APPENDIX 4
ASSESSMENT OF ICE BREAKING – SUBMITTED FOR PRODUCTION INCREASE PROPOSAL EXTENSION, MARCH 2021

March 5, 2021

MEMO

Response to Board Recommendation No. 5

In this recommendation, NIRB has requested Baffinland provide an assessment of the ongoing ice-management activities using the icebreaker (MSV Botnica), specifically in relation to the potential effects of these activities on noise levels on marine mammals and their activities along the Northern Shipping Route.

Firstly, Baffinland wished to note that shipping in support of the current Project is consistent with the nominal dates approved under the Early Revenue Phase (ERP). As described in Section 5.3.6 of the Supporting Information Package submitted by Baffinland for the 2020 Production Increase Proposal Extension Request ('Extension Request'), Baffinland has conducted an extensive environmental assessment for the Phase 2 Proposal ('Proposal'). While the Extension Request does not contain a dedicated Assessment of Icebreaking Operations, it does make reference to the one provided in relation to Phase 2, which has been publicly available since May 17, 2019 (Public Registry ID No. 325033-325047).

1.1 CURRENTLY ACTIVITY DESCRIPTION

Shipping currently occurs between approximately July 15 and October 15 each year, as approved under the original ERP Proposal. Under the currently approved Production Increase Proposal Extension to December 31, 2021 Baffinland is allowed to ship up to 6 Mtpa via 84 ore carriers during the shipping season. Shipping at the beginning and end of the shipping season requires ore carriers to be escorted by an icebreaking when ice concentrations and thickness warrant it. In the Spring transits that require icebreaker escorts are subject to transit restrictions for the purposes of limiting underwater noise and potential disturbance to marine mammals, including narwhal.

Icebreaking undertaken along the Northern Shipping Route is a limited Project activity that is only required at the beginning and end of the shipping season (referred to as the shoulder seasons). During these respective shoulder seasons, ice concentrations along the Northern Shipping Route are known to be variable on both a temporal and spatial scale. Consequently, icebreaking does not occur continuously along the entire Northern Shipping Route during these periods but rather at intermittent points during a given transit when thicker ice conditions are otherwise unavoidable by Project vessels. Based on annual ice conditions in the Regional Study Area (RSA), the level of icebreaking (e.g., duration, frequency, extent) will likely vary from year to year, and is likely to change over the lifetime of the Project given anticipated effects of climate change on annual sea ice extent.

1.1.1 Proposed Icebreaking Activities Associated with the Proposal

The following assumptions and scenarios were made and evaluated in the Golder (2019) Phase 2 Assessment of icebreaking operations during shipping shoulder seasons on marine biophysical Valued Ecosystem Components ('Icebreaking Assessment'):

1. Two icebreakers would be escorting vessels along the Northern Shipping Route, with each icebreaker escorting between one to four Project vessels (i.e. tug vessels, ore carriers, freight vessels or fuel tankers).
2. Two icebreakers with vessels in escort may cross paths at some point along the Northern Shipping Route
3. Two icebreakers would travel in tandem with one another to escort larger Capesize vessels.
4. Shipping would occur between July 01 and November 15 of each year, subject to ice conditions
5. If a remnant track from a previous transit was available, the icebreaker would follow the same path to minimize ice interactions
6. Icebreakers will maintain sustained speeds of 9 knots, unless prevailing safety conditions require a need to deviate from this speed restriction
7. Landfast ice must be naturally broken along the entire Northern Shipping Route before the start of the shipping season begins, including icebreaking operations.

As is highlighted in points number 1 to 3 above, and as was outlined in Section 5.3.1 of the Extension Request, icebreaking activities associated with the current operations are smaller in scope than what was assessed for the Proposal (Table 1). Subsequently, it was noted in the Production Increase Proposal Extension Request Application ('PIP Application') that the Icebreaking Assessment is overly conservative and provides a reasonable level of certainty that no significant adverse effects are predicted to occur as a result of icebreaking activities associated with current operations.

Table 1: Comparison of Approved Project to Scope Assessed for Phase 2

Description	Approved Project	Phase 2
Season Length	July 1 – November 15	July 15 – October 15~
Shipping Route	Baffin Bay-Eclipse Bay-Milne Inlet	Baffin Bay-Eclipse Bay-Milne Inlet
# of Vessels/# of Transits	84/168	176/352
# of Icebreaker	1	2
Speed Limits	9 knots	9 knots

1.1.2 Scope of Memo

It is noted that the icebreaking assessment for Phase 2 included an assessment of all potential effects of icebreaking on marine mammals (hearing impairment, acoustic disturbance, acoustic masking, ice entrapment and ship strikes) using multiple indicator species occurring in the RSA (bowhead whale, beluga, narwhal, Atlantic walrus, ringed seal, polar bear). For the purposes of addressing Board Recommendation No. 5, this memo is focused on summarizing the effects of icebreaking on local sea ice conditions, and the effects of icebreaking noise on the key marine mammal indicator species in the RSA; narwhal and ringed seal. For additional details, please refer to the PIP Application, the Icebreaking Assessment and additional documentation referenced below.

1.2 SEA ICE BREAK-UP AND FREEZE-UP DECAY AND FORMATION

At the start of the shipping season, icebreaking after landfast ice has naturally fractured could have an effect of slightly speeding up the transition process from heavy sea ice concentrations to open-water conditions, and therefore may slightly advance the date when open-water conditions prevail.

At the end of the shipping season, icebreaking could act to delay sea ice formation and produce relatively rough ice surfaces within the localized area affected by the icebreaker passage. The delay in freeze-up would be on the order of hours to days, depending on local air temperatures and wind/wave conditions. Any localized disruption in the timing of ice freeze-up would be restricted to a narrow swath along the ship track (assuming ice conditions are thick enough to result in the creation of a track). The effects would therefore be minimal in the context of the naturally occurring variability in the timing of formation and in the spatial context of landfast ice development. For additional information regarding historical break up and freeze up and impacts of icebreaking on ice, see Appendix 1.

During both shoulder seasons, if the ice is thick enough, icebreaking will spatially disturb contiguous ice cover by temporarily creating an open-water channel for the passage of Project ore carriers. It has been assumed that the beam width of an icebreaker and ore carrier is 24 m and 56 m, respectively. A conservative estimate of the total width of an icebreaker transit corridor (with escorted vessels) is 200 m. The Northern Shipping Route is 264 km long form Milne Port to the outer RSA boundary. This would result in a total sea ice area of 52.8 km2 that would be affected by icebreaking, which is equivalent to approximately 0.33% of available marine / sea ice habitat in the RSA. It is noted however, that this represents a worst-case scenario where ice conditions are concentrated such that the icebreaker creates a channel through ice along the entire length of the shipping corridor in the RSA, rather than travelling through ice that is already broken up and no longer contiguous in nature (as is normally the case during the shoulder seasons).

Overall, icebreaking activities are not expected to result in significant adverse effects on sea ice as Project icebreaking is strictly limited to the shoulder season and not during periods of landfast cover. Considering the overall speed over which the sea ice break-up and freeze-up process occurs naturally and the limited ice corridor that would be impacted by icebreaking activities during the shoulder seasons, the potential effects of icebreaking on local sea ice conditions are predicted to be negligible (unlikely to result in any significant changes in the timing of ice break-up and/or freeze-up).

1.2.1 Uncertainty

The linkages through which icebreaking can affect sea ice are well understood, and Project activities that may affect sea ice have been considered where appropriate. Prediction confidence for adverse effects on marine mammal ice habitats as a result of icebreaking is considered moderate to high as the extent of the habitat loss/fragmentation is well known and easy to measure. However, the historical record of repeated icebreaker escort activities along the Northern Shipping Route and in Milne Port is limited. Nevertheless, shipping through ice infested waters has been ongoing in the Canadian Arctic for many years, and experience gained from those operations has contributed to the effects assessment presented here.

1.3 UNDERWATER NOISE IMPACTS ON MARINE MAMMALS

1.3.1 Acoustic Assessment Overview

The assessment of potential underwater noise effects on marine mammals from icebreaking activities carried out in support of the Proposal included the following:

- a summary of marine mammal baseline conditions in the RSA during ice break-up and freeze-up periods;
- a review of the hearing abilities of the species under consideration;
- issues scoping (identification of key issues related to underwater noise and marine mammals for carry forward in the assessment);
- identification of underwater noise impact criteria for marine mammals (i.e., existing marine mammal acoustic thresholds for injury and behavioural disturbance);
- underwater noise modelling of icebreaking operations using different exposure scenarios for predicting the spatial and temporal extents of Project-generated underwater noise (i.e. zone of influence) relative to existing acoustic threshold criteria;
- a review of underwater noise monitoring results including sound level measurements of the MSV Botnica as it transited over two underwater recording stations in Eclipse Sound (under various ice escort configurations) during the 2019 early shoulder season, including a comparison to modelling results;
- a detailed evaluation of icebreaking impacts on marine mammals (including a summary of known effects of icebreaker noise on narwhal and ringed seal);
- identification of Project mitigation measures to avoid and/or minimize adverse effects of noise on marine mammals in the RSA;
- identification of residual effects (i.e., those effects remaining following effective application of mitigation), including a summary of:
    - the proportion of time icebreaking sound levels measured at two recording stations in Eclipse Sound exceeded the 120 dB disturbance onset threshold;

- the estimated range (R95%) of the 120 dB sound field radiating from the icebreaker based on both modelling results;
- an estimate of the daily disturbance exposure period marine mammals occurring along the shipping route would experience following exposure to icebreaking activities during the shoulder season (based on both modelling and monitoring data);
- an estimate on the total number of animals potentially exposed to icebreaker noise capable of resulting in injury or behavioural disturbance (per vessel transit);
- a review of narwhal movement data in the presence of icebreaking activities during the 2018 fall shoulder season based on animal-borne satellite tagging data;

- a determination of significance for each Project residual effect (by indicator species).

1.3.2 Mitigation Measures

In Section 5.3.4 of the PIP Application approved by NIRB, Baffinland provided a high-level summary of all relevant mitigations committed to by Baffinland to minimize effects on marine mammals. This list included those relevant to icebreaking activities associated with the current Project and are as follows:

- Defined shipping lane throughout RSA.
- Maintain constant speed and course when possible.
- No breaking of landfast ice.
- Between the period of 01 July and 30 July, a maximum of one icebreaker transit (with escorted vessels) will occur per 24-hour period where ice concentrations of 6/10 or greater cannot be avoided along the shipping route.
- Between the period of 01 July and 30 July, a maximum of two icebreaker transits (with escorted vessels) will occur per 24-hour period where ice concentrations of 3/10 or greater cannot be avoided along the shipping route.
- All Project vessels will reduce speeds to a voluntary maximum of 9 knots when travelling within the RSA.
- Establishment of a 40-km buffer zone (set-back area) at the floe-edge (extending from the Nunavut Settlement Boundary).
- All ice breaking activities will be conducted outside of the period of ringed seal denning, pupping, nursing and breeding periods.
- When marine mammals appear to be trapped or disturbed by Project vessel movements, the vessel will implement appropriate measures to mitigate disturbance, including stoppage of movement until wildlife move away from the immediate area (as safe navigation allows).

- All Project vessels will be provided with standard instructions to not approach within 300 m of a walrus or polar bear observed on sea ice.
- All Project vessels will be provided with standard instructions to operate their vessel in a manner that avoids separating an individual member(s) of a group of marine mammals from other members of the group.
- Baffinland will place Marine Wildlife Observers (via the SBO program) on ice breaking vessels during the shoulder season that will be responsible for recording relative abundance, group composition and behavior of marine mammals, and if relevant any incidences of marine mammal strike of near misses with Project vessels.
- Posting of ice analyst on board icebreaking vessels.
- Project aircrafts (helicopter and airplanes) will maintain an altitude of 450m over marine waters when possible.
- Establishment of restricted “no-go” zones to avoid key sensitive areas (Koluktoo Bay, Tremblay Sound, Bruce Head shoreline).
- No drifting in Eclipse Sound.
- Maximum of 3 vessels anchored at Ragged Island.
- Limiting vessel idling.

It is important to note that several of these mitigation measures have been implemented on a voluntary basis by Baffinland and exceed any applicable regulatory requirements in Canada. This suite of measures represents a more conservative practice of vessel traffic management than is demonstrated by any other industrial/commercial shipping operator or government vessel in the RSA (i.e., Canadian Coast Guard, Fisheries and Oceans Canada). Additionally, since receiving approval from the NIRB on the Extension Request, Baffinland has worked with DFO to update Baffinland’s commitments on the transit restrictions mitigations, which will apply beginning in summer 2021. The commitments are as follows:

1. Apply spring transit restriction mitigations as long as ice concentrations, as defined by the Canadian Ice Service, of greater than 3/10 persist along the Northern Shipping Route, or meet the obligations of applicable commitments to others if more conservative, to determine the earliest date for commencing the shipping season. Initiation of this commitment will begin in 2021.
2. Beginning in 2021, apply the following transit restriction mitigations in the fall:
    - When a continuous sailing route of open water and/or new ice (<10 cm) occurs between the entrance of Pond Inlet and Milne Port, then icebreaker transits and other unescorted vessels in the RSA may proceed under open-water operating conditions.
    - A maximum of two transits or four half transits will occur per day (24-h period) where grey ice (10-15 cm) cannot be avoided along the shipping route.

- No breaking of landfast ice along the shipping route.

A supplementary table on Project mitigations and monitoring was also provided in response to FWS Comments from DFO on the Extension Request (Appendix 2). This table outlined how, for each potential effect associated with the shipping operations for the Project, a mitigation to minimize or eliminate the effect has been applied by Baffinland and also described associated monitoring results that support conclusions about the efficacy of those mitigations to the time of submission.

1.3.3 Assessment Results for Narwhal

1.3.3.1 Acoustic Injury

Acoustic propagation modelling results indicated that underwater noise generated by icebreaking activities during the shoulder seasons would not exceed the established threshold for auditory injury in narwhal under any of the modelling scenarios considered in the Icebreaking Assessment (Golder 2019). The risk of acoustic injury (i.e., hearing impairment) in narwhal from icebreaking noise was therefore predicted to be negligible.

The model predictions were verified by measurements collected in the field during the 2019 shoulder season. All sound level measurements of icebreaker activities undertaken along the Northern Shipping Route in 2019 were below the threshold for auditory injury for narwhal (Frouin-Mouy et al. 2020).

3.3.3.2 Potential Acoustic Disturbance:

Based on best available science regarding underwater noise impacts on marine mammals, the assessment assumed that narwhal exposed to non-impulsive sound from icebreaking activities may exhibit a disturbance response where sound levels exceeded 120 dB re 1 µPa (SPL rms) (NOAA 2013).

Acoustic Modelling Results

For each icebreaker transit scenario considered in the acoustic model, the maximum distance to the 120 dB disturbance onset threshold was calculated. 'Disturbance onset' is considered to represent the threshold at which narwhal may begin to demonstrate behavioural responses ranging from subtle changes in swim speed and direction to minor and localized avoidance of a sound source.

Based on modelling results (Golder 2019), the range (R95%) associated with disturbance onset in narwhal was predicted to extend up to 44.3 km from the source in 10/10 ice, 42.5 km in 3/10 ice, and 26.3 km in open-water (0/10 ice) based on a maximum-case icebreaker transit scenario (two icebreakers escorting two capesize ore carriers in Eclipse Sound) (Table 1). For this scenario, a stationary narwhal positioned along the shipping corridor would have the potential to be in the 120 dB disturbance zone for a period of up to 10.4 h (for transits at 9 knots in 0/10 ice), 5.1 h (for transits at 9 knots in 3/10 ice), and 3.2 h (for transits at 4.6 knots in 10/10 ice) per icebreaker transit (Table 2).

