0.5374  0.2161     2.4871
## Scan|Swim away               0.6999  0.2189     3.1973
## Swim away|Rapid dive/splash  0.9837  0.2261     4.3510
## Rapid dive/splash|Unknown   11.4662  0.2263    50.6653
##
## Residual Deviance: 495.9585
## AIC: 509.9585
```

```r
model1$coefficients
```

```
##                              resp_dist va_vessel_activityTransiting open
water
##                          -0.0007670931                           -
0.2236102237
```

```r
## store table
(ctable <- coef(summary(model1)))
```

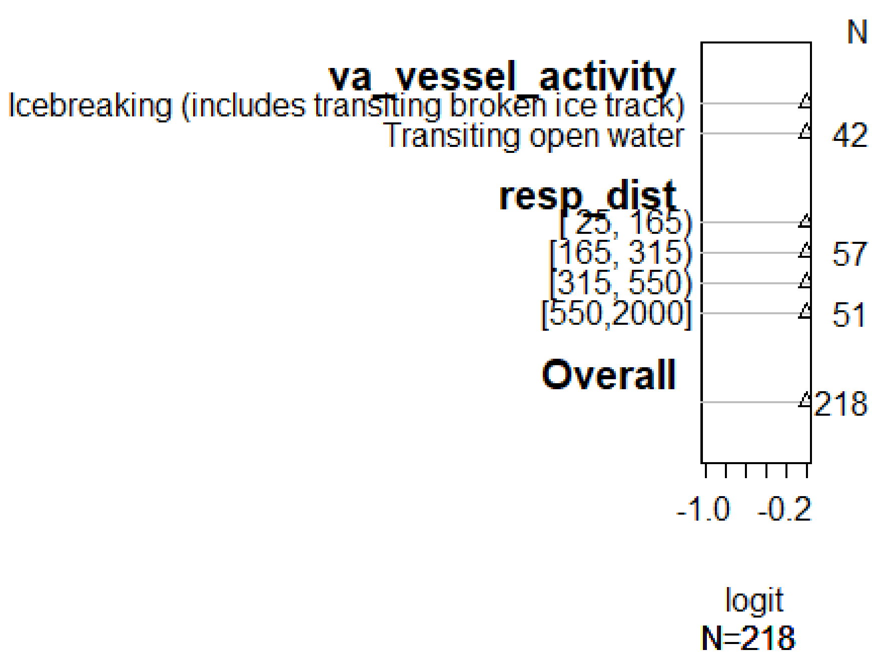
```
##                                                Value   Std. Error    t
value
## resp_dist                               -0.0007670931 0.0003692567 -
2.0773980
## va_vessel_activityTransiting open water -0.2236102237 0.3373520669 -
0.6628393
## No response|Regular Dive                -2.4426370044 0.2900925697 -
8.4201984
## Regular Dive|Scan                        0.5373970260 0.2160719036
2.4871213
## Scan|Swim away                           0.6998935620 0.2189031119
3.1972755
## Swim away|Rapid dive/splash              0.9837057568 0.2260893759
4.3509597
## Rapid dive/splash|Unknown               11.4661724336 0.2263119278
50.6653474
```

```
## calculate and store p values
p <- pnorm(abs(ctable[, "t value"]), lower.tail = FALSE) * 2

## combined table
(ctable <- cbind(ctable, "p value" = p))

##                                               Value   Std. Error    t
value
## resp_dist                                 -0.0007670931 0.0003692567 -
2.0773980
## va_vessel_activityTransiting open water -0.2236102237 0.3373520669 -
0.6628393
## No response|Regular Dive                  -2.4426370044 0.2900925697 -
8.4201984
## Regular Dive|Scan                          0.5373970260 0.2160719036
2.4871213
## Scan|Swim away                             0.6998935620 0.2189031119
3.1972755
## Swim away|Rapid dive/splash                0.9837057568 0.2260893759
4.3509597
## Rapid dive/splash|Unknown                 11.4661724336 0.2263119278
50.6653474
##                                                         p value
## resp_dist                                 0.0377648368823072809582
## va_vessel_activityTransiting open water 0.5074334506747946171856З
## No response|Regular Dive                  0.0000000000000000003758471
## Regular Dive|Scan                         0.0128781493922608663432
## Scan|Swim away                            0.0013873234314683174396
## Swim away|Rapid dive/splash               0.0000135542982665795130
## Rapid dive/splash|Unknown                 0.0000000000000000000000

## get 95% Confidence Intervals
(ci <- confint(model1)) # default method gives profiled CIs

## Waiting for profiling to be done...

##                                               2.5 %          97.5 %
## resp_dist                                 -0.001494015 -0.00004850567
## va_vessel_activityTransiting open water -0.892511975  0.43248125187

confint.default(model1) # CIs assuming normality

##                                               2.5 %          97.5 %
## resp_dist                                 -0.001490823 -0.00004336331
## va_vessel_activityTransiting open water -0.884808125  0.43758767758

## odds ratios
exp(coef(model1))

##                                 resp_dist va_vessel_activityTransiting open
water
```

```
##                                0.9992332
0.7996267

## OR (Odd Ratios) and CI (Confidence Intervals)
exp(cbind(OR = coef(model1), ci))

##                                                OR     2.5 %    97.5 %
## resp_dist                               0.9992332 0.9985071 0.9999515
## va_vessel_activityTransiting open water 0.7996267 0.4096255 1.5410766

#step(model1, direction = "forward")
# looking at diff methods, AIC is lowest for "logistic"
# need to test assumption of proportional odds


# Proportional Odds Assumptions
sf <- function(y) {
  c('Y>=1' = qlogis(mean(y >= 1)),
    'Y>=2' = qlogis(mean(y >= 2)),
    'Y>=3' = qlogis(mean(y >= 3)))
}
#below displays the (linear) predicted values we would get if we regressed
our dependent variable on our predictor variables one at a time, without the
parallel slopes assumption
(s <- with(Ringed_Sightings_water,
summary(as.numeric(mmo_bh_res_icebreak_water) ~va_vessel_activity +
resp_dist, fun=sf)))

## as.numeric(mmo_bh_res_icebreak_water)      N= 218
##
## +------------------+---------------------------------------------------+---
+----+--------+----------+
## |                  |                                                   |
N|Y>=1|    Y>=2|      Y>=3|
## +------------------+---------------------------------------------------+---
+----+--------+----------+
## |va_vessel_activity|Icebreaking (includes transiting broken ice
track)|176| Inf|2.054124|-0.8418924|
## |                  |                              Transiting open water|
42| Inf|2.001480|-1.0360919|
## +------------------+---------------------------------------------------+---
+----+--------+----------+
## |         resp_dist|                                       [ 25, 165)|
59| Inf|2.621039|-0.2384110|
## |                  |                                       [165, 315)|
57| Inf|2.140066|-1.1221428|
## |                  |                                       [315, 550)|
51| Inf|2.219203|-0.9718606|
## |                  |                                       [550,2000]|
51| Inf|1.410987|-1.4109870|
## +------------------+---------------------------------------------------+---
```

```
+----+--------+----------+
## |           Overall|
|218| Inf|2.043814|-0.8780695|
## +-----------------+--------------------------------------------------+---
+----+--------+----------+

#next  we evaluate the parallel slopes assumption by running a series of
binary logistic regressions with varying cutpoints on the dependent variable
and checking the equality of coefficients across cutpoints
glm(I(as.numeric(mmo_bh_res_icebreak_water) >= 2) ~ resp_dist,
family="binomial", data = Ringed_Sightings_water)

