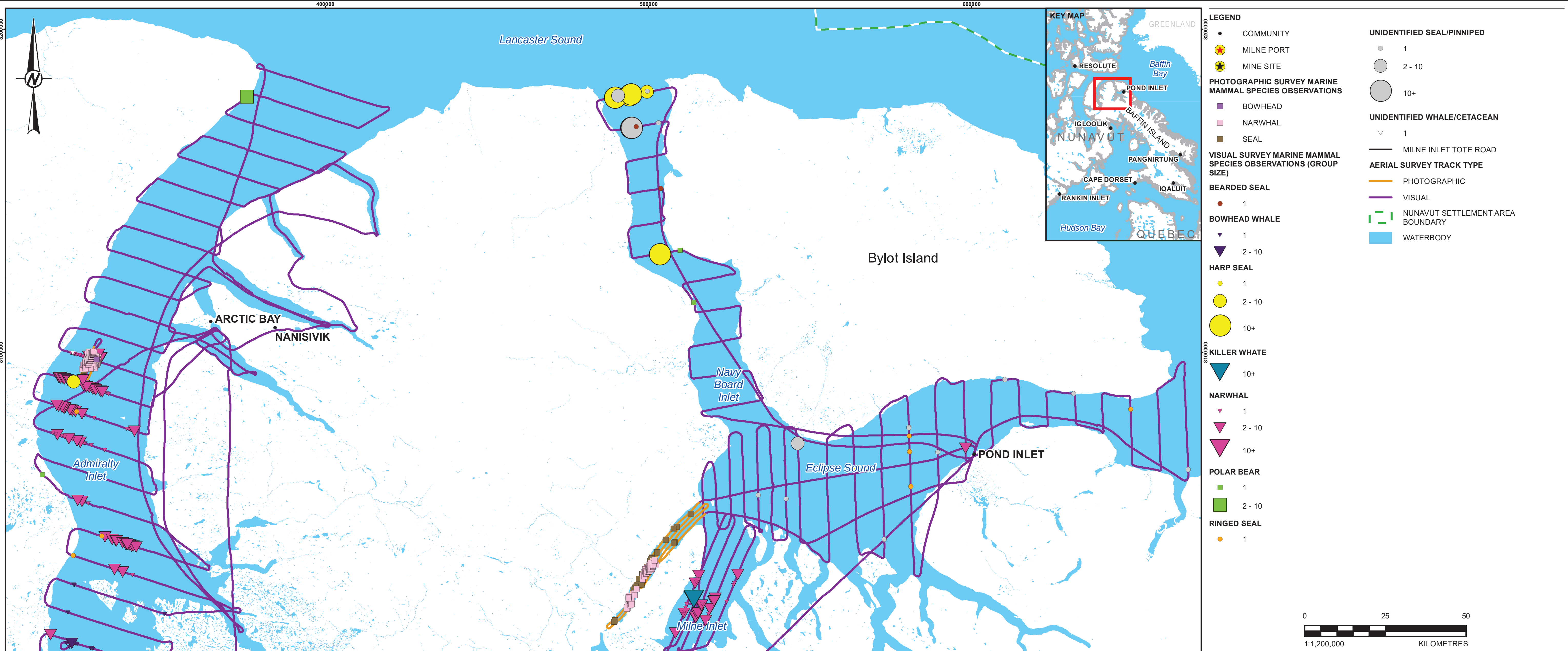


NOTE(S)

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

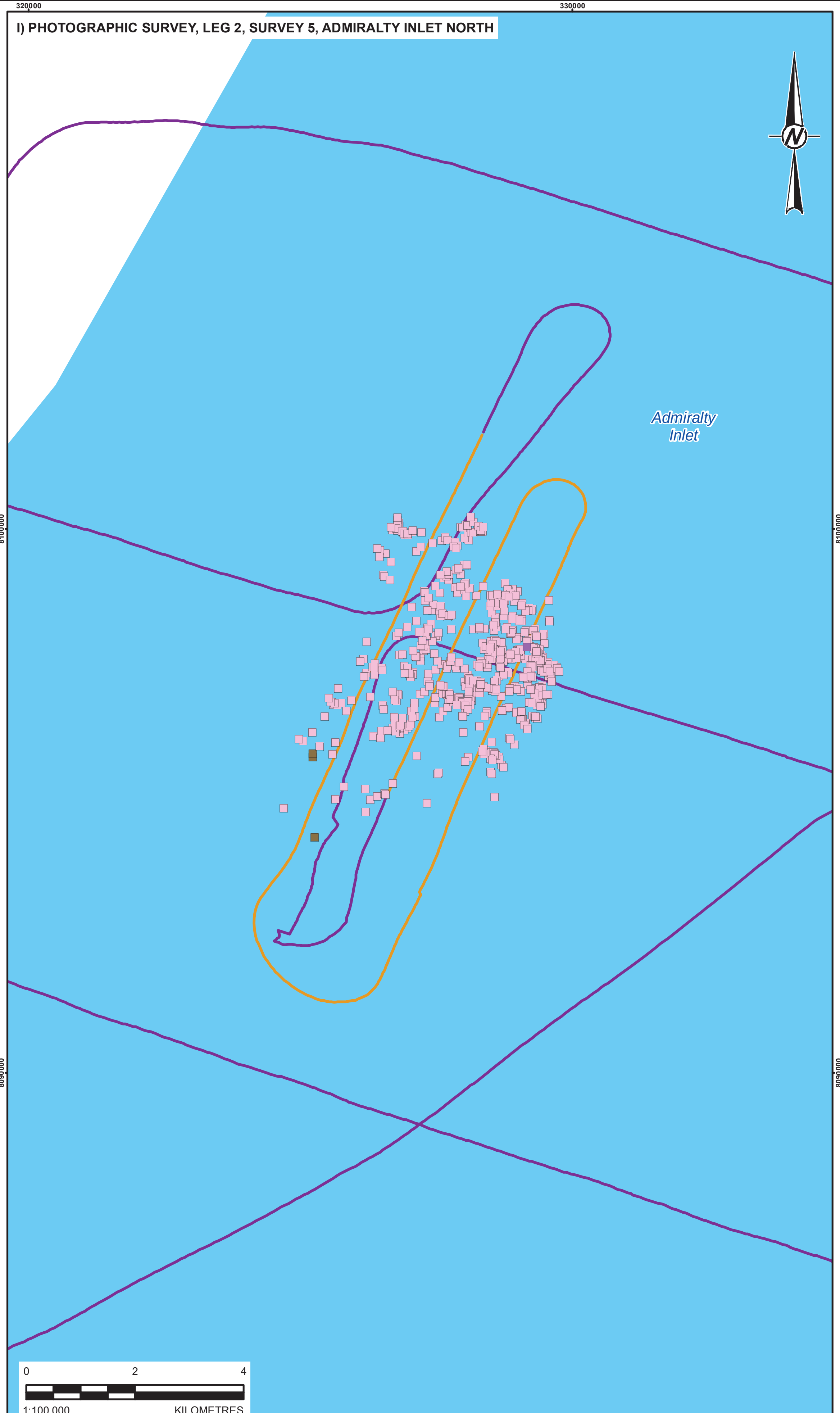
PROJECT
MARY RIVER PROJECT

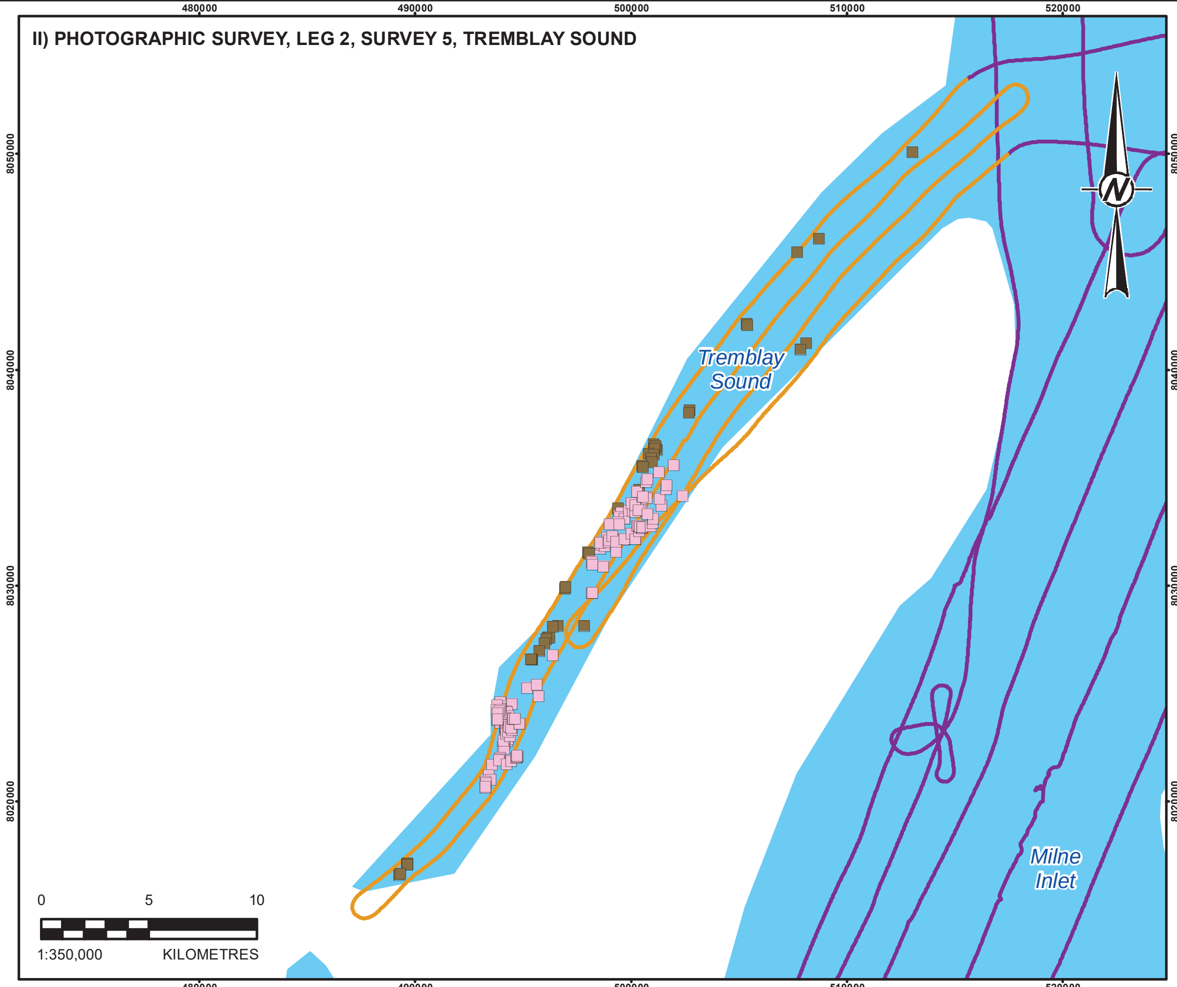
TITLE
DISTRIBUTION OF MARINE MAMMAL SPECIES DURING LEG 2, SURVEY 5 ON AUGUST 29-30, 2019 IN THE ECLIPSE SOUND AND ADMIRALTY INLET GRIDS

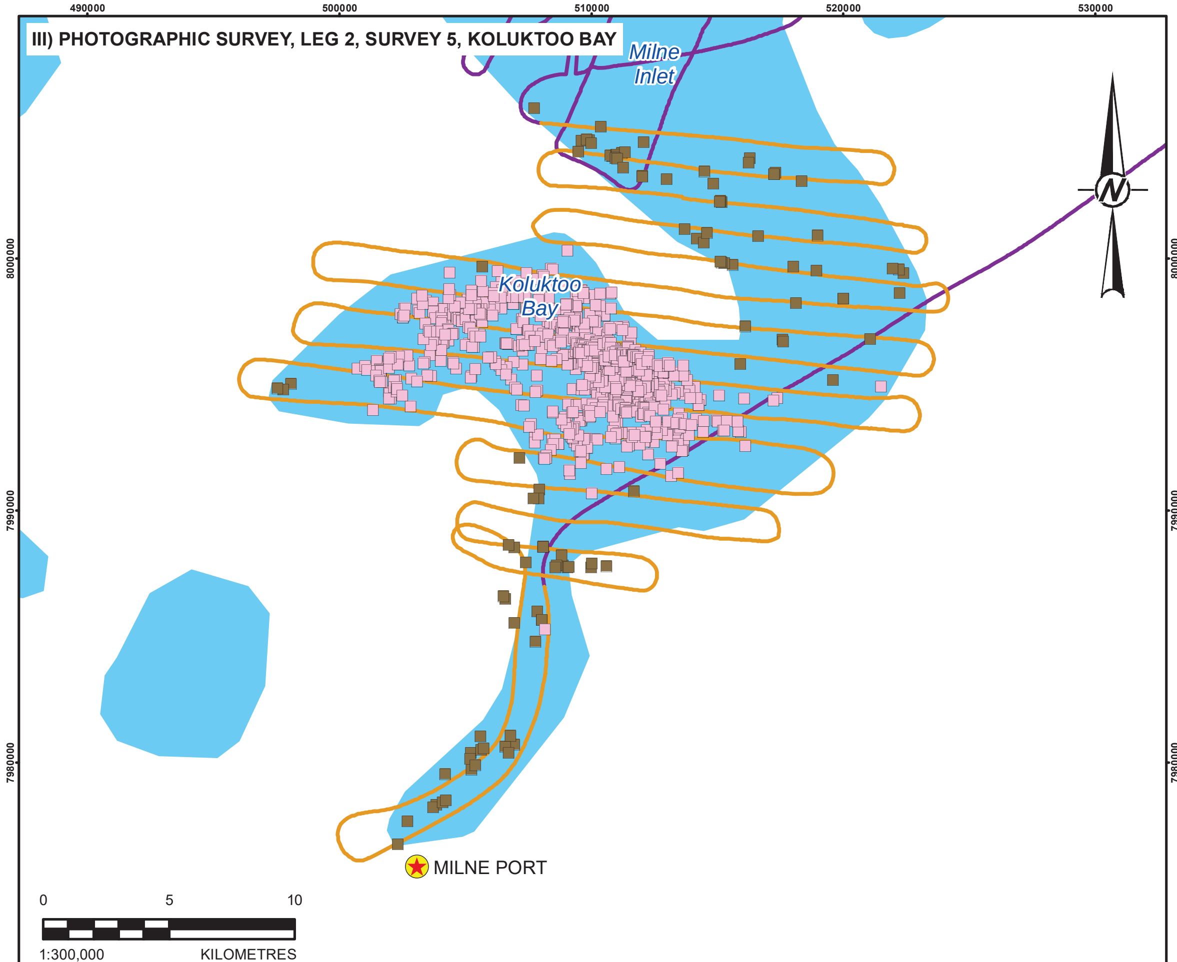
CONSULTANT
GOLDER

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

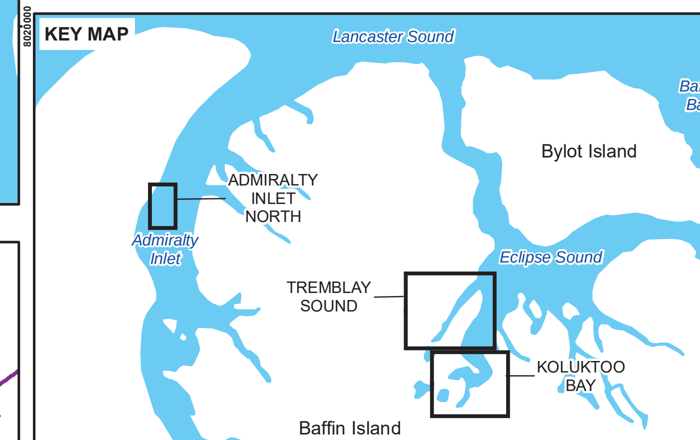
- COMMUNITY
- MILNE PORT

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.

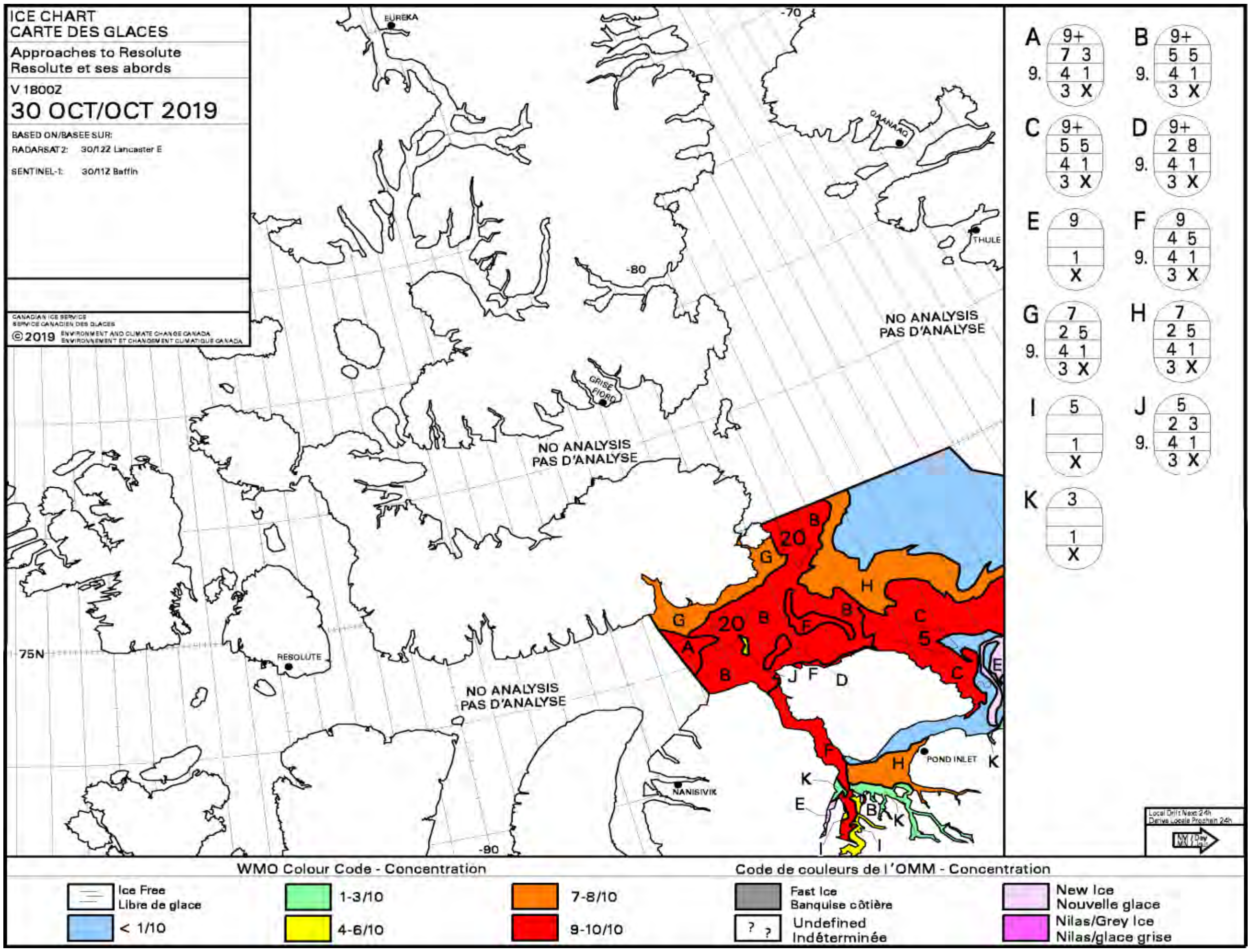


Figure 4: Canadian Ice Service chart for 30 October showing ice concentrations in Eclipse Sound and Milne Inlet.

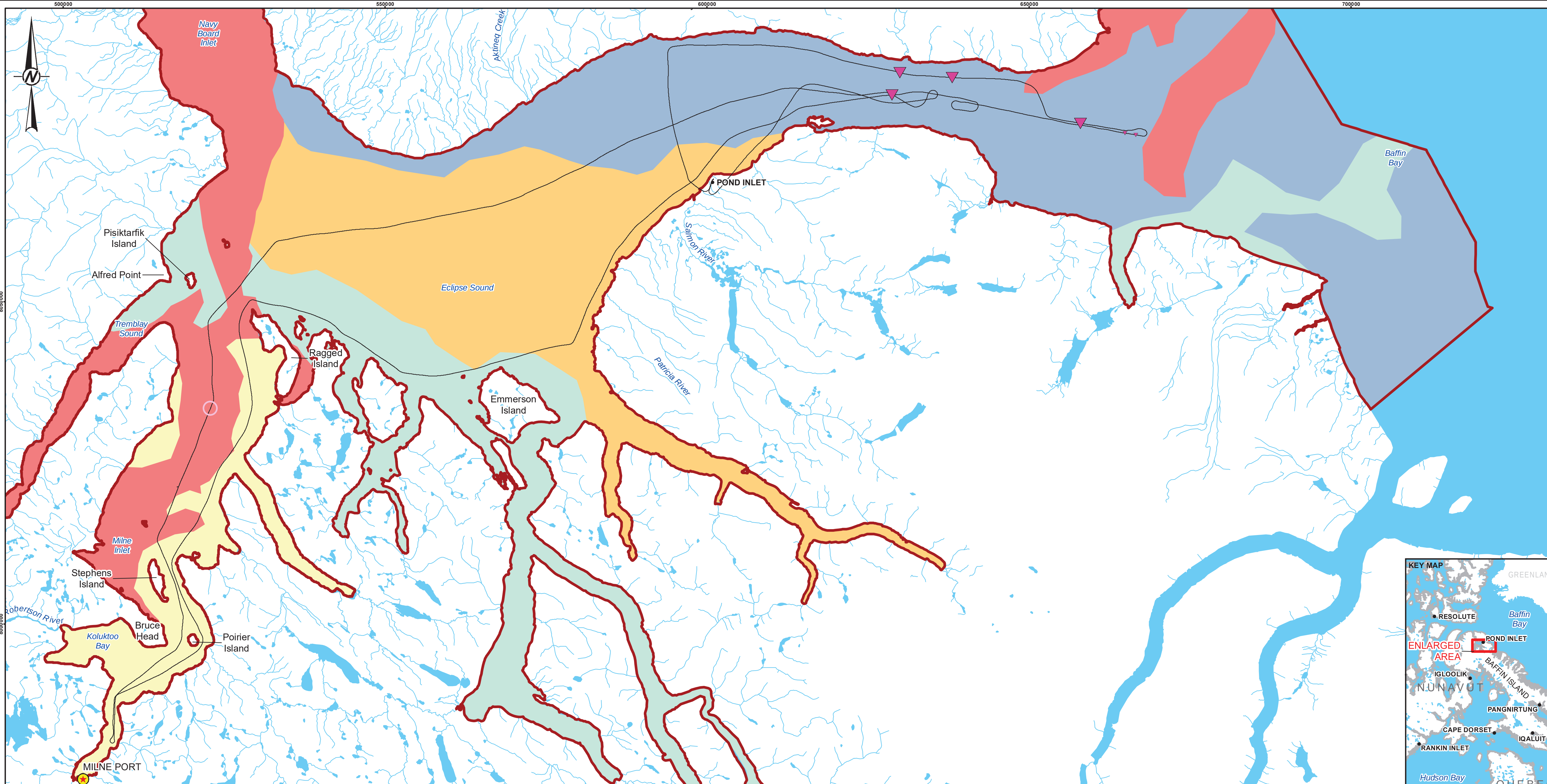
The first clearance survey was flown on 30 October, corresponding with the last icebreaker transit out of the RSA (while escorting a single ore carrier). At the time of the aerial survey, the icebreaker was located east of Pond Inlet transiting eastward toward Baffin Bay. Total aerial survey effort on 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
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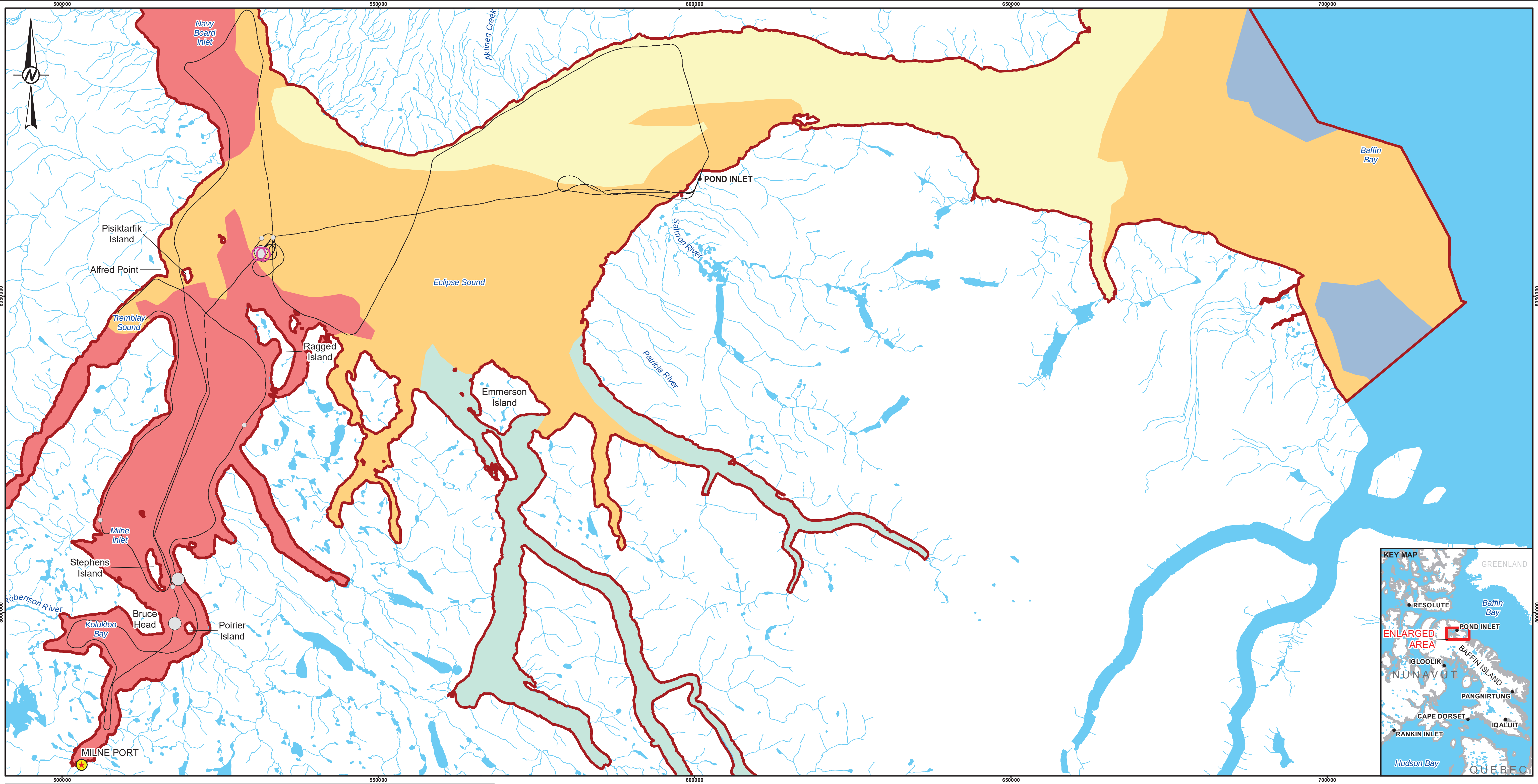


LEGEND

○	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

PATH: I:\2016\1663724\Mapping\MXD\38000_MM_Monitoring_TechMemo\1663724_38000_Fig06_SBO_ClearanceSurvey_Oct31_Rev0.mxd PRINTED ON: 2020-05-08 AT: 4:49:42 PM

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

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).