Table 2: Modelled distance to the 120 dB disturbance onset threshold for narwhal and total exposure period >120 dB re 1 uPa per icebreaker transit for three different icebreaker escort scenarios (based on Phase 2 Proposal) in various ice conditions along the Northern Shipping Route

Icebreaker Transit Scenario	Vessel speed (knots)	Ice concentration	Range (R95%) to 120 dB disturbance threshold* (km)	Total exposure period >120 dB per icebreaker transit
2 icebreakers + 2 capesize carriers	4.6	10/10	44.3	10.4 h
	9	3/10	42.5	5.1 h
	9	0/10 (open)	26.3	3.2 h
1 icebreaker + 2 capesize carriers	4.6	10/10	40.3	9.5 h
	9	3/10	37.3	4.5 h
	9	0/10 (open)	25.9	3.1 h
1 icebreaker + 1 capesize carrier	4.6	10/10	40.4	9.5 h
	9	3/10	34.9	4.2 h
	9	0/10 (open)	18.6	2.2 h

*Acoustic threshold for onset of disturbance in narwhal (onset of behavioural responses that can range from subtle changes in swim speed and direction to minor and localized avoidance of a sound source) (NOAA 2013).

Acoustic Monitoring Results

Underwater sound levels measured at two recording stations in Eclipse Sound during the 2019 early shoulder season were analyzed to determine the amount of time that sound levels exceeded the narwhal disturbance threshold of 120 dB re 1 µPa (Table 2; full summary in Frouin-Mouy et al. 2020). The one-minute averaged sound pressure level (SPL) was shown to rarely exceeded the 120 dB re 1 µPa threshold at either station, with exceedances observed for 1.9% of the total recording duration (28 days) at Ragged Island (AMAR–RI) and 1.4% of the total recording duration (28 days) at Bylot Island (AMAR–BI). On average, received sound levels at these stations exceeded the disturbance threshold of 120 dB re 1 µPa for less than one hour per day (Table 3).

Table 3: Average and maximum daily exposure durations for disturbance (120 dB re 1 µPa) for each recorder during the 2019 early shoulder

Acoustic Recorder		Average time per day with SPL > 120 dB (hours [minutes])	Maximum time per day with SPL > 120 dB (hours [minutes])
AMAR-BI (Bylot Island)	All recorded data	0.2 [12.6]	8.6 [516]
	Only data with vessels detected	0.2 [12.6]	8.6 [516]
AMAR-RI (Ragged Island)	All recorded data	1.3 [77.3]	10.6 [637]
	Only data with vessels detected	0.7 [44.1]	7.1 [427]

Predicted (i.e., modelled) values were compared to actual recorded icebreaking noise levels (as measured in the field) to assess accuracy of the model predictions including estimates of daily noise exposure > 120 dB. This was based on underwater sound levels of five separate icebreakers transiting in open-water over the Bylot Island recorder between 07 July and 04 August 2019. Results are presented in Table 4, including the total time per transit that underwater noise levels exceeded the 120 dB disturbance threshold. These measured values at Bylot Island were compared to the modelled value for the same icebreaker transit configuration (icebreaker + two capesize carriers in 0/10 ice) (highlighted in grey in Table 5). Results demonstrated that the measured noise fields associated with disturbance onset were less than half those predicted by modelling (Table 5) even when considering the loudest of the five icebreaker transits analyzed. For example, based on acoustic modelling, it was predicted that a narwhal exposed to an icebreaker accompanied by two ore carriers transiting in 0/10 ice would be subject to noise levels exceeding the disturbance threshold (≥120 dB) for a period lasting up to 3.1 h per transit. However, measured values at Bylot Island ultimately only exceeded 120 dB re 1 µPa for a maximum period of 0.5 to 1.3 h per transit (>58% lower than predicted). These results demonstrate that the acoustic modelling results are conservative and over-represent actual noise fields produced by icebreakers in the receiving environment. A summary of these results was presented in a technical memorandum filed with the Board in 2020 (Golder 2020; Public Registry ID No. 331438; Appendix 3).

For each icebreaker transit scenario, the calculated '120 dB vessel disturbance period' was multiplied by the number of anticipated icebreaker transits per day (based on existing transit restrictions during the shoulder season) to determine the total time in a day that noise levels would exceed the 120 dB disturbance threshold, known as the 'daily 120 dB disturbance period' (Table 5). Based on modeling data, the daily 120 dB disturbance period for narwhal ranged from 9.5 h in 10/10 ice conditions (restricted to one daily transit only) to 12.4 h in 0/10 ice conditions (assuming a maximum of 4 icebreaker transits per day would be possible in the shoulder season). These values correspond to transits of 1 icebreaker and 2 Capesize ore carriers. Based on measured data (which was only available for icebreaking transits in 0/10 ice conditions), the daily 120 dB disturbance period would be 5.2 h (based on 4 transits per day of 1 icebreaker and 2 Capesize ore carriers), equivalent to 18.8 h of 'quiet' time.

Table 4: Exposure Period ≥ 120 dB for Icebreaker Transits over Bylot Island station AMAR-BI in July 2019

Transit #	Date	Scenario	Speed (kn)	Horizontal Range to AMAR (m)	Course Heading	Time (min) > 120 dB per transit	Time (h) > 120 dB per transit
1	18-July-2019	Botnica with 2 carriers + tug	8.7	<70	250.4	75	1.3
2	19-July-2019	Botnica with no escorts (solo)	8.3	<120	71.3	33	0.5
3	20-July-2019	Botnica with 2 carriers	8.4	<64	250	43	0.7
4	22-July-2019	Botnica with 3 carriers	8.0	<43	250.6	69	1.2
5	23-July-2019	Botnica with 2 carriers	8.2	<82	65.4	37	0.6

Table 5: Comparison of modelled vs. measured daily disturbance exposure periods for icebreaker transits

Scenario	Speed	Ice Cover	Noise field – R95% range (km)	120 dB exposure period (h) per transit	# of transits per Day	120 dB daily exposure period (h)	"Quiet time" per day (h)**
1 icebreaker + 2 capesize carriers – MODELLED	4.6 knots	10/10	40.3	9.5	1	9.5	14.5
	9 knots	3/10	37.3	4.5	2	9	15
	9 knots	0/10	25.9	3.1	4	12.4	11.6
1 icebreaker + 2 capesize carriers - MEASURED (Bylot)	9 knots	0/10	N/A	1.3*	4	5.2	18.8

* 1.3 used as most conservative value as it is associated with the highest sound levels and largest noise field of the five transit scenarios.
** "quiet time" is defined as time in which marine mammals would not be exposed to ship noise above the 120 dB disturbance threshold

Based on a maximum-case icebreaker transit scenario (2 icebreakers escorting 2 capesize carriers), using corrected narwhal density estimates available for July/August and October/November (Baffinland 2012; Elliott et al 2015; Thomas et al. 2015), the estimated number of narwhal predicted to occur in the modelled disturbance zone is:

- 4,722 individuals during the Heavy Ice Regime (early summer);
- 4,702 individuals during the Moderate Ice Regime (early summer);

- 4,534 individuals during the Light Ice Regime (early summer);
- 3,745 individuals during the Heavy Ice Regime (fall); and
- 3,560 individuals during the Moderate Ice Regime (fall).

Based on a typical-case icebreaker transit scenario (1 icebreaker escorting 2 capesize carriers), using corrected narwhal density estimates identified above, the estimated number of narwhal predicted to occur in the modelled disturbance zone is:

- 4,717 individuals during the Heavy Ice Regime (early summer);
- 4,688 individuals during the Moderate Ice Regime (early summer);
- 4,510 individuals during the Light Ice Regime (early summer);
- 3,731 individuals during the Heavy Ice Regime (fall); and
- 3,536 individuals during the Moderate Ice Regime (fall).

In summary, up to 4,700 narwhal in Milne Inlet and Eclipse Sound may be temporarily exposed to sound levels capable of resulting in disturbance behaviour per icebreaker transit. This represents approximately 23% of the Eclipse Sound summer stock (estimated at 20,211 individuals based on NAMMCO 2010) and approximately 3% of the Baffin Bay population (estimated at 141,909 individuals based on Doniol-Valcroze et al. 2015). Temporary exposure in this case has been defined using existing acoustic monitoring data, with a total exposure period per icebreaker transit ranging from 30 min to 1.3 h (Table 4). This effect would be further mitigated through a daily limit on icebreaker transits in the RSA during the shoulder season when ice conditions exceed 3/10 concentration, as outlined in Section 3.2.2.

It is important to note that the estimates provided above for 'total daily disturbance exposure period' and 'total number of animals exposed to >120 dB per transit' are considered highly conservative with respect to assessing disturbance effects in narwhal. This is because they are based on disturbance range estimates derived from acoustic modelling (which are demonstrated to overestimate the extent of the noise fields) and they assume that all narwhal in the RSA are non-motile and occur exclusively on the shipping corridor.

Additionally, it is important to clarify that the 120 dB threshold does not account for the frequency of the ship noise source relative to narwhal hearing sensitivity. Shipping noise generally dominates ambient noise at low frequencies, with most energy occurring between 20 to 300 Hz and some components extending into the 1 to 5 kHz range (Richardson et al. 1995). Narwhal are considered high-frequency cetaceans (Southall et al. 2019) (previously recognized as mid-frequency cetaceans; NMFS 2018) with their most sensitive hearing occurring in the 20 to 100 kHz range (Richardson et al. 1995). Narwhal vocalization studies indicate that this species primarily vocalizes in the 300 Hz to 24 kHz range (Ford and Fisher 1978; Marcoux et al. 2011; Marcoux et al. 2012). Ship noise is therefore unlikely to result in major disturbance effects in narwhal given it is primarily emitted in the frequency band in which both species have lower hearing sensitivity (see Figure 1 and 2 below).

Observed Behavioural Responses to Icebreaking Activities in RSA

In August 2018, two narwhal (NW21 and NW22) were live captured in the RSA, instrumented with satellite telemetry tags and high-resolution dive tags, and released back to the ocean for the purpose of monitoring their daily movements in relation to fluctuating ice conditions in the RSA and in response to icebreaking operations and ship traffic along the Northern Shipping Route during the shipping season. Results from this study are available in a document filed with the NIRB (Golder 2019b, Appendix 4), with a brief summary provided below to provide context related to the present discussion of potential disturbance effects on narwhal from icebreaking activities.

Both NW21 and NW22 were shown to remain in the vicinity of the Northern Shipping Route for extended periods during the2018 fall shoulder season, despite being exposed to thickening ice conditions and regular icebreaking activities during the late shoulder season. Although the location data associated with NW21 were not of sufficient resolution to assess fine scale movements of this animal in relation to icebreaker movements, it was evident from the daily narwhal tracks that exposure to icebreaker and ship traffic during this time did not result in any large scale displacement of either narwhal from the RSA. In general, NW22 had multiple close encounters with the icebreaker and all vessel types throughout the fall shoulder season and did not appear to actively avoid icebreaking operations and associated vessel traffic as the season progressed. Of the total narwhal-vessel interaction events recorded for NW22 in 2019, 25 of these events occurred in relation to icebreaking transits undertaken by the MSV Botnica and one event occurred in relation to icebreaking transits by the CCGS Terry Fox. The distance between NW22 and an icebreaker during active transits (CPA < 54.4 km) ranged between 0.84 km and 52.97 km. Throughout the 19-day study period, NW22 remained within the modelled '120 dB disturbance' zone of the icebreaker (54.4 km) for 47.4% of the time.

NW22 interacted more closely with the MSV Botnica (with vessels in escort) toward the latter part of the late shoulder season (see Figure 13 in Golder 2019b). This finding may indicate possible habituation of the animal to icebreaking operations. It may also indicate that both the icebreaking vessel and animal were utilizing the path of least resistance (i.e., area with the least ice present) as the ice becomes increasingly dense later in the fall shoulder season. It is also possible that increasing ice concentration restricts movements by the animal, causing it to rely more heavily on the path created by icebreaking operations.

NW22 made regular crossings across the bow and the stern of all vessel types during the 2018 fall shoulder season (see Figure 14 in Golder 2019b). However, NW22 did not cross behind the stern of the Botnica (with vessels in escort) for a period of 4.5 hours following an active transit. As sound generated from vessels is known to radiate asymmetrically, with sound levels from the stern aspect typically being highest (Arveson and Vendittis 2000; McKenna et al. 2012), this finding may signify the animal's attempt to avoid the noisiest aspect of the vessel. However, the gap may also be due to data scarcity during the 2018 fall shoulder season (limited to one tagged animal). In addition, given the characteristics of sound that are generated from icebreaking operations and the way in which sound propagates under ice, the interpretation of the 4.5 h gap of crossing behind the stern of the vessel is not straightforward. It is also important to note that this result is based on a very limited dataset (a single animal over the course of

19 days), and further data collection and analysis is required to further evaluate this potential avoidance response. Continued acoustic monitoring of Project-related icebreaking operations is therefore warranted to assess the sound levels radiated from the stern of individual vessels, including icebreakers. This work is presently underwater as part of JASCO's 2020 icebreaking noise monitoring program with a summary draft report anticipated to be submitted to the Marine Environmental Working Group (MEWG) in Q2 2021.

Acoustic Masking

Icebreaking operations are anticipated to result in some degree of acoustic masking in narwhal; however, there currently are no established regulatory thresholds for masking to indicate at what level of masking may occur in marine mammals or what level of masking may result in biological consequences. In general, the science on the effects of masking is relatively young. Given this limitation, in order to better understand potential masking effects, JASCO analyzed the 2018-2019 acoustic monitoring data to estimate the level of listening range reduction (LRR) that would occur for narwhal due to icebreaker/shipping noise during the shoulder season relative to ambient conditions. Results from this work demonstrated that sound levels capable of masking would be intermittent and temporary in nature, and that narwhal are already exposed to similar levels of masking from natural sounds like wind and waves. This suggests they narwhal likely have some form of existing strategy for undertaking their normal day to day functions within an intermittently noisy environment.

There are several examples in the scientific literature where marine mammals have demonstrated an ability to modify their vocal behaviour to overcome competing sound sources in their environment (Au et al. 1985; Lesage et al. 1999); although this has not yet been studied in narwhal. As an example, beluga whales, a close relative of the narwhal, are known to be able to modify their calling frequency in the presence of shipping to avoid masking effects; by up-shifting their calls to frequencies that do not overlap with the shipping noise. The vocal repertoire of narwhal includes five different types of calls. Four of these call types have minimal frequency overlap with ship noise, including those associated with echolocation (i.e., biosonar) that is used for foraging and navigation. The fifth call type (whistles), which is associated with a social function, can occur at frequencies below 1 kHz which can overlap in frequency with ship noise, but generally occurs at frequencies of several kilohertz where there is little vessel noise overlap. For visual context, the degree of overlap between narwhal vocalizations and communication range relative to shipping noise is presented in Figure 1 and Figure 2.