##
## Call:  glm(formula = I(as.numeric(mmo_bh_res_icebreak_water) >= 2) ~
##     resp_dist, family = "binomial", data = Ringed_Sightings_water)
##
## Coefficients:
## (Intercept)    resp_dist
##   2.3403335   -0.0006589
##
## Degrees of Freedom: 217 Total (i.e. Null);  216 Residual
## Null Deviance:       155.3
## Residual Deviance: 153.7     AIC: 157.7

glm(I(as.numeric(mmo_bh_res_icebreak_water) >= 3) ~ resp_dist,
family="binomial", data = Ringed_Sightings_water)

##
## Call:  glm(formula = I(as.numeric(mmo_bh_res_icebreak_water) >= 3) ~
##     resp_dist, family = "binomial", data = Ringed_Sightings_water)
##
## Coefficients:
## (Intercept)    resp_dist
##  -0.5367107   -0.0008825
##
## Degrees of Freedom: 217 Total (i.e. Null);  216 Residual
## Null Deviance:       263.9
## Residual Deviance: 260   AIC: 264

#plotting these slops
s[, 4] <- s[, 4] - s[, 3]
s[, 3] <- s[, 3] - s[, 3]
s

## as.numeric(mmo_bh_res_icebreak_water)      N= 218
##
## +-----------------+--------------------------------------------------+---
+----+----+---------+
## |                 |                                                  |
N|Y>=1|Y>=2|     Y>=3|
## +-----------------+--------------------------------------------------+---
```

```
+----+----+---------+
## |va_vessel_activity|Icebreaking (includes transiting broken ice track)|176| Inf|   0|-2.896016|
## |                  |                                              Transiting open water|
42| Inf|   0|-3.037572|
## +------------------+---------------------------------------------------+---
+----+----+---------+
## |         resp_dist|                                                    [ 25, 165)|
59| Inf|   0|-2.859450|
## |                  |                                                    [165, 315)|
57| Inf|   0|-3.262209|
## |                  |                                                    [315, 550)|
51| Inf|   0|-3.191064|
## |                  |                                                    [550,2000]|
51| Inf|   0|-2.821974|
## +------------------+---------------------------------------------------+---
+----+----+---------+
## |           Overall|
|218| Inf|   0|-2.921884|
## +------------------+---------------------------------------------------+---
+----+----+---------+

plot(s, which=1:3, pch=1:3, xlab='logit', main=' ', xlim=range(-1:0))
```




```
#setting up that one neat graph revisit later
newdat <- data.frame( va_vessel_activity = rep(c("Icebreaking (includes transiting broken ice track)","Transiting open water"), each = 150),
```

```r
  resp_dist = rep(seq(from = 0, to = 2000, length.out = 100), 3))

newdat <- cbind(newdat, predict(model1, newdat, type = "probs", interval =
'confidence'))
head(newdat)
```

```
##                                    va_vessel_activity resp_dist No response
## 1 Icebreaking (includes transiting broken ice track)   0.00000  0.07997866
## 2 Icebreaking (includes transiting broken ice track)  20.20202  0.08112640
## 3 Icebreaking (includes transiting broken ice track)  40.40404  0.08228913
## 4 Icebreaking (includes transiting broken ice track)  60.60606  0.08346702
## 5 Icebreaking (includes transiting broken ice track)  80.80808  0.08466021
## 6 Icebreaking (includes transiting broken ice track) 101.01010  0.08586886
##   Regular Dive       Scan  Swim away Rapid dive/splash       Unknown
## 1    0.5512280 0.03695748 0.05967873         0.2721466 0.000010478522
## 2    0.5536803 0.03678442 0.05931063         0.2690879 0.000010317392
## 3    0.5561026 0.03660819 0.05893889         0.2660510 0.000010158739
## 4    0.5584944 0.03642886 0.05856365         0.2630361 0.000010002526
## 5    0.5608552 0.03624651 0.05818504         0.2600432 0.000009848715
## 6    0.5631846 0.03606122 0.05780320         0.2570724 0.000009697269
```

```r
lnewdat <- melt(newdat, id.vars = c( "va_vessel_activity", "resp_dist"),
                variable.name = "Level", value.name= "Probability")
head(lnewdat)
```

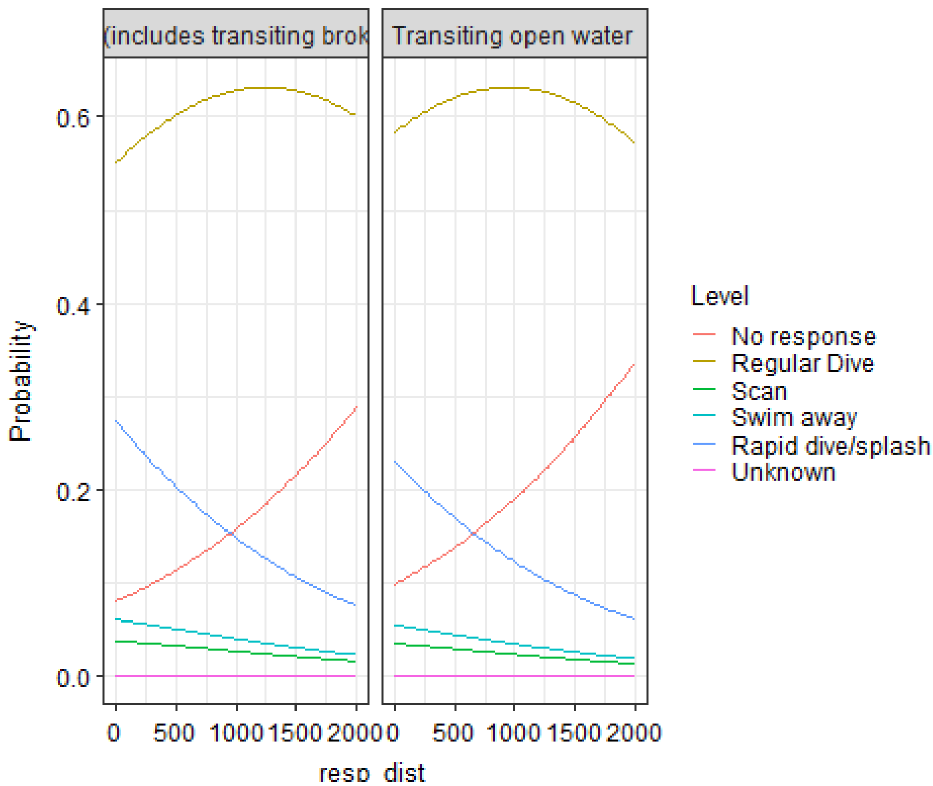
```
##                                    va_vessel_activity resp_dist       Level
## 1 Icebreaking (includes transiting broken ice track)   0.00000 No response
## 2 Icebreaking (includes transiting broken ice track)  20.20202 No response
## 3 Icebreaking (includes transiting broken ice track)  40.40404 No response
## 4 Icebreaking (includes transiting broken ice track)  60.60606 No response
## 5 Icebreaking (includes transiting broken ice track)  80.80808 No response
## 6 Icebreaking (includes transiting broken ice track) 101.01010 No response
##   Probability
## 1  0.07997866
## 2  0.08112640
## 3  0.08228913
## 4  0.08346702
## 5  0.08466021
## 6  0.08586886
```