Figure 7: Inuit researcher Ryan Arnakallak recording survey data on narwhal at the observation platform.

4.1 Summary of Results

A total of 285 RAD surveys were completed over the course of 26 days between 6 August and 1 September 2019. A summary of the 2019 RAD data, compared to that collected from 2014 to 2017, is included in Table 5. Similar to previous years, narwhal were the most common species recorded at Bruce Head in 2019, followed by ringed seal and bearded seal. Less common species sightings recorded during 2019 included killer whale (multiple sightings), bowhead whale (*n*=1), beluga (*n*=2), and polar bear (*n*=2, observed on opposite shore). The total number of narwhal sightings (corrected for effort) in 2019 was shown to be comparable to that reported in previous survey years, including from baseline monitoring conducted in 2014, prior to the start of shipping operations in the RSA (Table 5; Golder 2019a, 2019c; 2020c).

Table 5. Relative Abundance and Distribution (RAD) surveys at Bruce Head (2014–2019)

Statistic	Survey Year				
	2014	2015	2016	2017	2019
Survey dates	3 Aug–5 Sept	29 July–5 Sept	30 July–30 Aug	31 July–29 Aug	6 Aug–1 Sept
No. of active survey days	23	29	27	26	26
No. of survey days lost to weather	14	9	11	2	0
No. of observer hours (total)	103.2	148.7	159.3	97.3	139.3
Average daily survey effort (No. of RAD surveys)	7.8	10.8	11.9	6.2	11.0
No. of attempted RAD surveys	179	314	321	160(1)	289
No. of complete RAD surveys	166	313	311	109	285
Number of RAD surveys with zero narwhal counts	74	164	127	35	88
No. of narwhal sightings	**10,463**	**14,599**	**28,309**	**11,831**	**14,680**
No. of narwhal excluding ‘impossible’ sightability, standardized by effort (narwhal / h)	**101.4**	**98.2**	**178.0**	**121.8**	**107.6**
No. of ship transits during RAD effort	7	11	21	22	32

(1) = one survey out of the total 160 surveys was omitted from due to high chance of double-counting animals. All other values shown for 2017 in this table exclude this survey.

Daily standardized counts of narwhal in the Stratified Study Area (SSA) in 2019 ranged from zero narwhal/h (on 16, 23, and 28 August) to 360 narwhal/h on 15 August (Figure 8). The annual median value of daily standardized counts in 2019 (79.2 narwhal/h) was higher in 2019 than most previous years with the exception of 2017, whereas the annual mean value (105.6 narwhal/h) was lower in 2019 than most previous years with the exception of 2015.

Based on narwhal group size data recorded in the Behavioural Study Area (BSA), a total of 1,373 groups were recorded in 2019 with a mean group size of 3.7 narwhal/group (Figure 9). In comparison, 2014-2016 surveys resulted in records of only 250-761 groups, whereas 2017 surveys resulted in records of 2,424 groups. Mean annual group sizes in previous years ranged from 3.3 narwhal/group in 2016 to 4.34 narwhal/group in 2014.

These results suggest that, despite year over year increases in shipping in the RSA, narwhal continue to use the Bruce Head area and that relative narwhal abundance in this area, inferred from sighting rate (narwhal/h), remained consistent with pre-shipping (2014) levels. These results supported impact predictions made in the FEIS Addendum for the Early Revenue Phase (ERP), indicating that the Project is unlikely to result in significant residual adverse effects on narwhal in the RSA, defined as effects that compromise the integrity of the population either through mortality or via large-scale displacement or abandonment of the RSA

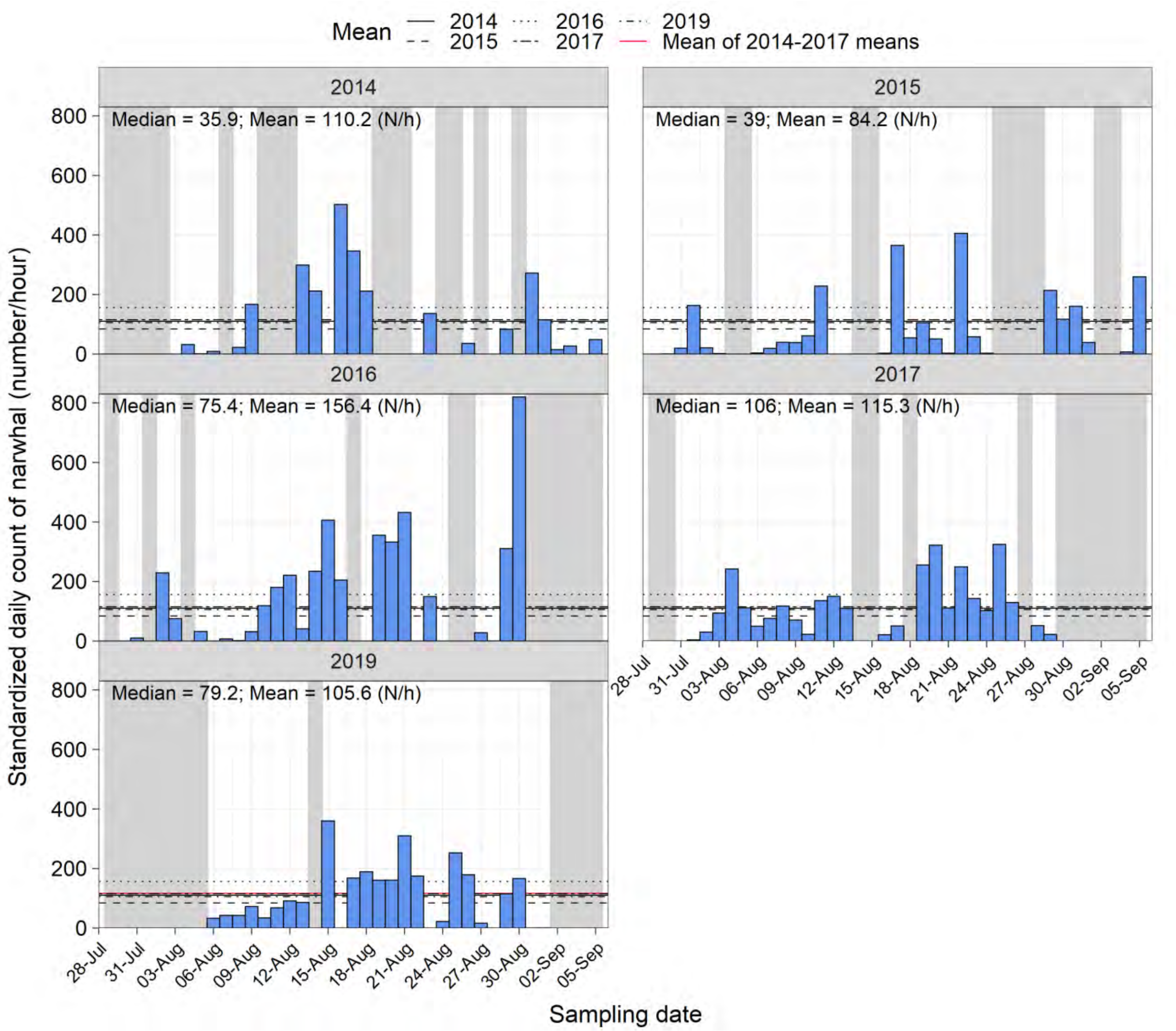


Figure 8: Standardized daily count of narwhal (animals/h) in SSA during RAD Surveys (2014-2019). Note: Grey shaded background represents days where no surveys occurred.

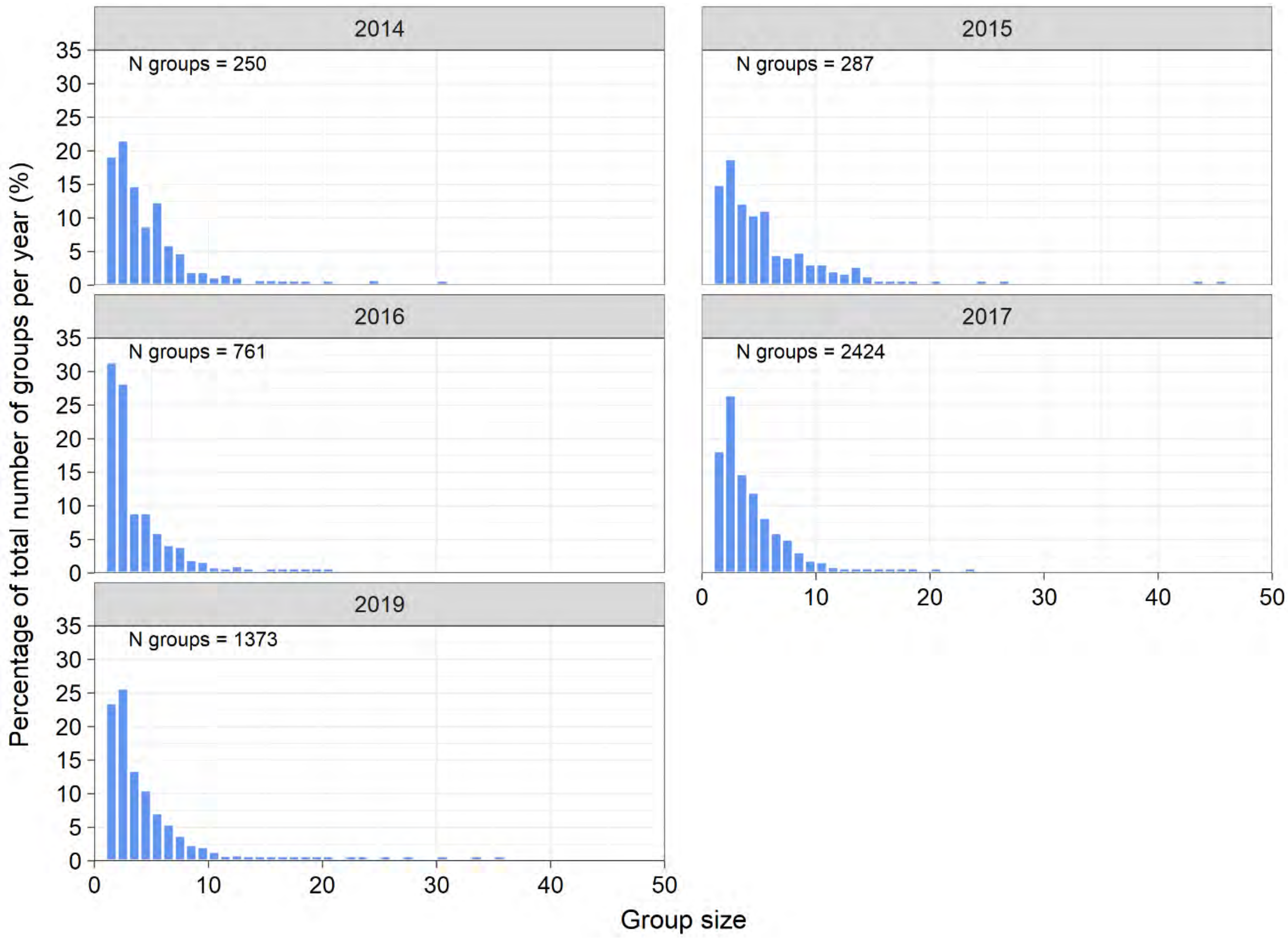


Figure 9: Group size and number of groups observed during narwhal counts in BSA (2014-2019).

Group Composition

A qualitative assessment of group composition by life stage recorded in 2019 indicated an overall similar group composition to previous years, with the majority of the sightings consisting of adult whales, followed by the yearling/juvenile category, followed by calves (Figure 10). Similar to previous years, both calves and yearlings were observed during most sampling days, with only two days (15 and 28 August 2019) with no calves or yearlings recorded. In 2019, the daily proportion of calves (relative to total narwhal counts) ranged between 0% (on 15 and 28 August) and 19% (on 9 August 2019). In previous years, mean annual percentage of calves ranged between 0% (in all years) and 23-50% (23% in 2014 and 50% in 2017). Annual mean values in 2019 (11.2%) were higher than all previously estimated annual means (2014=10.7%, 2016=9.7%, 2017=7.7%), except for 2015 when a mean annual value of 14% was recorded. The mean proportion of calves recorded in 2019 suggested that calf presence (calving success) at Bruce Head was occurring at a rate consistent with pre-shipping conditions, despite year-over-year increases in shipping in the RSA. These results supported impact predictions made in the FEIS Addendum for the ERP indicating that the Project is unlikely to result in significant residual adverse effects on narwhal in the RSA (those resulting in potential population-level effects).

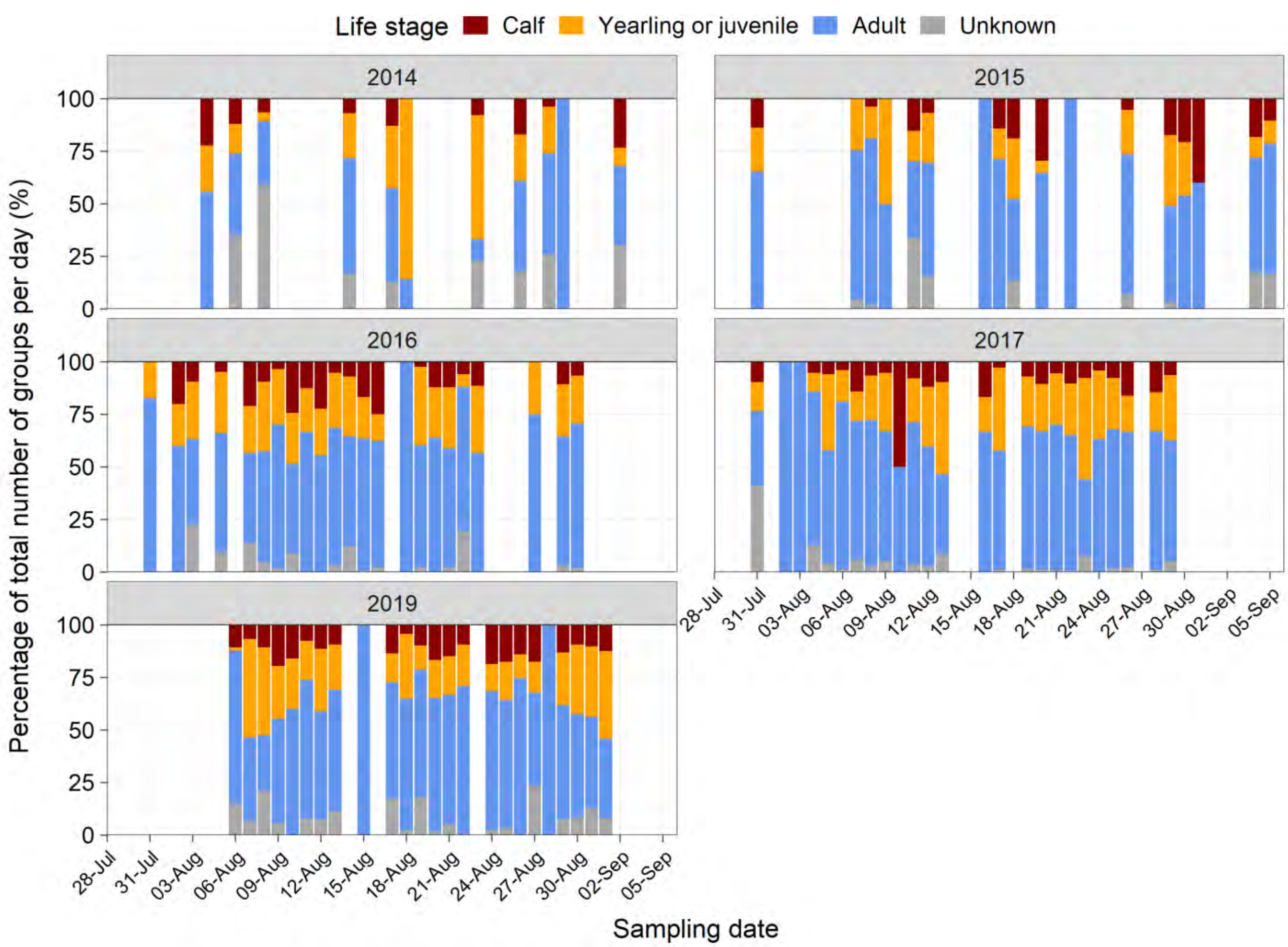


Figure 10: Daily recorded group composition during narwhal counts in BSA (2014-2019).

The following is a summary of key findings pertaining to narwhal behavioral response to vessel traffic and vessel noise based on five years of shore-based visual survey data collected at Bruce Head between 2014 and 2019:

Relative Abundance and Distribution

- The overall relative abundance of narwhal in the SSA, inferred from sighting rate (no. of narwhal per hour - corrected for effort), has remained relatively constant between 2014 and 2019 despite a gradual increase in iron ore shipping along the Northern Shipping Route during this period. Narwhal numbers in the RSA were shown to be comparable to baseline levels documented during the 2014 Bruce Head Monitoring Program, which took place prior to the start of iron ore shipping in the RSA. These findings are consistent with results from Baffinland's other narwhal monitoring programs demonstrating that the Bruce Head area continues to support high narwhal densities compared to other areas in the RSA (Elliott et al. 2015; Thomas et al. 2015; Golder 2020a; Golder 2020b).
- Within each study year, a likely but uncertain effect of vessel exposure on narwhal relative abundance in the study area (SSA) was observed. Specifically, vessel exposure was shown to result in a significant decrease in narwhal sightings in the SSA compared to when no vessels were present, but only when narwhal were exposed to vessels travelling north and away from the study area, and only at close exposure distances of 2-3 km. **These results suggest that the relative abundance of narwhal is influenced by vessel traffic at close distances, although the exact spatial extent of this effect could not be determined due to high data variability.**

Group Composition and Behavior

- Group Size: None of the effects of shipping (distance from vessel, vessel direction, vessel orientation relative to the Behavioural Study Area or BSA) on narwhal group size were shown to be statistically significant ($P>0.2$ for all effects). **These results suggest that narwhal neither congregate into larger groups nor fragment into smaller groups in response to vessel exposure.**
- Group Composition:
  - All narwhal life stage categories (adult females, adult males, yearlings/juveniles and calves) were recorded in the BSA throughout the five sampling years. The daily proportion of calves/yearlings recorded in the BSA (relative to the total number of narwhal observed per day) was higher in 2019 (annual mean of 11.2%) than all previous years (2014=10.7%, 2016=9.7%, 2017=7.7%), with the exception of 2015 (14%). This suggests that calving success at Bruce Head in 2019 is consistent with pre-shipping levels, despite year-over-year increases in shipping in the BSA.
  - Vessel traffic was shown to have a significant effect on group composition relative to calf/yearling presence (i.e., a significant interaction was observed between 'vessel distance', 'vessel direction' and 'vessel orientation relative to BSA'). Results suggest that the proportion of groups with calves/yearlings was similar between all four vessel traffic scenarios (i.e., vessel transiting toward/away BSA, vessel transiting southbound/northbound), but generally increased during close vessel encounters.
  - **Collectively, these results suggest that narwhal group composition did not significantly change between study years despite an increase in shipping activity during this period, but the proportion of groups with calves/yearlings was generally higher during close vessel encounters (although it is unknown whether this specific effect was significant).**

- Group Spread: Narwhal groups were more often observed in tight associations compared to loose associations under both vessel presence and vessel absence scenarios. In general, group spread did not significantly change during vessel-exposure events. However, loosely spread groups were less common when vessels headed away from the BSA (32% for northbound vessels and 30% for southbound vessels) than when vessels were heading toward the BSA (38% for northbound vessels and 32% for southbound vessels). **These results suggest that narwhal group spread did not significantly change during vessel exposure events.**

- Group Formation: Narwhal groups were most often observed in parallel formation under both vessel presence and vessel absence scenarios. A possible but uncertain effect of vessel distance on narwhal group formation was evident that depended on vessel direction, with the most consistent effect suggested for southbound vessels moving away from the BSA. However, none of the shipping-related variables were statistically significant. **These results suggest that narwhal group formation did not significantly change in the BSA during vessel exposure events; however, the detection power for this response variable was low.**

- Group Direction: Vessel traffic was shown to have a significant effect on travel of narwhal groups in the BSA (i.e., a significant interaction was observed between ‘vessel distance’, ‘vessel direction’ and ‘vessel orientation relative to BSA’ although the effect on travel direction was shown to be variable). Narwhal groups were predominantly observed traveling south through the BSA. Southbound travel was least common when southbound vessels were headed away from the BSA, and most common when northbound vessels were headed away from the BSA. **These findings suggest that narwhal groups may experience some level of avoidance behaviour in the wake of vessels transiting through Milne Inlet (i.e., narwhal groups appear to avoid “following” vessels) but that travel direction by narwhal groups is relatively less affected during the approach of vessels.**

- Travel Speed: The majority of the observed narwhal groups travelled at a medium speed, regardless of vessel exposure conditions. A lack of statistical significance of any of the vessel-related variables (vessel distance, vessel travel direction, vessel orientation relative to BSA) indicates that the effect of vessel exposure on narwhal travel speed was not detected. The nature of the data for fast-travelling groups was not adequate to test for the effect of vessel exposure on increased travel speed in the BSA. **These results suggest that narwhal did not decrease their travel speed or demonstrate a ‘freeze’ response during vessel exposure events.**

- Distance from Bruce Head Shore: Narwhal groups were observed more often within 300 m of the Bruce Head shore under both vessel presence and vessel absence scenarios. Offshore groups (>300 m) were detected less frequently with increasing Beaufort scale values, suggesting a decreased detection ability at distance with deteriorating sea state. Furthermore, vessel traffic was shown to result in a significant decrease in ’distance from shore’ (i.e., significant interaction was between ‘vessel distance’, ‘vessel direction’ and ‘vessel orientation). This effect appeared to be largely attributed to vessel traffic moving toward the BSA. **The results suggest that narwhal swim closer to shore when in close proximity to vessels moving toward the BSA.**

Overall, results from this five-year shore-based monitoring study support impact predictions made in the Final Environmental Impact Statement (FEIS) for the Early Revenue Phase (ERP), in that ship noise effects on narwhal will be limited to localized avoidance behaviour, consistent with low to moderate severity responses (Southall et al. 2007; Finneran et al. 2017). No evidence was observed of large-scale avoidance behaviour, displacement effects, or abandonment of the summering grounds (high severity responses), which might in turn result in a population or stock-level consequence (consistent with the definition of a non-significant effect used in the FEIS).

4.2 Inuit Researcher Feedback

Following the completion of the 2019 Bruce Head Monitoring 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:

- The observation location is good because the narwhal travel to Koluktoo Bay.
- Narwhal didn't mind the ships. They are getting used to it.
- When doing RAD counts, didn't see narwhal leaving the shipping lane when a ship would come through.
- Didn't notice narwhal diving when shipping activity came through.
- This habituation was also seen from the Nanisivik area according to one observer's grandfather.
- The ship would have to be closer to the narwhal by one ship length before they would change behaviour.
- Narwhal react to ships like when they are hunted, then they calm down once the ship has passed.
- Probably not seeing the effects of shipping right now but they will become more apparent later.
- Not worried that narwhal would be hit by ships.
- Narwhals move closer to shore early in the shipping season and then are less affected later.
- Narwhal would avoid the area at the point when hunters were there.
- Hunting by humans and hunting by killer whales have more of an impact of whales than shipping.
- Seals are pretty much everywhere. Saw killer whales, but not bowhead whales.
- Seals aren't disturbed by ships, focus more on narwhal.
- The whales did not react to the helicopters or planes.

5.0 2019 PASSIVE ACOUSTIC MONITORING (PAM) PROGRAM

This section provides a summary of underwater sound levels measured during icebreaking operations during the shoulder season and shipping operations during the open-water period of 2019, to support an updated assessment of acoustic impacts (injury, disturbance and masking effects) on marine mammals relative to Baffinland's Phase 2 Proposal (Section 7.0). These results were analyzed and interpreted relative to the scale of acoustic impacts that were predicted through acoustic modelling assessments for the ERP (Baffinland 2013) and the Phase 2 Proposal (Golder 2019b; 2019e). This section includes information prepared in response to Final Written Submission DFO Comment 3.7.2 (October 2019) and updated Final Written Submission (January 2020) DFO Comment 3.3.1, in which DFO recommended that Baffinland estimate the extent of listening range reduction (LRR) associated with the proposed increased transits, considering different areas of the RSA including Milne Inlet and Eclipse Sound.