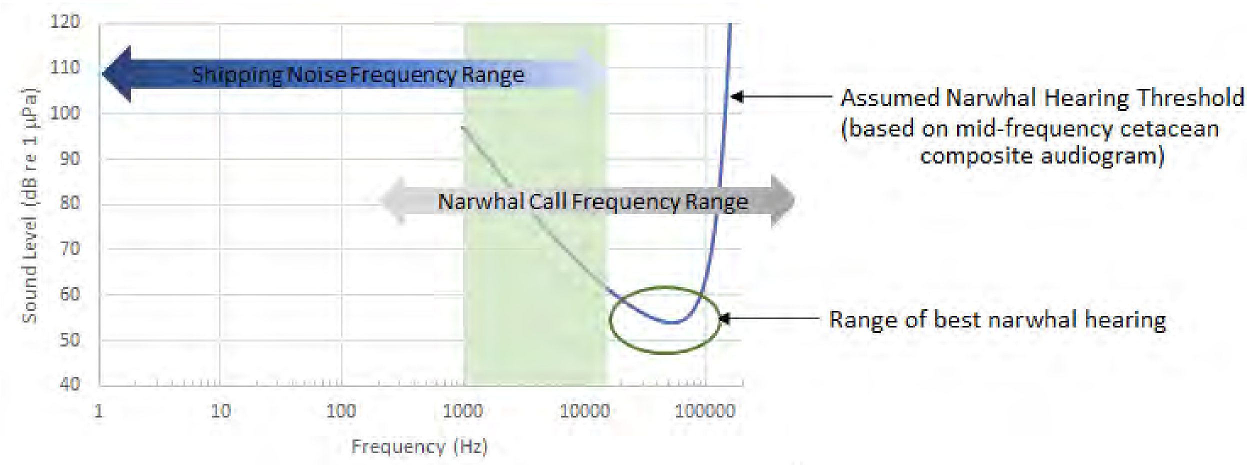

Figure 1: Shipping Noise in Comparison to Narwhal Communication Range

Notes: Blue arrow depicts frequencies where vessel noise occurs. Ship noise is louder at low frequencies (left of plot) shown in darker blue shading and quieter at higher frequencies (right of plot) shown in lighter blue shading.
Grey arrow depicts frequencies where narwhals vocalize; the lowest frequencies are used less often (shown in lighter grey) and the higher frequencies are used more often (shown in darker grey).
The area shaded in green represents the area of frequency overlap area between vessel noise and the narwhal hearing ability.
The blue curve shows the hearing threshold for mid-frequency cetaceans including narwhal. Their most sensitive hearing in the frequency range is circled in green, which is fully outside of the range where there is vessel noise.

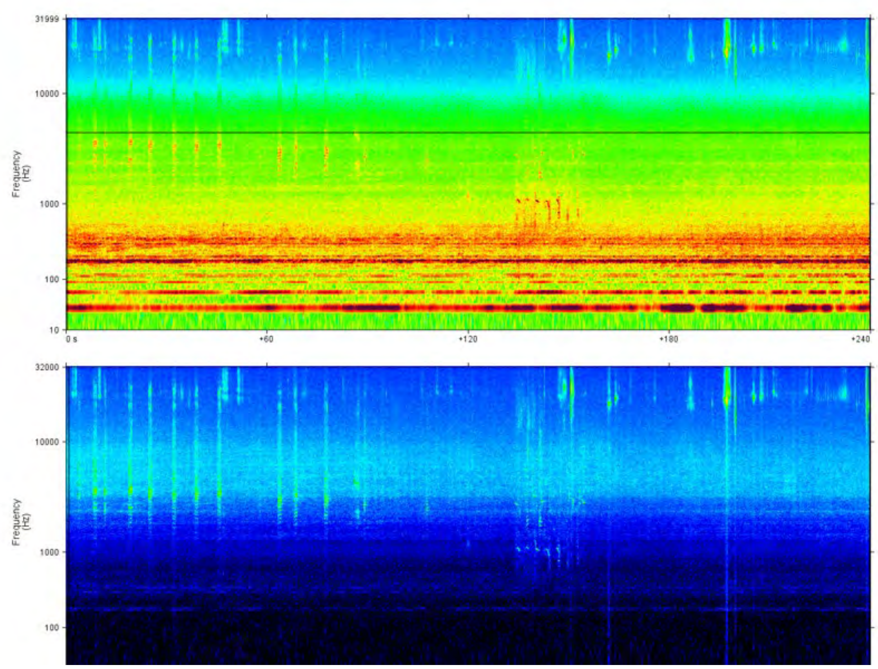

Figure 2: Shipping Noise Relative to Narwhal Hearing Ability

Notes: Top plot represents full broadband sound levels with no frequency filtering applied to account for narwhal hearing.
Bottom plot represents sound levels filtered for narwhal hearing (showing only the sound that narwhal can hear).
In the top plot, the thick solid red bands running across the plot at the bottom of the plot show vessel noise. The spots of red and green in the middle and top of the plot are different types of narwhal calls. Note that the vessel noise shown in red is not visible in the bottom plot, but note the narwhal calls in the middle and top of the plot are still present and detectable.

In summary, given that some level of frequency overlap exists between shipping noise and narwhal communication, there is potential for some degree of acoustic masking to occur at an unknown distance from the source. Given that icebreaking noise is predicted to be temporary in nature, that narwhal are already exposed to similar levels of masking from natural sounds in their environment (i.e., wind and waves), and that narwhal communication and hearing occurs predominantly at much higher frequencies than icebreaker noise, it is considered unlikely that residual acoustic masking effects will result in a measurable change at the population or stock level within the RSA. Effects are predicted to be limited to temporary and localized disturbance effects. The residual environmental effect of masking on narwhal due to icebreaking noise is therefore predicted to be not significant.

1.3.4 Assessment Results for Ringed seal

1.3.4.1 Acoustic Injury:

Acoustic propagation modelling results indicated that underwater noise generated by icebreaking activities during the shoulder seasons would not exceed the established threshold for auditory injury in ringed seal under any of the modelling scenarios considered in the Icebreaking Assessment (Golder 2019). The risk of acoustic injury (i.e., hearing impairment) in ringed seal from icebreaking noise was therefore predicted to be negligible.

The model predictions were verified by measurements collected in the field during the 2019 shoulder season. All sound level measurements of icebreaker activities undertaken along the Northern Shipping Route in 2019 were below the threshold for auditory injury for ringed seal (Frouin-Mouy et al. 2020).

1.3.4.2 Potential Acoustic Disturbance

Based on acoustic modelling results, the predicted range (R95%) for disturbance onset in ringed seal (based on a 70 dB sensation level) was predicted to extend up to 1.03 km from the source in 10/10 ice, 85 m in 3/10 ice, and 70 m in open-water (0/10 ice) based on a maximum-case icebreaker transit scenario (two icebreakers escorting two capesize ore carriers in Eclipse Sound (Table 6). For these scenarios, a stationary ringed seal positioned along the shipping corridor would have the potential to be in the disturbance zone for a period of up to 1 min (for transits at 9 knots in 0/10 ice), 6 min (for transits at 9 knots in 3/10 ice), and 15 min (for transits at 4.6 knots in 10/10 ice) per icebreaker transit.

Table 6 presents the estimated ranges for disturbance onset at each modelled location for all transit speeds and ice conditions considered in the acoustic model. Detailed modelling results are presented in Golder (2019a). Distances to the disturbance onset threshold are considered conservative estimates as this threshold does not account for the overall duration of noise exposure to the animal, nor does it account for the frequency of the noise source relative to ringed seal hearing sensitivity.

Table 6 Distance (R95%) to Ringed Seal Disturbance Onset Threshold (70 dB sensation level) based on Maximum-Case Icebreaker Transit Scenario (2 icebreakers escorting 2 capesize ore carriers) at Study Locations in RSA in 10/10, 3/10* and 0/10 Ice Concentrations.

Table 6: Distance (R95%) to Ringed Seal Disturbance Onset Threshold (70 dB sensation level) based on Maximum-Case Icebreaker Transit Scenario (2 icebreakers escorting 2 capesize ore carriers) at Study Locations in RSA in 10/10, 3/10* and 0/10 Ice Concentrations

Modelled Location	Disturbance Range (R95%) in m		
	10/10 Ice @ 4.6 knots	3/10* Ice @ 9 knots	0/10 Ice @ 9 knots
Milne Inlet	1,030	850	70
Eclipse Sound	1,030	850	70
Pond Inlet	800	350	70
Floe Edge	N/A	N/A	N/A

Note: Source data (JASCO 2019 from Golder 2019 – Table 12). *indicates disturbance and avoidance distance when icebreaker is actually engaged with ice (in 3/10 ice concentrations, icebreaker is assumed to engage with ice at most 30% of the time).

Estimated Number of Ringed Seal Exposed Per Transit

An estimated 15,947 ringed seals are predicted to occur in the combined areas of Eclipse Sound, Pond Inlet and Milne Inlet (5,755 individuals in Eclipse Sound East; 2,457 individuals in Eclipse Sound West; 4,212 individuals in Pond Inlet; 2,763 individuals in Milne Inlet North, and 759 individuals in Milne Inlet South). This is based on ringed seal density estimates from Yurkowski et al. (2019): 1.40 individuals/km2 for Milne Inlet and 0.98 individuals/km2 for Eclipse Sound, and includes a correction factor of 2.46 for availability bias (Born et al. 2002) and 1.22 for perception bias (Frost et al. 1988).

Based on a maximum-case icebreaker transit scenario (2 icebreakers escorting 2 capesize carriers), using corrected ringed seal density estimates available for June (Yurkowski et al. 2018), the estimated number of ringed seal predicted to occur in the calculated disturbance zone is:

- 199 individuals during the Heavy Ice Regime (early summer);
- 128 individuals during the Moderate Ice Regime (early summer);
- 84 individuals during the Light Ice Regime (early summer);
- 238 individuals during the Heavy Ice Regime (fall); and
- 93 individuals during the Moderate Ice Regime (fall).

As no region-specific density estimates were available for ringed seal during the shoulder season months (July/August, October/November), density estimates for June were used to estimate the number of individuals likely to exhibit avoidance and disturbance behaviour. Actual numbers will be lower as some of the ringed seal population will have left the Local Study Area (LSA) to embark on their foraging phase during the early shoulder season and during the latter shoulder season some of the ringed seal population will not have returned yet from their foraging phase. It is quite likely that at least some of the same ringed seals, will be affected multiple times by icebreaking during the course of a single shoulder season.

For icebreaking operations, if it is assumed that approximately 70 to 200 ringed seal in Milne Inlet and Eclipse Sound will exhibit avoidance of the icebreaking noise source per icebreaker transit, this represents <1% of the population of ringed seals in the Canadian Arctic. Based on available evidence, ringed seals seem tolerant of industrial activity, and disturbance effects are expected to be localized, temporary and restricted to the shoulder season, we would not anticipate abandonment or long-term displacement behavior, or any carry-over effects at the population level. As a result, the residual effects of disturbance on ringed seal from icebreaking activities is expected to be not significant.

The above estimates are meant to serve as a guide for potential effects and indicators for monitoring and follow-up. There is uncertainty associated with these estimates, including the avoidance threshold level, density estimates and their correction factors, vessels modelled in the acoustic study, and how ringed seal in the RSA may respond to icebreaker transits during the shoulder season. There is also uncertainty regarding the duration of the effect and how repeated exposure to icebreaking activities may affect ringed seal (e.g., the number of ringed seal exposed to noise levels above the 80 dB avoidance criterion over the full duration of the shoulder seasons). Based on available evidence, ringed seals seem tolerant of industrial activity, and disturbance effects are expected to be localized, temporary and restricted to the shoulder season, we would not anticipate abandonment or long-term displacement behavior, or any carry-over effects at the population level.

1.3.4.3 Acoustic Masking

The potential effects of acoustic masking in ringed seal are dependent on the received sound level and the frequency content of the received sound signal relative to hearing ability in this species and the level of natural background noise. Ringed seals are not a particularly vocal species, with highest calling rates observed during the spring breeding season (Stirling et al. 1983). The majority of their calls occur in the 400 Hz to 16 kHz frequency range (Stirling 1973; Cummings et al. 1984), which is in the frequency range of the loudest icebreaking noise. Ringed seal have a flat audiogram between 1 kHz and 30 to 50 kHz (Møhl 1968; Terhune and Ronald 1972, 1975; Terhune 1981), with best in-water hearing sensitivity reported at 49 dB re 1 µPa (12.8 kHz) (Sills et al. 2015).

There is no evidence of acoustic masking in ringed seal in the available literature, although given the degree of frequency overlap between icebreaker noise and ringed seal hearing, animals occurring within the modelled disturbance zones are predicted to experience some degree of masking due to icebreaker noise on a temporary basis (limited to icebreaker interactions occurring within the shoulder season). Masking effects on ringed seal are likely limited as animals are likely to temporarily move out of the zone of avoidance during an icebreaker transit.

It is anticipated that ringed seal will actively avoid icebreakers traveling along the Northern Shipping Route and any effect would be localized and short-term. With the effective implementation of mitigation, the residual environmental effects of acoustic masking on ringed seal from icebreaker noise are predicted to be not significant.

1.3.5 Uncertainty

This section identifies key sources of uncertainty in the present effects assessment and the level of confidence that adverse effects will not be worse than predicted. Confidence in the assessment of environmental significance is related to the following elements:

- Understanding of marine mammal population dynamics, foraging ecology, dive behaviour, functional hearing ability and vocal behaviour, predator/prey dynamics, seasonal migratory movements, reproductive and social behaviour, and ecological role in the Eastern High Arctic ecosystem;
- Adequacy of baseline data for understanding current conditions and future changes unrelated to the Project (e.g., extent of future developments, climate change, catastrophic events);
- Understanding of Project-related adverse effects on complex ecosystems that contain interactions across different scales of time and space; and
- Knowledge of the effectiveness of the environmental design features and mitigation for reducing or removing adverse effects (e.g., vessel speed restrictions).

Ecosystems are complex, characterized by interactions across multiple scales, nonlinearity, self-organization, and emergent properties (Boyce 1992; Holling 1992; Levin 1998; Wu and Marceau 2002). These characteristics can confound understanding of ecosystem processes and limit capacity to make predictions on, for example, population sizes. One of the challenges is to aggregate and simplify available ecological knowledge, retain what is essential and disregard that which is not essential at the particular scale of interest.

Like all scientific results and inferences, residual impact predictions must be tempered with uncertainty associated with the data and the current knowledge of the system. It is anticipated that the baseline data are moderately sufficient for understanding current conditions, and that there is a moderate level of understanding of Project related adverse effects on the ecosystem.

It is understood that development activities will directly and indirectly affect marine habitat, and behaviour/movement of marine wildlife species; however, long-term monitoring studies documenting the resilience of marine animals to development and the time required to reverse adverse effects are lacking. Direct disturbance from previous, existing, and future development footprints was estimated to affect a small fraction of the natural range of most marine mammal indicator species considered in the present assessment. However, uncertainty remains surrounding the degree to which some effects may occur (e.g., magnitude and duration).

Forecasting a future that may be outside the range of observable baseline environmental conditions is clearly challenging (because of climate change for example; Walther et al. 2002). Quantifying changes to habitat provides a static assessment of a species' environment, ignoring change that may occur over time as a result of ecological succession and natural disturbances such as climatic events. Thus, there is less certainty in long-term predictions of reversibility (e.g., over periods extending beyond 100 years).

However, there is a high level of confidence that the regional landscape will be different with or without the Project in future decades.

There is some uncertainty in terms of how narwhal will respond to icebreaking traffic in the narrow waterways of Milne Inlet. There exists similar uncertainty concerning masking effects on narwhal communication from icebreaking noise in these areas. Baffinland will continue to conduct tailored environmental effects monitoring programs to evaluate narwhal responses to vessel traffic along the shipping corridor, including future icebreaking transits. This will include acoustic monitoring studies to assess for potential acoustic masking effects of shipping on narwhal, as well as potential adverse effects of shipping on narwhal communication. Baffinland remains committed to working with DFO and the MEWG to ensure its environmental management and monitoring programs adequately account for its shoulder season activities, including icebreaking operations.

1.4 SUMMARY

Table 7 provides a summary of the impact rating criteria and significance determinations for the effects assessment as it relates to underwater noise effects on narwhal and ringed seal. The ratings consider both Project incremental and Project combined effects for both species based on the three key effect pathways associated with underwater noise: acoustic injury, behavioural disturbance and acoustic masking. The information provided for in Table 7 was previously submitted to the NIRB in a 2019 marine mammal monitoring memo (Golder 2020; Public Registry ID No. 331438; Appendix 4). A detailed description of the assessment methodology is provided in FEIS Volume 2, Section 3, including the approach used for characterizing residual effects and determining significance (Baffinland 2012).