```r
lnewdat<-lnewdat %>%
  filter("Level" != "NA")
head(lnewdat)
```

```
##                                    va_vessel_activity resp_dist       Level
## 1 Icebreaking (includes transiting broken ice track)   0.00000 No response
## 2 Icebreaking (includes transiting broken ice track)  20.20202 No response
## 3 Icebreaking (includes transiting broken ice track)  40.40404 No response
## 4 Icebreaking (includes transiting broken ice track)  60.60606 No response
## 5 Icebreaking (includes transiting broken ice track)  80.80808 No response
## 6 Icebreaking (includes transiting broken ice track) 101.01010 No response
```

```
##   Probability
## 1  0.07997866
## 2  0.08112640
## 3  0.08228913
## 4  0.08346702
## 5  0.08466021
## 6  0.08586886
```

```
ggplot(lnewdat, aes(x = resp_dist, y = Probability, colour = Level)) +
  geom_line()+facet_wrap(~va_vessel_activity, labeller
=labeller(mmo_behaviour_init_sight~va_vessel_activity))+theme_all
```



#Review by DRmalso includes prediction plots

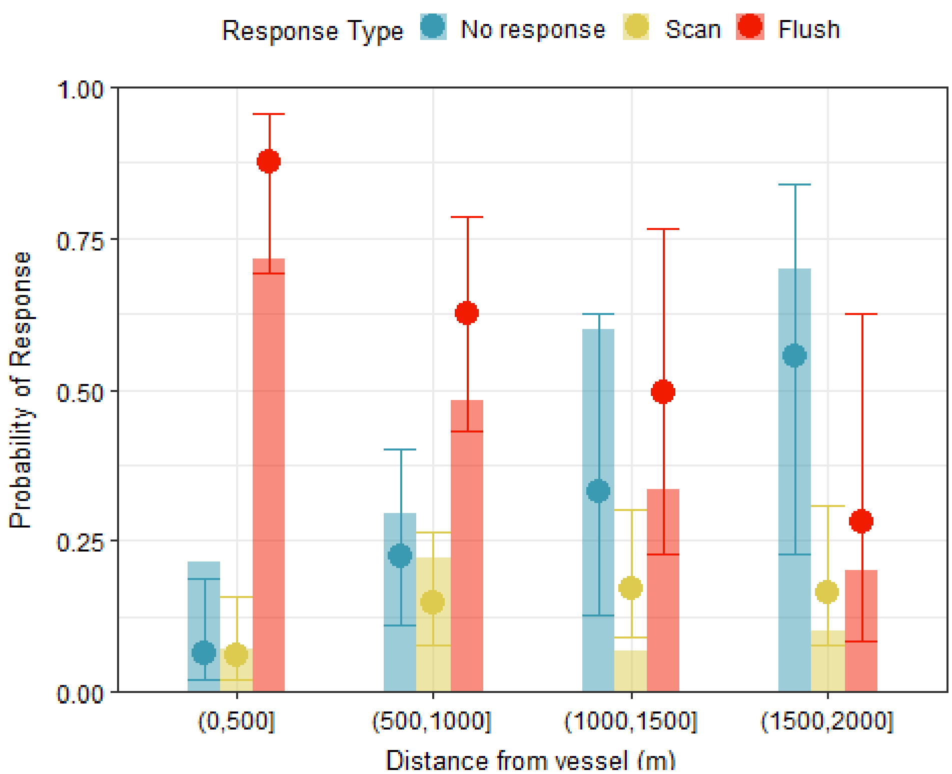
```
###################################################################
### DR . prediction plots with observed and predicted values
####ice
## with selected model that uses distance as a category instead of continuous
model2
```

```
## formula:
## as.factor(mmo_bh_res_icebreak_water) ~ dist_bin +
as.factor(va_vessel_activity)
## data:    Ringed_Sightings_water
##
##  link  threshold nobs logLik  AIC    niter max.grad cond.H
##  logit flexible  218  -246.93 509.85 8(1)  7.78e-13 5.7e+02
```

```
##
## Coefficients:
##                                  dist_bin(500,1000]
##                                             -0.9503
##                                 dist_bin(1000,1500]
##                                             -0.1723
##                                 dist_bin(1500,2000]
##                                             -0.7060
## as.factor(va_vessel_activity)Transiting open water
##                                             -0.1784
##
## Threshold coefficients:
##    No response|Regular Dive           Regular Dive|Scan
##                     -2.3056                      0.7013
##              Scan|Swim away Swim away|Rapid dive/splash
##                      0.8648                      1.1495

model2 <- clm(mmo_bh_res_icebreak ~ dist_bin + va_vessel_activity, data =
Ringed_Sightings_ice)


## effect of distance (with vessel activity held constant at icebreaking)

newdata <- expand.grid(va_vessel_activity=  "Icebreaking (includes transiting
broken ice track)",
                dist_bin = unique(Ringed_Sightings_ice$dist_bin))

preds <- predict(model2,newdata=newdata,type="prob")$fit

preds <- newdata %>%
    bind_cols(preds)

lwr <- predict(model2,newdata=newdata,type="prob",interval = TRUE, level =
0.95)$lwr
upr <- predict(model2,newdata=newdata,type="prob",interval = TRUE, level =
0.95)$upr

lwr <- lwr %>%
    as.tibble() %>%
    bind_cols(newdata) %>%
    pivot_longer(cols="No response":"Flush")%>%
    dplyr::rename(LCL = value)

## Warning: `as.tibble()` was deprecated in tibble 2.0.0.
## ℹ Please use `as_tibble()` instead.
## ℹ The signature and semantics have changed, see `?as_tibble`.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

```
upr <- upr %>%
    as.tibble() %>%
    bind_cols(newdata) %>%
    pivot_longer(cols="No response":"Flush")%>%
    dplyr::rename(UCL = value)

plotdat <- preds %>%
    as.tibble() %>%
    pivot_longer(cols="No response":"Flush") %>%
    left_join(lwr)%>%
    left_join(upr)

## Joining with `by = join_by(va_vessel_activity, dist_bin, name)`
## Joining with `by = join_by(va_vessel_activity, dist_bin, name)`

obs <- Ringed_Sightings_ice %>%
    group_by(mmo_bh_res_icebreak,dist_bin) %>%
    dplyr::summarize(N=n()) %>%
    ungroup()

## `summarise()` has grouped output by 'mmo_bh_res_icebreak'. You can
override
## using the `.groups` argument.

obs.total <- Ringed_Sightings_ice %>%
    group_by(dist_bin) %>%
    dplyr::summarize(N.Total=n()) %>%
    ungroup()

obs <- obs %>%
    left_join(obs.total) %>%
    mutate(Prob = N / N.Total,
         DataType = "Observed") %>%
    dplyr::rename(value = Prob,
                name = mmo_bh_res_icebreak)

## Joining with `by = join_by(dist_bin)`

plotdat$name <- factor(plotdat$name, levels=c("No response","Scan","Flush"))

p1 <- ggplot()+
    geom_bar(data=obs,aes(x=dist_bin,y=value,fill=name), width=0.5,
        stat="identity",position=position_dodge(width=0.5),alpha=0.5)+
    geom_point(data = plotdat, aes(x=dist_bin,y=value,colour=name),
        position=position_dodge(width=0.5),size=4)+
    geom_errorbar(data=plotdat,
aes(x=dist_bin,ymin=LCL,ymax=UCL,colour=name),
        position=position_dodge(width=0.5),width=0.5)+wes3+wes3col+
    xlab("Distance from vessel (m)")+
    ylab("Probability of Response")+
  labs(fill = "Response Type", colour = "Response Type")+
```