In 2019, JASCO Applied Sciences (JASCO) deployed Autonomous Multichannel Acoustic Recorders (AMARs) (i.e., acoustic monitoring stations) at five locations in Eclipse Sound and Milne Inlet. The purpose for these recorders was to document underwater noise levels along the shipping corridor, to monitor marine mammal presence along the shipping corridor near Bruce Head and in Koluktoo Bay, and to compare measured (actual) ship noise levels to estimated ship noise levels determined through underwater noise modelling undertaken in support of the FEIS Addendum for the Phase 2 Proposal. Three AMARs (AMAR-1, AMAR-2, AMAR-3) were deployed in Milne Inlet South (Table 6; **Figure 11**) over a two-month period (August–September 2019) to collect acoustic data during the open water season, concurrently with visual observer data collected as part of the Bruce Head Shore-based Monitoring Program. An additional two AMARS were deployed along the nominal shipping route in Eclipse Sound, near Ragged Island (AMAR-RI) and south of Bylot Island (AMAR-BI) in May 2019 to record icebreaker and ore carrier noise during vessel transits in Eclipse Sound. The recorder near Bylot Island was only deployed for the spring shoulder season (28 days); the recorder near Ragged Island remained in place throughout the 2019 open water season (85 days total). Both of these recorders were redeployed at the end of the open water season to record sounds during the Fall 2019 and Spring 2020 shoulder seasons.

A description of the data collection and analytical methodology for the 2019 Passive Acoustic Monitoring Program is provided in Frouin-Mouy et al. (2020).

Table 6. AMAR acoustic recorder deployment periods, locations and depths in 2019

Station	Latitude	Longitude	Depth (m)	Deployment Date	Recording Start Date	Retrieval Date	Recording Duration (days)
AMAR−1	72.02756	-80.64772	190	5 Aug 2019	5 Aug 2019	28 Sep 2019	55
AMAR−2	72.07000	-80.75969	202.5	5 Aug 2019	5 Aug 2019	28 Sep 2019	55
AMAR−3	72.06717	-80.51808	223.5	5 Aug 2019	5 Aug 2019	28 Sep 2019	55
AMAR−RI1	72.55747	-80.20761	120	20 May 2019	7 Jul 2019	4 Aug 2019	28
AMAR−RI2	72.55803	-80.20856	121.5	4 Aug 2019	4 Aug 2019	29 Sep 2019	57
AMAR−BI	72.72328	-79.21328	330	21 May 2019	7 Jul 2019	4 Aug 2019	28

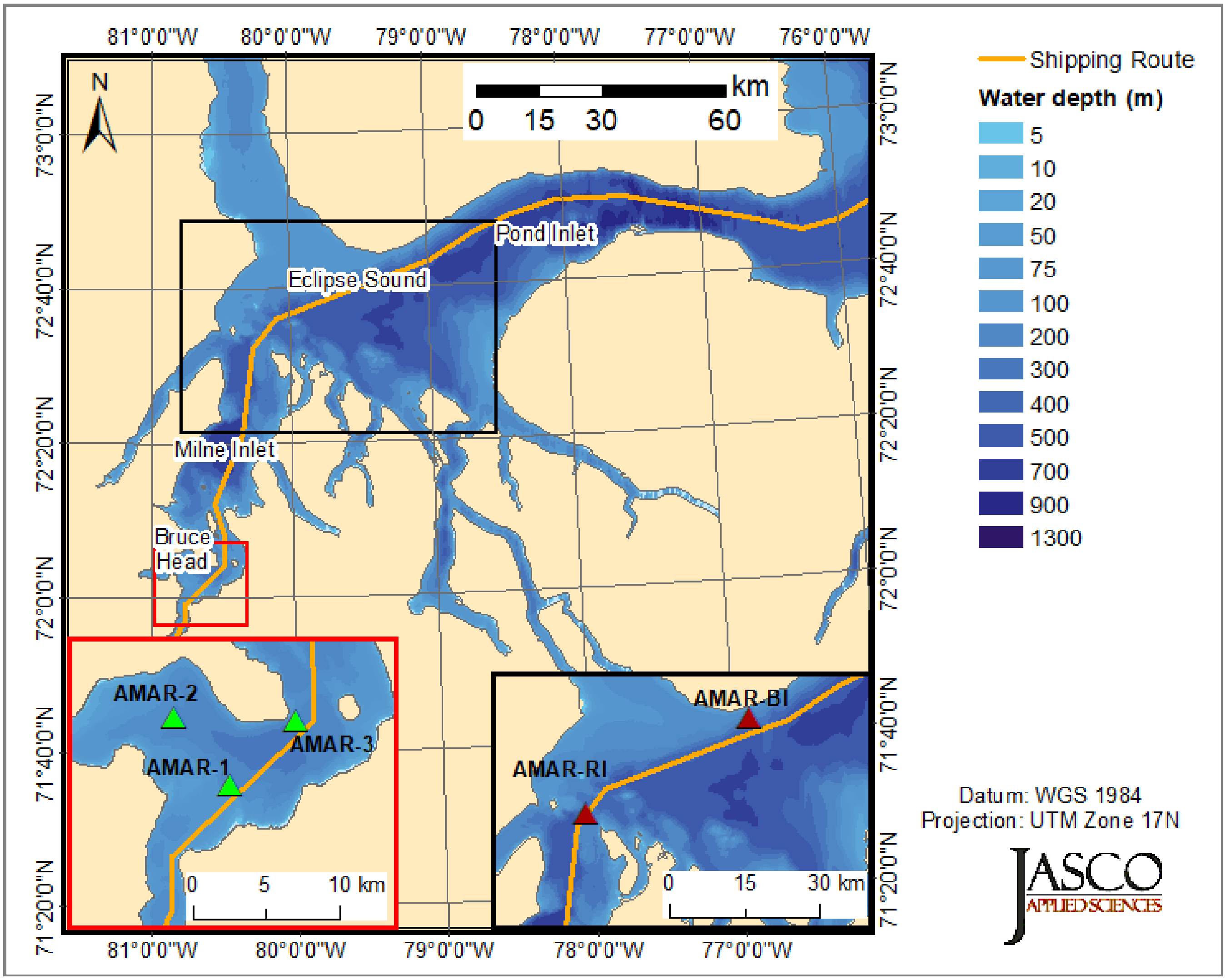


Figure 11: Acoustic monitoring area and locations of recorder stations across Milne Inlet South (red inset, AMAR-1, AMAR-2, AMAR-3), Milne Inlet North (black inset, AMAR-RI), and Eclipse Sound (black inset, AMAR-BI)

5.1 Summary of Results

5.1.1 Sound Levels during Early Shoulder Season

5.1.1.1 Sound Pressure Level (SPL)

The results of the ambient analyses for the early shoulder season (07 Jul to 04 Aug 2019) are shown in Table 7 and Figure 12 through Figure 14 for the Bylot Island (AMAR-BI) and Ragged Island (AMAR-RI) recording stations. Both AMAR stations showed an increase in Sound Pressure Level (SPL) for frequencies under 1,000 Hz over the month of recording. This increase was largely attributed to the increase in vessel traffic, weather, and wave induced noise at these locations due to decreasing ice presence and the beginning of the shipping season. The two AMAR stations were located on the nominal shipping route in Milne Inlet North and in Eclipse Sound.

AMAR-RI had overall higher sound levels than AMAR-BI, likely due to AMAR–RI's shallower deployment location (120 m at Ragged Island compared to 330 m at Bylot Island). AMAR–RI would have been exposed to a greater amount of vessel, flow, and surface sounds. Curves showing empirical distribution functions, or SPL exceedance percentages, are shown in Figure 15. These curves show that 98.1% and 98.6% of the data were below 120 dB re 1 µPa at AMAR-RI and AMAR-BI, respectively. That is, sound levels recorded AMAR-BI and AMAR-RI exceeded the 120 dB disturbance threshold (NOAA 1998[1]) for only 1.4% and 1.9% of the recording periods, respectively.

Table 7: Broadband sound pressure level (SPL) values for AMAR-RI at Ragged Island and AMAR-BI near Bylot Island during early shoulder season shipping.

Station	Min broadband SPL (dB re 1 µPa)	Max broadband SPL (dB re 1 µPa)	Mean broadband SPL (dB re 1 µPa)
AMAR-RI	80.2	151.3	102.2
AMAR-BI	83.9	141.7	99.7

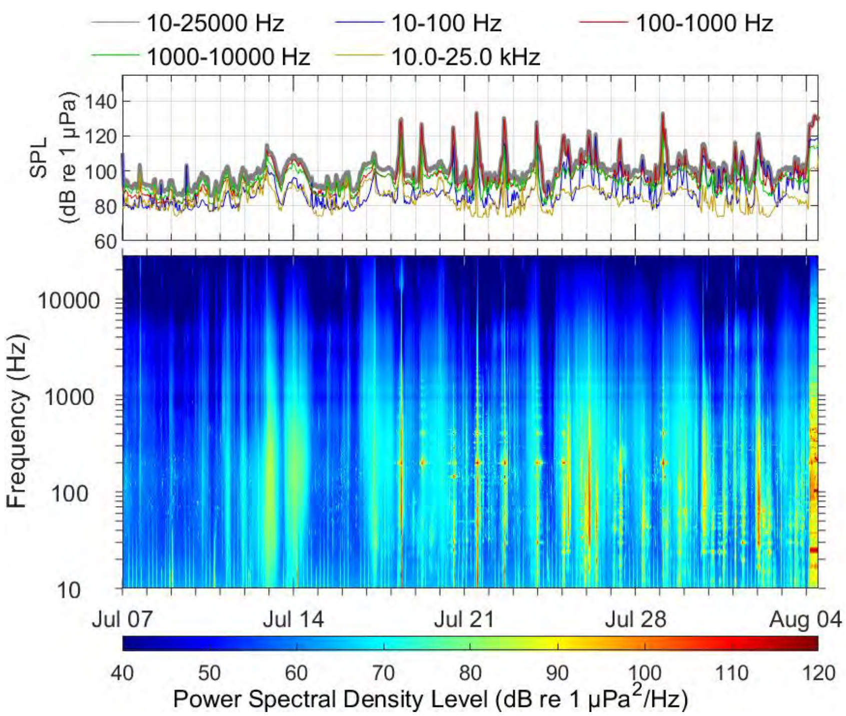


Figure 12: AMAR-BI during early shoulder season: Spectrogram (bottom) and in-band sound pressure level (SPL) (top). Vessel transits associated with the Project commenced on 17 July 2019. Sharp peaks in the SPL time series indicate vessel transits past the recorder.

[1] This criterion, defined as when broadband SPL exceeds 120 dB re 1 µPa, is the current disturbance threshold used by NOAA for assessing disturbance to marine mammals by continuous-type sounds such as vessel noise.

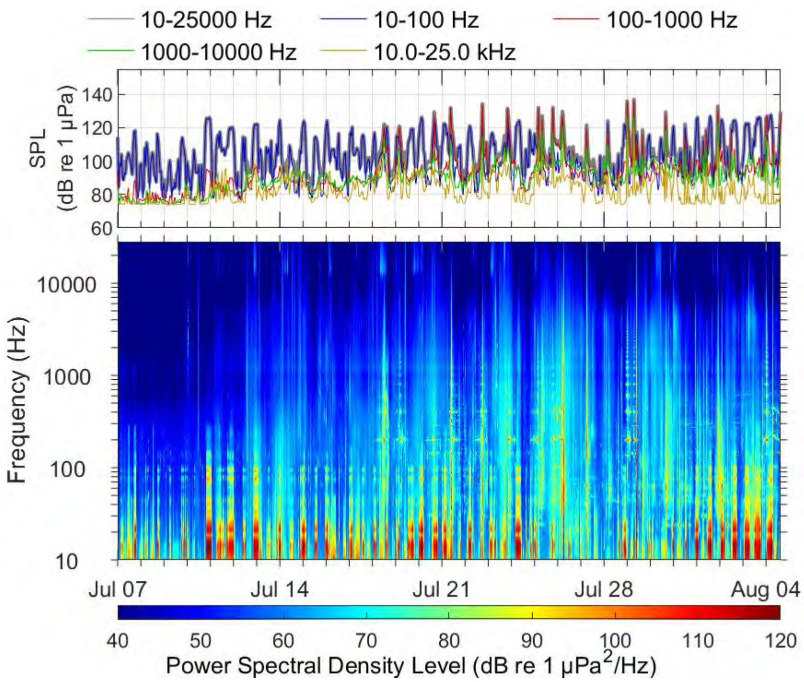


Figure 13: AMAR-RI during early shoulder season: Spectrogram (bottom) and in-band sound pressure level (SPL) (top). Vessel transits associated with the Project commenced on 17 July 2019. Sharp peaks in the SPL time series that indicate vessel transits past the recorder are most identifiable in the 1000-10000 Hz band that is less impacted by flow noise at this recorded that is dominant in the 10-100 Hz band.

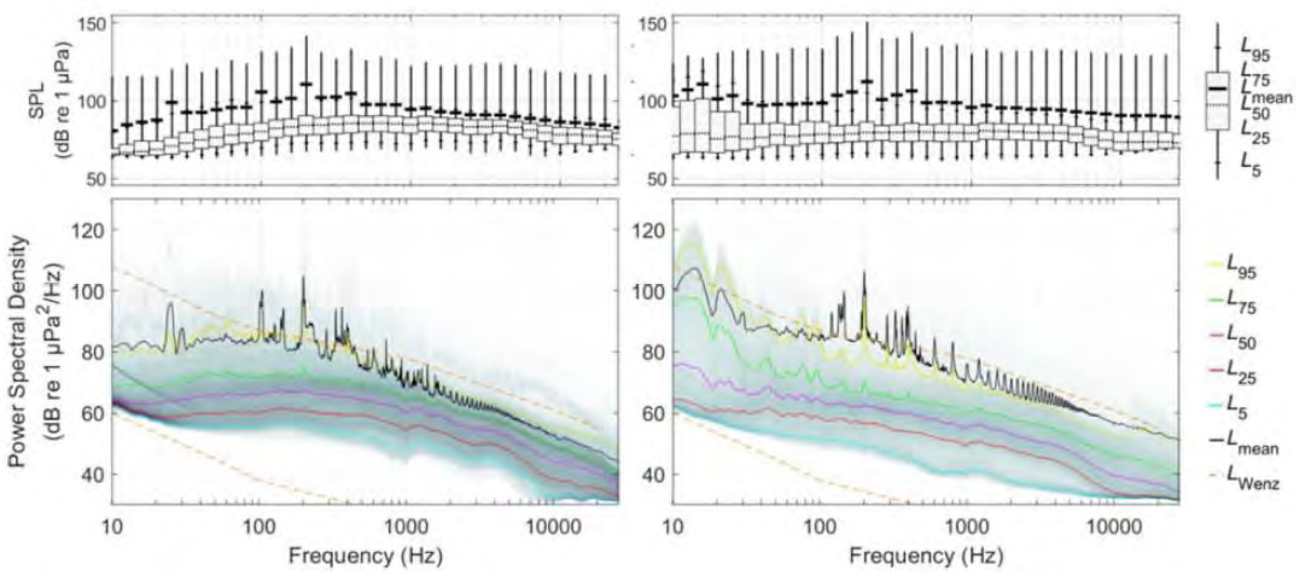


Figure 14: AMAR-BI (left) and AMAR-RI (right) during early shoulder season: Percentiles and mean of 1/3-octave-band SPL and percentiles and spectral density (grayscale) of 1-min power spectral density levels (bin width: 1 Hz) compared to limits of prevailing noise (Wenz 1962). L_{mean} = arithmetic mean (ISO 2017).

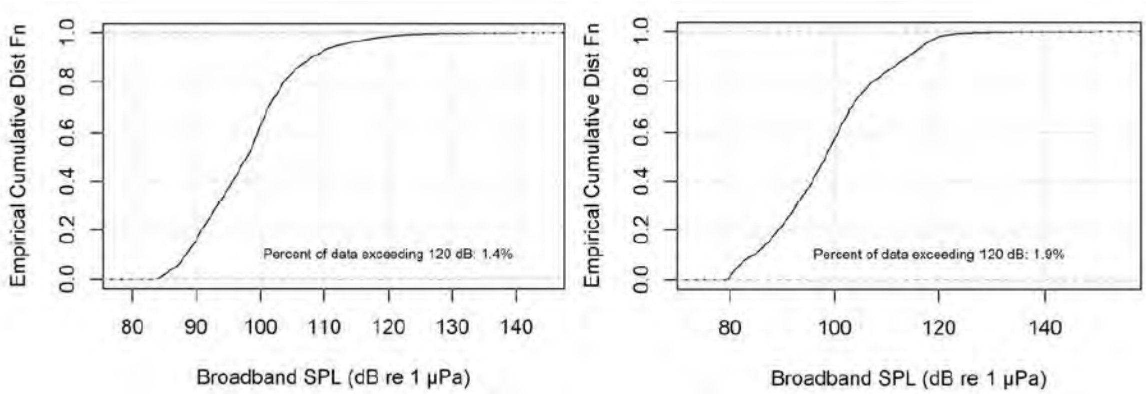


Figure 15: Empirical cumulative distribution functions for AMAR-BI (left) and AMAR-RI (right) during 2019 early shoulder season.

5.1.1.2 Daily Sound Exposure Level (SEL)

Statistical distributions of the daily unweighted SEL recorded between 07 July and 04 August 2019 on the Bylot Island (AMAR-BI) and Ragged Island (AMAR-RI) recorders are presented in Figure 16. SEL values plotted in black represent total SEL (ambient + vessel noise), while SEL data plotted in gold represent periods when only vessels were present in the recordings. Also shown is a statistical distribution of the number of hours per day in which vessels were detected on each AMAR (for any portion of that hour), and the number of vessels detected per day on each AMAR. This summary includes all vessels recorded on the AMARs and may include vessels that were not associated with Baffinland's operations. Project-related vessels did not begin shipping in the RSA in 2019 until 17 July, evident in these plots as increases in the daily SEL, and the mean SPL are noted at both AMAR-BI and AMAR-RI after this date, along with an increase of the proportional contribution of sounds from vessels after this date.

Figure 17 and Figure 18 illustrate the daily unweighted SEL and the mean sound pressure level (SPL, L_{mean}) measured each day at AMAR-BI and AMAR-RI, respectively. Levels were often higher at AMAR-RI than AMAR-BI, particularly for broadband SEL, which is attributed to enhanced sound propagation in the shallower waters near Ragged Island. There were a few days with elevated daily SEL at both stations, such as at the start of Project shipping season on 17 July. Another example occurred 26 July when there were multiple Project vessels transiting inbound along the Northern Shipping Route. Both AMAR-RI and AMAR-BI were located on the shipping route, and on 26 July an increase in hourly SPL occurred at AMAR-BI approximately one hour before a similar increase was observed at AMAR-RI. Automatic Identification System (AIS) records indicate that the icebreaker MSV Botnica escorted the fuel tanker Sarah Desgagnes to Milne Port on that day. On the same day, the ore carrier Nordic Oshima transited past both recorders on its outbound transit from Milne Port.

Frequency-weighted daily SEL values were calculated for the five marine mammal functional hearing groups using the approach described in the US National Marine Fisheries Services (NMFS 2018) guidance for assessing acoustic impacts. These levels are presented in Figure 19. None of the thresholds for either permanent or temporary hearing threshold shift (PTS and TTS) were exceeded throughout the recordings at either AMAR-RI or AMAR-BI during the early shoulder season, for any marine mammal species occurring in the Project area.

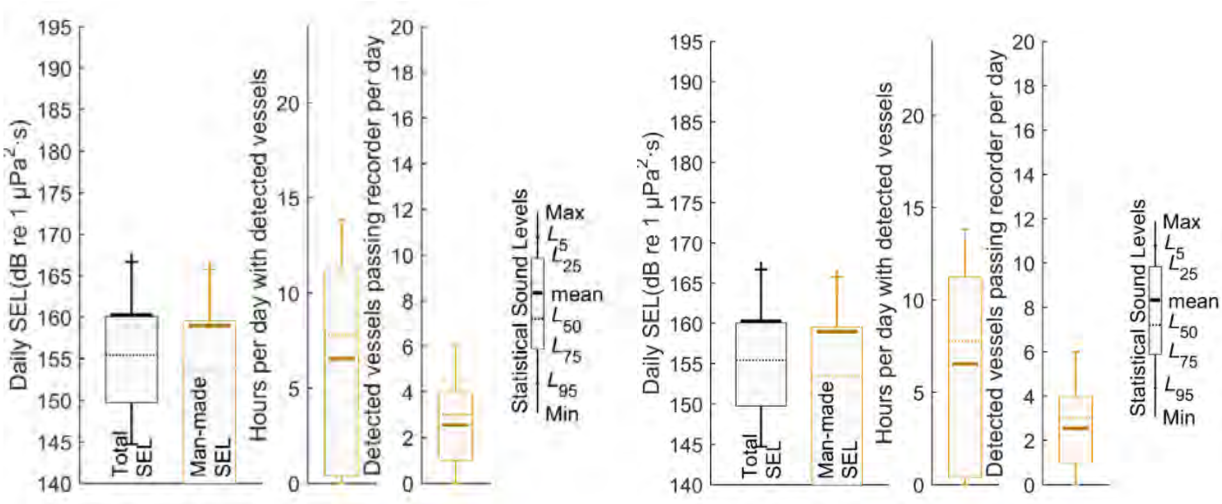


Figure 16: AMAR-BI (left) and AMAR-RI (right): Statistical distribution of the SEL, summary SEL statistics for periods when vessels were detected, hours per day that vessels were detected, and the number of vessels detected per day between 07 July and 04 August 2019.

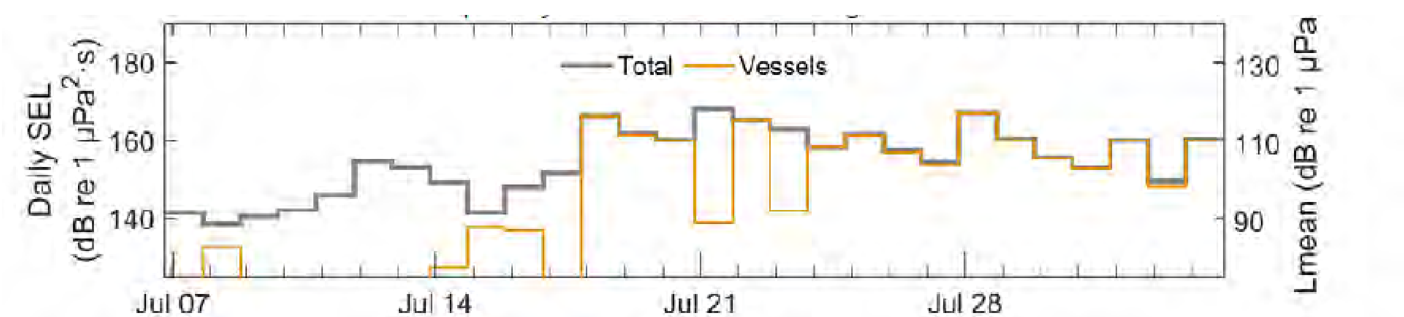


Figure 17: AMAR-BI: Daily SEL (left axis) and daily mean SPL (right axis) for data recorded between 07 July and 04 August 2019.

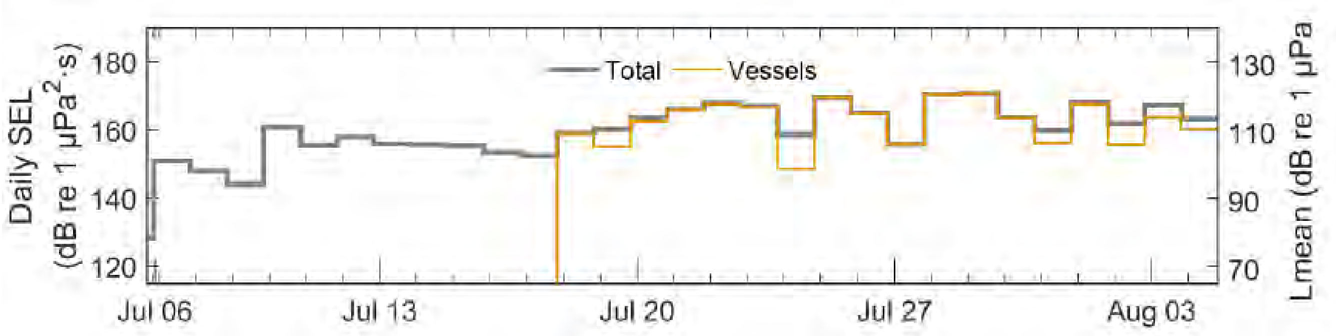


Figure 18: AMAR-RI: Daily SEL (left axis) and daily mean SPL (right axis) for data recorded between 07 July 7 and 04 August 2019.