Given that no significant residual effects are predicted with respect to icebreaking impacts on marine mammals for the Proposal, it is reasonable to assume this also applies to icebreaking activities associated with current operations. It is also noted that mitigation measures developed for icebreaking activities under Phase 2 are also presently applied to current icebreaking operations.

In closing, icebreaking noise associated with the current phase of the Project are not predicted to result in significant residual effects on marine mammals in the RSA. Project mitigation measures have been, and will continue to be monitored for at an appropriate frequency throughout the life of the Project to confirm that effects of the Project remain within the range of effects identified in the assessment predictions, to identify any unforeseen effects, should they occur, and to confirm that mitigations are working as intended.

Table 7: Residual effect ratings and significance determinations for underwater noise impacts from icebreaking activities on narwhal and ringed seal along the Northern Shipping Route

Residual Effect	Residual Effect Evaluation Criteria					Significance	Qualifiers**	
	Magnitude	Extent	Frequency	Duration	Reversibility		Probability (Likelihood of Effect Occurring)	Certainty (Confidence in Effects Prediction)
Narwhal (BB and ES*)								
Hearing impairment	-	-	-	-	-	-	I (Unlikely)	III (High)
Disturbance	Level II	Level II	Level II	Level II	Level I	N	II (Moderate)	II (Medium)
Acoustic masking	Level II	Level II	Level II	Level II	Level I	N	II (Moderate)	II (Medium)
Combined Project Effects[1]	Level II	Level II	Level II	Level II	Level I	N		II (Medium)
Ringed seal								
Hearing impairment	-	-	-	-	-	-	I (Unlikely)	III (High)
Disturbance	Level II	Level II	Level II	Level II	Level I	N	II (Moderate)	II (Medium)
Acoustic masking	Level II	Level II	Level II	Level II	Level I	N	II (Moderate)	II (Medium)
Combined Project Effects	Level II	Level II	Level II	Level II	Level I	N		II (Medium)

Notes:
Magnitude: 1 (Level I) = an effect on the exposed indicator/VEC that results in a change that is not distinguishable from natural variation and is within regulated values; 2 (Level II) = an effect that results in some exceedance of regulated values and/or results in a change that is measurable but allows recovery within one to two generations; 3 (Level III) = an effect predicted to exceed regulated values and/or result in a reduced population size or other long-lasting effect on the subject of the assessment.
Extent: 1 (Level I) = confined to the LSA; 2 (Level II) = beyond the LSA and within the RSA; 3 (Level III) = beyond the RSA
Frequency: 1 (Level I) = infrequent (rarely occurring); 2 (Level II) = frequent (intermittently occurring); 3 (Level III) = continuous
Duration: 1 (Level I) = short-term (<5 years); 2 (Level II) = medium-term (life of Project); 3 (Level III) = long-term (beyond the life of the project) or permanent
Reversibility: 1 (Level I) = fully reversible after activity is complete; 2 (Level II) = partially reversible after activity is complete; 3 (Level III) = non-reversible after the activity is complete. Note: Reversibility is considered for biological VECs at the population level. Therefore, although an effect like mortality is irreversible, the effect at the population level might be reversible.
Significance Rating: S=Significant, N=Not Significant, P=Positive
Qualifiers- only applicable to significant effects**
Probability: 1 (Level I) = unlikely; 2 (Level II) = moderate; 3 (Level III) = likely
Certainty: 1 (Level I) = low; 2 (Level II) = medium; 3 (Level III) = high
*BB: Baffin Bay population; ES: Eclipse Sound summer stock (sub-population)
** Inclusion of qualifiers for probability and certainty is not consistent with original FEIS methodology which stipulates that qualifiers are only applicable to significant effects.

[1] Regarding the combined effect of behavioral disturbance and acoustic masking, it is important to note that acoustic masking is actually a type of behavioural disturbance, with masking effects occurring at the lower level of behavioural impacts in marine mammals (Pine et al. 2018). In essence, these two pathways are already inherently combined, as reflected in the assessment by the identical effect ratings and significance determinations in Table 7. While limited masking from ship noise is predicted to occur for narwhal and ringed seal in the RSA as demonstrated through acoustic modelling, the levels are comparable to those animals in the RSA already regularly experience from ambient noise sources (i.e., natural weather events), and it is not presently possible to determine or calculate the biological consequence of this effect, if one exists.

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Appendix 1

Impacts of Ice Breaking on Ice

ENFOTEC

Impact of icebreaking activities within the approaches to the Milne Inlet Port Site (Northern Shipping Route to Milne Port)

1. Standard definitions

Fast ice: Sea ice which forms and remains fast along the coast, where it is attached to the shore, to an ice wall, to an ice front, between shoals or grounded icebergs. [...] Fast ice may be formed in situ from sea water or by freezing of floating ice of any age to the shore, and it may extend a few metres or several hundred kilometres from the coast. (Source: WMO Sea Ice Nomenclature, volume 1, 2014 https://library.wmo.int/doc_num.php?explnum_id=4651)

Pack ice: Term used in a wide sense to include any area of sea ice other than fast ice no matter what form it takes or how it is disposed. [This term is used] when concentrations are high, i.e. 7/10 or more. (Source: WMO Sea Ice Nomenclature, volume 1, 2014 https://library.wmo.int/doc_num.php?explnum_id=4651)

Breakup: This term refers to a particular length of time in which ice disappears in a given area (generally 1 to 2 weeks). However, breakup does not necessarily imply a decay or melt of ice, but can also indicate a movement of ice out of a particular area. (Source: Canadian Ice Service Ice Glossary, https://www.canada.ca/en/environment-climate-change/services/ice-forecasts-observations/latest-conditions/glossary.html)

Freeze-up: This term refers to a particular length of time in which ice appears in a given area (generally 1 to 2 weeks). However, freeze-up does not necessarily imply a growth of ice, but can also indicate a movement of ice into a particular area. (Source: Canadian Ice Service Ice Glossary, https://www.canada.ca/en/environment-climate-change/services/ice-forecasts-observations/latest-conditions/glossary.html)

2. Impact of breaking ice at the beginning of the shipping season

Breaking ice, after the landfast ice has fractured, could have an effect of slightly speeding up the process of clearing out all the ice in the channels.

Ships heading to the Milne Inlet Port Site can enter Pond Inlet as soon as the fracture of the fast ice occurs (referred to as breakup). Since the approaches to the port site are infested with sea ice for days after the initial breakup, an icebreaker escort is needed to ensure safe and efficient navigation along the Northern Shipping Route to the Milne Inlet Port Site.

When breakup occurs, what was landfast ice is fractured into vast floes that linger in Pond Inlet, Eclipse Sound and Pond Inlet. Initially, some of these floes can span almost the full width of the channel. They repeatedly fracture into smaller pieces that, ultimately, are either flushed out into Baffin Bay, or melt before getting there. This process unfolds rapidly, with the ice cover going from landfast to open water in as little as two weeks (Table 1).

Because icebreaking activities involve fragmenting ice floes into smaller pieces, they can have a minor catalyzing effect in the transition from high sea ice concentration to open water, and therefore may slightly advance the date when open water conditions prevail. In order to facilitate the escort operation, the icebreaker will generally aim to follow a route that is as straight as possible, which may result in breaking floes rather than following leads or fractures. That being said, once the ice concentration begins to diminish, the vessels can navigate more easily through the open leads and areas (regimes) that contain less ice, thereby reducing the impact of icebreaking on the sea ice cover.

Table 1. Dates of Ice events for the for the Milne Inlet, Eclipse Sound, and Pond Inlet area (approaches to Baffinland port) from 1997 to 2018, based on Canadian Ice Service daily and weekly ice charts.

Year	Break-up	Open water	Freeze-up	Fast Ice	Presence of drift ice during OW season	Open water season
1997	July 24	August 7	October 2	November 13	Late Aug. / early Oct.	56 days
1998	July 16	August 10	October 19	November 16	No	70 days
1999	July 26	August 18	October 11	November 8	No	54 days
2000	July 12	July 31	October 16	November 6	No	77 days
2001	July 23	August 15	October 15	November 5	No	61 days
2002	July 27	August 15	October 21	November 4	No	67 days
2003	July 15	August 1	September 29	November 10	Mid Aug. / late Sept.	59 days
2004	July 19	August 11	October 18	November 15	Late Sept. / early Oct.	68 days
2005	July 29	August 15	October 14	Late December	No	60 days
2006	July 14	July 28	October 23	November 27	No	87 days
2007	July 19	August 6	October 11	November 19	No	66 days
2008	July 18	August 1	October 6	November 24	No	66 days
2009	July 17	August 6	October 12	November 16	No	67 days
2010	July 15	August 5	October 11	November 15	No	67 days
2011	July 8	July 29	October 21	November 14	No	84 days
2012	July 12	August 18	October 15	November 19	No	58 days
2013	July 20	August 9	October 7	November 4	No	59 days
2014	July 24	August 9	October 23	October 27	No	75 days
2015	July 17	July 25	October 19	November 9	No	86 days
2016	July 11	July 23	October 10	November 16	Early Oct.	79 days
2017	July 15	August 8	October 10	November 6	Mid Aug. / early Oct.	63 days
2018	July 20	August 13	September 27	October 22	Early Aug. / early Oct.	46 days
Mean	*July 18*	*August 6*	*October 12*	*November 11*	*N/A*	*67 days*
Variability	*21 days*	*26 days*	*26 days*	*36 days*	*N/A*	*40 days*

3. Impact of breaking ice at the end of the shipping season

At freeze-up, ship passage can slow down the formation of the ice and the resulting broken ice pieces could add rubble into an otherwise somewhat-smooth landfast ice surface.

The document "Mary River Project Final Environmental Impact Statement, Volume 8 Marine Environment" (2012) describes the impact of vessel passage on the formation of new ice at the time of freeze-up, in fall. The following text applies as much to the Steensby Port area as to the Northern Shipping Route to Milne Port, and covers well the expected impacts of icebreaking on sea ice at the time of freeze-up.

> […] Icebreaking could delay formation of a continuous, competent ice surface due to repeated disturbance of newly formed ice. The timing of freeze-up is variable and can begin between late October and late November, depending upon weather conditions. It is thought that any localized disruption in the timing of ice formation will be restricted to a small area around the ship track, the effects of which would be minimal in the context of the naturally occurring variability in the timing of formation, and in the spatial context of landfast ice development […].
>
> Ice freeze up occurs during period of low temperature and calm seastate (no winds). Under these conditions, ice forms quickly and newly formed ice then acts as a buffer to retard wind-induced wave formation. During this period of rapid ice formation, high winds or other phenomena can act to break up the newly formed ice and cause it to raft and otherwise break up. Eventually, the low air temperature and even brief periods of calm water will result in formation of an ice cover that is thick enough to resist these disruptive forces and the ice continues to grow both in thickness and aereal extent. […] Vessel passage during the period of ice freeze up can act to delay ice formation and can produce relatively rough ice surface within the area affected by the ships passage (VBNC, 1997). The delay would be in the order of hours to days, depending on the air temperature and presence of calm conditions (low wind, waves). The effect can be moderated by reducing ships speed as it passes through areas of landfast ice formation. […]
>
> As an aside, the presence of even modest surface disturbance due to wind/waves will cause new ice to break up during the initial freeze period. The bow wave and the wake of a ship will have the same effect. With enough cold weather, ice formation will occur regardless of surface disturbance, but ice broken during the initial freezing will have a rougher surface than that which is formed under calm conditions. The spatial extent of this will be highly variable, depending upon the timing and level of disruption by wind, naturally occurring waves, and by ships during the initial freeze period. Alteration of the ice surface will have negligible effect on the sea ice.

Appendix 2

Summary of Mitigation and Monitoring

Table 1: Baffinland Mitigation and Monitoring Overview

Potential Effect	Mitigation	Intended Outcome of Mitigation	Monitoring Program	Summary of Project Monitoring Results 2015-2019
Ship Strike	9 knot speed restriction Placement of Marine Wildlife Observers on icebreaking vessels Commitment to not break landfast ice All icebreaking activities will be conducted outside of sensitive life cycle periods for ringed seal (pupping, nursing and mating periods) All Project vessels will maintain constant speed and course (as save navigation allows) When marine mammals appear to be trapped or disturbed by Project vessel movements, the vessel will implement appropriate measures to mitigate disturbance All Project vessels are provided with standard instructions to not approach within 300m of a walrus or polar bear observed on sea ice All Project vessels are provided with standard instructions to operate their vessel in a manner that avoids separating an individual member(s) of a group of marine mammals from other members of the group. Establishment of restricted “no-go” zones to avoid key sensitive areas (Koluktoo Bay, Tremblay Sound, western shore of Milne Inlet).	Avoid marine mammal mortality or injury as a result of Project operations	Ship-Based Observer Program Bruce Head Shore-Based Monitoring Program Narwhal Tagging Monitoring Program Marine Mammal Aerial Surveys	No ship-strikes to any marine mammals have been observed since the start of Project operations from any of the marine-based monitoring programs, nor reported by any of the Project vessel operators, through community-based monitoring initiatives or by local community members. 2017 and 2018 narwhal tagging data demonstrate that narwhal effectively avoid ships at ranges that would impede being struck by the vessel. Based on aerial survey data, the Eclipse Sound narwhal summer stock population has remained stable since start of shipping operations. Current abundance estimate of the stock is consistent (within 10%) with pre-shipping levels (e.g. 2014) confirmed via 2016 and 2019 aerial surveys.
Ice Entrapment	Commitment to not break landfast ice Avoidance of ice if and when safe to do so When marine mammals appear to be trapped or disturbed by Project vessel movements, vessels will implement appropriate management measures to mitigate disturbance.	To avoid ice entrapment events as a result of icebreaking activities.	Narwhal Tagging Monitoring Program Ship-Based Observer Program End of Season Aerial Clearance Survey	Based on 2017 and 2018 tagging data, all tagged narwhal had migrated out of the RSA into Baffin Bay by mid-October, prior to formation of landfast ice in the RSA. Based on tagging studies and SBO data, icebreaking effects on narwhal during the late shoulder season are consistent with those predicted in the FEIS (limited to temporary and localized disturbance effects, no entrapment predicted). Project-related icebreaking operations did not result in displacement of narwhal from the RSA. Evidence of narwhal actively avoiding the sternward track of icebreaking vessels for a period of several hours following interaction.