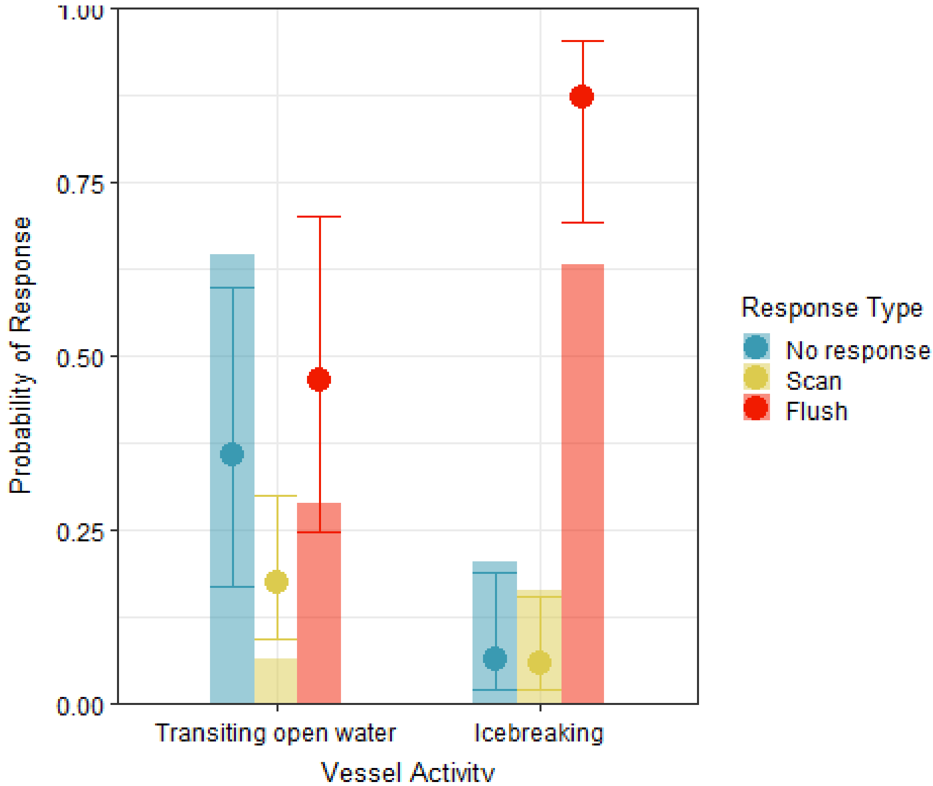
```
    scale_y_continuous(expand=c(0,0))+
    coord_cartesian(ylim=c(0,1))+
    theme_all+
    theme(legend.position="top")
    #theme_all
p1
```



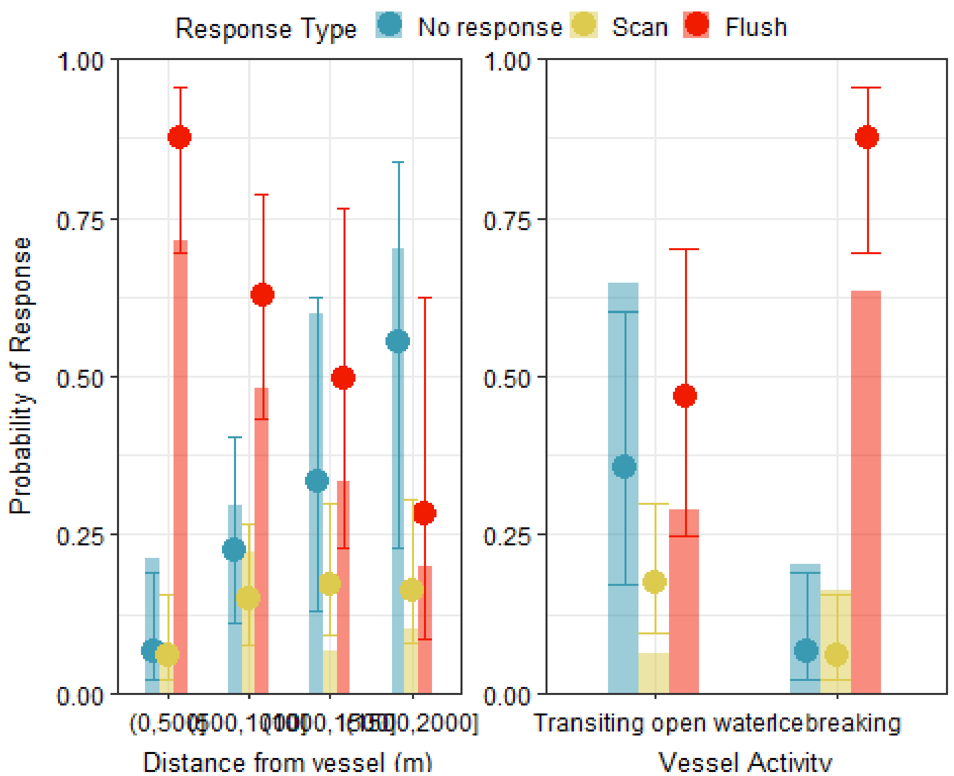

```
ggsave("Ice - Probability by distance.png", width = 6.9, height = 4.5, units
= "in")

## predicted and observed seem to fit okay.

### Plot of effect of vessel activity (with distance held at 0-500m)

newdata <- expand.grid(va_vessel_activity =
unique(Ringed_Sightings_ice$va_vessel_activity),
                dist_bin = unique(Ringed_Sightings_ice$dist_bin)[1])

preds <- predict(model2,newdata=newdata,type="prob")$fit

preds <- newdata %>%
    bind_cols(preds)

lwr <- predict(model2,newdata=newdata,type="prob",interval = TRUE, level =
0.95)$lwr
upr <- predict(model2,newdata=newdata,type="prob",interval = TRUE, level =
```

```
0.95)$upr

lwr <- lwr %>%
    as.tibble() %>%
    bind_cols(newdata) %>%
    pivot_longer(cols="No response":"Flush")%>%
    dplyr::rename(LCL = value)

upr <- upr %>%
    as.tibble() %>%
    bind_cols(newdata) %>%
    pivot_longer(cols="No response":"Flush")%>%
    dplyr::rename(UCL = value)

plotdat <- preds %>%
    as.tibble() %>%
    pivot_longer(cols="No response":"Flush") %>%
    left_join(lwr)%>%
    left_join(upr)

## Joining with `by = join_by(va_vessel_activity, dist_bin, name)`
## Joining with `by = join_by(va_vessel_activity, dist_bin, name)`

obs <- Ringed_Sightings_ice %>%
    group_by(mmo_bh_res_icebreak,va_vessel_activity) %>%
    dplyr::summarize(N=n()) %>%
    ungroup()

## `summarise()` has grouped output by 'mmo_bh_res_icebreak'. You can
override
## using the `.groups` argument.

obs.total <- Ringed_Sightings_ice %>%
    group_by(va_vessel_activity) %>%
    dplyr::summarize(N.Total=n()) %>%
    ungroup()

obs <- obs %>%
    left_join(obs.total) %>%
    mutate(Prob = N / N.Total,
         DataType = "Observed") %>%
    dplyr::rename(value = Prob,
                name = mmo_bh_res_icebreak)

## Joining with `by = join_by(va_vessel_activity)`

plotdat$name <- factor(plotdat$name, levels=c("No response","Scan","Flush"))

plotdat$va_vessel_activity <- dplyr::recode(plotdat$va_vessel_activity,
            "Icebreaking (includes transiting broken ice track)" =
"Icebreaking")
```

```
obs$va_vessel_activity <- dplyr::recode(obs$va_vessel_activity,
            "Icebreaking (includes transiting broken ice track)" =
"Icebreaking")

p2 <- ggplot()+
    geom_bar(data=obs,aes(x=va_vessel_activity,y=value,fill=name), width=0.5,
        stat="identity",position=position_dodge(width=0.5),alpha=0.5)+
    geom_point(data = plotdat, aes(x=va_vessel_activity,y=value,colour=name),
        position=position_dodge(width=0.5),size=4)+
    geom_errorbar(data=plotdat,
aes(x=va_vessel_activity,ymin=LCL,ymax=UCL,colour=name),
        position=position_dodge(width=0.5),width=0.5)+wes3+wes3col+
    xlab("Vessel Activity")+
    ylab("Probability of Response")+
  labs(fill = "Response Type", colour = "Response Type")+
    scale_y_continuous(expand=c(0,0))+
    coord_cartesian(ylim=c(0,1))+
    theme_all
    theme(legend.position="top")

## List of 1
##  $ legend.position: chr "top"
##  - attr(*, "class")= chr [1:2] "theme" "gg"
##  - attr(*, "complete")= logi FALSE
##  - attr(*, "validate")= logi TRUE

    #theme_all


p2
```