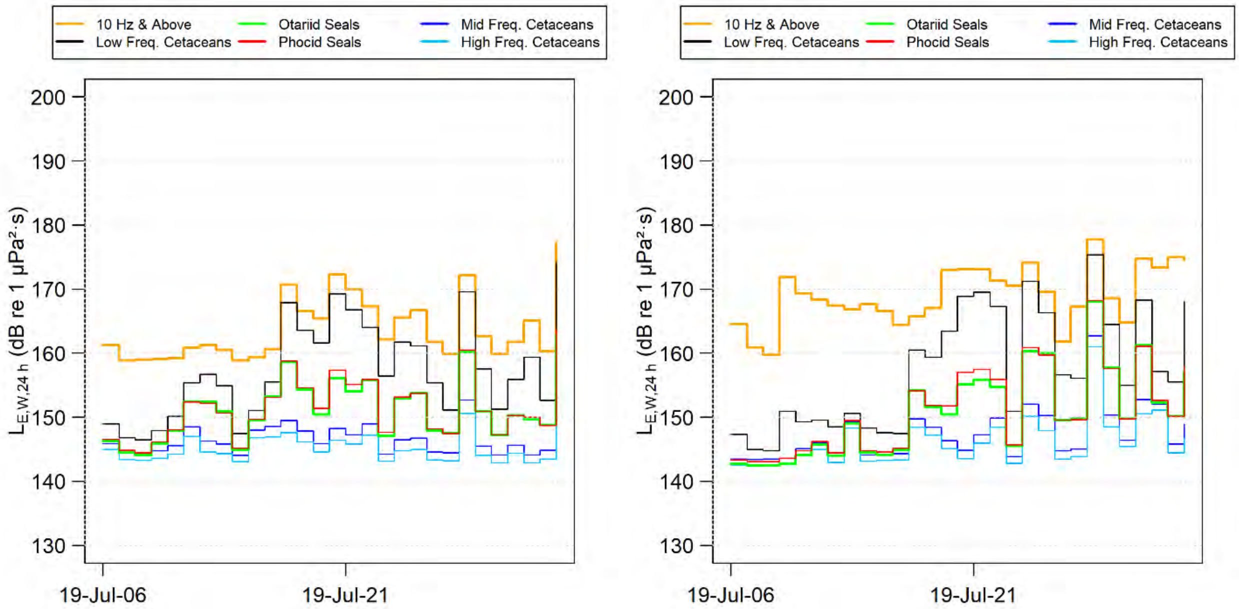


Figure 19: AMAR-BI (left) and AMAR-RI (right): The staircase plot depicts the daily SEL, weighted for marine mammal hearing using the NMFS (2018) functions.

5.1.2 Sound Levels during Open-water Season

5.1.2.1 Sound Pressure Level (SPL)

For the open-water recording period, AMAR–RI was redeployed at the same location as the early shoulder season. AMAR–BI was not redeployed during the open-water season. However, three additional AMARs were deployed in Milne Inlet South with recordings made between 5 August and 28 September 2019. AMAR-1 was located on the shipping lane at the entrance of Koluktoo Bay. AMAR-2 was located in Koluktoo Bay, approximately 6 km west of the nominal shipping lane. AMAR-3 was located on the shipping lane between Poirier Island and Bruce Head, approximately 6 km north of AMAR-1. All three recorders were deployed in approximately 200 m water depth. The Long-term Spectral Averages (LTSAs) and band-level plots for the four AMAR stations deployed during the open-water period are shown in Table 8 and Figure 20 through Figure 23.

AMAR-1 and AMAR-3 recorded higher sound levels in the 30–300 Hz range, which was attributed to their closer proximity to vessel traffic (Figure 24). AMAR-1, AMAR-2 and AMAR-3 had elevated percentile levels near 20 kHz (Figure 24) that were attributed to the presence of narwhal echolocation clicks (Figures 20, 21 and 22). AMAR-RI did not show elevated percentile levels near 20 kHz (Figure 24), clicks were not acoustically detected at this station (Figure 23). Empirical distribution function curves showing SPL exceedance percentages are shown in Figure 25. These plots illustrate that exceedances of 120 dB re 1 µPa were rare at all stations. Recorded SPL exceeded 120 dB re 1 µPa for 3% of the total recording period at AMAR-1 (the highest percentage of all AMAR recording locations) which was located on the nominal shipping route, and for only 0.8% of the total recording period at AMAR-2 which was located in Koluktoo Bay away from the nominal shipping lane.

Table 8: Broadband sound pressure level (SPL) values for recorders in Milne Inlet South (AMAR-1, AMAR-2, AMAR-3) and near Ragged Island (AMAR-RI) during open-water season shipping

Station	Min broadband SPL (dB re 1 µPa)	Max broadband SPL (dB re 1 µPa)	Mean broadband SPL (dB re 1 µPa)
AMAR-1	80.7	150.2	103.3
AMAR-2	82.1	153.9	103.6
AMAR-3	80.1	145.2	102.7
AMAR-RI	80.3	154.1	98.2

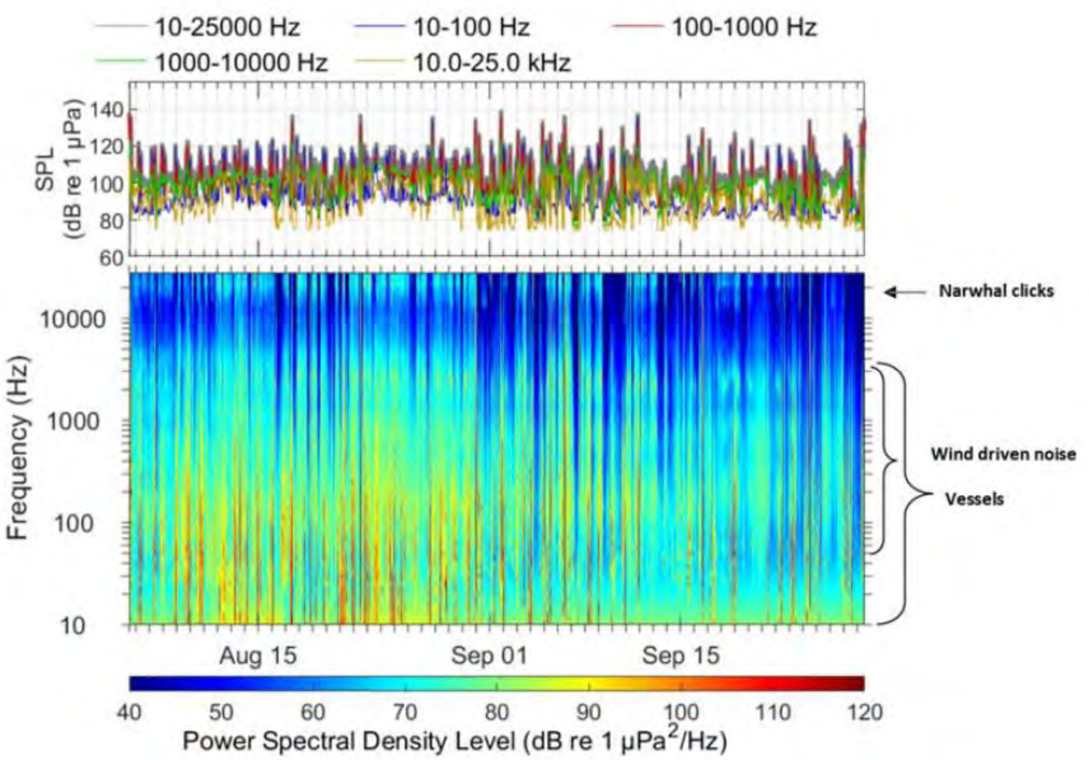


Figure 20: AMAR-1: Spectrogram (bottom) and in-band sound pressure level (SPL) (top).

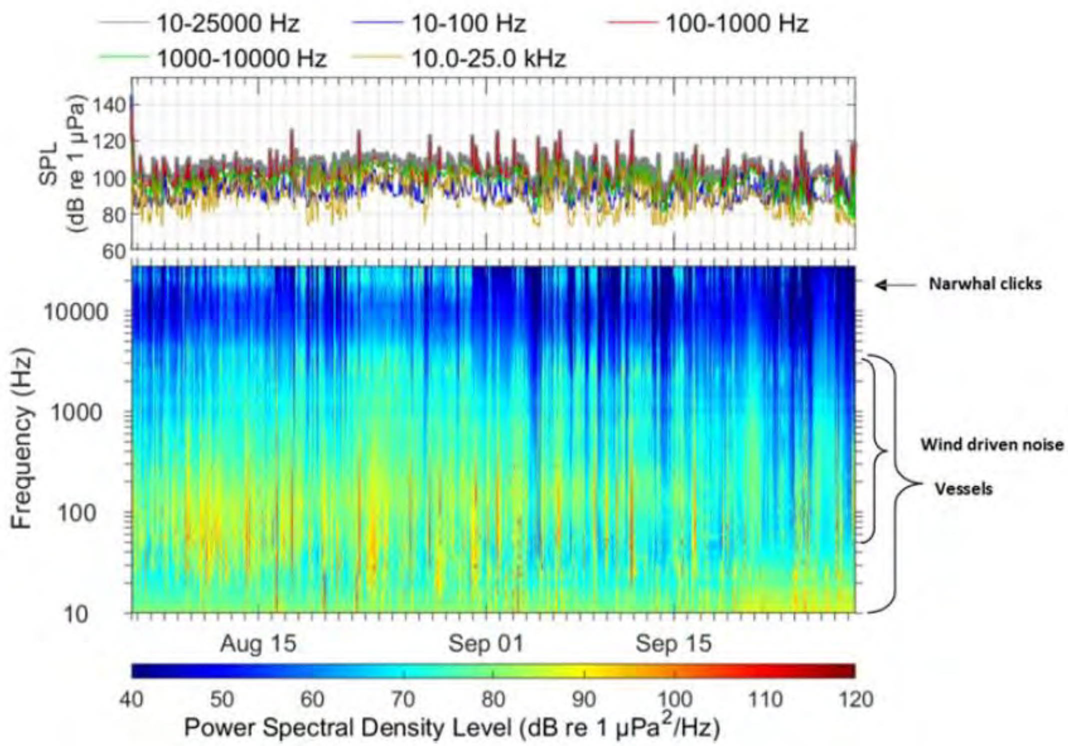


Figure 21: AMAR-2: Spectrogram (bottom) and in-band sound pressure level (SPL) (top).

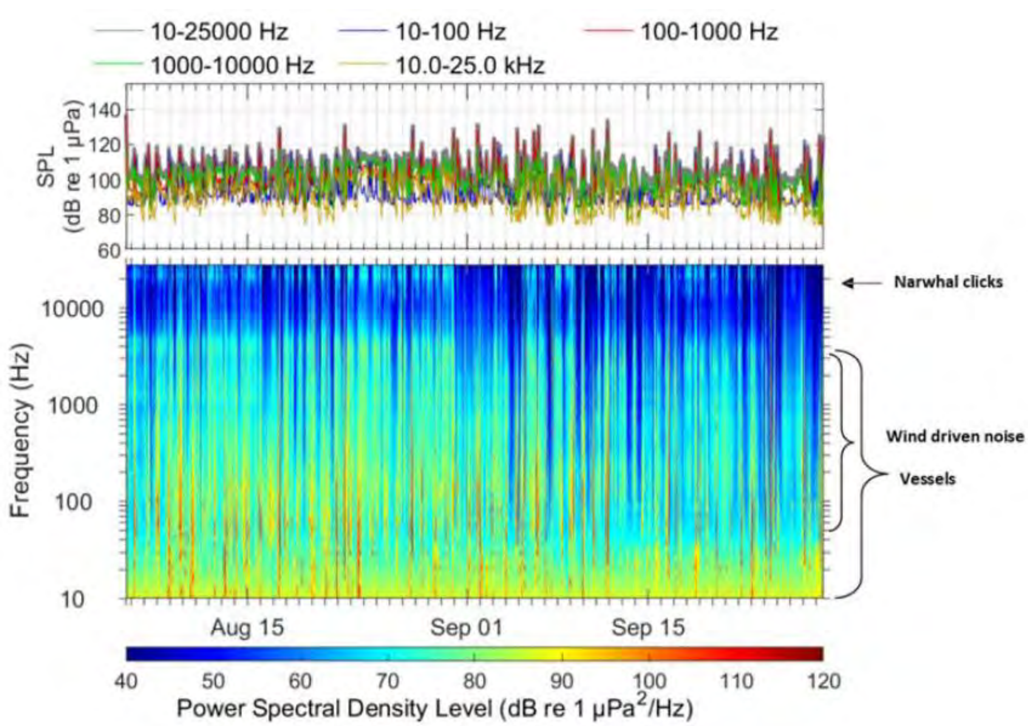


Figure 22: AMAR-3: Spectrogram (bottom) and in-band sound pressure level (SPL) (top).

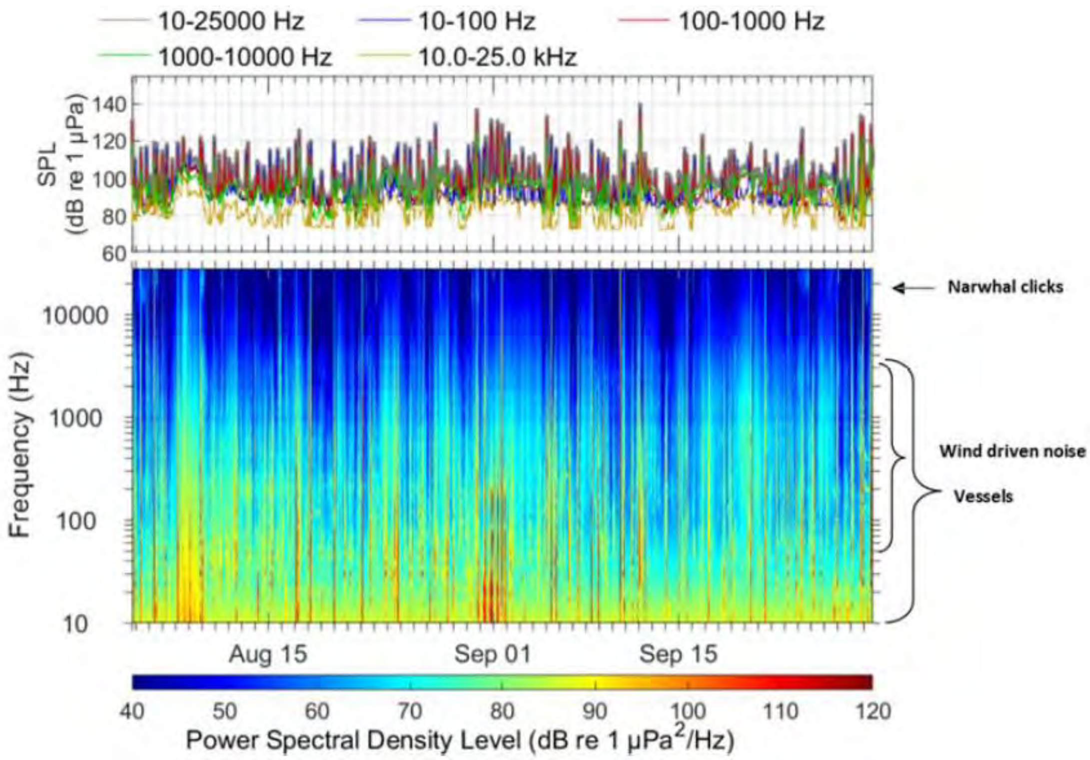


Figure 23: AMAR-RI: Spectrogram (bottom) and in-band sound pressure level (SPL) (top).

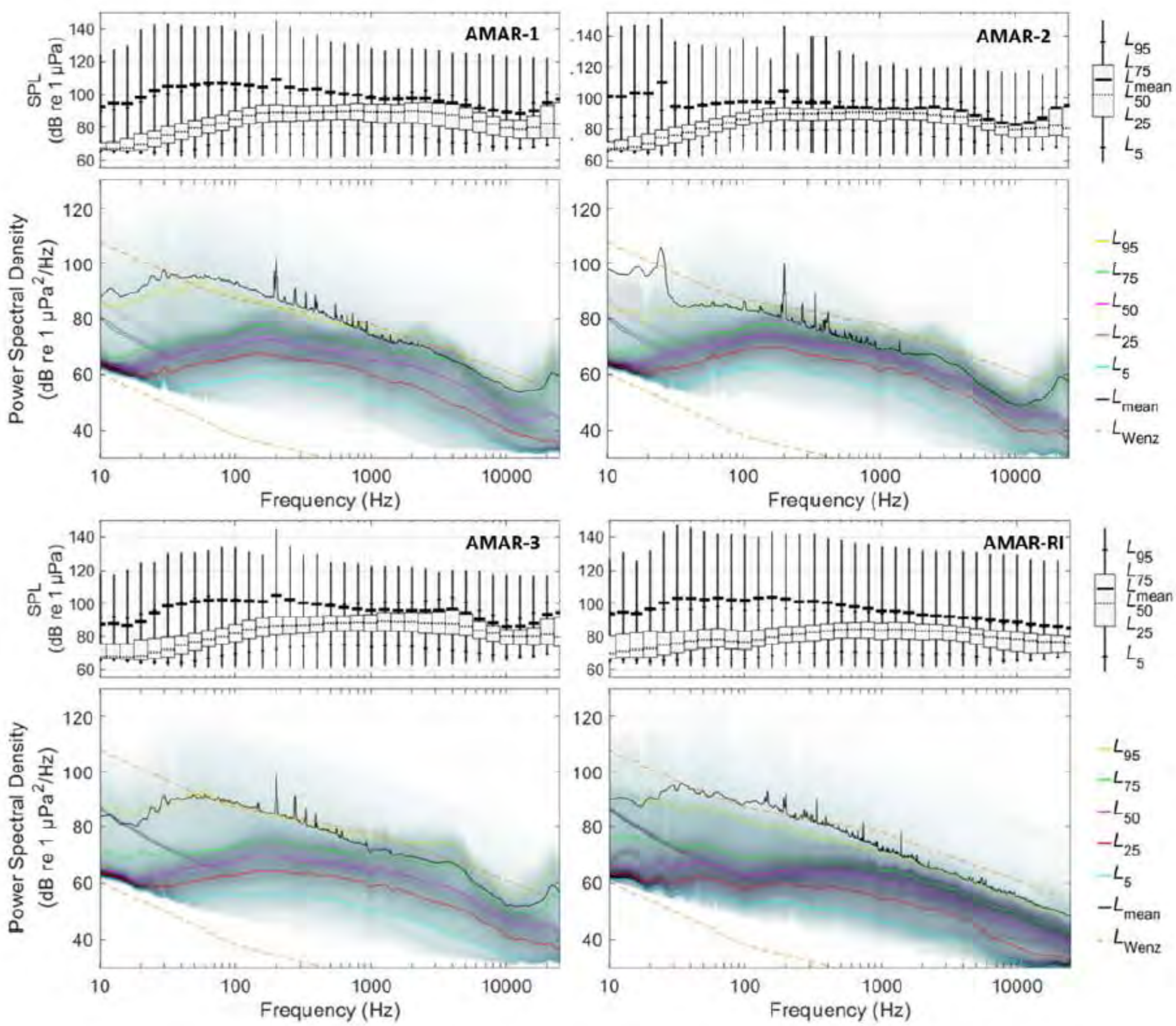


Figure 24: Percentiles and mean of 1/3-octave-band SPL and percentiles and probability density (grayscale) of 1-min power spectral density levels compared to the limits of prevailing noise (Wenz 1962). L_{mean} is the arithmetic mean (ISO 18405 2017).

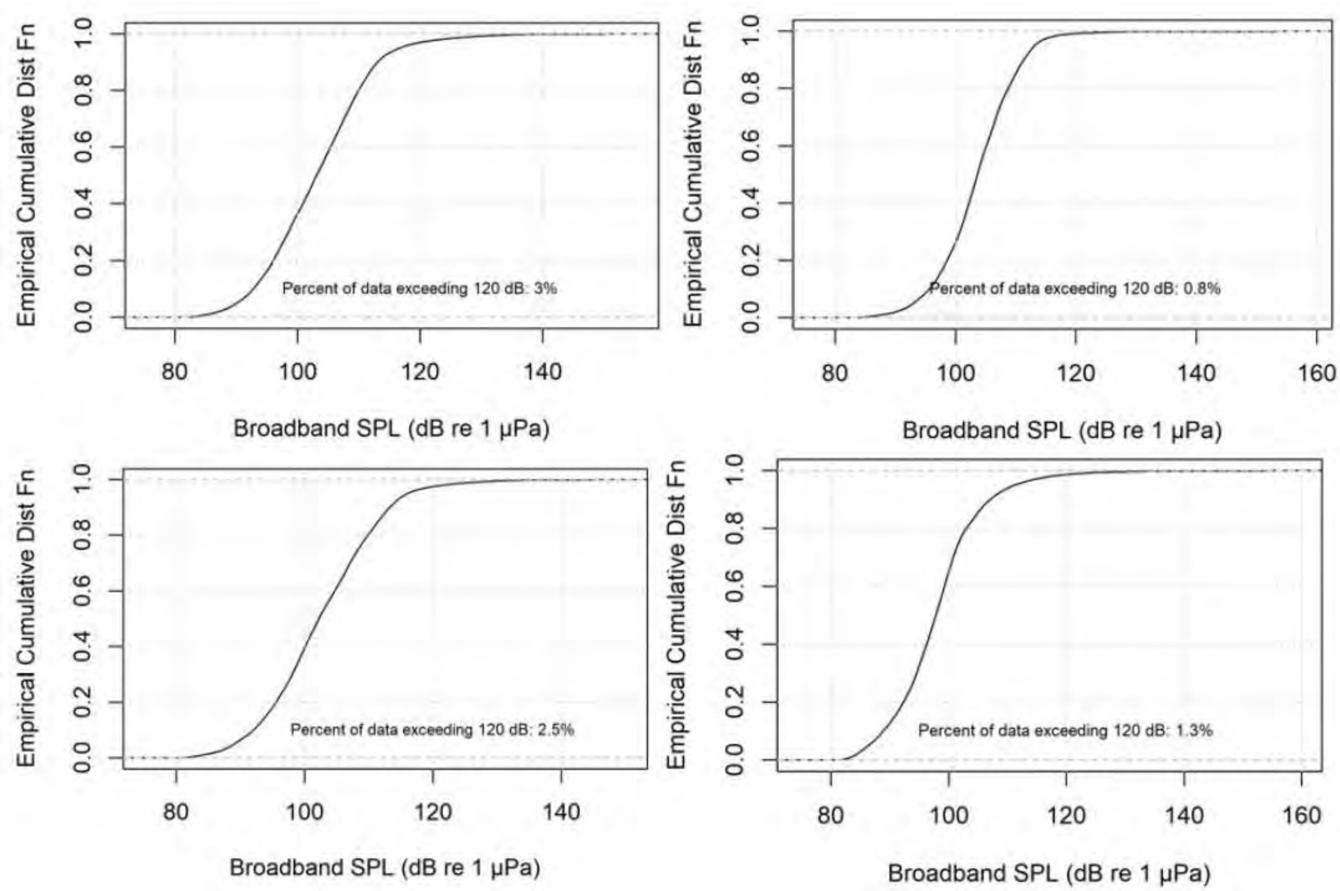


Figure 25: Empirical cumulative distribution functions for AMAR-1 (top left), AMAR-2 (top right), AMAR-3 (bottom left) and AMAR-RI (bottom right).

5.1.2.2 Daily Sound Exposure Level (SEL)

Figure 26 presents the statistical distributions of the daily unweighted SEL recorded on the Bruce Head and Ragged Island AMARs between 04 August and 28 September 2019. This summary includes all recorded data and may include sound from vessels that are not associated with Baffinland's operations. Figures 27 through 30 illustrate the daily unweighted SEL and the mean SPL (L_{mean}) per day for AMAR-1, AMAR-2, AMAR-3 and AMAR-RI, respectively.

Frequency-weighted daily SEL values were calculated for the five marine mammal functional hearing groups according to the definitions in the US National Marine Fisheries Services (NMFS 2018) guidance for assessing acoustic impacts on marine mammals; these are shown in **Figure 31**. At all recording locations, sound levels were below the acoustic thresholds for injury, for either a temporary reduction in hearing (TTS) or a permanent loss in hearing (PTS) for any marine mammal species occurring in the Project area.

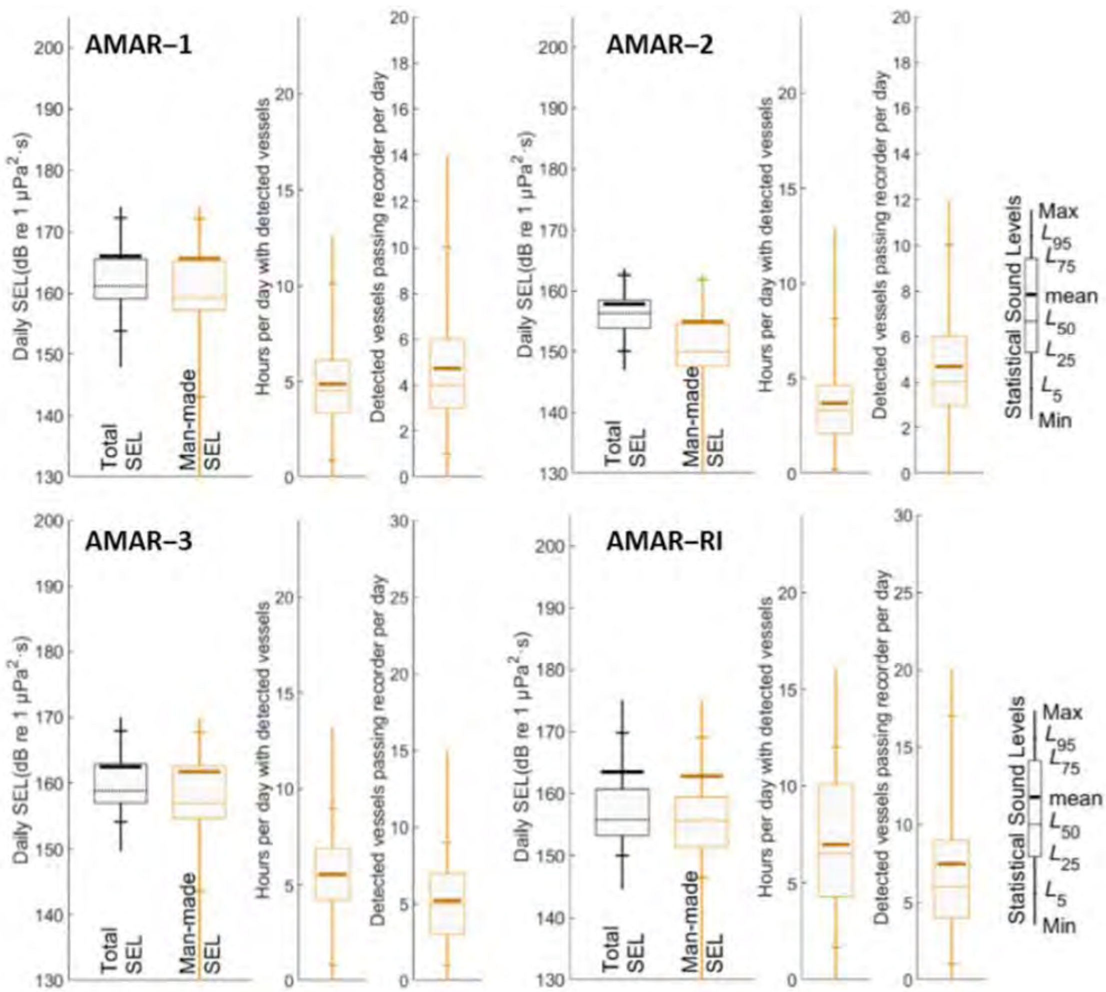


Figure 26: Statistical distribution of SEL, summary SEL statistics for periods when vessels were detected, hours per day that vessels were detected, and the number of vessels detected per day between 04 August and 28 Sept 2019.