Table 1: Baffinland Mitigation and Monitoring Overview

Potential Effect	Mitigation	Intended Outcome of Mitigation	Monitoring Program	Summary of Project Monitoring Results 2015-2019
				Based on aerial surveys undertaken during the fall of 2019 (after completion of shipping), no entrapment events were recorded.
Hearing Impairment	Not required as marine mammal acoustic injury thresholds were not exceeded in any of the modelling scenarios. This was subsequently confirmed through passive acoustic monitoring program.	N/A	Passive Acoustic Monitoring Program	Monitoring results confirm modelling predictions that marine mammal injury thresholds are not being exceeded as a result of Project activities.
Acoustic Disturbance	Establishment of a 40-km 'buffer zone' at entrance of RSA Avoidance of ice if and when safe to do so Establishment of restricted "no-go" zones to avoid key sensitive areas (Koluktoo Bay, Tremblay Sound, western shore of Milne Inlet).	Reduce the acoustic disturbance zone (spatial area) in the RSA.	Marine Mammal Aerial Survey Program (including pre-season aerial survey and post-season clearance survey) Bruce Head Shore-Based Monitoring Program Ship-Based Observer Program Narwhal Tagging Program Passive Acoustic Monitoring Program (Bruce Head, Milne North, Eclipse Sound)	Based on aerial survey data, the Eclipse Sound narwhal summer stock population has remained stable since start of shipping operations. Current abundance estimate of the stock is consistent (within 10%) with pre-shipping levels (e.g. 2014) confirmed via 2016 and 2019 marine mammal aerial surveys. Based on aerial survey and SBO data, higher number of bowhead whale recorded in 2019 (when shipping levels were highest in the RSA) than in previous survey years. Based on shore-based monitoring data, the total number of narwhal (standardized by effort) recorded at Bruce Head was higher in heavier shipping years (2016, 2018, 2019) than prior to shipping (2014) and Year 1 of shipping (2015). The mean proportion of calves recorded at Bruce Head was similar across all survey years (and higher in 2019 than all other survey years except for 2015). Based on tagging studies and shore-based monitoring data, disturbance effects on narwhal are consistent with those predicted in the FEIS (limited to temporary and localized effects). Acoustic recordings of a Post-Panamax vessel travelling in Eclipse Sound, collected in 2019 as part of JASCO's acoustic monitoring program, indicate that the daily 120 dB exposure period is, on average, less than 1.3 h per day, or equivalent to 22.7 h of quiet time per day.
	Restriction of transits in heavier ice conditions	To minimize the amount of time narwhal will be exposed to noise levels that would onset disturbance and avoidance behaviours.		
	9 knot speed restriction	Reduce the noise output of all Project vessels		
	Commitment to not break landfast ice	Reduce the noise output of icebreaker operations, and therefore reduce acoustic disturbance zone and daily exposure period.		
	All Project vessels will maintain constant speed and course (as safe navigation allows)	Reduce the acoustic disturbance zone (spatial area) in the RSA		

Table 1: Baffinland Mitigation and Monitoring Overview

Potential Effect	Mitigation	Intended Outcome of Mitigation	Monitoring Program	Summary of Project Monitoring Results 2015-2019
	No drifting of Project vessels in Eclipse Sound (as safe navigation allows)	Reduce the acoustic disturbance zone (spatial area) and daily exposure period		
	Maximum of 3 vessels anchored at Ragged Island	Reduce the acoustic disturbance zone (spatial area)		
Acoustic Masking	Establishment of a 40-km 'buffer zone' at entrance of RSA Establishment of restricted "no-go" zones to avoid key sensitive areas (Koluktoo Bay, Tremblay Sound, western shore of Milne Inlet).	Reduce the acoustic disturbance zone (spatial area) in the RSA.	Marine Mammal Aerial Survey Program (including pre-season aerial survey and post-season clearance survey) Bruce Head Shore-Based Monitoring Program Ship-Based Observer Program Narwhal Tagging Program Passive Acoustic Monitoring Program (Bruce Head, Milne North, Eclipse Sound)	Based on aerial survey data, the Eclipse Sound narwhal summer stock population has remained stable since start of shipping operations. Current abundance estimate of the stock is consistent (within 10%) with pre-shipping levels confirmed via 2016 and 2019 marine mammal aerial surveys. Based on shore-based monitoring data, the total number of narwhal (standardized by effort) recorded at Bruce Head was higher in heavier shipping years (2016, 2018, 2019) than prior to shipping (2014) and Year 1 of shipping (2015). The mean proportion of calves recorded at Bruce Head was similar across all survey years (and higher in 2019 than all other survey years except for 2015). Based on tagging studies and shore-based monitoring data, disturbance effects on narwhal are consistent with those predicted in the FEIS (limited to temporary and localized effects). Acoustic recordings of a Post-Panamax vessel travelling in Eclipse Sound, collected in 2019 as part of JASCO's acoustic monitoring program, indicate that the daily 120 dB exposure period is, on average, less than 1.3 h per day, or equivalent to 22.7 h of quiet time per day.
	Restriction of transits in heavier ice conditions	To minimize the amount of time narwhal will be exposed to noise levels that would onset disturbance and avoidance behaviors.		
	9 knot speed restriction	Reduce the noise output of all Project vessels		
	Commitment to not break landfast ice	Reduce the noise output of icebreaker operations, and therefore reduce acoustic disturbance zone and daily exposure period		
	All Project vessels will maintain constant speed and course (as safe navigation allows)	Reduce the acoustic disturbance zone (spatial area) in the RSA		
	No drifting of Project vessels in Eclipse Sound (as safe navigation allows)	Reduce the acoustic disturbance zone (spatial area) and daily exposure period		
	Maximum of 3 vessels anchored at Ragged Island	Reduce the acoustic disturbance zone (spatial area)		

Appendix 3

2019 Marine Mammal Monitoring Summary

GOLDER

TECHNICAL MEMORANDUM

DATE 25 May 2020 1663724-186-TM-Rev3-38000

TO Lou Kamermans
Baffinland Iron Mines Corporation

FROM Phil Rouget, Golder Associates Ltd. **EMAIL** prouget@golder.com

SUMMARY OF RESULTS FOR THE 2019 MARINE MAMMAL MONITORING PROGRAMS

1.0 INTRODUCTION

This technical memorandum serves as an update to an earlier technical memorandum entitled '2019 Marine Mammal Monitoring Programs – Updated Preliminary Results' (Golder 2020a) submitted to the Nunavut Impact Review Board (NIRB) on 21 February 2020. Newly presented information includes additional and updated analyzed data for the 2019 marine mammal monitoring programs. Details on methodology are provided in the earlier version of the report (Golder 2019a) and in the respective annual reports for each monitoring program.

Notification of Errata in original version of Golder Technical Memorandum No. 1663724-186-TM-Rev2-38000 (Golder 2020f): Please note that Table 22 (page 68) has been revised in this version of the technical memorandum. The correction applied to Table 22 relates specifically to the 'Probability' and 'Certainty' qualifiers for combined Project effects on bowhead whale. The 'Probably' qualifier was initially identified as a Level 1 (unlikely); this has been corrected to 'no qualifier' (blank cell). The 'Certainty' qualifier was initially identified as a Level III (High) – this has been corrected to a Level II (medium).

2.0 PROJECT OVERVIEW

In 2019, the following marine mammal programs were undertaken by Baffinland:

- Marine Mammal Aerial Survey Program
- Bruce Head Shore-based Monitoring Program
- Passive Acoustic Monitoring (PAM) Program
- Ship-based Observer (SBO) Program
- 2017/2018 Narwhal Tagging Study (integrated data analysis and reporting completed in 2019)

3.0 2019 MARINE MAMMAL AERIAL SURVEY PROGRAM

This section presents a summary of the results of the 2019 Marine Mammal Aerial Survey Program which substantiate the conclusions of the assessment of Project effects on marine mammals relative to Baffinland's Phase 2 Proposal (see Section 7.0).

Marine mammal aerial surveys were conducted by Golder Associates Ltd. (Golder) in the North Baffin area during August 2019 in collaboration with Inuit researchers from Pond Inlet and Arctic Bay. The objectives of the surveys were to obtain abundance and density estimates of narwhal during the peak open-water season for the Eclipse Sound summer stock area. Aerial surveys were conducted using visual/observer-based line-transect sampling combined with aerial photography surveys. Survey design, methodology and analysis were finalized in consultation with DFO Science. Results from two of the aerial surveys (Aug 21-22 and Aug 25-27) completed in Eclipse Sound during the open-water season were used to generate a 2019 abundance estimate for the Eclipse Sound narwhal summer stock. These surveys were considered to have high precision as they were conducted in optimal survey conditions and were largely based on photographic results. A detailed description of data collection and analytical methodology for the 2019 Marine Mammal Aerial Survey Program is provided in Golder (2019a; 2020e).

3.1 Summary of Results

A total of five surveys were attempted in the Eclipse Sound survey grid during the open-water season (Figures B-6 through B-10 in Golder 2020e) between 17–30 August 2019. Each survey included data collected by on-board Marine Mammal Observers (MMOs) as well as photographic surveys for segments of the survey grid with high concentrations of narwhal. Survey tracklines are presented in Golder 2020e (Appendix B - Figures B-1 through B-15) along with locations of marine mammal sightings recorded by the onboard observers (uncorrected for distance from trackline). Four of the five surveys (Surveys 1,3,4 and 5) achieved complete coverage of the survey grid. Survey conditions were good to moderate for the majority of the five surveys. Survey 2 could not be completed due to logistical issues (aviation fuel closure at Pond Inlet airport). The total number of marine mammals recorded on each survey, based on observer-based data only, is presented in Table 1. Photographic surveys were flown in these strata on Surveys 1, 3, 4, and 5; photographic results are presented in

Table 2.

Narwhal were concentrated in Tremblay Sound and in Milne Inlet South / Koluktoo Bay during the open-water season, as shown in Figure 1A and 1B (Survey 3), Figure 2A and 2B (Survey 4) and Figures 3A and 3B (Survey 5) which depict observer-based and photographic data combined (note these figures present sightings data for both Admiralty Inlet and Eclipse Sound survey grids, although the present memorandum is focused specifically on the Eclipse Sound area). During Survey 5, large numbers of narwhal were recorded in Milne Inlet North but not in dense enough aggregations to warrant a photographic survey (Figures B-9 and B-10 in Golder 2020e). Relatively few narwhal were recorded in Eclipse Sound or Navy Board Inlet during the five surveys conducted in August. Four bowhead whales were observed in the RSA during the open-water surveys on August 17. Three of the bowheads were observed opportunistically by observers during a photographic survey in Tremblay Sound and one was observed on-transect near the entrance to Tremblay Sound.

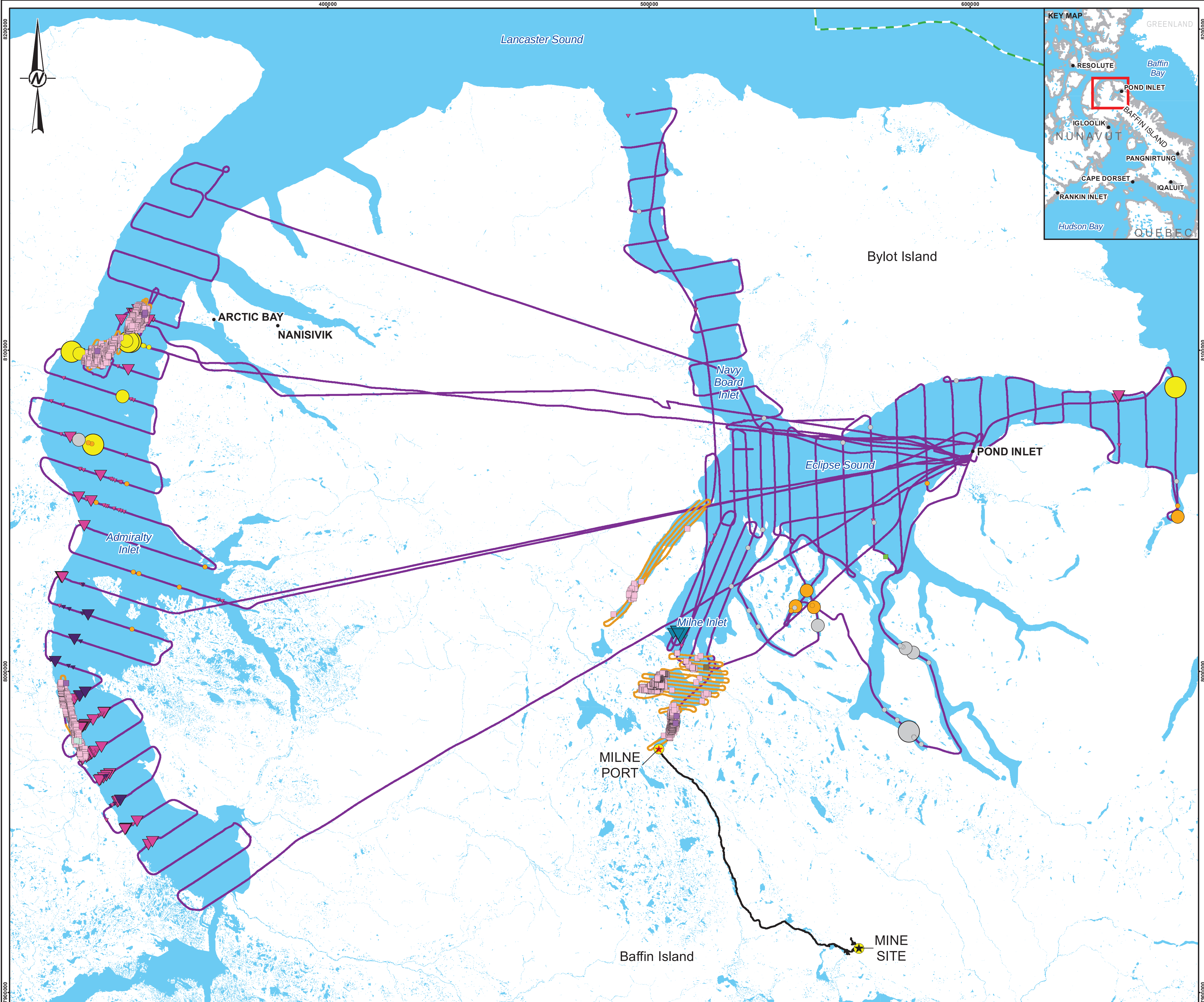
Table 1: Marine mammal sightings (on and off-effort) recorded during visual-surveys in Eclipse Sound - August 2019

Species	Survey 1		Survey 2		Survey 3		Survey 4		Survey 5	
	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals
Narwhal	39	172	4	4	9	11	101	265	37	64
Bowhead Whale	4	4	0	0	0	0	0	0	0	0
Beluga Whale	1	1	0	0	0	0	0	0	0	0
Killer Whale	0	0	0	0	1	11	1	3	1	15
Unidentified Whale	1	1	0	0	0	0	0	0	0	0
Ringed Seal	5	5	0	0	8	14	0	0	4	4
Harp Seal	30	404	0	0	1	15	8	96	6	154
Bearded Seal	0	0	0	0	0	0	0	0	2	2
Unidentified Seal	9	11	23	23	26	72	5	9	16	46
Polar Bear	2	4	0	0	1	1	2	7	2	2
Total	**91**	**602**	**27**	**27**	**46**	**124**	**117**	**380**	**68**	**287**

Table 2: Photographic survey sightings in the Eclipse Sound grid during August 2019

Grid	Survey	Stratum[a]	Narwhal		Bowhead[b]		Polar Bear[b]		Unidentified Seal	
			No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals	No. Sightings	No. Animals
Eclipse	3	MIS	1,417	3,176	1	1	0	0	0	0
Eclipse	3	TS	93	240	0	0	0	0	0	0
Eclipse	4	MIS	1,901	3,644	0	0	0	0	85	87
Eclipse	4	MIN	751	997	0	0	0	0	15	15
Eclipse	4	TS	218	424	0	0	1	1	57	58
Eclipse	5	MIS	924	1,558	0	0	0	0	107	129
Eclipse	5	TS	163	463	0	0	0	0	43	57

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



LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BELUGA
- BOWHEAD
- NARWHAL
- SEAL

VISUAL SURVEY MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE

- 1
- 2 - 10

HARP SEAL

- 1
- 2 - 10
- 10+

KILLER WHATE

- 1
- 2 - 10
- 10+

NARWHAL

- 1
- 2 - 10

POLAR BEAR

- 1

RINGED SEAL

- 1
- 2 - 10

UNIDENTIFIED SEAL/PINNIPED

- 1
- 2 - 10
- 10+

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 25 50

1:1,200,000 KILOMETRES

NOTE(S)