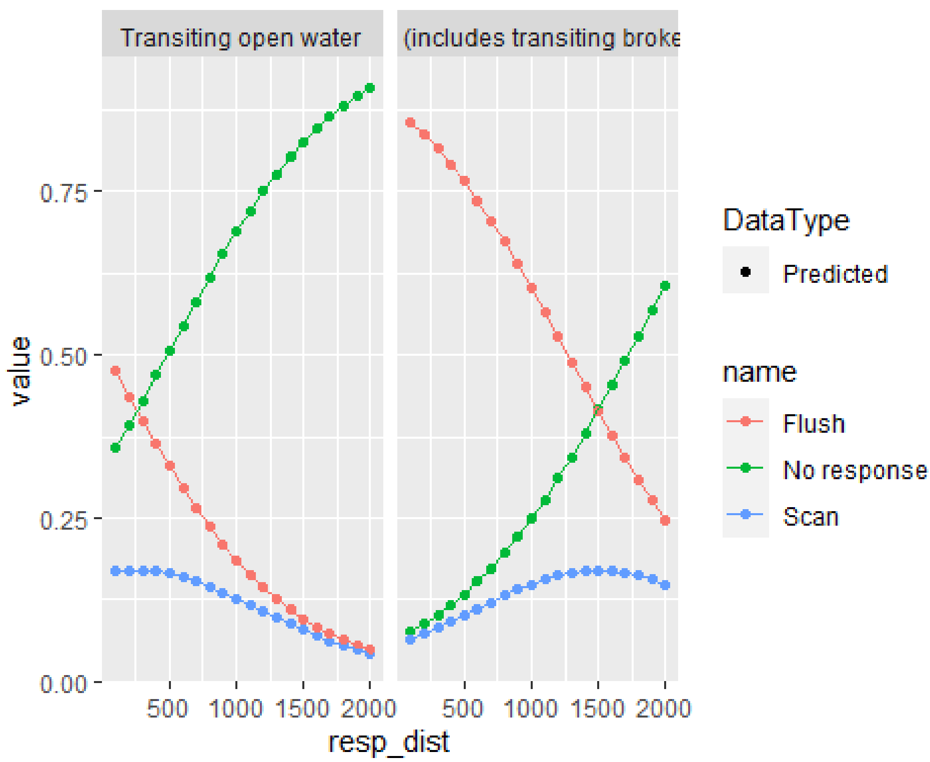



```
ggsave("Ice - Probability by vessel activity.png", width = 5.5, height = 3.5,
units = "in")



###combine into single plot

p_1_2<-ggarrange(p1,p2+rremove("ylab"), nrow= 1, ncol=2, common.legend =
TRUE)
p_1_2
```



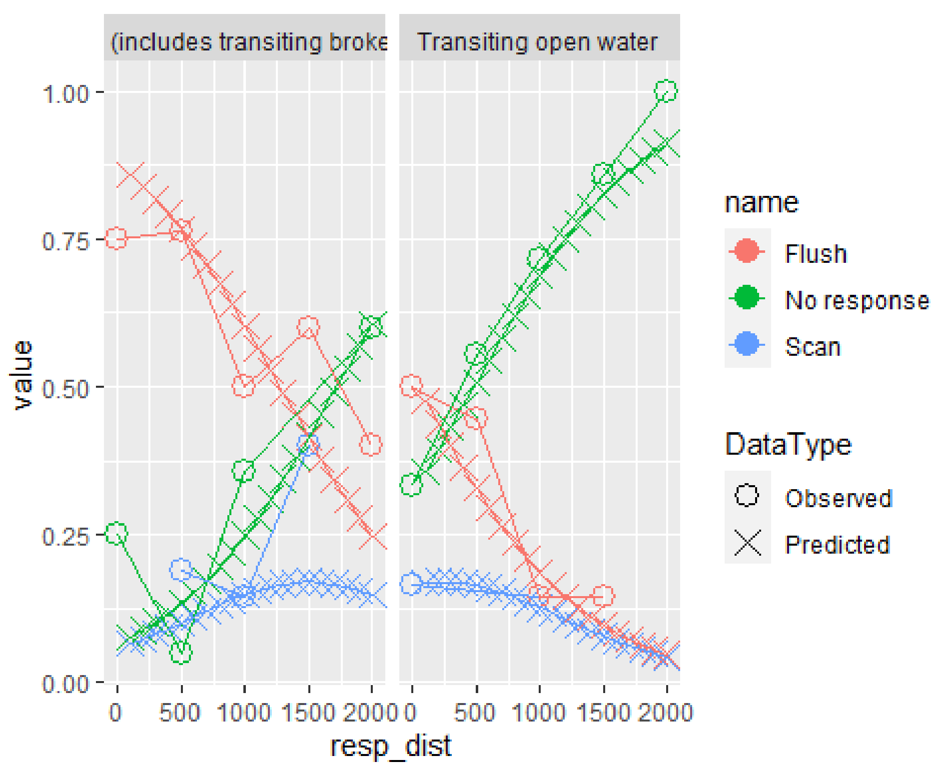

```
ggsave("Ice - Probability Combined.png", width = 4000, height = 2000, units =
"px")
## make plot with distance as continuous
model <- clm(mmo_bh_res_icebreak ~ resp_dist + va_vessel_activity, data =
Ringed_Sightings_ice)

model

## formula: mmo_bh_res_icebreak ~ resp_dist + va_vessel_activity
## data:    Ringed_Sightings_ice
##
##  link  threshold nobs logLik AIC    niter max.grad cond.H
##  logit flexible  80   -65.12 138.25 7(0)  1.21e-07 1.2e+07
##
## Coefficients:
##                                resp_dist va_vessel_activityTransiting open
water
##                                -0.001532                                 -
1.897244
##
## Threshold coefficients:
## No response|Scan       Scan|Flush
##           -2.637           -1.949

newdata <- expand.grid(va_vessel_activity =
unique(Ringed_Sightings_ice$va_vessel_activity),
                resp_dist = seq(100,2000,100) )
```

```
preds <- predict(model,newdata=newdata,type="prob")
names(preds) <- ""

newdata <- newdata %>%
    bind_cols(preds)

plotdat <- newdata %>%
    pivot_longer(cols=c("No response","Scan","Flush")) %>%
    mutate(DataType = "Predicted")

ggplot(data = plotdat, aes(x=resp_dist,y=value,colour=name,shape=DataType))+
    geom_point()+
    geom_line()+
    facet_wrap(~va_vessel_activity)
```




```
obs <- Ringed_Sightings_ice %>%
    mutate(resp_dist = plyr::round_any(resp_dist, 500)) %>%
    group_by(mmo_bh_res_icebreak,va_vessel_activity,resp_dist) %>%
    dplyr::summarize(N=n()) %>%
    ungroup()

## `summarise()` has grouped output by 'mmo_bh_res_icebreak',
## 'va_vessel_activity'. You can override using the `.groups` argument.
```

```r
obs.total <- Ringed_Sightings_ice %>%
    mutate(resp_dist = plyr::round_any(resp_dist, 500)) %>%
    group_by(va_vessel_activity,resp_dist) %>%
    dplyr::summarize(N.Total=n()) %>%
    ungroup()

## `summarise()` has grouped output by 'va_vessel_activity'. You can override
## using the `.groups` argument.

obs <- obs %>%
    left_join(obs.total) %>%
    mutate(Prob = N / N.Total,
         DataType = "Observed") %>%
    dplyr::rename(value = Prob,
                name = mmo_bh_res_icebreak)

## Joining with `by = join_by(va_vessel_activity, resp_dist)`

plotdat <- plotdat %>% bind_rows(obs)

ggplot(data = plotdat, aes(x=resp_dist,y=value,colour=name,shape=DataType))+
    geom_point(size=4)+
    geom_line()+
    facet_wrap(~va_vessel_activity)+
    scale_shape_manual(values=c(1,4))
```




```r
ggplot()+
    geom_point(data = plotdat,
```

```
aes(x=resp_dist,y=value,colour=name,shape=DataType),size=4)+
    geom_line()+
    facet_wrap(~va_vessel_activity)+
    scale_shape_manual(values=c(1,4))
```