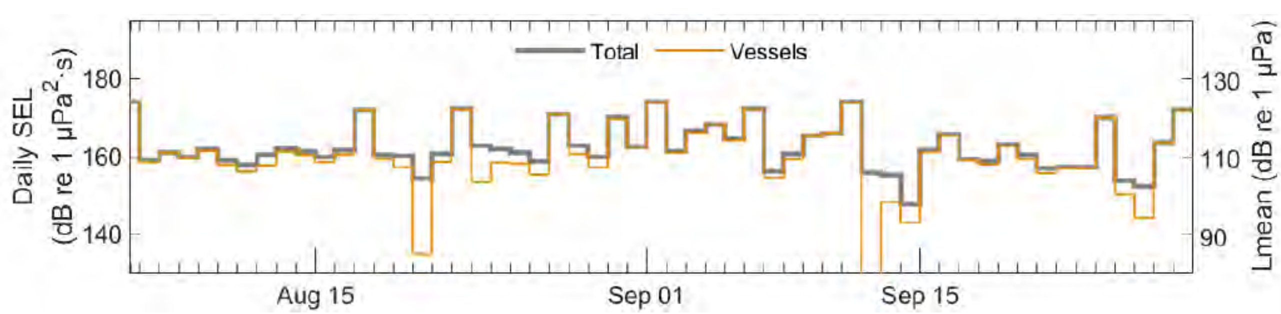


Figure 27: AMAR-1: Daily SEL (left axis) and daily mean SPL (right axis) for data recorded between 04 August and 28 Sept 2019.

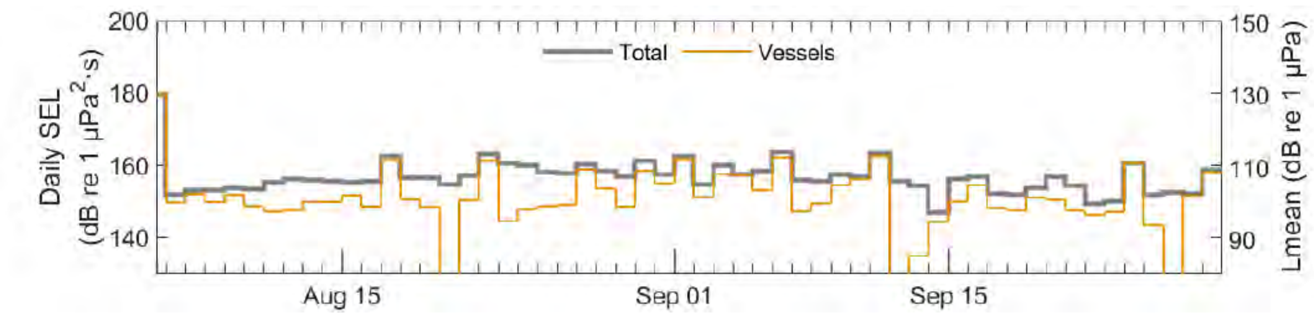


Figure 28: AMAR-2: Daily SEL (left axis) and daily mean SPL (right axis) for data recorded between 04 August and 28 Sept 2019.

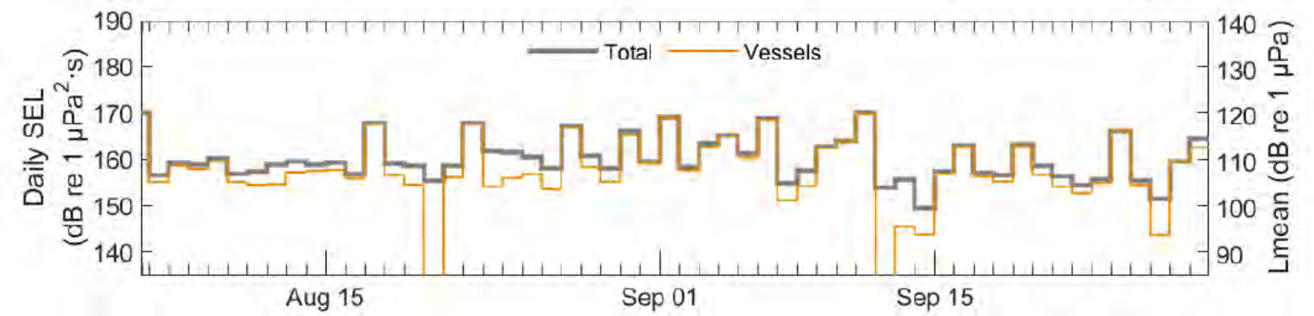


Figure 29: AMAR-3: Daily SEL (left axis) and daily mean SPL (right axis) for data recorded between 04 August and 28 Sept 2019.

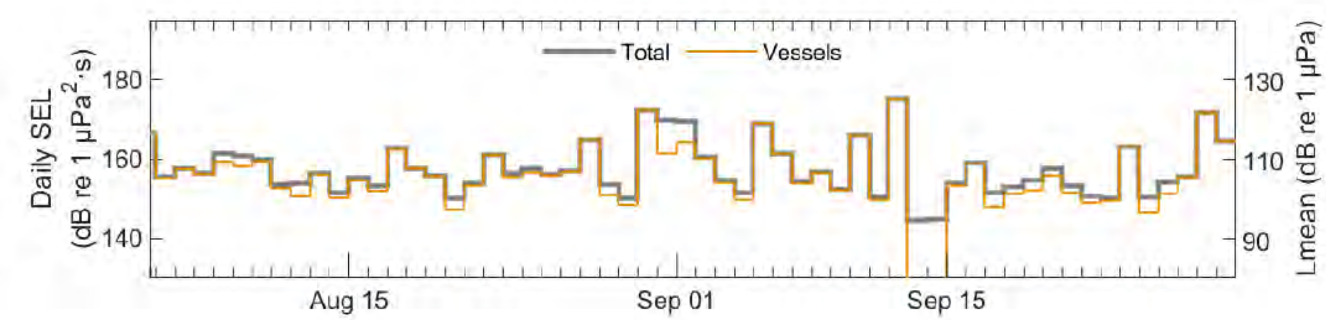


Figure 30: AMAR-RI: Daily SEL (left axis) and daily mean SPL (right axis) for data recorded between 04 August and 28 Sept 2019.

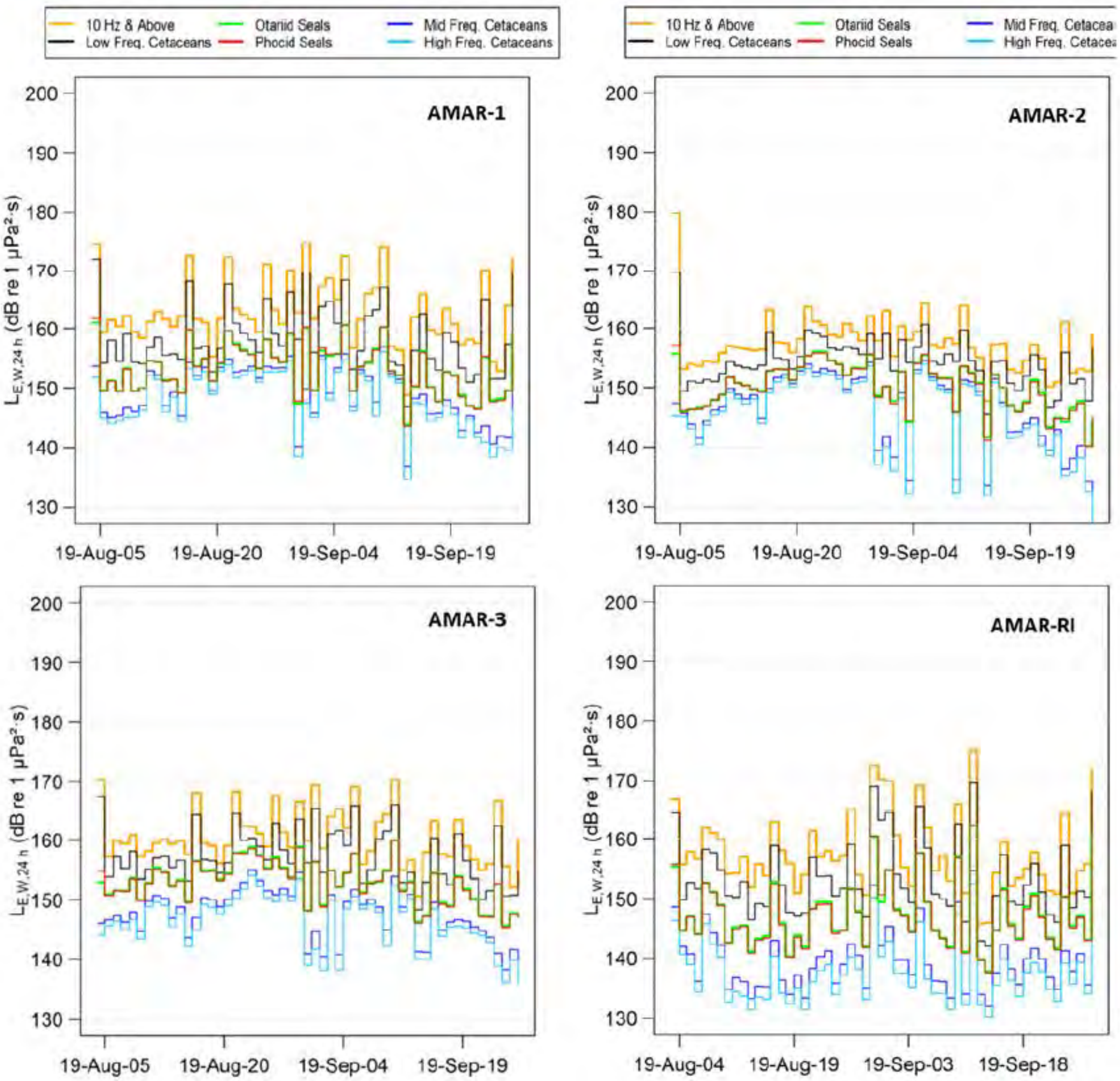


Figure 31: Staircase plots depicting daily SEL at four AMAR stations along Northern Shipping Route, weighted for marine mammal hearing using NMFS (2018) functions.

5.1.3 Exposure Duration and Quiet Time Per Day

5.1.3.1 Early Shoulder Season - Icebreaker Sound Levels

Underwater sounds levels were measured at two AMAR stations between 07 July and 04 August 2019, covering the entire duration of the spring shoulder shipping season, which included icebreaker transits to escort ore carriers. Measured sound levels for five icebreaker transits over the Bylot Island AMAR were analyzed to determine the total amount of time per transit in which sound levels exceeded both the disturbance onset threshold (120 dB re 1 µPa) and the avoidance threshold (135 dB) at Bylot Island, with results presented in Table 9 and Table 11, respectively. Measured values were subsequently compared to predicted (i.e., modelled) values for the same transiting scenario at Bylot Island (icebreaker escort + two ore carriers in 0/10 ice) to evaluate relative conservancy of the model used in the Phase 2 assessment of icebreaking activities (Golder 2019b). Results demonstrated that the measured noise fields associated with disturbance and avoidance were less than half those predicted by modelling (

Table 10 and Table 12) 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). Similarly, for the same icebreaker transit scenario, modelling results predicted that the exposure period for avoidance (≥135 dB) would last up to 20 min per transit. Measured values at Bylot Island indicated that the avoidance exposure period was actually in the range of 0 to 10 min per transit (>50% lower than predicted). These results supported assumptions that acoustic modelling results are conservative and over-representative of measured effects.

Table 9: 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 10: Comparison of modeled vs. measured daily noise exposure periods for icebreaker transits – Disturbance$^{120\ dB}$

Scenario	Speed	Ice Cover	Noise field – R95% range (km)	R95% exposure period (h) per transit	# of transits per Day	Cum. 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 (Transit 1 from Table 6) 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 animals would not be exposed to ship noise above the disturbance threshold

Table 11: Exposure Period ≥ 135 dB for Icebreaker Transits over Bylot Island station AMAR-BI in July 2019

Transit No.	Date	Scenario	Speed (kn)	Horizontal Range to AMAR (m)	Course Heading	Time (min) > 135 dB per transit	Time (h) > 135 dB per transit
1	18-July-2019	Botnica with 2 carriers + tug	8.7	<70	250.4	10	0.2
2	19-July-2019	Botnica with no escorts (solo)	8.3	<120	71.3	4.7	0.1
3	20-July-2019	Botnica with 2 carriers	8.4	<64	250	None	None
4	22-July-2019	Botnica with 3 carriers	8.0	<43	250.6	6	0.1
5	23-July-2019	Botnica with 2 carriers	8.2	<82	65.4	3	0.1

Table 12: Comparison of modelled vs. measured daily noise exposure periods for icebreaker transits - Avoidance$^{135\ dB}$

Scenario	Speed	Ice Cover	Noise field – R95% range (km)	R95% Exposure Period (h) per transit	Average # of Transits per Day	Avg. Exposure Period (h) per day	"Quiet time" per day (h)
1 icebreaker + 2 Capesize carriers - MODELLED	4.6 knots	10/10	8.7	2	1	2	22
	9 knots	3/10	6.6	0.8	2	1.6	22.4
	9 knots	0/10	2.5	0.3	4	1.2	22.8
1 icebreaker + 2 Capesize carriers - MEASURED (Bylot)	9 knots	0/10		0.2	4	0.8	23.2

* 0.2 used as most conservative value (Transit 1 from Table 8) 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 animals would not be exposed to ship noise above the disturbance threshold

5.1.3.2 Open-water Season

Measured underwater sound levels from the five AMAR stations were analyzed to determine the daily exposure period in which sound levels exceeded the disturbance onset threshold of 120 dB re 1 µPa (Table 13; Figure 32).These measured values from the open-water deployments were subsequently compared to predicted (i.e., modelled) daily and maximum exposure periods for each AMAR station to evaluate the relative conservancy of the model used in the Phase 2 assessment for the open-water shipping season (TSD 24, Appendix B).

Average Case

During the 2019 open-water shipping season AMAR deployment (i.e., data collected from August 05 to September 28), recorded underwater sound levels exceeded 120 dB re 1 uPa for an average daily exposure period of 0.2 h at AMAR-RI2, 0.4 h at AMAR-1, 0.1 h at AMAR-2 and 0.3 h at AMAR-3. This was equivalent to an average daily quiet time period (i.e., time in which animals would not be exposed to noise above the disturbance threshold) that ranged between 22.7 and 23.8 h per day (location dependent) during the open-water period. These values were derived from all recorded data, including periods that were not identified by JASCO's automated detector as containing vessel noise. Recordings showed that natural ambient noise sources such as wind and precipitation could also result in prolonged exceedances of the 120 dB re 1 µPa threshold.

Open-water recordings at AMAR-1 exceeded 120 dB for 0.4 h per day on average, which was the highest average daily exposure period of all the open-water AMAR recordings (Table 13). These results were representative of existing conditions under the Early Revenue Phase, with an expected average of two transits per day of Postpanamax sized ore carriers. It can therefore be assumed, based on the measured data, that a single transit of a Postpanamax sized ore carrier would result in a 120 dB exposure period of at most 0.2 h (highest daily average of 0.4 h, divided by two transits). During Phase 2, it is anticipated that there would be two Postpanamax and three Capesize ore carrier transits in the RSA on an average shipping day. Acoustic modelling indicated that the per-transit 120 dB exposure duration for a Capesize ore carrier (modelled at 2.2 h) was 1.7 times longer than that for a Postpanamax ore carrier (modelled at 1.3 h). To account for cumulative effects, one additional transit per day by a non-Project vessel is anticipated in the RSA, conservatively assumed to emit sound that is equivalent to or less than a Capesize ore carrier. Using exposure durations based on the 2019 measurements, and a scaling factor of 1.7 for transits of Capesize ore carriers, we estimate that under a cumulative effects scenario, a stationary animal near the shipping lane would be exposed to underwater sound levels ≥120 dB re 1 µPa for 1.7 hours on an average day in Phase 2 (Table 14), providing 22.3 h of quiet time per day.

Table 13: Average and maximum daily exposure durations for disturbance (120 dB) for each recorder during the 2019 early shoulder and open-water shipping seasons

Recorder	Average Hours [Minutes] per Day with SPL > 120 dB	Maximum Hours [Minutes] per Day with SPL > 120 dB	% of Total Recording with SPL >120 dB
Early Shoulder Season Deployment (July 07 to August 04)			
AMAR-BI (all recorded data)	0.2 [12.6]	8.6 [516.0]	1.4%
AMAR-BI (only data with vessels detected)	0.2 [12.6]	8.6 [516.0]	0.4%
AMAR-RI1 (all recorded data)	1.3 [77.3]	10.6 [637.0]	1.9%
AMAR-RI1 (only data with vessels detected)	0.7 [41.1]	7.1 [427.0]	0.5%
Open-water Season Deployment (August 05 to September 28)			
AMAR-RI2 (all recorded data)	0.2 [10.9]	3.1 [184.0]	1.3%
AMAR-RI2 (only data with vessels detected)	0.1 [3.1]	0.7 [43.0]	0.4%
AMAR-1 (all recorded data)	0.4 [23.6]	2.3 [136.0]	3%
AMAR-1 (only data with vessels detected)	0.1 [8.1]	0.8 [47.0]	1%
AMAR-2 (all recorded data)	0.1 [6.3]	1.4 [82.0]	0.8%
AMAR-2 (only data with vessels detected)	0.0 [2.1]	0.5 [28.0]	0.3%
AMAR-3 (all recorded data)	0.3 [19.4]	2.4 [145.0]	2.5%
AMAR-3 (only data with vessels detected)	0.1 [6.8]	0.9 [52.0]	0.9%

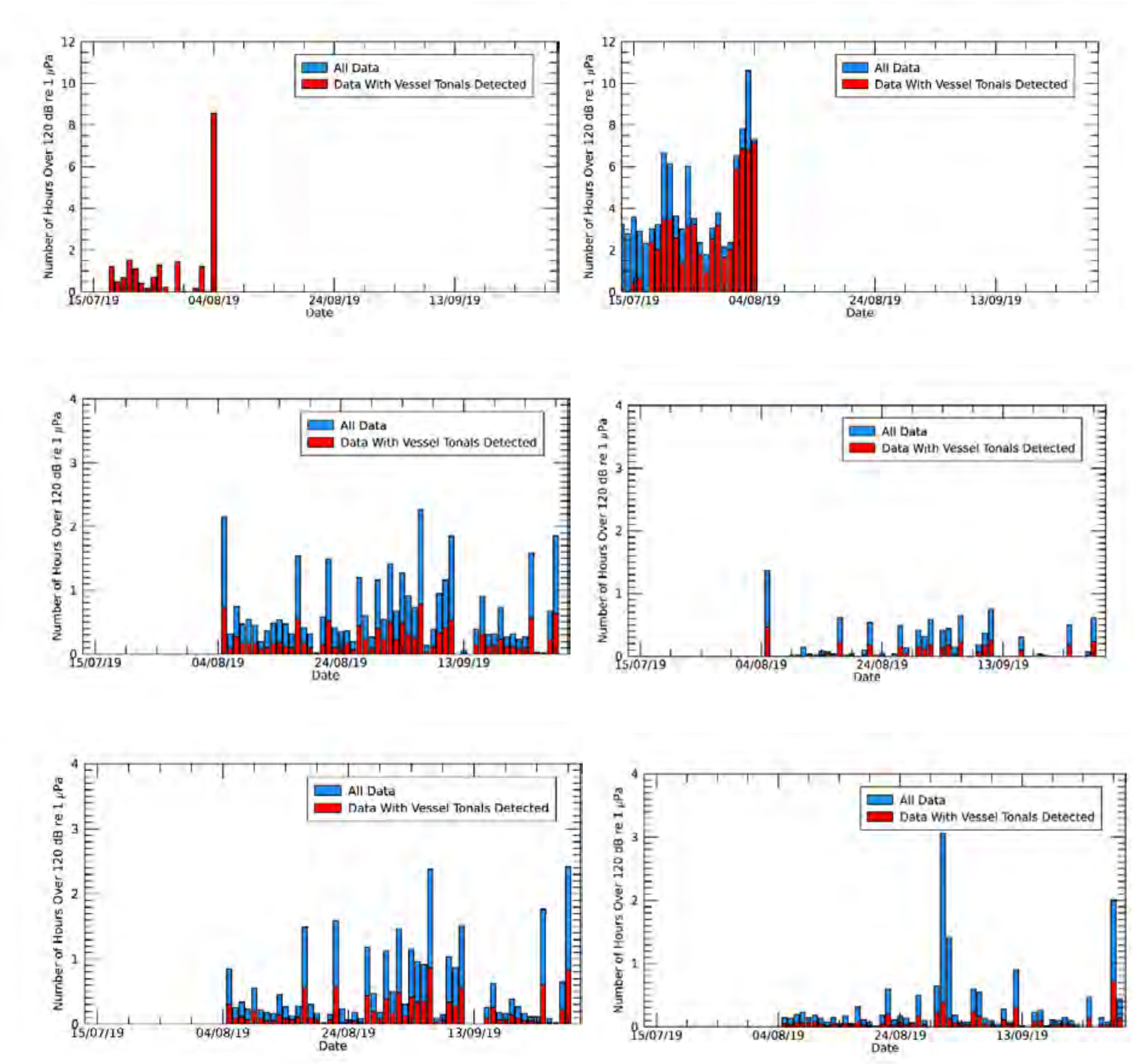


Figure 32: Hours per day with recorded SPL exceeding 120 dB re 1 µPa at (top left) AMAR-BI, (top right) AMAR-RI1, (middle left) AMAR-1, (middle right) AMAR-2, (bottom left) AMAR-3, and (bottom right) AMAR-RI2.

Table 14: Estimates of daily exposure duration and daily quiet time for Phase 2 Shipping based on modelled and measured sound levels - Average Case

Vessel Type	Exposure period (h) per transit	Average # of Transits per Day	Daily Exposure Period (h)	Daily Quiet Time Period (h)
MODELLED				
1 Postpanamax	1.3	2	2.6	21.4
1 Capesize	2.2	3*	6.6	17.4
1 Non-project vessel**	2.2	1	2.2	21.8
Combined		6	11.4	12.6
MEASURED				
1 Postpanamax	0.2	2	0.4	23.6
1 Capesize	0.34	3*	1.0	23.0
1 Non-project vessel**	0.34	1	0.3	23.7
Combined		6	**1.7**	**22.3**

*One of the daily Capesize transits represents a fuel or cargo ship transit. As no source levels were available for fuel or cargo ships, the conservative approach was to use the louder sound footprint of the Capesize carrier. **The non-Project vessel transit was assumed to have the same acoustic footprint as a Capesize carrier.

Maximum Case

During the 2019 shipping season, recorded underwater sound levels exceeded 120 dB re 1 µPa for a maximum daily exposure period of 10.6 h (Figure 32; Table 13), which was equivalent to a minimum daily quiet time period of 13.4 h. This maximum exposure event occurred on 3 August 2019 at the Ragged Island recorder (AMAR-RI1), a day during which four ore carriers transited past this recorder in open water conditions. The calculation considered all recorded data, including periods when JASCO's automated vessel detector did not identify vessel sounds in the acoustic recordings; during these times ambient noise sources such as wind and precipitation can result in prolonged exceedances of the 120 dB re 1 µPa threshold. Considering only periods when the automated detector noted vessel presence, the recorded SPL exceeded 120 dB re 1 µPa for a maximum daily exposure period of 7.1 h on that day (equivalent to a minimum daily quiet time of 16.9 h).

The days with the longest durations of exposure at or above 120 dB occurred during the shoulder season AMAR deployment, in the early portion of the open water season (25 July to 4 August). During this time, atypically high numbers of vessels transited past the recorder in the form of convoys with the icebreaker, the initial arrival of cargo and fuel, and the initial arrival of Project tugs. During the remainder of the open water shipping season (5 August to 28 September), with more typical daily transit numbers, the maximum exposure duration at 120 dB was 3 h in one day (equivalent to 21 h of quiet time) near Ragged Island (AMAR-RI2). It is possible that ambient levels resulted in a prolonged exposure duration at this location; considering only the periods identified by the automated detector as containing vessel noise, the maximum exposure duration was 0.7 h.

Under a maximum case scenario for ship traffic needed for Phase 2 operations, it is anticipated that there would be up to four Postpanamax and four Capesize ore carrier transits per day in the RSA. Furthermore, one additional transit per day by a non-Project vessel is anticipated to occur in the RSA (conservatively assumed to be equivalent in size to a Capesize ore carrier). Using the scaling factor for Capesize vessels (1.7x), and based on exposure durations calculated using 2019 acoustic measurements, it is estimated that a stationary animal near the shipping lane would be exposed to a cumulative (Project and non-Project) noise exposure period (≥ 120 dB) of up to 2.5 h per day under a maximum daily transit scenario (nine transits in total) during the Phase 2 open-water season, equivalent to 21.5 h of quiet time per day (Table 15).