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

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

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

CONSULTANT
GOLDER

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

PROJECT NO.	CONTROL	REV.	FIGURE
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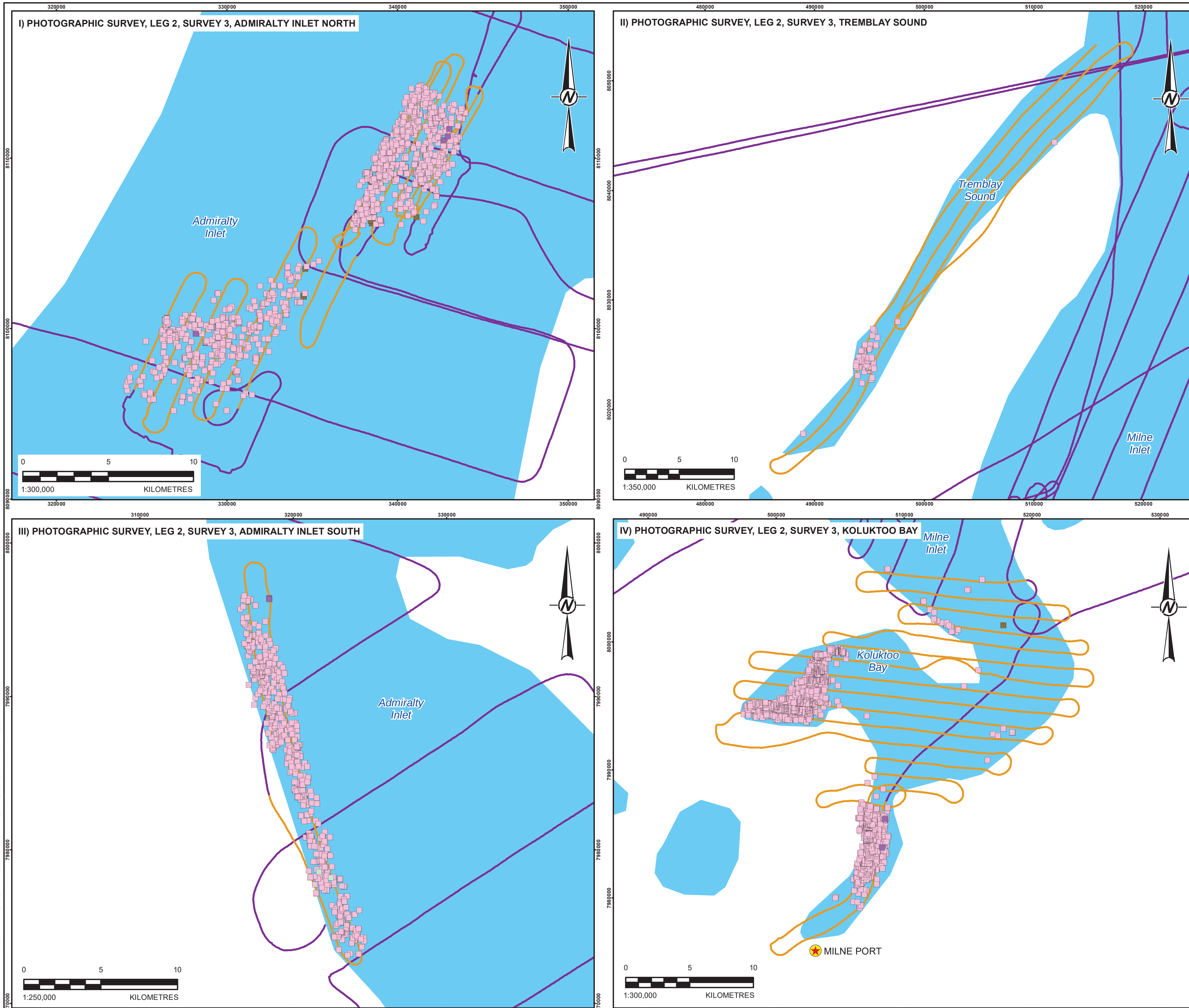


LEGEND

- COMMUNITY
- MILNE PORT

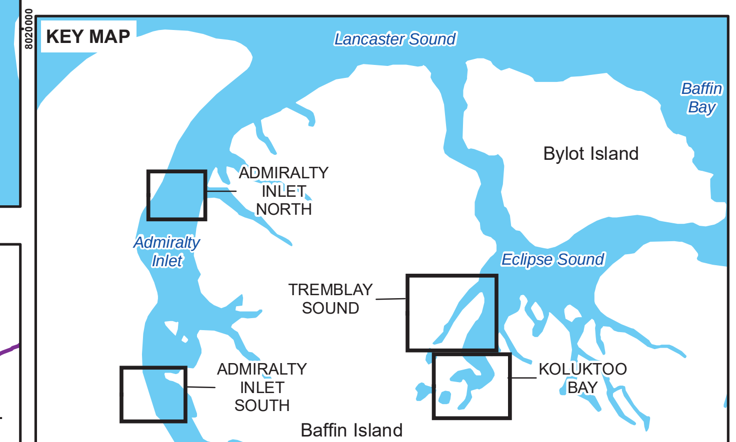
PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BELUGA
- BOWHEAD
- NARWHAL
- SEAL

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- WATERBODY

KEY MAP



REFERENCE(S)
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PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

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

CONSULTANT
GOLDER

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

PROJECT NO.	CONTROL	REV.	FIGURE
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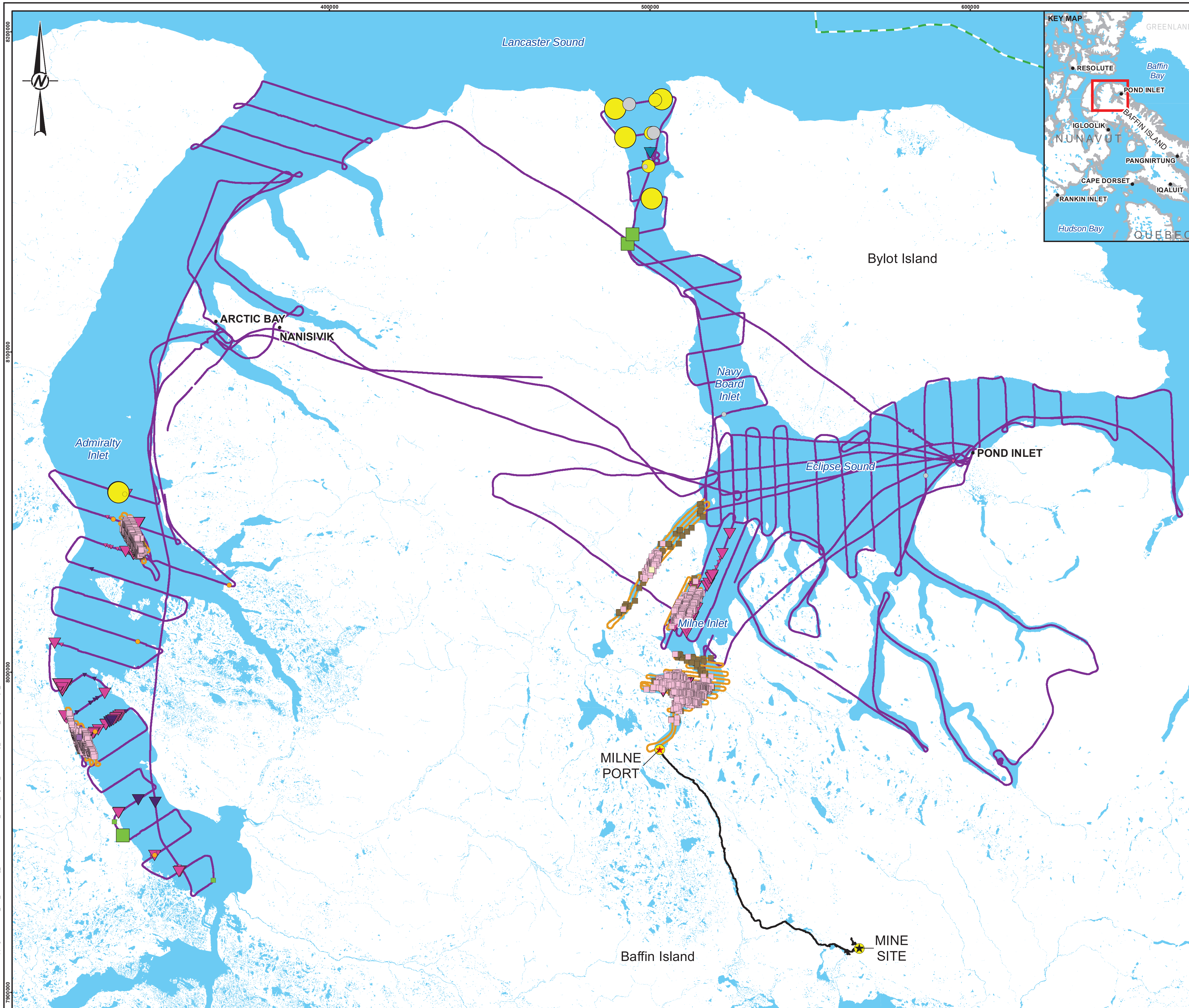

LEGEND

- COMMUNITY
- MILNE PORT
- MINE SITE

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD
- NARWHAL
- POLAR BEAR
- SEAL

VISUAL SURVEY MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE

- 1
- 2 - 10

HARP SEAL

- 1
- 2 - 10
- 10+

KILLER WHATE

- 2 - 10

NARWHAL

- 1
- 2 - 10
- 10+

POLAR BEAR

- 1
- 2 - 10

RINGED SEAL

- 1

UNIDENTIFIED SEAL/PINNIPED

- 1
- 2 - 10

- MILNE INLET TOTE ROAD

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- NUNAVUT SETTLEMENT AREA BOUNDARY
- WATERBODY

0 25 50

1:1,200,000 KILOMETRES

NOTE(S)

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

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

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

CONSULTANT
GOLDER

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

PROJECT NO.	CONTROL	REV.	FIGURE
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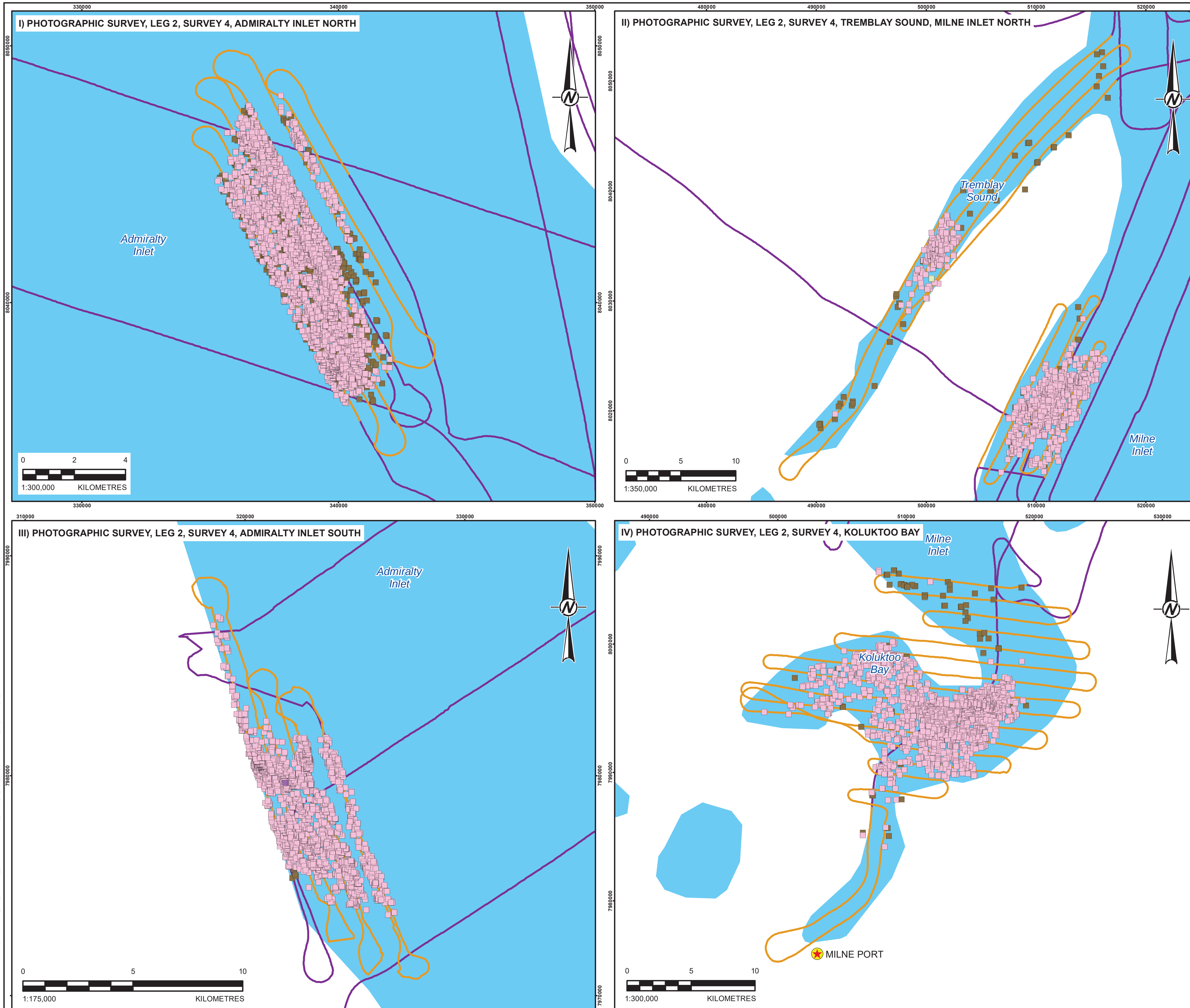


LEGEND

- COMMUNITY
- MILNE PORT

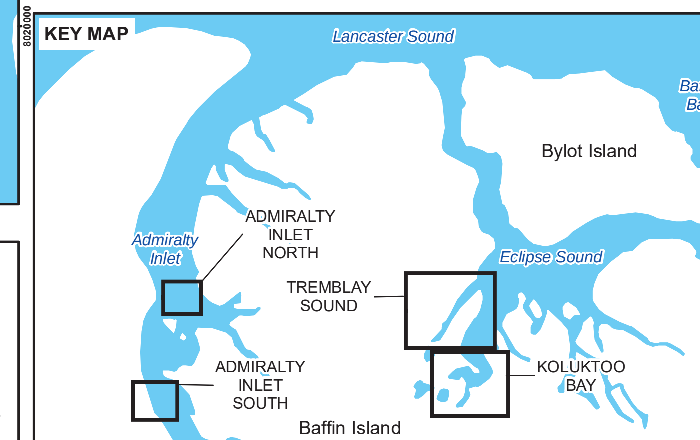
PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD
- NARWHAL
- POLAR BEAR
- SEAL

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- WATERBODY

KEY MAP



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PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
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PROJECT
MARY RIVER PROJECT