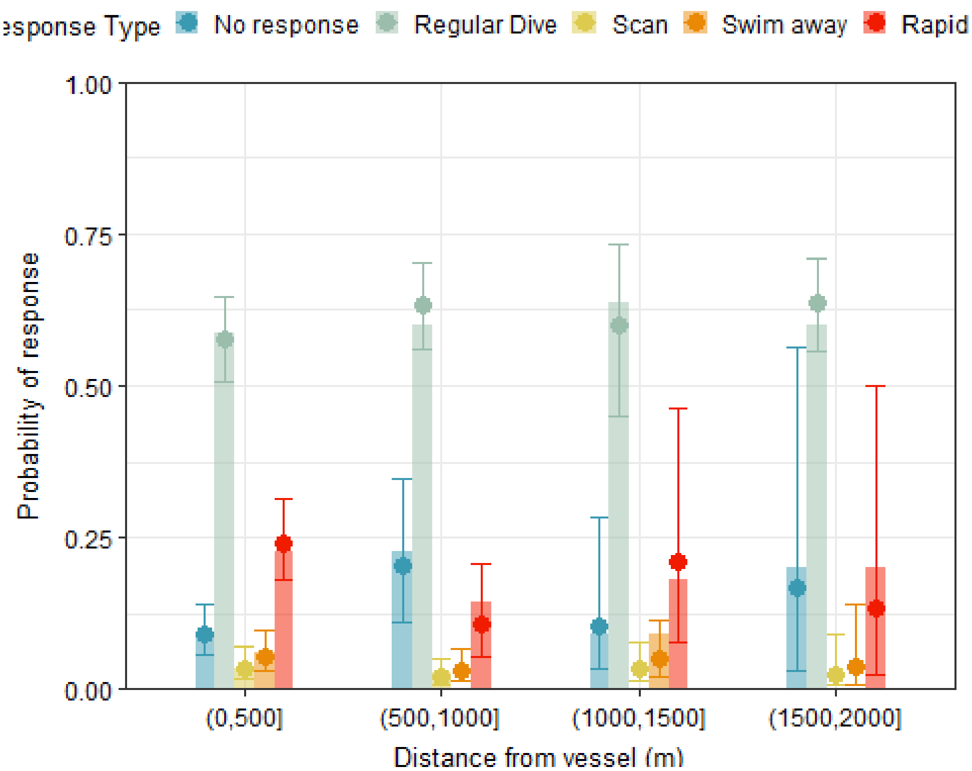

```
## similar results as with categorical distance.  fits pretty well.

## Additional Model diagnostics ('sure' package)

library(sure)

## Registered S3 method overwritten by 'sure':
##   method   from
##   plot.gof EnvStats
##
## Attaching package: 'sure'
##
## The following object is masked _by_ '.GlobalEnv':
##
##     df1

model.polr <-  polr(mmo_bh_res_icebreak ~ resp_dist + va_vessel_activity,
data = Ringed_Sightings_ice,Hess=TRUE)
model.polr <-  polr(mmo_bh_res_icebreak ~ dist_bin + va_vessel_activity, data
= Ringed_Sightings_ice,Hess=TRUE)

summary(model.polr)
```

```
## Call:
## polr(formula = mmo_bh_res_icebreak ~ dist_bin + va_vessel_activity,
##     data = Ringed_Sightings_ice, Hess = TRUE)
##
## Coefficients:
##                                          Value Std. Error t value
## dist_bin(500,1000]                      -1.425     0.6384  -2.233
## dist_bin(1000,1500]                     -1.961     0.7427  -2.641
## dist_bin(1500,2000]                     -2.874     0.8991  -3.196
## va_vessel_activityTransiting open water -2.072     0.5555  -3.730
##
## Intercepts:
##                    Value   Std. Error t value
## No response|Scan -2.6570  0.6147    -4.3227
## Scan|Flush       -1.9422  0.5752    -3.3766
## Flush|Unknown    29.1342  0.5752    50.6503
##
## Residual Deviance: 126.9596
## AIC: 140.9596

sres <- resids(model.polr)

#autoplot(model.polr,what="qq")  # qq of fitted values okay.  this works in R
version 3.X,not 4.X
#autoplot(sres, what = "qq")    # qq of residuals not great.
#autoplot(sres, what = "covariate", x = Ringed_Sightings_ice$dist_bin, xlab =
"x")
#autoplot(sres, what = "covariate", x =
Ringed_Sightings_ice$va_vessel_activity, xlab = "x")
#autoplot(sres, what = "covariate", x = Ringed_Sightings_ice$resp_dist, xlab
= "x")

# minor deviation from normality but good enough.
# No remainign relationship of residuals with predictors.

# another test of proportional odds (parallel slopes)
car::poTest(model.polr)

##
## Tests for Proportional Odds
## polr(formula = mmo_bh_res_icebreak ~ dist_bin + va_vessel_activity,
##     data = Ringed_Sightings_ice, Hess = TRUE)
##
##                                                     b[polr]     b[>No
response]
## Overall
## dist_bin(500,1000]                      -1.4252837388199726 -
1.0494785880815727
## dist_bin(1000,1500]                     -1.9610386584873889 -
1.9653607362129422
```

```
## dist_bin(1500,2000]                        -2.8738392773245343 -
2.8624455045363741
## va_vessel_activityTransiting open water -2.0718470095219121 -
2.3096963530607706
##                                                       b[>Scan]
b[>Flush]
## Overall
## dist_bin(500,1000]                         -1.5165011314210992 -
0.0000000000000231
## dist_bin(1000,1500]                        -1.7235658069254316 -
0.0000000000000269
## dist_bin(1500,2000]                        -2.7466535918062052 -
0.0000000000000251
## va_vessel_activityTransiting open water -1.8024279618306862
0.0000000000000236
##                                         Chisquare df Pr(>Chisq)
## Overall                                      3.82  8       0.87
## dist_bin(500,1000]                           0.68  2       0.71
## dist_bin(1000,1500]                          0.25  2       0.88
## dist_bin(1500,2000]                          0.03  2       0.99
## va_vessel_activityTransiting open water      1.33  2       0.51

# also suggests it's okay.



###water
### Plot of effect of vessel activity (with distance held at 0-500m)
#confirm no unknowns


modelw<-clm(mmo_bh_res_icebreak_water ~ dist_bin+ va_vessel_activity, data =
Ringed_Sightings_water)

newdata <- expand.grid(va_vessel_activity=  "Icebreaking (includes transiting
broken ice track)",
                dist_bin = unique(Ringed_Sightings_water$dist_bin))

preds <- predict(modelw,newdata=newdata,type="prob")$fit
names(preds) <- ""

preds <- newdata %>%
    bind_cols(preds)

lwr <- predict(modelw,newdata=newdata,type="prob",interval = TRUE, level =
0.95)$lwr
upr <- predict(modelw,newdata=newdata,type="prob",interval = TRUE, level =
0.95)$upr
```

```
lwr <- lwr %>%
    as.tibble() %>%
    bind_cols(newdata) %>%
    pivot_longer(cols="No response":"Rapid dive/splash")%>%
    dplyr::rename(LCL = value)


upr <- upr %>%
    as.tibble() %>%
    bind_cols(newdata) %>%
    pivot_longer(cols="No response":"Rapid dive/splash")%>%
    dplyr::rename(UCL = value)

plotdat <- preds %>%
    pivot_longer(cols="No response":"Rapid dive/splash") %>%
    left_join(lwr)%>%
    left_join(upr)

## Joining with `by = join_by(va_vessel_activity, dist_bin, name)`
## Joining with `by = join_by(va_vessel_activity, dist_bin, name)`

obs <- Ringed_Sightings_water %>%
    group_by(mmo_bh_res_icebreak_water,dist_bin) %>%
    dplyr::summarize(N=n()) %>%
    ungroup()

## `summarise()` has grouped output by 'mmo_bh_res_icebreak_water'. You can
## override using the `.groups` argument.

obs.total <- Ringed_Sightings_water %>%
    group_by(dist_bin) %>%
    dplyr::summarize(N.Total=n()) %>%
    ungroup()

obs <- obs %>%
    left_join(obs.total) %>%
    mutate(Prob = N / N.Total,
         DataType = "Observed") %>%
    dplyr::rename(value = Prob,
                name = mmo_bh_res_icebreak_water)

## Joining with `by = join_by(dist_bin)`

plotdat$name <- factor(plotdat$name,
    levels=c("No response","Regular Dive", "Scan", "Swim away","Rapid
dive/splash"))

full <- expand.grid(name =
unique(Ringed_Sightings_water$mmo_bh_res_icebreak_water),
        dist_bin = unique(Ringed_Sightings_water$dist_bin))
```