Table 15: Estimates of exposure duration and quiet time for Phase 2 Shipping based on measured exposure durations - Maximum Case

	Exposure period (h) per transit	Average # of Transits per Day	Daily Exposure Period (h)	Daily Quiet Time Period (h)
MODELLED				
1 Postpanamax carrier	1.3	4	5.2	18.8
1 Capesize carrier	2.2	4*	8.8	15.2
1 Non-project vessel**	2.2	1	2.2	21.8
Combined		9	16.2	7.8
MEASURED				
1 Postpanamax carrier	0.2	4	0.8	23.2
1 Capesize carrier	0.34	4*	1.4	22.6
1 Non-project vessel**	0.34	1	0.3	23.7
Combined		9	**2.5**	**21.5**

*Two of the daily Capesize transits represents a fuel or cargo ship transit. As no source levels were available for fuel or cargo ships, the conservative approach was to use the louder sound footprint of the Capesize carrier. **The non-Project vessel transit was assumed to have the same acoustic footprint as a Capesize carrier.

For the most common marine mammals occurring in the RSA (i.e., narwhal and ringed seal), it is important to note that the daily noise exposure periods presented above were considered to be conservative estimates for assessing disturbance effects, as the 120 dB threshold does not account for the frequency of the ship noise source relative to narwhal and ringed seal 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). Ringed seal vocalizations occur in the 400 Hz to 16 kHz frequency range, with dominant frequencies concentrated above 5 kHz

(Stirling 1973; Cummings et al. 1984). Ship noise is therefore unlikely to result in major disturbance effects in narwhal or ringed seal given it is primarily emitted in the frequency band in which both species have lower hearing sensitivity. The maximum disturbance ranges presented herewith should therefore be considered as conservative estimates.

Based on these updated calculations of daily noise exposure periods based on empirical acoustic data collected from several representative locations in the RSA in 2019, and in light of the updated assessment of acoustic disturbance effects presented above, there is even greater confidence in the Phase 2 effects assessment that the proposed number of ore carrier voyages (n=176) will not result in significant residual impacts on marine mammals in the RSA (i.e., those resulting in potential population-level effects).

5.1.4 Listening Range Reduction (LRR)

The term ‘listening space’ refers to the area over which sources of sound can be detected by an animal at the center of the space. An assessment of lost listening space (or area) has been traditionally applied to in-air sounds for assessing noise effects on birds; only in recent years has it been applied to the assessment of underwater noise effects on marine mammals (Pine et al. 2018). In support of the conclusions made in Phase 2 assessment, listening range reductions (LRR) for narwhal were calculated to evaluate the effects of shipping noise on the listening space of marine mammals during the shoulder and open-water seasons. The LRR method assesses how sound travels through the water from a ship and compares this information to the basic hearing capabilities of an animal of interest; in this case narwhal. LRR calculates a fractional reduction in an animal’s listening range when exposed to a combination of anthropogenic and natural ambient noise sources compared to that under natural ambient conditions (i.e., representing the proportional reduction in distance at which a signal of interest can be heard at a frequency, in the presence of noise). LRR does not provide absolute areas or volumes of space. However, a benefit of the LRR method is that it does not rely on source levels of the sounds of interest. Instead, the method depends only on the rate of sound transmission loss.

LRR was calculated for three representative frequencies (corresponding with different narwhal vocalization types) for all five AMAR locations in the RSA, three near Bruce Head (AMAR-1, AMAR-2 and AMAR-3), one near Ragged Island (AMAR-RI) and one near Bylot Island (AMAR-BI). Calculation of the LRR at each AMAR location was carried out using the same methodology outlined in the 2018 Bruce Head Passive Acoustic Monitoring report (Frouin-Mouy et al. 2019). At each location, the LRR was determined for 1 kHz (representative of narwhal burst pulses), 5 kHz (representative of whistles and knock trains) and 25 kHz (representative of clicks and high frequency buzzes). The recording data were divided into periods with and without vessel detections. The normal listening range was determined using the maximum of the mid-frequency cetacean audiogram (see Table A-9 in Finneran 2015) or the median 1-minute sound pressure level without vessels in each of the 1/3-octave-bands of interest as the baseline hearing threshold. The geometric spreading coefficient was set to a nominal value of 15. The analysis was performed for each 1 dB of increased 1/3-octave-band SPL above the normal condition.

LRR calculations are presented in Table 16 for both a >50% and >90 % reduction in listening range (>50% LRR and >90% LRR), for all five recorder locations and the three representative frequencies. Figure 33 presents results for the AMARs deployed during the early shoulder season and Figure 34 presents results for the AMARs deployed during the open-water season. During the 2019 open-water shipping season, vessels (Project and non-Project related) were detected in the acoustic recordings for between 15% (at AMAR-2) and 29% (AMAR-RI – open-water deployment) of the total acoustic recording durations (1,297 hours at AMAR-2 and 1,345 hours at AMAR-RI – open-water redeployment), with vessel detections most common at AMAR-RI. Additional information is presented below for three representative recorder locations; AMAR-RI which is located directly on the nominal shipping lane near Ragged Island, AMAR-1 which is located directly on the shipping lane in Milne Inlet South, and AMAR-2 which is located in Koluktoo Bay, approximately 6 km away from the nominal shipping lane.

Table 16: Percentage of time associated with >50% and >90% LRR at each acoustic recorder location

Recorder	1 kHz		5 kHz		25 kHz	
	>50% LRR	>90% LRR	>50% LRR	>90% LRR	>50% LRR	>90% LRR
Early Shoulder Season Deployments						
AMAR-BI (ambient noise data)	0.2	0	21.0	0.3	30.5	8.4
AMAR-BI (data with vessels detected)	1.8	0.3	22.4	1.3	30.4	6.3
AMAR-RI (ambient noise data)	0	0	24.5	0.8	36.7	16.9
AMAR-RI (data with vessels detected)	4.1	0.9	48.7	5.1	50.8	26.3
Open-water Season Deployments						
AMAR-1 (ambient noise data)	0.9	0	29.3	0.1	45.9	36.4
AMAR-1 (data with vessels detected)	10.1	2.1	27	3.0	32.6	22.9
AMAR-2 (ambient noise data)	0.2	0	14.7	0	45.6	37.7
AMAR-2 (data with vessels detected)	3.3	0.1	9.6	0.2	33.0	26.3
AMAR-3 (ambient noise data)	0.8	0	33.0	3.1	42.0	33.2
AMAR-3 (data with vessels detected)	8.1	1.2	34.0	4.6	37.0	25.7
AMAR-RI (ambient noise data)	0.1	0	15.5	0.2	31.7	6.2
AMAR-RI (data with vessels detected)	3.3	0.8	14.7	2.0	24.4	6.2

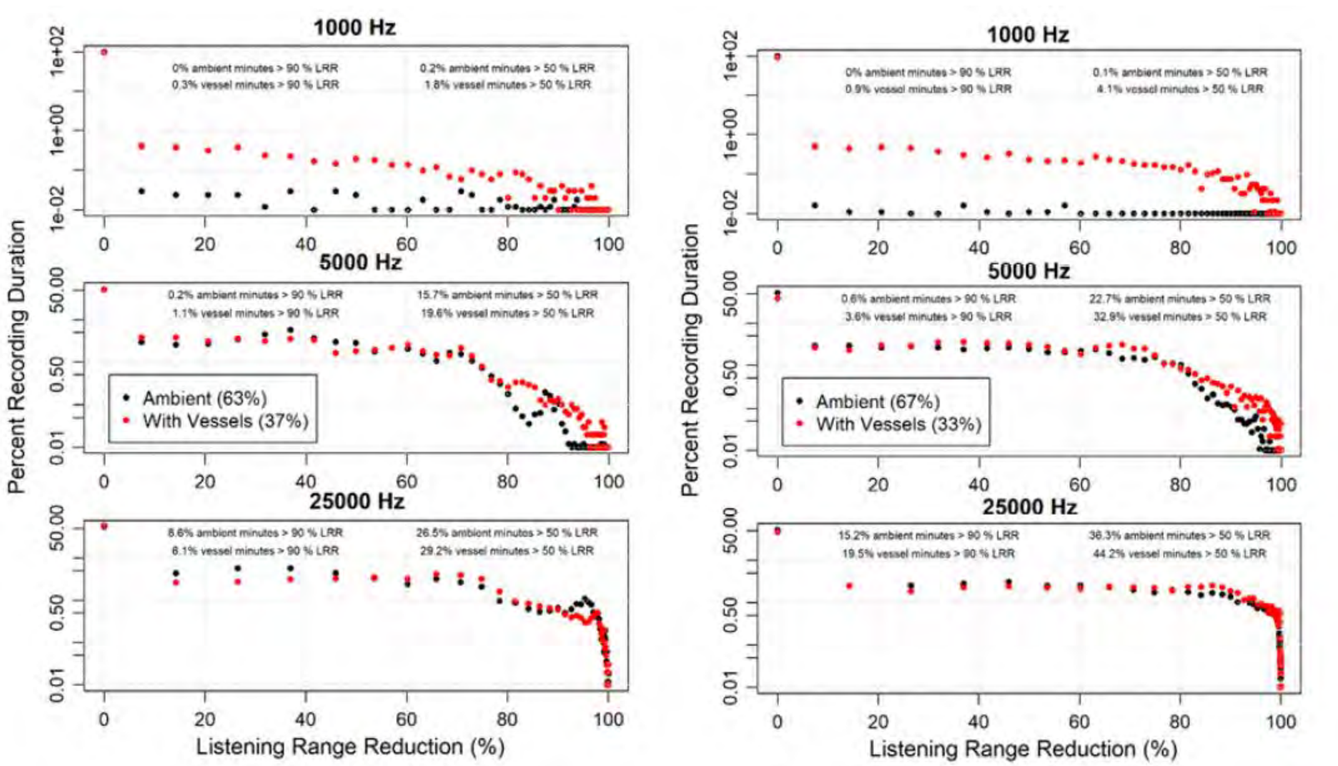


Figure 33: Listening range reduction (LRR) during the early shoulder season for the three considered frequencies at AMAR-BI (left) AMAR-RI (right). For each station, the top figure shows LRR for the 1 kHz 1/3-octave-band, which is representative of burst pulses, the middle figure shows LRR for the 5 kHz 1/3-octave-band, which is representative of listening for whistles and knocks, and the bottom figure shows LRR for 25 kHz which is representative of clicks and high-frequency buzzes. The black dots show the distribution of LRR for ambient data only, while the red dots show the distribution of LRR for minutes with vessel detections. The black dots show the distribution of LRR for ambient noise data only (no vessels), while the red dots show the distribution of LRR for recordings with vessels detected (vessels + ambient noise). The y-axis is logarithmic to better illustrate the rare high LRR events.

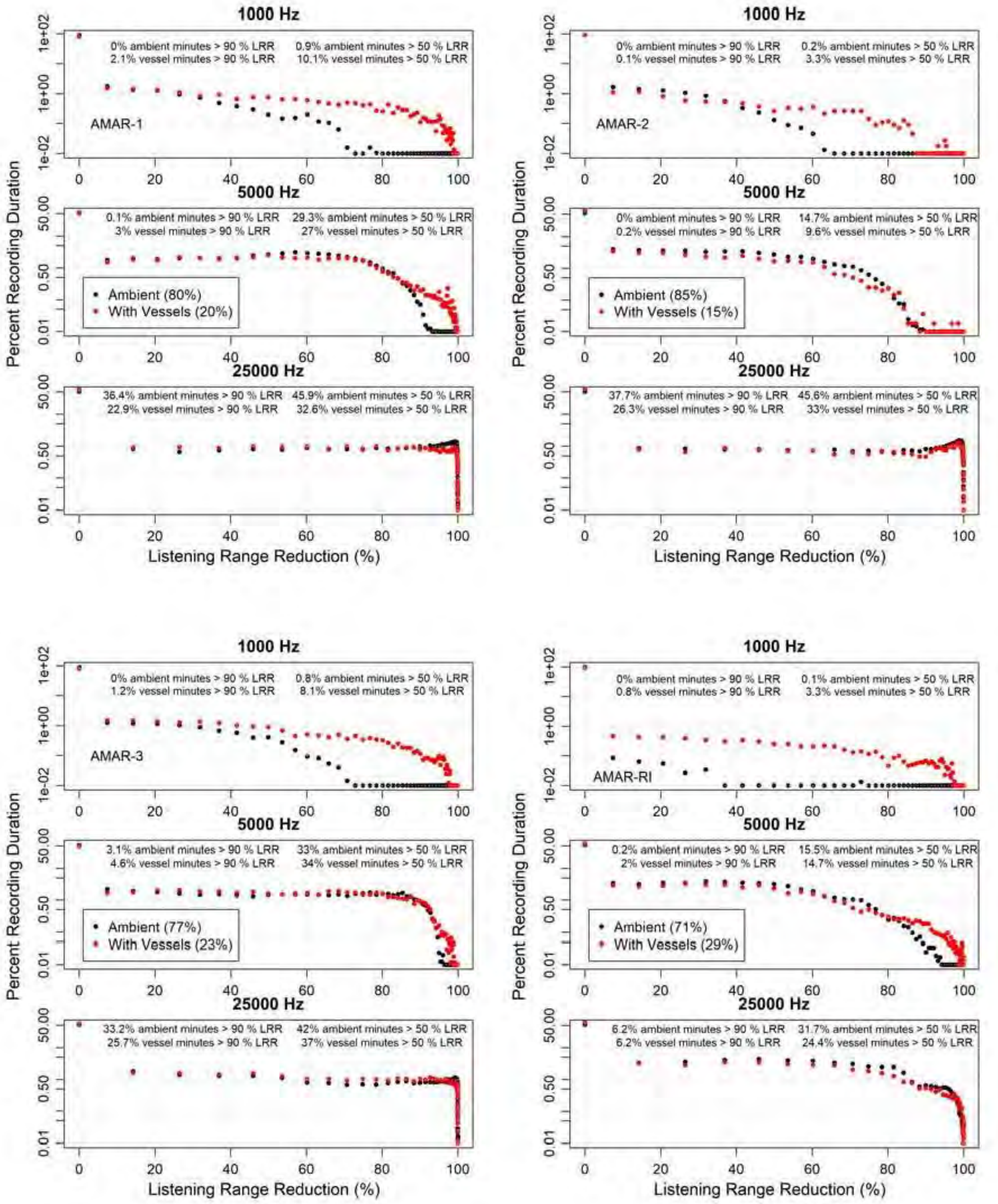


Figure 34: Listening range reduction (LRR) during the open-water season for the three considered frequencies at each station. For each station, the top figure shows LRR for the 1 kHz 1/3-octave-band, which is representative of burst pulses, the middle figure shows LRR for the 5 kHz 1/3-octave-band, which is representative of listening for whistles and knocks, and the bottom figure shows LRR for 25 kHz which is representative for clicks and high-frequency buzzes. The black dots show the distribution of LRR for ambient data only, while the red dots show the distribution of LRR for minutes with vessel detections. The black dots show the distribution of LRR for ambient noise data only (no vessels), while the red dots show the distribution of LRR for recordings with vessels detected (vessels + ambient noise). The y-axis is logarithmic to better illustrate the rare high LRR events.

AMAR-RI (Ragged Island)

AMAR-RI was located directly on the nominal shipping route adjacent to the Ragged Island anchorage locations. Vessel noise was most common at this recorder location, with vessels acoustically detected on 33% of the early shoulder season recording (163 out of 493 h) and on 29% of the open water season recording (390 out of 1,345 h). Greater than 50% LRR occurred most frequently at AMAR-RI during the early shoulder season. A summary of the LRR calculations for each of the three considered frequencies, with a relative comparison to ambient noise (i.e., data with no vessels present) is as follows.

1 kHz (burst pulses):

During the early shoulder season, >50% LRR occurred for sound at 1 kHz (a frequency component of narwhal burst pulses) during 4.1% of the time vessels were detected on the recording (7 of 163 h). This means that 96% of the time when vessel noise was detectable in the shoulder season at AMAR-RI, a stationary narwhal would be able to detect a sound at 1 kHz to distances over half of their full detection range, and 4% of the time when vessel noise was detectable in the shoulder season at this location, their detection range at this frequency would be reduced by at least half. Because the hearing threshold for narwhal at 1 kHz is higher than the median ambient sound level at this frequency, ambient noise did not cause appreciable LRR for this vocalization type during any of the early shoulder season recording (0 of 521 h without vessels detected). **Overall, vessel noise resulted in greater than 50% LRR for sound at 1kHz for 1% of the total recording period during the early shoulder season (7 of 493 h).**

During the open-water season, >50% LRR occurred for sound at 1 kHz during 3.3% of the time vessels were detected on the recording (13 of 390 h). Ambient noise caused >50% LRR for sound at 1 kHz during 0.1% of the recordings when no vessels were detected acoustically (1 of 955 h). **Overall, ambient noise caused >50% LRR for sound at 1 kHz for 0.07% of the total open water recording period (1 of 1,345 h), while vessel noise caused >50% LRR for sound at 1 kHz for 1% of the open water recording period (13 of 1,345 h).**

5 kHz (whistles and knock trains):

During the early shoulder season, >50% LRR occurred for sound at 5 kHz (a frequency component of narwhal whistles and knock trains) during 48.7% of the time vessels were detected acoustically on the recording at AMAR-RI (79 of 163 h). In comparison, ambient noise during the early shoulder season resulted in >50% LRR for sound at 5 kHz during 24.5% of the recordings when no vessels were detected (80 of 330 h). **Overall, both ambient noise and vessels resulted in >50% LRR for sound at 5 kHz for 16% of the total shoulder season recording period (80 of 493 h from ambient noise and 79 of 493 h from vessel noise).**

During the open water season, >50% LRR occurred for sound at 5 kHz during 14.7% of the time vessels were detected on the recording at AMAR-RI (57 of 390 h). Ambient noise resulted in >50% LRR for sound at 5 kHz during 15.5% of the recordings when no vessels were detected acoustically (148 of 955 h). **Overall, ambient noise resulted in >50% LRR for sound at 5 kHz for 11% of the total open water recording period (148 of 1,345 h), while vessel noise resulted in >50% LRR for sound at 5 kHz for 4.2% of the total open water recording period (57 of 1,345 h).**

25 kHz (clicks and high-frequency buzzes):

During the early shoulder season, >50% LRR occurred for sound at 25 kHz (a frequency component of narwhal clicks and high-frequency buzzes) during 50.8% of the time vessels were detected acoustically on the recording at AMAR-RI (83 of 163 h). During this same period, ambient noise resulted in >50% LRR for sound at 25 kHz during

36.7% of the recordings when no vessels were detected (121 of 330 h). **Overall, >50% LRR occurred for sound at 25 kHz for 41% of the total recording period during the early shoulder season; 25% of this was related to ambient noise (121 of 493 h) and 12% of this was related to vessel noise (83 of 493 h).**

During the open water season, >50% LRR occurred for sound at 25 kHz during 24% of the time vessels were detected on the recording (94 of 390 h). Ambient noise resulted in >50% LRR for sound at 25 kHz during 32% of the recordings when no vessels were detected acoustically (306 of 955 h). **Overall, >50% LRR occurred for sound at 25 kHz for 37% of the total recording period during the open water season; 23% of this was related to ambient noise (306 of 1,345 h) and 14% of this was related to vessel noise (191 of 1,345 h).**

AMAR-1 (Milne Inlet Shipping Lane)

AMAR–1 was located directly on the nominal shipping route in Milne Inlet South, adjacent to the entrance to Koluktoo Bay. It was only deployed during the open water season. Vessels were acoustically detected on 20% of the recording (259 out of 1,297 h). A summary of the LRR for each of the three considered frequencies, with a relative comparison to ambient noise (i.e., no vessels present) is as follows.

<u>1 kHz (burst pulses):</u>

During the open water season, greater than 50% LRR for sound for 1 kHz (a frequency component of narwhal burst pulses) occurred during 10.1% of the time vessels were detected on the recording (26 of 259 h). Ambient noise resulted in greater than 50% LRR for sound at 1 kHz during 0.9% of the recordings when no vessels were detected acoustically (9 of 1,038 h). **Overall, ambient noise resulted in greater than 50% LRR for sound at 1 kHz for 0.7% of the total open water recording period (9 of 1,297 h), while vessel noise resulted in greater than 50% LRR for sound at 1 kHz for 2% of the open water recording period (26 of 1,297 h).**

<u>5 kHz (whistles and knock trains):</u>

During the open water season, greater than 50% LRR for sound at 5 kHz (a frequency component of narwhal whistles and knock trains) occurred during 27% of the time vessels were detected on the recording (70 of 259 h). Ambient noise resulted in greater than 50% LRR for sound at 5 kHz during 29% of the recordings when no vessels were detected acoustically (301 of 1,038 h). **Overall, ambient noise resulted in greater than 50% LRR for sound at 5 kHz for 23% of the total open water recording period (301 of 1,297 h), while vessel noise resulted in greater than 50% LRR for sound at 5 kHz for 5% of the total open water recording period (70 of 1,297 h).**

<u>25 kHz (clicks and high-frequency buzzes):</u>

During the open water season, greater than 50% LRR for sound at 25 kHz (a frequency component of narwhal clicks and high-frequency buzzes) occurred during 32.6% of the time vessels were detected on the recording (85 of 259 h). Ambient noise resulted in greater than 50% LRR for sound at 25 kHz during 45.9% of the recordings when no vessels were detected acoustically (476 of 1,038 h). **Overall, ambient noise resulted in greater than 50% LRR for sound at 25 kHz for 37% of the total open water recording period (476 of 1,297 h), while vessel noise resulted in a 50% LRR for clicks for 7% of the total open water recording period (85 of 1,297 h).**

AMAR-2 (Koluktoo Bay)

AMAR–2 was located in Koluktoo Bay, approximately 6 km west of the nominal shipping route in Milne Inlet South. AMAR–2 was only deployed during the open water season. Vessels were acoustically detected in 15% of the recording (195 out of 1,297 h). A summary of the LRR for each of the three considered frequencies, with a relative comparison to ambient noise (i.e., no vessels present) is as follows.

1 kHz (burst pulses):

During the open water season, >50% LRR for sound at 1 kHz occurred during 3.3% of the time vessels were detected on the recording (6 of 195 h). Ambient noise resulted in >50% LRR for sound at 1 kHz during 0.2% of the recordings when no vessels were detected acoustically (2 of 1,102 h). **Overall, ambient noise resulted in >50% LRR for sound at 1 kHz for 0.1% of the total open water recording period (2 of 1,297 h), while vessel noise resulted in >50% LRR for sound at 1 kHz for 0.4% of the open water recording period (6 of 1,297 h).**

5 kHz (whistles and knock trains):

During the open water season, >50% LRR occurred for sound at 5 kHz (a frequency component of narwhal whistles and knock trains) during 9.6% of the time vessels were detected on the recording (19 of 195 h). Ambient noise resulted in >50% LRR for sound at 5 kHz during 14.7% of the recordings when no vessels were detected acoustically (162 of 1,102 h). **Overall, ambient noise resulted in >50% LRR for sound at 5 kHz for 12% of the total open water recording period (162 of 1,297 h), while vessel noise resulted in >50% LRR for sound at 5 kHz for 1% of the total open water recording period (19 of 1,297 h).**

25 kHz (clicks and high-frequency buzzes):

During the open water season, >50% LRR for sound at 25 kHz (a frequency component of narwhal clicks and high-frequency buzzes) occurred during 33% of the time vessels were detected on the recording (64 of 195 h). Ambient noise resulted in >50% LRR for sound at 25 kHz during 45.6% of the recordings when no vessels were detected acoustically (502 of 1,102 h). **Overall, ambient noise resulted in >50% LRR for sound at 25 kHz for 39% of the total open water recording period (502 of 1,297 h), while vessel noise resulted in >50% LRR for sound at 25 kHz for 5% of the total open water recording period (64 of 1,297 h).**

LRR for Phase 2 Shipping Operations

The results above were reflective of present shipping operation conditions under the 6 MTPA shipping operations, derived from 2019 measurements of approximately 166 transits of Postpanamax sized ore carriers from 28 days during the early shoulder season days and 55 days during the open-water season.

Under Phase 2 operations, a total of 324 Postpanamax carrier transits and 28 Capesize carrier transits are anticipated per shipping season. Postpanamax vessels can therefore be assumed to be detectable twice as often under a Phase 2 setting compared to the ERP setting (324 expected transits compared to 166 measured transits), meaning that Postpanamax vessels would be detectable between 30% and 60% of the time under Phase 2 operations (location dependent), with the same expected probability of LRR during those times as presented above. Capesize vessels would be detectable for approximately 15% of that time. This estimate is based on the fact that Capesize vessels would occur less often compared to Postpanamax vessels (the expected 28 Capesize transits is 8% of the expected 324 Postpanamax transits), but would be detectable for longer periods of time per transit owing to the higher sound levels from these larger vessels (the exposure duration of a Capsize transit is predicted to be

1.7 times that for a Postpanamax vessel). Scaling 8% up by a factor of 1.7 yields 15%. Based on this approach, it is estimated that Capesize vessels would be detectable between approximately 4.5% (15% of 30%) and 9% (15% of 60%) of the shipping season under Phase 2 operations.