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

CONSULTANT
GOLDER

YYYY-MM-DD	2020-05-08
DESIGNED	TT
PREPARED	AA
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PROJECT NO.	CONTROL	REV.	FIGURE
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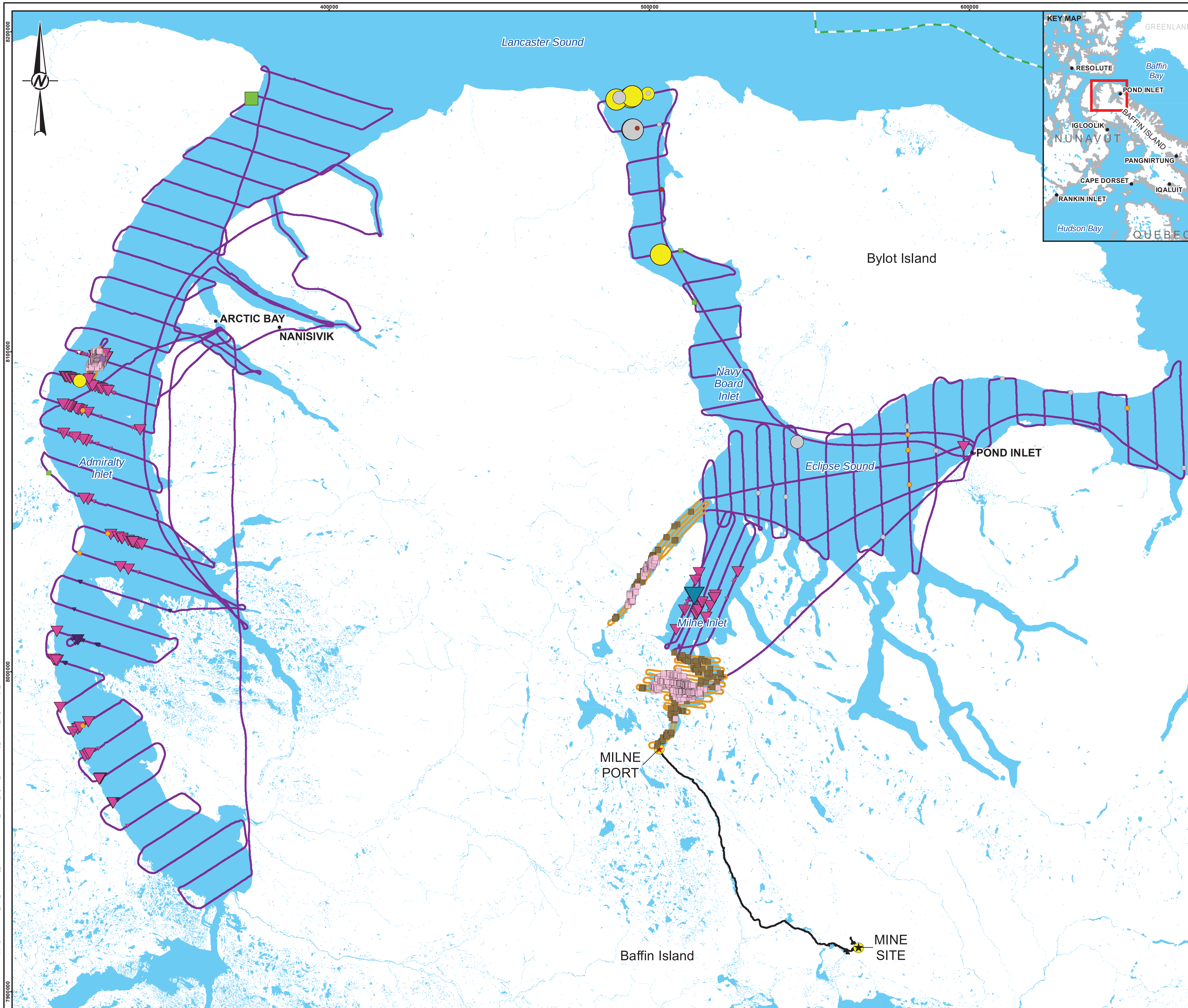

LEGEND

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- MILNE PORT
- MINE SITE

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD
- NARWHAL
- SEAL

VISUAL SURVEY MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

BOWHEAD WHALE
- 1
- 2 - 10

HARP SEAL
- 1
- 2 - 10
- 10+

KILLER WHATE
- 10+

NARWHAL
- 1
- 2 - 10
- 10+

POLAR BEAR
- 1
- 2 - 10

RINGED SEAL
- 1

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

UNIDENTIFIED WHALE/CETACEAN
- 1

- MILNE INLET TOTE ROAD

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

0 25 50
1:1,200,000 KILOMETRES

NOTE(S)

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

REFERENCE(S)

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

CLIENT
BAFFINLAND IRON MINES CORPORATION

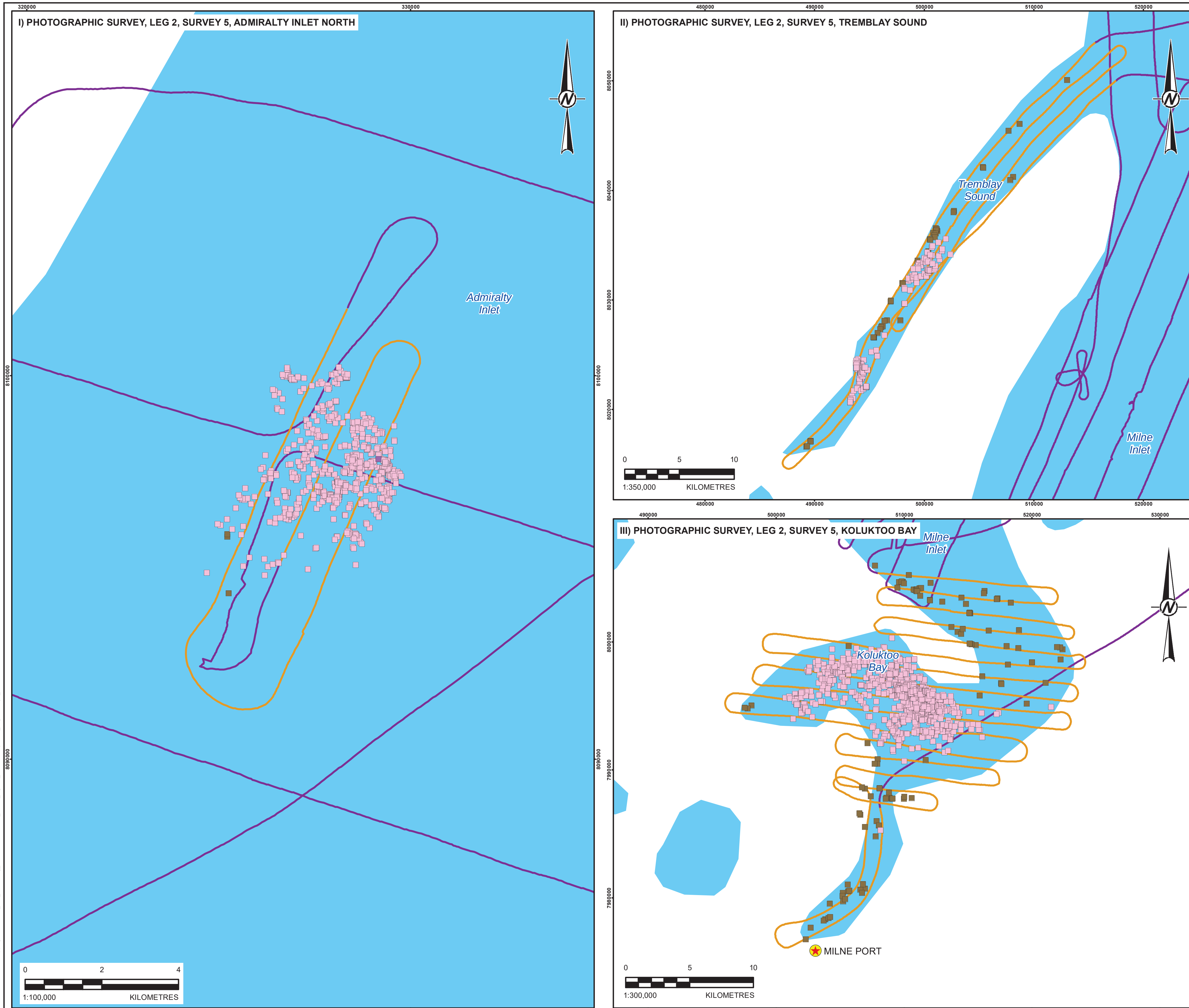
PROJECT
MARY RIVER PROJECT

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

CONSULTANT
GOLDER

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

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	38000	0	3-A



LEGEND

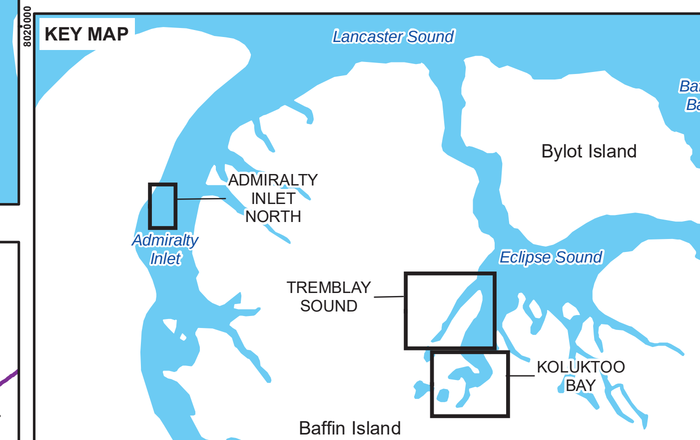
- COMMUNITY
- MILNE PORT

PHOTOGRAPHIC SURVEY MARINE MAMMAL SPECIES OBSERVATIONS

- BOWHEAD
- NARWHAL
- SEAL

AERIAL SURVEY TRACK TYPE

- PHOTOGRAPHIC
- VISUAL
- WATERBODY



REFERENCE(S)

HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT

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

CONSULTANT

GOLDER

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

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	38000	0	3-B

3.2 Narwhal Eclipse Sound Stock – 2019 Abundance Estimate

For the Eclipse Sound summer stock, narwhal abundance estimates were calculated for three surveys (Table 3). Narwhal abundance estimates for the Eclipse Sound grid ranged from 4,879 to 12,088 narwhals (CV=0.06 and 0.08, respectively; Table 3). Survey 3 and 4 were completed within a total of six days, and the difference in the abundance estimates may have been due to sampling variation resulting from non random movements of narwhal within the survey period or influences from killer whales which may have positively or negatively biased the numbers, as opposed to a true change in abundance. Survey 5 may have missed an aggregation of narwhals which resulted in the low abundance estimate. Consequently, we averaged the two abundance estimates from Survey 3 and 4 using an effort-weighted mean, where effort was measured by the area covered over the total area of the survey. This resulted in a final Eclipse Sound 2019 stock estimate of 9,931 narwhals (CV=0.05).

Table 3: Narwhal abundance estimates based on visual and photographic surveys in Eclipse Sound - August 2019

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

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

3.3 Comparison to Previous Aerial Surveys

For comparative purposes, the 2019 Eclipse Sound narwhal summer stock abundance estimate based on data from Survey 3 and 4 was consistent with previous yearly estimates including those prior to the start of Baffinland shipping operations in 2015 (Table 4). The abundance estimate of 9,931 narwhal falls within the 95% CI of all previous DFO abundance estimates for the Eclipse Sound summer stock. This finding is consistent with impact predictions made in the FEIS Addendum for the Early Revenue Phase (ERP) that the Project is unlikely to result in significant residual adverse effects on narwhal in the RSA (defined as effects that would compromise the integrity of the population either through mortality or via large-scale displacement or abandonment of the RSA).

Table 4: Comparison of abundance estimates for Eclipse Sound narwhal summer stock (2004-2019)

Stock	Year	Date	Abundance	CV	95% CI	Source
Eclipse Sound	2004	August	20,225	0.36	9,471 – 37,096	Richard et al. 2010
Eclipse Sound	**2013**	**18-19 Aug**	**10,489**	**0.24**	**6,342 – 17,347** [b]	**Doniol-Valcroze et al. 2015**
Eclipse Sound	**2016**	**Aug 7-10**	**12,039**	**0.23**	**7,768 – 18,660**	**Marcoux et al. 2019**
Eclipse Sound	2016	Aug 15	20,093	0.57	6,449 – 104,339	Golder 2018 (DFO data)
Eclipse Sound	2016	Aug 21	12,955	0.16	7,245 – 23,166	Golder 2018 (DFO data)
Eclipse Sound	2019	Survey 3 (Aug 21/22)	7,765	0.04	7,182–8,396	Golder 2020e (Baffinland data)
Eclipse Sound	2019	Survey 4 (Aug 25-27)	12,088	0.08	10,388–14,066	Golder 2020e (Baffinland data)
Eclipse Sound	2019	Survey 5 (Aug 29/30)	4,879[a]	0.06	4,322–5,507	Golder 2020e (Baffinland data)
Eclipse Sound	**2019**	**Survey 3 and 4**	**9,931**	**0.05**	**9,009–10,946**	**Golder 2020e (Baffinland data)**

3.4 End of Shipping Season Aerial Clearance Survey

An aerial survey (i.e., clearance survey) was flown in the RSA at the end of the shipping season on 30-31 October 2019. The purpose of this survey was to monitor the shipping corridor and adjacent areas for potential narwhal entrapment events following the completion of Baffinland's 2019 shipping operations in the RSA. Ice conditions in the RSA during the aerial survey consisted of 4-6/10 in Milne Inlet South, 9-10/10 in Milne Inlet North, a mixture of 1-1/10 in Western Eclipse, 7-8/10 in Eastern Eclipse, and open water (<1/10) in Pond Inlet and the entrance to Baffin Bay. Figure 4 shows the distribution of regional ice concentrations for 30 October 2019 based on Canadian Ice Service Charts.

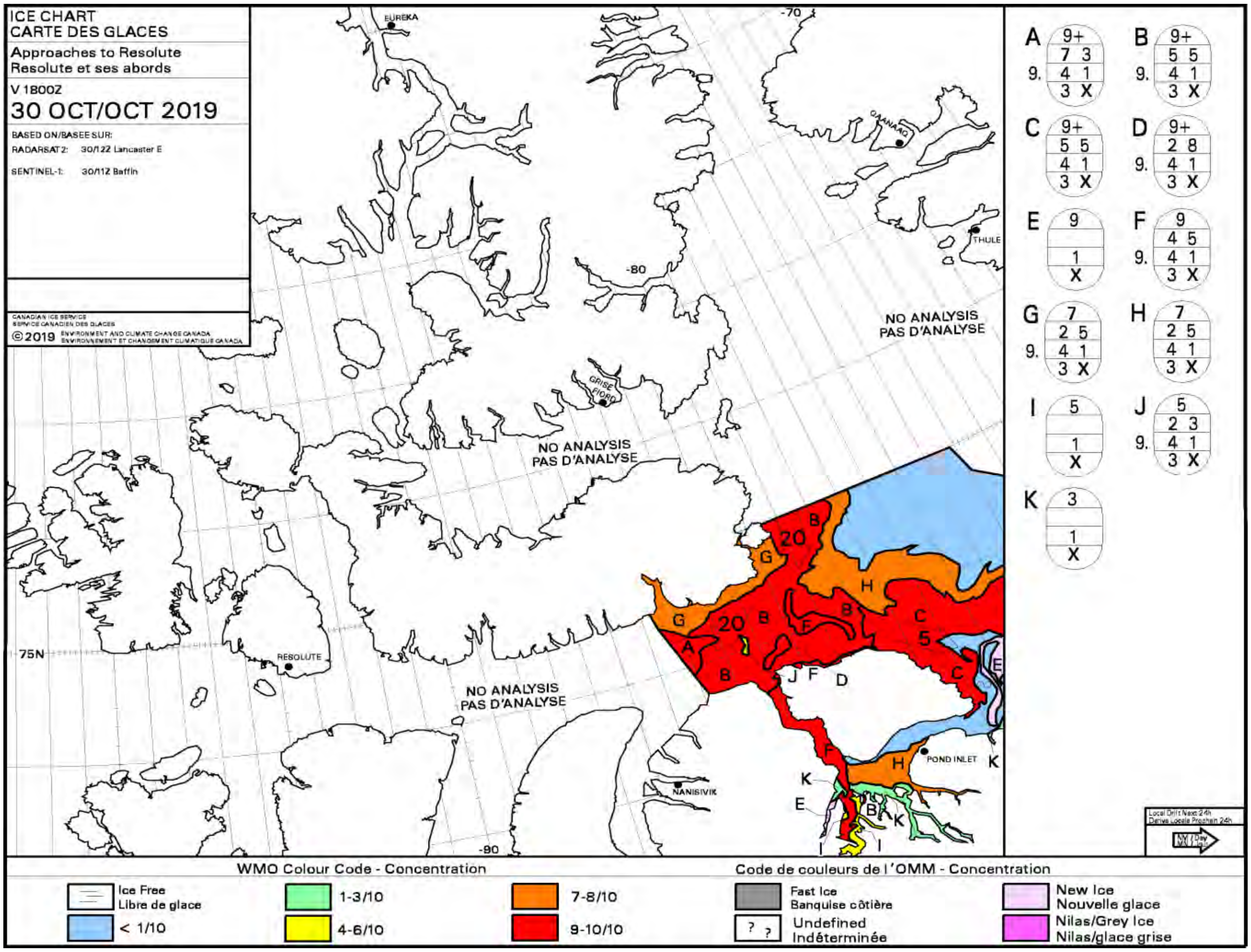


Figure 4: Canadian Ice Service chart for 30 October showing ice concentrations in Eclipse Sound and Milne Inlet.