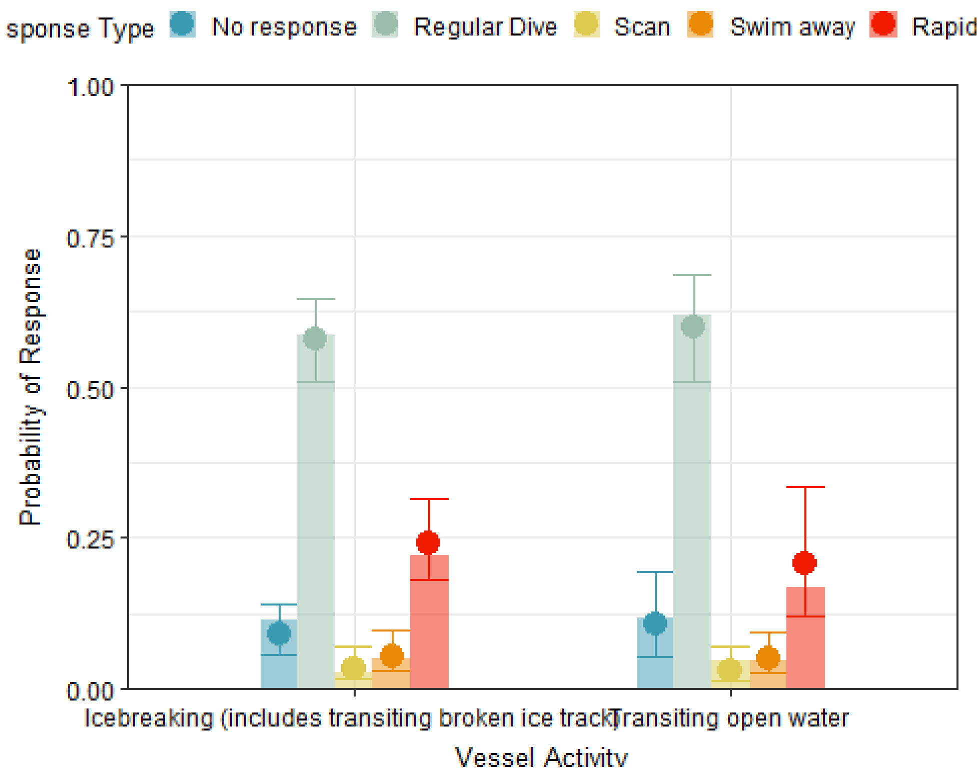
```r
obs <- obs %>%
    full_join(full)

## Joining with `by = join_by(name, dist_bin)`

obs$value[is.na(obs$value)] <- 0

str(obs)

## tibble [20 × 6] (S3: tbl_df/tbl/data.frame)
##  $ name    : Factor w/ 6 levels "No response",..: 1 1 1 1 2 2 2 2 3 3 ...
##  $ dist_bin: Factor w/ 4 levels "(0,500]","(500,1000]",..: 1 2 3 4 1 2 3 4
1 2 ...
##  $ N       : int [1:20] 15 8 1 1 98 21 7 3 6 1 ...
##  $ N.Total : int [1:20] 167 35 11 5 167 35 11 5 167 35 ...
##  $ value   : num [1:20] 0.0898 0.2286 0.0909 0.2 0.5868 ...
##  $ DataType: chr [1:20] "Observed" "Observed" "Observed" "Observed" ...

p3 <- ggplot()+
    geom_bar(data=obs,aes(x=dist_bin,y=value,fill=name), width=0.5,
        stat="identity",position=position_dodge(width=0.5),alpha=0.5)+
    geom_point(data = plotdat, aes(x=dist_bin,y=value,colour=name),
        position=position_dodge(width=0.5),size=3)+
    geom_errorbar(data=plotdat,
aes(x=dist_bin,ymin=LCL,ymax=UCL,colour=name),
        position=position_dodge(width=0.5),width=0.5)+
    labs(colour="Response Type",fill="Response Type")+
    xlab("Distance from vessel (m)")+
    ylab("Probability of response")+
    scale_y_continuous(expand=c(0,0))+
    coord_cartesian(ylim=c(0,1))+
    theme_all+wes5+wes5col+
    theme(legend.position="top")
    #
p3
```