Since the noise footprint for a Capesize vessel is larger than that for a Postpanamax vessel, there would be a higher occurrence of LRR on narwhal vocalizations when Capesize vessels transit past a stationary narwhal compared to that elicited by a Postpanamax vessel. There are no data that can be used to quantify this effect and this effect is not straightforward to model. To estimate the increased occurrence of LRR in the presence of a Capesize vessel, an increase of 3 dB was applied to the sound levels recorded at each AMAR during periods when vessels were detected to estimate the occurrence of LRR for Capesize vessels. The value of 3 dB was based on the modelling undertaken for Phase 2 which assumed a 3 dB difference in source levels between a Capesize and Postpanamax vessel. The resulting LRR occurrences for these simulated received levels are presented in Table 17. On average, the values are approximately 1.7 times those of the values in Table 16, a value which also corresponds with the exposure duration scaling factor applied in Section 4.1.3. Therefore, scaling the LRR probabilities in Table 16 by a factor of 1.7 (as shown in Table 17) is assumed to provide a reasonable estimate of the amount of time that the listening range for narwhal vocalizations would be reduced by >50% and >90% during periods when Capesize vessels would be detectable on the recordings.

Table 17: Estimate percent of time with >50% and >90% Listening Range Reduction (LRR) that would occur at each acoustic recorder location if received levels were 3 dB higher at times when vessels were detected (reflective of what conditions would be for Capeseize carriers).

Recorder	1 kHz		5 kHz		25 kHz	
	>50% LRR	>90% LRR	>50% LRR	>90% LRR	>50% LRR	>90% LRR
AMAR-1 (ambient noise data)	0.9	0	29.3	0.1	45.9	36.4
AMAR-1 (data with vessels detected)	15.2	3.4	40	4.6	38.4	28.1
AMAR-2 (ambient noise data)	0.2	0	14.7	0	45.6	37.7
AMAR-2 (data with vessels detected)	6.1	0.3	22.9	0.3	37.9	29.8
AMAR-3 (ambient noise data)	0.8	0	33.0	3.1	42.0	33.2
AMAR-3 (data with vessels detected)	14.9	2.1	44.9	10.7	47.7	31.7
AMAR-RI (ambient noise data)	0.1	0	15.5	0.2	31.7	6.2
AMAR-RI (data with vessels detected)	5.3	1.2	31.9	3.2	43	11.8

5.1.4.1 Potential Effects of LRR on Acoustic Masking

Although DFO Science has expressed concern that the acceptable risk threshold for LRR for narwhal has not been scientifically demonstrated by Baffinland, it is well known that currently there are no established regulatory thresholds under any jurisdiction that would aid in the determination of significance of acoustic masking effects on narwhal. As described in Hemerra (2019), Erbe et al. (2016) characterize acoustic masking as a complex phenomenon. Masking levels can be variable and dependent on the physiological and anatomical characteristics and activity of the sender and receiver, the levels of ambient noise and the degree of habituation of the individuals, as well as any anti-masking strategies employed. There is no vocalization masking model developed in the literature that is narwhal-specific and no research is available on the hearing ability (i.e., audiogram) of narwhal (Erbe et al. 2016). More research is needed to understand the process and biological significance of masking, as well as the risk of masking by various anthropogenic activities, before masking can be incorporated into regulation strategies or approaches for mitigation (Erbe et al. 2016).

Updated calculations for LRR based on 2019 measured data confirm assumptions made in the Phase 2 effects assessment that Project shipping has the potential to result in acoustic masking effects on narwhal that are measurable. However, based on monitoring results from 2019 which provide further insights into the magnitude and frequency at which this will occur, there is even greater confidence in the assessment that Project shipping is unlikely to compromise stock or population integrity. Mitigation measures, such as reduced ship speeds in the RSA and limited icebreaker transits during the early shoulder season, are expected to reduce potential effects of acoustic masking on narwhal and proposed marine mammal monitoring programs supportive of the Phase 2 Proposal will help address uncertainty and fill outstanding data gaps.

6.0 2019 SHIP-BASED OBSERVER PROGRAM

This section presents a summary of the results of the 2019 Ship-based Observer (SBO) Program to support an updated assessment of Project effects on marine mammals relative to Baffinland's Phase 2 Proposal (Section 7.0). The 2019 SBO Program took place onboard the icebreaker MSV Botnica during the early summer (Leg 1: 19–29 July) and fall shoulder season (Leg 2: 5-28 October). A detailed description of data collection and analytical methodology for the 2019 Marine Mammal Aerial Survey Program is provided in Golder (2019a; 2020d).

6.1 Summary of Results

Total monitoring effort for both survey legs was 268.7 h covering 3,089 km. Total monitoring effort during Leg 1 was 100.4 h covering 1,119 km. Total monitoring effort during Leg 2 was 168.3 h travelling 1,970 km. Although there were nearly twice as many observation days in Leg 2 compared to Leg 1 (24 vs. 11 days), this was not reflected in overall survey effort given the longer daylight hours during Leg 1 (mean daily effort= 11 h) compared to Leg 2 (mean daily effort = 7 h).

Seven different species of marine mammals were observed during the 2019 SBO Program: narwhal, beluga whale, bowhead whale, ringed seal, harp seal, bearded seal and polar bear. A total of 304 marine mammal sightings comprising 2,785 individuals were recorded (Table 18). Killer whale and walrus were not recorded in the RSA during either survey leg in 2019; however both species are known to occur in the region.

During Leg 1, a total of 152 marine mammal sightings comprising 2,453 individuals were recorded (Table 18). Species identified included ringed seal (61 sightings of 722 individuals), narwhal (27 sightings of 385 individuals), harp seal (24 sightings of 136 individuals), bowhead whale (22 sightings of 24 individuals), bearded seal (four sightings of four individuals), polar bear (two sightings of two individuals) and beluga (one sighting of one individual). There were also nine sightings of unconfirmed pinniped species (comprising 1,176 individuals) and two sightings of unconfirmed cetacean species (comprising three individuals).

During Leg 2, a total of 152 marine mammal sightings comprising 332 individuals were recorded (Table 18). Species identified included ringed seal (53 sightings of 58 individuals), narwhal (27 sightings of 103 individuals), harp seal (25 sightings of 117 individuals), bearded seal (one sighting of one individual) and bowhead whale (one sighting of one individual). There were also 44 sightings of unconfirmed pinniped species (49 individuals) and one sighting of an unconfirmed cetacean species (comprising three individuals). No polar bear or beluga were observed during the fall surveys.

Table 18. Marine mammal sightings recorded during the 2019 Ship-based Observer Program

Species	Early Summer (July 19-29)				Fall (0ct 05-28)			
	In Water		On Ice		In Water		On Ice	
	No. of Sightings	No. of Animals	No. of Sightings	No. of Animals	No. of Sightings	No. of Animals	No. of Sightings	No. of Animals
Narwhal	27	385	0	0	27	103	0	0
Beluga	1	1	0	0	0	0	0	0
Bowhead	22	24	0	0	1	1	0	0
Unknown Whale	2	3	0	0	1	3	0	0
Ringed Seal	48	49	13	673	52	56	1	2
Harp Seal	24	136	0	0	25	117	0	0
Bearded Seal	1	1	3	3	1	1	0	0
Unknown Seal	4	4	5	1,172	36	37	8	12
Polar Bear	0	0	2	2	0	0	0	0
Total	**129**	**603**	**23**	**1,850**	**143**	**318**	**9**	**14**

Narwhal

A total of 54 narwhal sightings comprising 488 individuals were recorded in the RSA in 2019, with a higher number of animals observed during Leg 1 (n=385) than Leg 2 (n=103) (Table 18). Narwhal were observed from the vessel as early as 19 July and as late as 28 October. During Leg 1, sightings were concentrated in eastern Eclipse Sound near Pond Inlet and near Bruce Head in southern Milne Inlet (Figure 35). During Leg 2, sightings were concentrated in Eclipse Sound near the southwest tip of Bylot Island and in Milne Inlet North near Ragged Island (Figure 36). Mean narwhal group size in 2019 was nine (ranging from 1 to 100 animals). No mothers with calves were observed during the 2019 SBO Program.

Beluga Whale

There was one sighting of a single beluga whale in Milne Inlet South during Leg 1, observed near the entrance to Koluktoo Bay (Table 18; Figure 35).

Bowhead Whale

A total of 22 bowhead sightings comprising 24 individuals were recorded in the RSA in 2019 (Table 18). All of the sightings occurred during Leg 1 (Figure 35), with the exception of one solitary bowhead observed during Leg 2 north of Ragged Island (Figure 36). Bowhead sightings during Leg 1 were primarily concentrated in Eclipse Sound with several individuals also observed in Milne Inlet South and Milne Inlet North near Ragged Island. All sightings consisted of solitary animals with the exception of two separate sightings of a pair of bowheads during Leg 1.

Ringed Seal

A total of 114 ringed seal sightings comprising 780 individuals were recorded in the RSA in 2019 (Table 18). During Leg 1, ringed seal were distributed along the entire shipping corridor, with multiple large group sightings (>10 animals) recorded in Milne Inlet North (Figure 37). During Leg 2, ringed seal were observed primarily in Eclipse Sound with only a few sightings recorded in Milne Inlet and Baffin Bay (Figure 38). In-water sightings consisted primarily of solitary animals (95 out of 100 sightings). On-ice sightings consisted of solitary animals or in groups ranging in size from 2 to 300 animals, with a median group size of 7.5.

Harp Seal

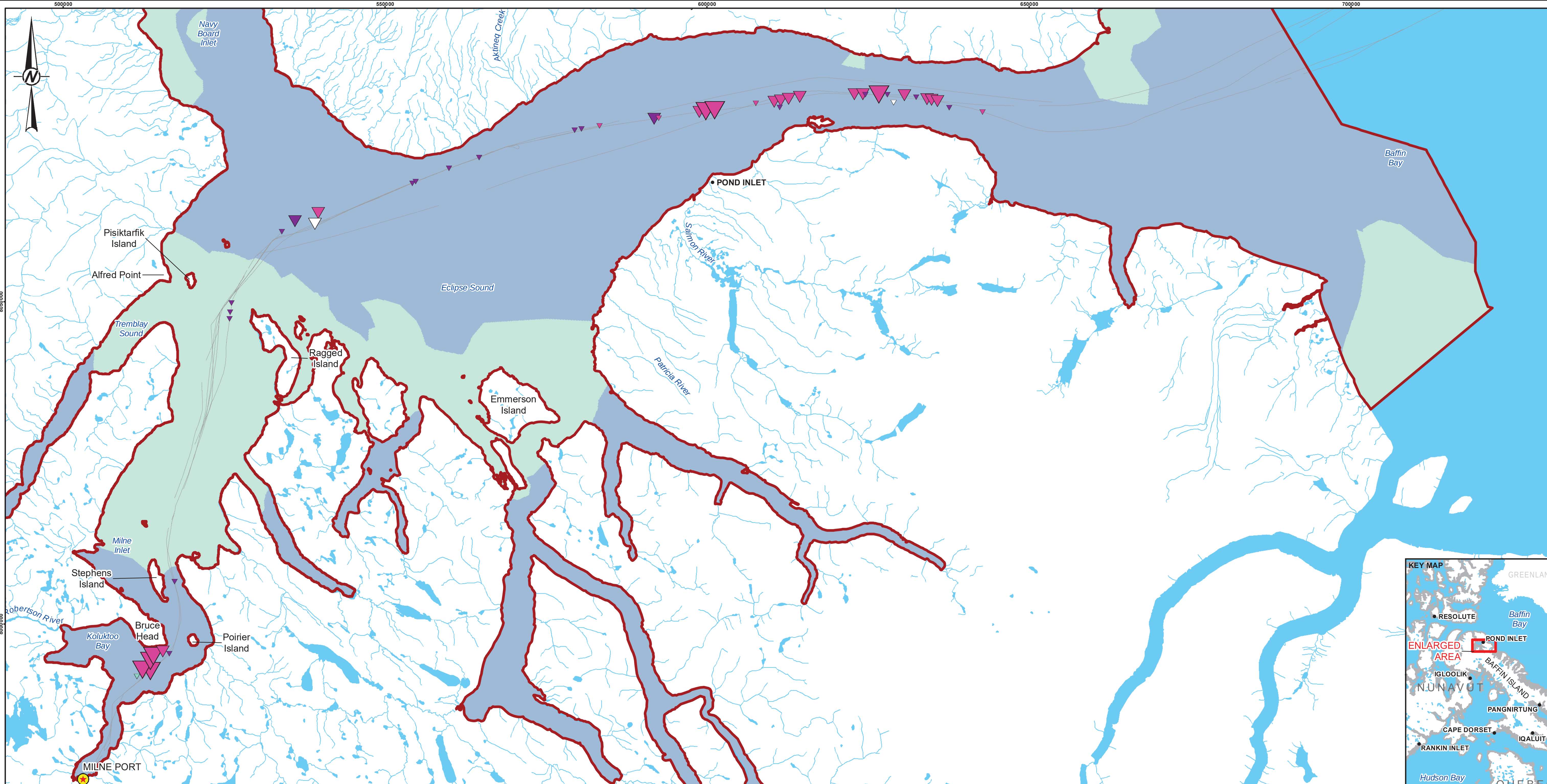
A total of 49 harp seal sightings comprising 253 individuals were recorded in the RSA in 2019 (Table 18). During both Leg 1 and Leg 2, harp seal were observed primarily in Eclipse Sound and eastward towards the entrance to Eclipse Sound (Tuqsukatta) (Figure 37 and Figure 38). All in-water sightings consisted of solitary animals or in groups ranging in size from two to 25 animals, with a median group size of two. No harp seals were observed on ice during either survey leg.

Bearded Seal

A total of five bearded seal sightings (all solitary animals) were recorded in the RSA in 2019 (Table 18). Four of the sightings occurred during Leg 1, three of which were on-ice (Figure 37). The lone sighting recorded during Leg 2 consisted of a solitary animal observed in-water at the entrance to Baffin Bay (Figure 38).

Polar Bear

Only two polar bear sightings were recorded in the RSA in 2019, both on the same day (20 July), with each sighting consisting of a solitary polar bear walking on the sea ice in Milne Inlet North (Table 18; Figure 37). The first polar bear was observed approximately 1 km from the vessel. The second polar bear was observed 12 minutes later, approximately 3 km from the vessel. There was also one incidental polar bear sighting made by the ship crew on July 21 at 02:00 when the MWOs were not on watch. The bear was observed in Milne Inlet North (near Ragged Island) where it was resting on the ice ahead of the vessel at an unknown distance before running away.



LEGEND

- • COMMUNITY
- MILNE PORT

CETACEAN SPECIES OBSERVATIONS (GROUP SIZE)

BELUGA
- 1

BOWHEAD WHALE
- 1
- 2 - 10

NARWHAL
- 1
- 2 - 10
- 10+

UNIDENTIFIED WHALE
- 1
- 2 - 10

- MILNE INLET TOTE ROAD
- SURVEY TRACK (JULY 19 - 29, 2018)
- WATERCOURSE
- MARINE MAMMAL REGIONAL STUDY AREA
- WATERBODY

SUMMER MEAN PERCENT ICE CONCENTRATION (JULY 19 TO 29, 2018)
- ICE FREE
- 0-10%
- 10-30%
- 40-60%
- 70-80%
- 90-100%

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
DISTRIBUTION OF CETACEAN OBSERVATIONS FROM 19-29 JULY 2019

PROJECT NO.	CONTROL	REV.	FIGURE
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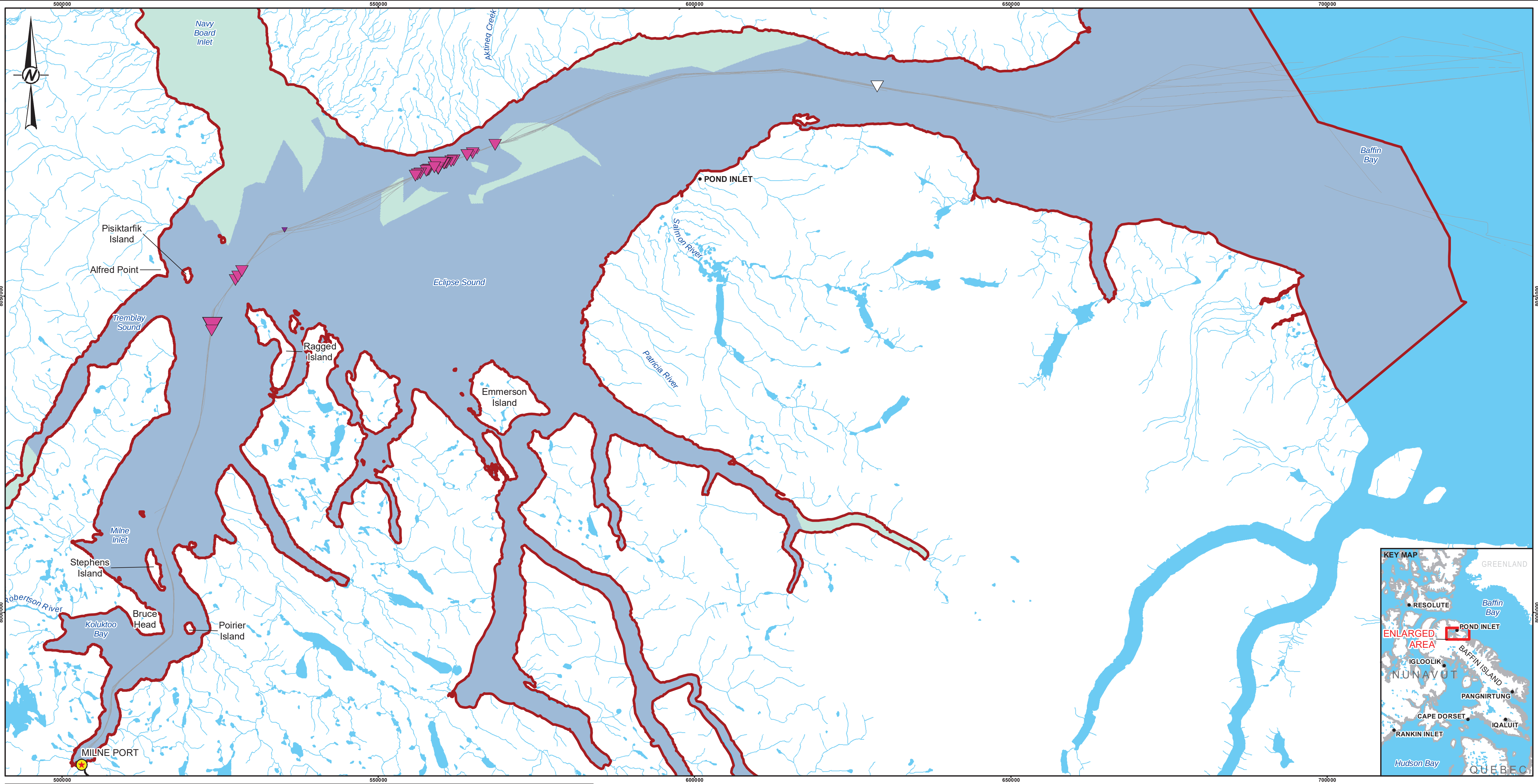

LEGEND

- • COMMUNITY
- MILNE PORT

CETACEAN SPECIES OBSERVATIONS (GROUP SIZE)

BOWHEAD WHALE

- ▼ 1

NARWHAL

- ▼ 1
- ▼ 2 - 10
- ▼ 10+

UNIDENTIFIED WHALE

- ▽ 2 - 10

- MILNE INLET TOTE ROAD
- SURVEY TRACK (OCTOBER 5-28, 2019)
- WATERCOURSE
- MARINE MAMMAL REGIONAL STUDY AREA
- WATERBODY

FALL MEAN PERCENT ICE CONCENTRATION (OCTOBER 5 TO 28, 2019)

- ICE FREE
- 0-10%
- 10-30%
- 40-60%
- 70-80%
- 90-100%

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
DISTRIBUTION OF CETACEAN OBSERVATIONS FROM 5-28 OCTOBER 2019

PROJECT NO.	CONTROL	REV.	FIGURE
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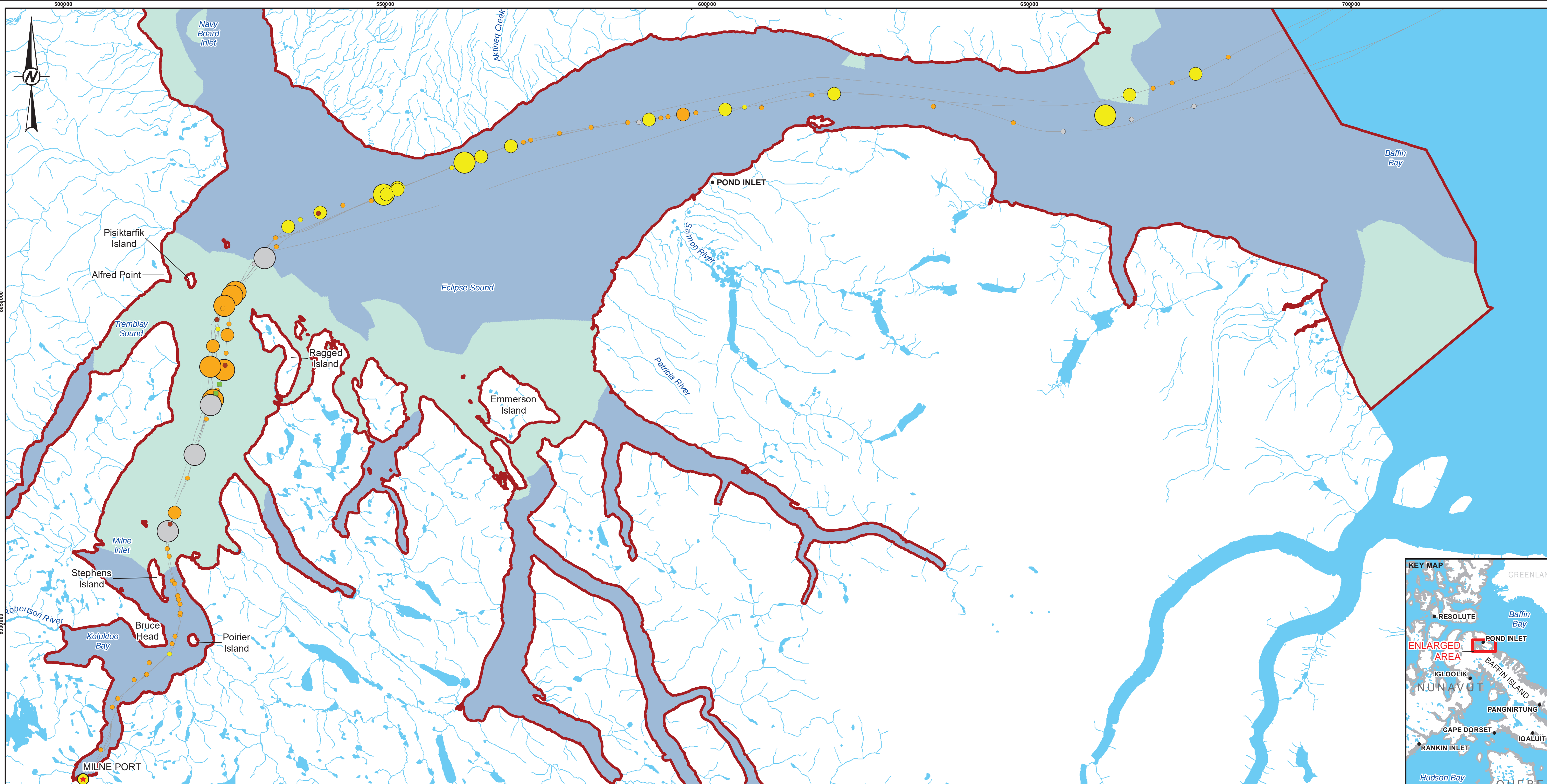

LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL
- 1

HARP SEAL
- 1
- 2 - 10
- 10+

POLAR BEAR
- 1

RINGED SEAL
- 1
- 2 - 10
- 10+

UNIDENTIFIED SEAL
- 1
- 10+

- MILNE INLET TOTE ROAD
- SURVEY TRACK (JULY 19 - 29, 2018)
- WATERCOURSE
- MARINE MAMMAL REGIONAL STUDY AREA
- WATERBODY

SUMMER MEAN PERCENT ICE CONCENTRATION (JULY 19 TO 29, 2019)
- ICE FREE
- 0-10%
- 10-30%
- 40-60%
- 70-80%
- 90-100%

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
DISTRIBUTION OF PINNIPED AND POLAR BEAR OBSERVATIONS FROM JULY 19-29, 2019