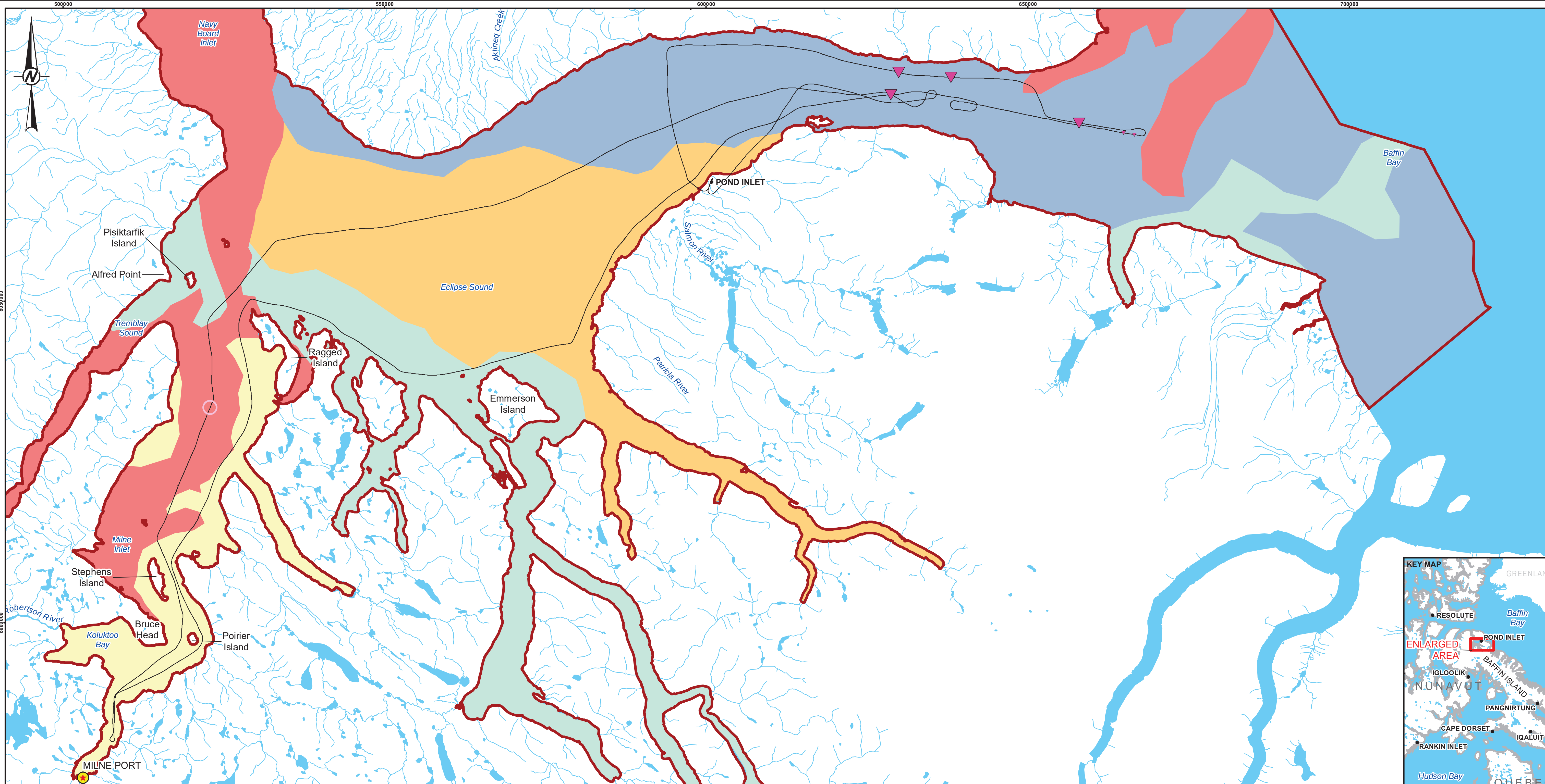
The first clearance survey was flown on 30 October, corresponding with the last icebreaker transit out of the RSA (while escorting a single ore carrier). At the time of the aerial survey, the icebreaker was located east of Pond Inlet transiting eastward toward Baffin Bay. Total aerial survey effort on 30 October consisted of 3 hours and 19 minutes, covering 604.3 km (Figure 5). The aircraft flew the clearance survey at a speed of 100 knots and at an approximate altitude of 333 m (1,000 feet) along the full extent of the nominal shipping route from the entrance of the RSA to Milne Port. The aircraft then returned north tracking along the east shore of Milne Inlet, the south shores of Eclipse Sound West, Eclipse Sound East, and Pond Inlet returning to the entrance of the RSA. The aircraft then returned westward following the south coast of Bylot Island to Sermilik Glacier, and then crossing southward across Eclipse Sound and returning to Pond Inlet (Figure 5). Historical entrapment areas in the RSA, including south of Bylot Island and north of Ragged Island, were covered during the survey. A total of six narwhal sightings comprising 14 individuals were recorded during the 30 October survey. All animals were located east of Pond Inlet and near the entrance to Baffin Bay, with all animals travelling eastbound at the time of sighting. The three most easterly sightings (n=7) were observed in the general vicinity of the icebreaker escort. One sighting of a potential narwhal footprint (depression left in water or thin ice following a dive) was also reported in Milne Inlet North between Athole

Point and Eskimo Inlet. The aircraft circled over this area repetitively to confirm the sighting but no narwhal were observed.

The second clearance survey was flown on 31 October when all Project vessels were confirmed to be outside of the RSA. Total aerial survey effort on 31 October consisted of 4 hours and 32 minutes, covering 709 km (Figure 6). The aircraft flew the clearance survey at a speed of 100 knots and at an approximate altitude of 333 m, transiting initially westward through central Eclipse Sound, then turning south in Milne Inlet North following the nominal shipping route to Milne Port. Upon arriving at Milne Port, the aircraft turned north to survey Koluktoo Bay, then transited eastward to the east side of Poirier Island before turning north and tracking along the eastern shore of Milne Inlet up to Ragged Island. The aircraft then crossed Milne Inlet and entered the north end of Tremblay Sound but had to abort this portion of the survey due to low cloud cover. The aircraft tracked back down the western shore of Milne Inlet to the south end of Stephens Island, returning north through central Milne Inlet following the nominal shipping to Eclipse Sound West, before proceeding into south Navy Board Inlet. Due to poor weather and low cloud cover in Navy Board Inlet, the plane turned back south into Eclipse sound and surveyed the areas north of Ragged Island and Curry Island before returning back to Pond Inlet via the south coast of Bylot Island (Figure 6). Historical entrapment areas in the RSA, including south of Bylot Island and north of Ragged Island, were covered during the survey.

No narwhal sightings were recorded during the 31 October survey. Two sightings of potential narwhal footprints were recorded, both in Eclipse Sound West north of Ragged Island. The aircraft circled over this area repetitively to confirm the sighting but no narwhal were observed (Figure 6). Other marine mammals recorded on 31 October included eight sightings of unidentified seals: three in western Eclipse Sound, four in central Milne Inlet near Stephens Island and one south of Ragged Island.

Results of the end of season aerial clearance survey confirm that no entrapments occurred in 2019 as a result of Project shipping.



LEGEND

POSSIBLE NARWHAL FOOTPRINTS

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

NARWHAL

- 1
- 2-9
- 10+

COMMUNITY

MILNE PORT

CLEARANCE SURVEY AERIAL TRACK

WATERCOURSE

MARINE MAMMAL REGIONAL STUDY AREA

WATERBODY

ICE CONCENTRATION

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

0 10 20

1:600,000 KILOMETRES

REFERENCE(S)

ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019 AND DECEMBER 13, 2019. GEOGRAPHIC NAMES, HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT - 2019 SHIP-BASED OBSERVER PROGRAM

CONSULTANT

GOLDER

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

TITLE
MARINE MAMMAL SIGHTINGS RECORDED DURING END OF SEASON CLEARACE AERIAL SURVEY - OCTOBER 30

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	38000	0	5

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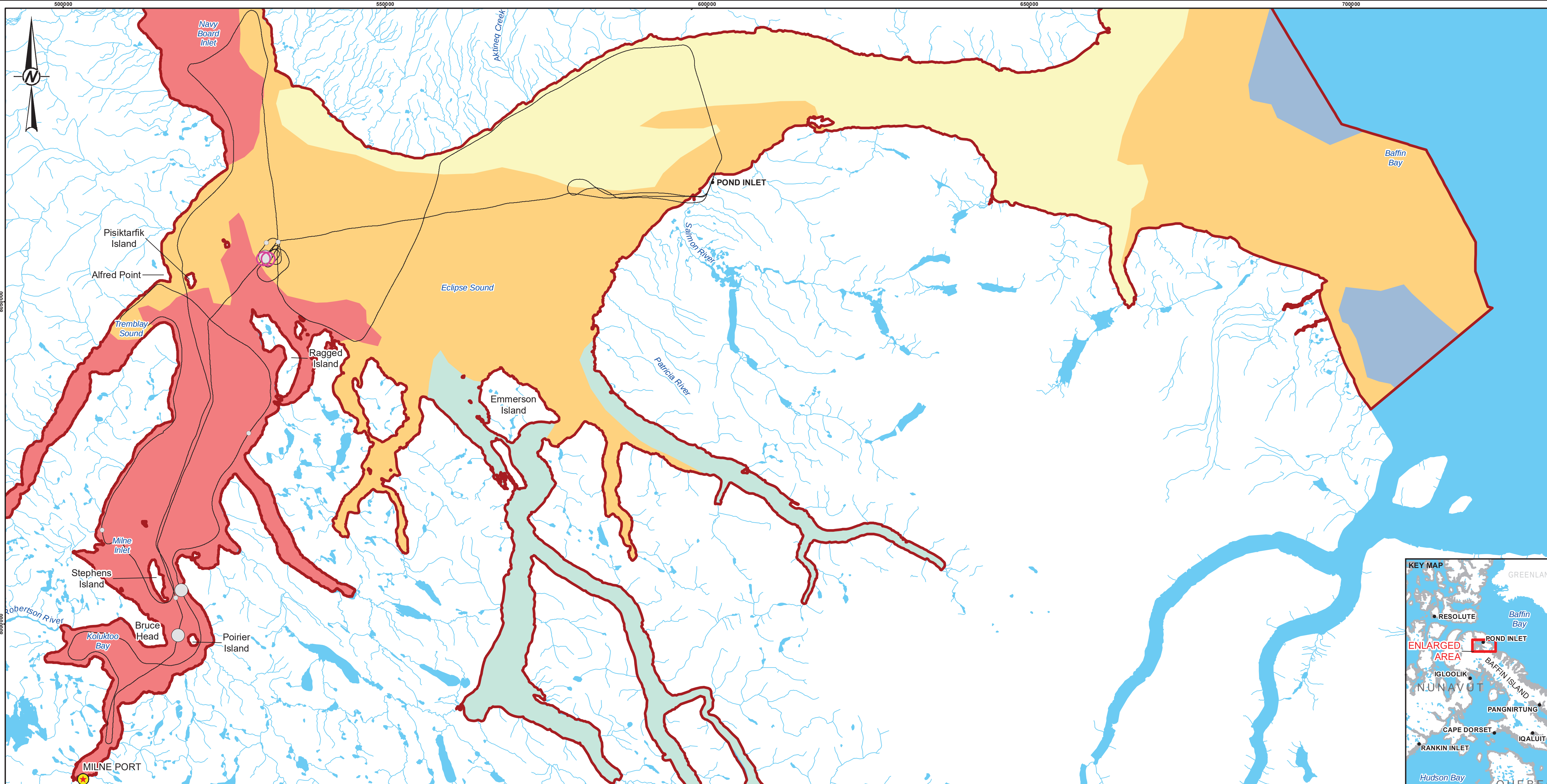

LEGEND

- NARWHAL FOOTPRINTS

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

UNIDENTIFIED SEAL

- 1
- 2-9

- COMMUNITY
- MILNE PORT
- CLEARANCE SURVEY AERIAL TRACK
- WATERCOURSE
- MARINE MAMMAL REGIONAL STUDY AREA
- WATERBODY

ICE CONCENTRATION

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

0 10 20
1:600,000 KILOMETRES

REFERENCE(S)
ICE CONCENTRATION OBTAINED FROM CANADIAN ICE SERVICE, GOVERNMENT OF CANADA. DAILY ICE CHARTS – APPROACHES TO RESOLUTE BAY. ACCESSED SEPTEMBER 19, 2019 AND DECEMBER 13, 2019. GEOGRAPHIC NAMES, HYDROGRAPHY, POPULATED PLACE, AND PROVINCIAL BOUNDARY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 17 DATUM: NAD 83

CLIENT
BAFFINLAND IRON MINES CORPORATION

PROJECT
MARY RIVER PROJECT - 2019 SHIP-BASED OBSERVER PROGRAM

CONSULTANT
GOLDER

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

TITLE
MARINE MAMMAL SIGHTINGS RECORDED DURING END OF SEASON CLEARACE AERIAL SURVEY - OCTOBER 31

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	38000	0	6

3.5 Inuit Researcher Feedback

Following the completion of the 2019 Aerial Survey Program, all Inuit Researcher participants were interviewed to garner feedback on the program, observations made in the field, and recommendations moving forward. Following is a summary of the feedback provided specific to this program:

- Ice was thin this year compared to other years.
- No narwhals last year. This year we saw them.
- One of the first surveys, saw narwhal following the ship coming through the ice.
- Aerial survey saw whales at the same places that hunter see them, but you can see more from the plane.
- Seal are everywhere; lots of seals out there. Number of seals are not down due to hunting or boating.
- One beluga seen in a group of 80-100 narwhal.
- 50 bowhead whales spotted; that was quite unexpected.
- Hard to tell if shipping activities have changed whale behaviour.
- When the ships had no speed limits, the narwhal would move away. When the ships have a speed limit, the narwhal aren't as afraid. The speed limit is good.
- Ore carriers are slow enough that they don't change the behaviour of the whales. Ships could go faster.
- Heard that ships were parked at the floe edge last year. No ships at the floe edge this year and the whales came in. Thinking this helped.
- Before the ships, narwhal used to the fill the whole fjord, but now with shipping they hug the shore.
- Cruise ships were going faster than the ore carriers.
- No narwhals around the ore carriers.

4.0 2019 BRUCE HEAD SHORE-BASED MONITORING PROGRAM

To investigate narwhal response to shipping noise and close ship encounters along a confined section of the Northern Shipping Route, the Bruce Head Shore-based Monitoring Program has been conducted annually (with the exception of 2018) since 2014, following a pilot project in 2013. This program was designed to specifically evaluate potential disturbance of marine mammals from shipping activities that may result in changes in animal abundance, distribution, and migratory movements within the RSA. This section presents a summary of the integrated results from the five-year monitoring program at Bruce Head, which substantiate the conclusions of the combined assessment of Project effects on marine mammals relative to Baffinland's Phase 2 Proposal (Section 7.0).

During the open water season of 2019, visual survey data were collected from a cliff-based observation platform overlooking the Northern Shipping Route to investigate potential narwhal response to shipping activities, with information collected on relative abundance and distribution (RAD), group composition, and behaviour of narwhal (Figure 7). Additional data were collected on environmental conditions and anthropogenic activities (e.g., shipping and hunting activities) to distinguish between the potential effects of Project-related shipping activities and confounding factors that may also affect narwhal behaviour. A detailed description of data collection and analytical methodology for the 2019 Marine Mammal Aerial Survey Program is provided in Golder (2019a; 2020c).