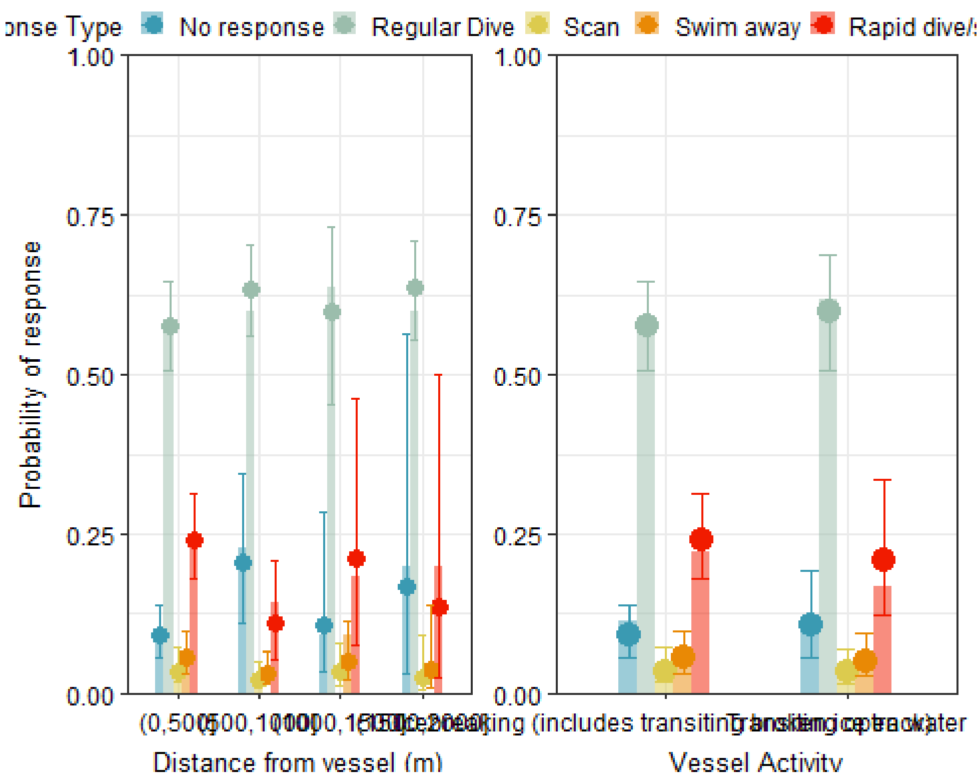

```
ggsave("Water - Probability by distance.png", width = 6.9, height = 4.5,
units = "in")

### Plot of effect of vessel activity (with distance held at 0-500m)
newdata <- expand.grid(va_vessel_activity =
unique(Ringed_Sightings_water$va_vessel_activity),
                dist_bin = unique(Ringed_Sightings_water$dist_bin)[1])

preds <- predict(modelw,newdata=newdata,type="prob")$fit
names(preds) <- ""

preds <- newdata %>%
    bind_cols(preds)

lwr <- predict(modelw,newdata=newdata,type="prob",interval = TRUE, level =
0.95)$lwr
upr <- predict(modelw,newdata=newdata,type="prob",interval = TRUE, level =
0.95)$upr

lwr <- lwr %>%
    as.tibble() %>%
    bind_cols(newdata) %>%
    pivot_longer(cols="No response":"Rapid dive/splash")%>%
    dplyr::rename(LCL = value)
```

```r
upr <- upr %>%
    as.tibble() %>%
    bind_cols(newdata) %>%
    pivot_longer(cols="No response":"Rapid dive/splash")%>%
    dplyr::rename(UCL = value)

plotdat <- preds %>%
    pivot_longer(cols="No response":"Rapid dive/splash") %>%
    left_join(lwr)%>%
    left_join(upr)

## Joining with `by = join_by(va_vessel_activity, dist_bin, name)`
## Joining with `by = join_by(va_vessel_activity, dist_bin, name)`

obs <- Ringed_Sightings_water %>%
    group_by(mmo_bh_res_icebreak_water,va_vessel_activity) %>%
    dplyr::summarize(N=n()) %>%
    ungroup()

## `summarise()` has grouped output by 'mmo_bh_res_icebreak_water'. You can
## override using the `.groups` argument.

obs.total <- Ringed_Sightings_water %>%
    group_by(va_vessel_activity) %>%
    dplyr::summarize(N.Total=n()) %>%
    ungroup()

obs <- obs %>%
    left_join(obs.total) %>%
    mutate(Prob = N / N.Total,
         DataType = "Observed") %>%
    dplyr::rename(value = Prob,
                name = mmo_bh_res_icebreak_water)

## Joining with `by = join_by(va_vessel_activity)`

plotdat$name <- factor(plotdat$name,
    levels=c("No response","Regular Dive", "Scan", "Swim away","Rapid
dive/splash"))

full <- expand.grid(name =
unique(Ringed_Sightings_water$mmo_bh_res_icebreak_water),
        va_vessel_activity =
unique(Ringed_Sightings_water$va_vessel_activity))

obs <- obs %>%
    full_join(full)

## Joining with `by = join_by(name, va_vessel_activity)`
```

```r
obs$value[is.na(obs$value)] <- 0

str(obs)

## tibble [10 × 6] (S3: tbl_df/tbl/data.frame)
##  $ name              : Factor w/ 6 levels "No response",..: 1 1 2 2 3 3 4
4 5 5
##  $ va_vessel_activity: chr [1:10] "Icebreaking (includes transiting broken
ice track)" "Transiting open water" "Icebreaking (includes transiting broken
ice track)" "Transiting open water" ...
##  $ N                 : int [1:10] 20 5 103 26 5 2 9 2 39 7
##  $ N.Total           : int [1:10] 176 42 176 42 176 42 176 42 176 42
##  $ value             : num [1:10] 0.1136 0.119 0.5852 0.619 0.0284 ...
##  $ DataType          : chr [1:10] "Observed" "Observed" "Observed"
"Observed" ...

p4 <- ggplot()+
    geom_bar(data=obs,aes(x=va_vessel_activity,y=value,fill=name), width=0.5,
        stat="identity",position=position_dodge(width=0.5),alpha=0.5)+
    geom_point(data = plotdat, aes(x=va_vessel_activity,y=value,colour=name),
        position=position_dodge(width=0.5),size=4)+
    geom_errorbar(data=plotdat,
aes(x=va_vessel_activity,ymin=LCL,ymax=UCL,colour=name),
        position=position_dodge(width=0.5),width=0.5)+wes5+wes5col+
    xlab("Vessel Activity")+
    ylab("Probability of Response")+
  labs(fill = "Response Type", colour = "Response Type")+
    scale_y_continuous(expand=c(0,0))+
    coord_cartesian(ylim=c(0,1))+
    theme_all+
    theme(legend.position="top")
    #
p4
```




```
ggsave("Water - Probability by vessel activity.png", width = 5.5, height =
3.5, units = "in")



###combine into single plot

p_3_4<-ggarrange(p3,p4+rremove("ylab"), nrow= 1, ncol=2, common.legend =
TRUE)
p_3_4
```




```
ggsave("Water - Probability Combined.png", width = 4000, height = 2000, units
= "px")



################################################################################
```

wsp.com