PROJECT NO.	CONTROL	REV.	FIGURE
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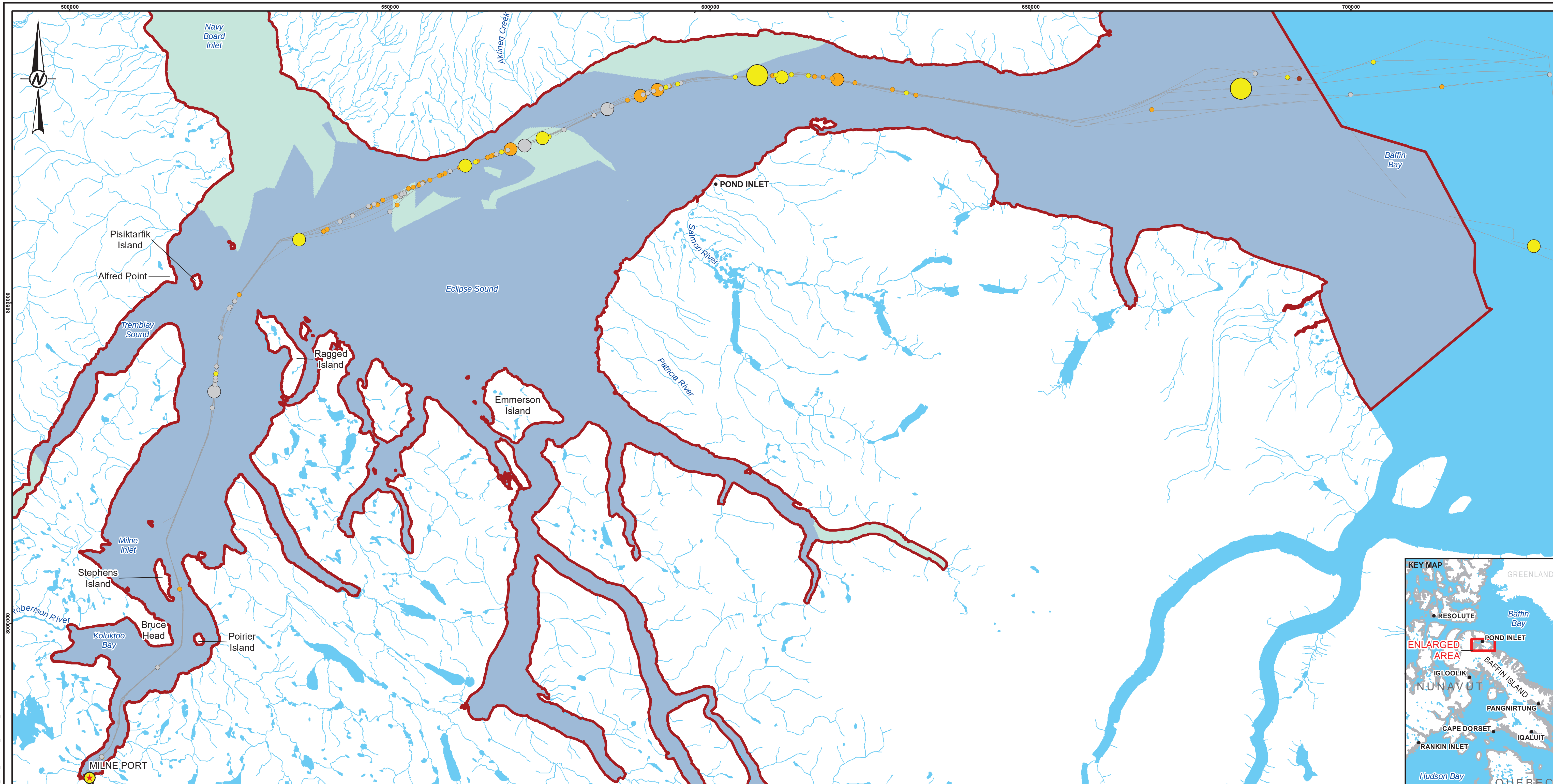

LEGEND

- COMMUNITY
- MILNE PORT

MARINE MAMMAL SPECIES OBSERVATIONS (GROUP SIZE)

BEARDED SEAL

- 1

HARP SEAL

- 1
- 2 - 10
- 10+

RINGED SEAL

- 1
- 2 - 10

UNIDENTIFIED SEAL

- 1
- 2 - 10

- MILNE INLET TOTE ROAD
- SURVEY TRACK (OCTOBER 5-28, 2019)
- WATERCOURSE
- MARINE MAMMAL REGIONAL STUDY AREA
- WATERBODY

FALL MEAN PERCENT ICE CONCENTRATION (OCTOBER 5 TO 28, 2019)

- ICE FREE
- 0-10%
- 10-30%
- 40-60%
- 70-80%
- 90-100%

0 10 20
1:600,000 KILOMETRES

REFERENCE(S)
MILNE PORT INFRASTRUCTURE DATA OBTAINED FROM CLIENT MAY 28, 2018 AND BY HATCH, JANUARY 25, 2017, RETRIEVED FROM KNIGHT PIESOLD LTD. FULCRUM DATA MANAGEMENT SITE MAY 19, 2017. 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
DISTRIBUTION OF PINNIPED OBSERVATIONS FROM OCTOBER 5-28, 2019

PROJECT NO.	CONTROL	REV.	FIGURE
1663724	38000	0	38

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Relative Abundance of Marine Mammals in the RSA

The relative abundance of marine mammals in the RSA, expressed as the animal detection rate (no. of animals relative to survey effort in km) in Table 19 below, was 0.90 animals/km (0.10 sightings per km). More animals were observed during Leg 1 (2.19 animals/km) than during Leg 2 (0.17 animals/km). Table 19 provides a summary of sighting rates and animal detection rates by species and between survey legs. All marine mammal species, including narwhal, occurred in higher relative abundance in the RSA during Leg 1 than during Leg 2.

Table 19: Sighting and animal detection rate (relative abundance) of marine mammals in RSA

Species	Early Summer (July 19-29)		Fall (0ct 05-28)		Combined	
	No. of Sightings (No. of Individuals)	Relative Detection Rate*	No. of Sightings (No. of Individuals)	Relative Detection Rate	No. of Sightings (No. of Individuals)	Relative Detection Rate
Narwhal	27 (385)	0.0241 (0.3441)	27 (103)	0.0137 (0.0523)	54 (488)	0.0175 (0.1580)
Beluga whale	1 (1)	0.0009 (0.0009)	0 (0)	0 (0)	1 (1)	0.0003 (0.0003)
Bowhead	22 (24)	0.0197 (0.0214)	1 (1)	0.0005 (0.0005)	23 (25)	0.0074 (0.0081)
Unknown whale	2 (3)	0.0018 (0.0027)	1 (3)	0.0005 (0.0015)	3 (6)	0.0010 (0.0019)
Ringed seal	61 (722)	0.0545 (0.6452)	53 (58)	0.0269 (0.0294)	114 (780)	0.0369 (0.2525)
Harp seal	24 (136)	0.0214 (0.1215)	25 (117)	0.0127 (0.0594)	49 (253)	0.0159 (0.0819)
Bearded seal	4 (4)	0.0036 (0.0036)	1 (1)	0.0005 (0.0005)	5 (5)	0.0016 (0.0016)
Unknown seal	9 (1,176)	0.0080 (1.0509)	44 (49)	0.0223 (0.0249)	53 (1,225)	0.0172 (0.3965)
Polar bear	2 (2)	0.0018 (0.0018)	0 (0)	0(0)	2 (2)	0.0006 (0.0006)
Total	152 (2,453)	0.1358 (2.1921)	253 (332)	0.0771 (0.1685)	304 (2,785)	0.0984 (0.9015)

Note: * sightings/km (individuals/km)

6.2 Comparison to 2018 SBO Program

The relative abundance of marine mammals in the RSA was similar in 2019 (0.90 individuals/km) to that observed in 2018 (0.88 individuals/km) (Table 20). Species observed in greater relative abundance in 2019 included narwhal, beluga, and bowhead whale. For these species, the increase was reflective of more animals observed during Leg 1 (similar numbers were seen during Leg 2 in both years). Less ringed seal and harp seal were observed in 2019 compared to 2018, although this was likely associated with the large number of unconfirmed seal species recorded in 2019 (n=1,225) compared to 2018 (n=760) (Table 20). When considering all seal categories (confirmed and unconfirmed species), a similar number of seals were observed in both years.

The observed increase in narwhal relative abundance in 2019 may have been reflective of abnormally low numbers of narwhal in the RSA in 2018, as reported by community members and as supported by low catch rates that year. Hunters found the opposite to be true in 2019 when narwhal were regularly observed throughout the RSA and in large groups (R. Arnakallak, Pers. Comm. 2020). The increase in relative abundance observed in 2019 may have also been a result of new adaptive management measures implemented during the early 2019 shoulder season to specifically reduce icebreaker noise impacts on narwhal, such as the 40 km floe edge buffer zone and a reduced number of icebreaker transits per day in the RSA in heavy ice conditions.

Overall, 2018 and 2019 results suggest that marine mammals in the RSA are not demonstrating large-scale displacement or abandonment from the RSA during or following icebreaking operations, and that mitigation measures implemented during the 2019 early shoulder season (e.g., limited number of transits, 40 km buffer area, etc.) are demonstrating to be effective.

6.3 2013-2015 SBO Programs

The main species observed during the initial SBO programs in 2013, 2014 and 2015, prior to the 2018 and 2019 SBO Programs, were narwhal, ringed seal and harp seal (SEM 2016). Less observation effort during earlier SBO programs (5.5 h in 2013, 9 h in 2014 and 9 h in 2015) resulted in a lower number of sightings compared to the 2018 and 2019 programs. In 2013, a total of five narwhal, 453 ringed seal, 10–15 harp seal and one unidentified seal were observed (SEM 2016). In 2014, a total of 7–9 narwhal, two ringed seal and one unidentified seal were observed (SEM 2016). In 2015, a total of 5–10 narwhal and one ringed seal were observed (SEM 2016). Results from the 2013-2015 SBO Programs were not directly comparable to results from 2018 and 2019.

Table 20: Relative abundance of marine mammals in RSA – A comparison between 2018 and 2019 SBO Programs

Species	Combined 2018		Combined 2019	
	No. of Individuals	Relative Abundance*	No. of Individuals	Relative Abundance*
Narwhal	175	0.0555	488	0.1580
Beluga whale	0	0.0000	1	0.0003
Bowhead whale	0	0.0000	25	0.0081
Unidentified Whale	1	0.0003	6	0.0019
Ringed Seal	1,069	0.3389	780	0.2525
Harp Seal	754	0.2391	253	0.0819
Bearded Seal	5	0.0016	5	0.0016
Unidentified Seal	760	0.2410	1,225	0.3965
Polar Bear	2	0.0006	2	0.0006
Total	**2,766**	**0.8770**	**2,785**	**0.9015**

Note: *individuals/km

6.4 Closest Point of Approach to Vessel

During each recorded marine mammal sighting, the distance between the detected marine mammal and the ship was estimated. The initial distance at which a marine mammal was observed by the MWO was noted and if the animal was subsequently observed again at a closer distance to the ship, the Closest Point of Approach (CPA) was updated. Table 21 presents a summary of CPAs recorded for sightings during all scheduled marine mammal watches in 2019. CPAs for pinnipeds ‘on ice’ and ‘in-water’ were calculated separately given differences in animal detectability and animal behaviours between the two environments (i.e., as pinnipeds are more easily detected on ice than in-water).

Table 21: Closest Point of Approach (CPA) distances recorded during the 2019 SBO Program

	Narwhal	Beluga	Bowhead Whale	Unidentified Whale	Ringed Seal	Harp Seal	Bearded Seal	Unidentified Seal	Polar Bear
Leg 1: Early Summer (July 19-29)									
In-water									
Mean CPA (m)	792.6	1000.0	729.5	550.0	223.8	330.8	600.0	237.5	n/a
Range (m)	200-2500	1000	200-1500	200-900	50-900	60-800	600	100-400	n/a
# Sightings	27	1	24	2	48	24	1	4	0
On ice									
Mean CPA (m)	n/a	n/a	n/a	n/a	830.8	n/a	233.3	1180.0	2000.0
Range (m)	n/a	n/a	n/a	n/a	100-2000	n/a	100-300	100-2000	1000-3000
# Sightings	0	0	0	0	13	0	3	5	2
Leg 2: Fall (0ct 05-28)									
In-water									
Mean CPA (m)	1175.9	n/a	3700.0	n/a	415.8	315.4	800.0	824.7	n/a
Range (m)	250-5000	n/a	3700	n/a	30-1500	10-900	800	10-5000	n/a
# Sightings	28	0	1	0	54	27	1	36	0
On ice									
Mean CPA (m)	n/a	n/a	n/a	n/a	400.0	n/a	n/a	5062.5	n/a
Range (m)	n/a	n/a	n/a	n/a	400	n/a	n/a	500-8000	n/a
# Sightings	0	0	0	0	1	0	0	8	0

Narwhal

The CPA for narwhal ranged from 200 to 2,500 m (mean = 792.6 m) during Leg 1, and from 250 to 5,000 m (mean = 1,175.9 m) during Leg 2 (Table 21). Mean CPA distances were significantly larger in Leg 2 than during Leg 1 (Mann-Whitney U = 191, p = 0.003).

Beluga Whale

The single observation of a beluga whale during Leg 1 corresponded with a CPA of 1,000 m (Table 21).

Bowhead Whale

The CPA for bowhead whale during Leg 1 ranged from 200 to 1,500 m (mean = 729.5 m; Table 21). The single bowhead whale sighting during Leg 2 corresponded with a CPA of 3,700 m.

Ringed Seal

The CPA for ringed seal in-water ranged from 50 to 900 m (mean = 223.8 m) during Leg 1, and from 30 to 1,500 m (mean = 415.8 m) during Leg 2 (Table 21). The mean CPA distances were significantly larger in Leg 2 than during Leg 1 (Mann-Whitney U = 901.0, p = 0.016). The CPA for ringed seal on ice ranged from 100 to 2,000 m (mean = 830.8 m) during Leg 1. The only sighting of a pair of ringed seal on ice during Leg 2 corresponded with a CPA of 400 m.

Harp Seal

The CPA for harp seals in-water ranged from 60 to 800 m (mean = 330.8 m) during Leg 1, and from 10 to 900 m (mean = 315.4 m) during Leg 2 (Table 21), with no significant difference between seasons (Mann-Whitney U = 308, p = 0.880). Harp seals were not observed on ice during the 2019 SBO Program.

Bearded Seal

The single bearded seal in-water sighting during Leg 1 corresponded with a CPA of 600 m (Table 21) and the single bearded seal in-water sighting during Leg 2 corresponded with a CPA of 800 m (Table 21). The CPA for ringed seal on-ice ranged from 100 to 300 m during Leg 1 (mean = 233.3 m; Table 21). No on-ice sightings of bearded seal occurred during Leg 2.

Polar Bear

Two polar bears were observed during Leg 1; the first was observed on the ice with a CPA of 1,000 m and the second was observed on the ice with a CPA of 3,000 m.

Overall, the 2019 CPA results supported impact predictions that animals demonstrate localized avoidance of the ship. This provides further confidence that a vessel strike on a marine mammal is unlikely to occur based on current vessel speeds in the RSA (9 knot speed restriction). These results also further support impact predictions made in the FEIS Addendum for the Early Revenue Phase (ERP), that the Project is unlikely to result in significant residual adverse effects on narwhal in the RSA, defined as effects that compromise the integrity of the population either through mortality (i.e., ship strikes) or via large-scale displacement or abandonment of the RSA.

6.5 Inuit Researcher Feedback

Following the completion of the 2019 SBO Program, two Inuit Researchers that participated in the program in 2019 and in past years were interviewed to garner feedback on the program, observations made in the field, and recommendations moving forward. The following is a summary of the feedback provided specific to this program:

- Once the ice breaks up, narwhal are everywhere.
- Narwhal swim away from ship if it is coming at them. Some may be curious around this ship.
- Did not notice narwhal swimming behind the ship’s ice tracks.
- When the ship is closer, the narwhal travel faster than when the ship is farther away.

- Marine mammals usually keep their distance from ships.
- Seals move out of the way.
- Bowhead whales have not been observed near the ship. They are normally to the side and swim fast.

7.0 2017/2018 INTEGRATED NARWHAL TAGGING STUDY

This section provides a summary of narwhal behavioural responses to shipping operations during the 2017 and 2018 shipping seasons in the RSA, to support an updated assessment of potential ship strikes and disturbance effects on marine mammals relative to Baffinland's Phase 2 Proposal (Section 7.0). These results have been analyzed and interpreted relative to the scale of impacts that were predicted through a comprehensive review of scientific literature, available empirical data, and through acoustic modelling undertaken for Phase 2.

To investigate behavioural response of narwhal to vessels transiting the Northern Shipping Route, Golder partnered with Fisheries and Oceans Canada (DFO) to undertake a narwhal tagging study during 2017 and 2018 based out of Tremblay Sound, Nunavut. The collaborative research program involved Golder expanding on DFO's existing tagging program by supplying additional biologging tags that were customized to address Baffinland's Project-specific study objectives related to understanding behavioural response of narwhal to vessel traffic. A total of 24 narwhal were live-captured in Tremblay Sound during summer of 2017 and 2018 (20 narwhal in 2017 and four narwhal in 2018) and instrumented with a combination of biologging tags. Biologging tags monitored the fine-scale lateral movements of narwhal, their dive behaviour, and habitat use throughout their summering grounds in the coastal fjord system of northern Baffin Island.

Behavioural response of narwhal to Project ore carriers and other non-Project related vessel traffic present within the Project's RSA was investigated by comparing animal-borne tag data with AIS vessel-tracking data collected during the 2017 and 2018 shipping seasons. Behavioural responses considered in this study included changes in narwhal surface movement (e.g., horizontal displacement, travel speed, habitat re-occupation) and changes in dive behaviour; with the latter component assessing potential changes in surface time, dive rate, bottom dive depth, time at depth, dive duration, and descent speed during encounters with large- (≥100 m in length) and medium-sized vessels (50–99 m in length).

For analysis of narwhal dive behaviour, the dataset included high-resolution dive data obtained for six narwhal, each fitted with a backpack tag possessing Fastloc GPS capability and a MiniPAT tow tag (Wildlife Computers). A total of 92 vessel-narwhal interactions were identified in which the closest point of approach (CPA) between individual narwhal and a given vessel was within 3 km. Subsurface movements of each animal were then analyzed as a function of distance from transiting vessels (CPA to 10 km) in relation to vessel non-exposure (>10 km) periods.

A larger subset of narwhal associated with GPS tag data was incorporated into the surface behaviour analysis as this component was not limited by the small sample size of individuals that were successfully fitted with high resolution dive tags. The dataset used for analysis of surface movement relative to vessel traffic included 14 narwhal fitted with GPS Fastloc location tags (ten SPLASH10 tags and four CTD-SRDL tags). Potential changes in narwhal surface behaviour were also examined as a function of distance from transiting vessels within the 10 km exposure zone and compared against periods of non exposure (> 10 km).

A description of the data collection and analytical methodology for the 2017 and 2018 Integrated Narwhal Tagging study is provided in Golder (2020).

7.1 Summary of Results

The following is a summary of key findings pertaining to narwhal behavioural response to vessel traffic based on a comparison of animal-borne tag data with AIS ship-tracking data during the 2017 and 2018 shipping seasons:

- Narwhal positional data from 2017 and 2018 demonstrated that tagged narwhal occurred in all strata during the summer period but were more common in certain areas of the RSA, namely Milne Inlet South, Koluktoo Bay, Milne Inlet North and Tremblay Sound. High use areas in the RSA included the central portion of Tremblay Sound, the western shore of Milne Inlet North, and most of Koluktoo Bay and Milne Inlet South, particularly in areas south of Bruce Head (i.e., entrance to Koluktoo Bay) and in Assomption Harbour (i.e., Milne Port site). These results were consistent with areas of high narwhal concentrations identified during baseline aerial surveys conducted in the RSA during 2007, 2008, 2013 and 2014 (Elliott et al. 2015; Thomas et al. 2015) prior to the commencement of iron ore shipping along the Northern Shipping Route.
- With respect to interactions between tagged narwhal and existing shipping in the RSA, the majority of the GPS data collected during 2017 and 2018 occurred when narwhal were >10 km from medium- and large-sized vessels (Project and non-Project related). Vessel exposure events (<10 km) occurred throughout the RSA but were more common in the Milne Inlet South and Koluktoo Bay strata due to the confined nature of the channel along this part of the Northern Shipping Route.
- Satellite tag data from 2017 indicated that several of the tagged narwhal moved between Eclipse Sound and Admiralty Inlet during their deployment period. These results supported the notion that some degree of mixing occurs between the Eclipse Sound and Admiralty Inlet stocks during the shipping season.
- Narwhal dive behavioural responses that were shown to be significantly influenced by ship noise and/or close ship encounters included surface time, dive duration, and bottom dives; the latter only during periods when narwhal were engaged in bottom diving at the initial time of vessel exposure. No significant effects were observed for dive rate, time at depth, descent speed, or bottom dives (during periods when narwhal were not actively diving to the bottom at the initial time of exposure). The distance at which significant changes were observed in dive behaviour ranged from 1 to 5 km dependent on the response variable. This corresponded with an exposure period ranging from 7 to 36 min per vessel transit (based on a 9-knot travel speed), with animals returning to their pre-response behaviour following the exposure period (temporary effect). The frequency of this effect was considered intermittent given that vessels were within 5 km of a tagged narwhal for <1% of the GPS datapoints collected in the RSA during 2017 and 2018.
- Narwhal surface movement responses that were shown to be significantly influenced by ship-generated noise included turning angle and orientation relative to vessel (low level severity responses). No significant effects were observed for travel speed, horizontal displacement or habitat re-occupation. The distance at which significant changes were observed in surface movement behaviour ranged from 4 to 10 km dependant on the response variable. This corresponded with an exposure period ranging from 29 to 54 min per vessel transit (based on a 9 knot travel speed), with animals returning to their pre-response behaviour following the exposure period (temporary effect). The frequency of this effect was considered intermittent given that vessels were within 10 km of a tagged narwhal for <7% of the GPS datapoints collected in the RSA during 2017 and 2018. Although no significant effect was observed for horizontal displacement, a clear spatial gap in narwhal positional data was evident in the immediate proximity of the vessel (within 0.5 km of the vessel's port and starboard beam and within 1 km of its bow and stern). This gap may reflect close-range avoidance behaviour but may also be a function of the low-resolution GPS location data available.

Overall, results from the 2017 and 2018 narwhal tagging study supported predictions made in the FEIS for the ERP, in that ship noise effects on narwhal will be limited to temporary, short-term avoidance behaviour, consistent with low to moderate severity responses (Southall et al. 2007; Finneran et al. 2017). No evidence was observed of large-scale avoidance behaviour, displacement effects, or abandonment of the summering grounds (high severity responses), which might in turn result in a population or stock-level consequence (consistent with the definition of a non-significant effect used in the FEIS).

8.0 COMBINED EFFECTS ASSESSSMENT

In their Final Written Submissions (DFO 3.11 (October 2019) and DFO 3.7 (January 2020)), DFO requested that Baffinland conduct an assessment examining all combined effects of the Project. Table 22 addresses this request, and considers both Project incremental and Project combined effects for each marine mammal VEC based on the five key effect pathways identified: vessel strikes, entrapment in ice, acoustic injury, acoustic behavioural disturbance and acoustic masking from shipping operations, along with a determination of significance. 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.

The previous effects assessment submissions have demonstrated that, following implementation of known and effective mitigation measures, three of these effect pathways (vessel strikes, entrapment and acoustic injury) are not predicted to occur and hence are not predicted to act in combination with the two remaining effect pathways (acoustic disturbance and acoustic masking).

Regarding the combined effect of behavioral disturbance and acoustic masking, it is important to note that acoustic masking is actually a form 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 shown by the identical effect ratings and significance determinations in Table 22. While limited masking from ship noise is predicted to occur for marine mammals 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.

Table 22: Updated residual effect ratings and significance determinations for Marine Mammal VECs - Phase 2

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)
Ice entrapment	Level I	Level I	Level I	Level II	Level I	N	I (Unlikely)	III (High)
Ship strikes	Level I	Level I	Level I	Level II	Level I	N	I (Unlikely)	III (High)

Residual Effect	Residual Effect Evaluation Criteria						Qualifiers**	
	Magnitude	Extent	Frequency	Duration	Reversibility	Significance	Probability (Likelihood of Effect Occurring)	Certainty (Confidence in Effects Prediction)
Combined Project Effects	Level II	Level II	Level II	Level II	Level I	N		II (Medium)
Beluga								
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)
Ice entrapment	Level I	Level I	Level I	Level II	Level I	N	I (Unlikely)	III (High)
Ship strikes	Level I	Level I	Level I	Level II	Level I	N	I (Unlikely)	III (High)
Combined Project Effects	Level II	Level II	Level II	Level II	Level I	N		II (Medium)
Bowhead whale								
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)
Ship strikes	Level I	Level I	Level I	Level II	Level I	N	I (Unlikely)	III (High)
Combined Project Effects	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)
Ship strikes	Level I	Level I	Level I	Level II	Level I	N	I (Unlikely)	III (High)
Change in habitat	Level I	Level I	Level II	Level II	Level I	N	I (Unlikely)	III (High)
Combined Project Effects	Level II	Level II	Level II	Level II	Level I	N		II (Medium)
Polar bear								
Ship strikes	Level I	Level I	Level I	Level II	Level I	N	I (Unlikely)	III (High)
Combined Project Effects	Level 1	Level1	Level 1	Level II	Level I	N		III (High)

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)
**Qualifiers provided for at the request of DFO. Inclusion is not consistent with FEIS methodology that indicates qualifiers are only applicable to significant effects.

With the effective implementation of mitigation measures currently in place (e.g., 9 knot speed restriction, 40-km buffer zone, limited icebreaker transits during shoulder season, etc.), it is predicted that the residual combined effects of the Project on marine mammals in the RSA will be limited to temporary and localized avoidance behavior. In summary, when all potential effects on marine mammals are combined, no significant residual effects are predicted for any of the marine mammal VECs in the RSA, that is no effects at the population or stock level, either through mortality or from large-scale displacement or abandonment from the RSA, are anticipated.

9.0 SUMMARY

Baffinland's marine mammal monitoring programs were based on a comprehensive 'multiple lines of evidence' approach for detection of potential Project effects, using an integrated combination of remote sensing and shore-based, vessel-based, aerial-based and acoustic-based monitoring methods. Collectively, these multi-year monitoring programs provided a comprehensive evaluation of potential shipping effects on marine mammals during the shipping period. Potential effects on marine mammals detected as part of this process were evaluated against impact predictions made in the FEIS, and in light of the various mitigation measures presently implemented as part of Baffinland's current shipping operations.

Overall, monitoring results collected to date, in concert with available modelling data, supported impact predictions made in the FEIS Addendum for ERP shipping operations, in that no marine mammal mortalities are anticipated to occur in the RSA from ship strikes, and that acoustic impacts from shipping on marine mammals will be limited to temporary, short-term avoidance behaviour, consistent with low to moderate severity responses (Southall et al. 2007; Finneran et al. 2017). Through the monitoring programs, no evidence has been observed of large-scale avoidance behaviour, displacement effects, or abandonment of the summering grounds (consistent with high severity responses), which might in turn result in a population or stock-level consequence (consistent with the definition of a non-significant effect used in the FEIS).

10.0 CLOSURE

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

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