APPENDIX 8C

UNDERWATER NOISE MODELLING

APPENDIX 8C-1

UNDERWATER NOISE MODELLING FOR STEENSBY INLET, FOXE BASIN AND HUDSON STRAIT

Assessment of Underwater Noise for the Mary River Iron Mine

Construction and Operation of the Steensby Inlet Port Facility.

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1. Introduction

JASCO Applied Sciences has performed an acoustic modelling study of the underwater noise expected from construction and operation of the Steensby Inlet Port Facility for the Mary River Iron Mine.

The proposed Mary River Iron Mine is located on North Baffin Island, Nunavut. A large dock facility will be built in Steensby Inlet for year round shipping operations of the iron ore with large ore-carriers. The proposed shipping route is from Steensby Inlet, through the Fox Basin, along the northern shore of Hudson Strait, and into the Atlantic.

The construction of the main ore-loading dock will require deepening of the sea bottom. The seabed at Steensby Island is represented by granites with thin cover of coarse sediments. Before the bottom material can be removed, blasting with pre-drilling for the blasting, is required. The loose materials after blasting will be removed by a dredge. The drilling and blasting operations are proposed to be carried out from ice, while the dredging is expected to be performed during open water season. The modelling location for the construction was chosen at the proposed location of the ore-loading jetty.

The operation of the port facility will involve tug manoeuvres in the vicinity of the port (ore-carriers assisted docking, ice management during ice season) and ore-carriers passing along the shipping route. Two types of tugs are expected to operate at the port: summer tugs and winter tugs with higher ice-class. Ore-carriers with ±190,000 DWT are planned to be used on the route. One modelling location for the tug operations was chosen in the vicinity of the ore-loading jetty. Three locations for the noise modelling from the ore-carriers were chosen along the shipping route after consultations with LGL Limited.

The modelling for the port operation was performed for three seasons: open water (August), thin ice conditions (February), and thick ice conditions (May). Each of the specific construction activities was modelled only for the season, during which it was expected to be carried out.

The modelling was performed for an extended frequency range — 10–20,000 Hz. The source levels for each of the modelled noise sources were estimated based on an extensive literature review as well as JASCO’s own source level database.

The seasonal changes were considered in the model in three ways:

1. Variation of the sound speed profile
2. Increased source levels (e.g. as the vessels have to push their way through ice)
3. Increased attenuation of the sound energy due to interaction with the ice cover

The results of the modelling are presented in different forms suitable for further noise impact assessment. For each modelling scenario the following output produced:

- Areal map of Sound Pressure Level (SPL) field distribution contoured with 10 dB step
- Tables of threshold distances to the broadband levels, calculated based on flat-weighted as well as M-weighted (4 different curves) result
- Tables of estimated maximum sound levels at specified distances for 1/3 octave band central frequency from 10 Hz to 20,000 Hz. The tables are presented in a separate Excel spread sheet document.

2. Source Levels

2.1. Port Construction and Operation

2.1.1. Drilling

Drilling is required to install blast charges into the rock. The drilling of blast holes is expected to be performed from ice, i.e. during the late winter, when the ice cover is the thickest. In the absence of final design, reasonable assumptions were made about the drilling operation and specifications of the drill rig. , e.g. that drilling will occur through hard rock with a drill bit diameter of about 100 mm or less suitable to install charges of 50–75 mm diameter.

Two datasets were considered for estimating possible source levels of the drilling operation:

Mann et al. (2009) published a study on under-ice anthropogenic noise at a winter-based diamond exploration project on Kennady Lake (Northwest Territories, Canada). This publication presents an acoustic spectrum from a small diameter (63.5 mm) coring drill bit. The drill rig was installed on top of ice with thickness of 1.63 m. The water depth was 15 m. During acoustic recordings the hydrophone was placed at a distance of 5 m from the source. The spectrum graph (frequency range 10–20,000 Hz) was digitized, converted into third-octave bands, and back-propagated to 1 m using spherical spreading law. The resultant source levels for the coring drilling in 1/3 octave bands are presented on Figure 1 with black line.

JASCO's recordings of a Beatle drill (Mouy and Zykov, 2009) were also used to provide alternative source levels. This drilling was performed through a metamorphic rock with a drill bit diameter of 610 mm. The drill rig was installed on a temporary metal frame, which was resting on the river bottom. The water depth at the drill site was 9 m, hydrophone was placed 10 m from the rig, mid-water column. The range of the recorded frequencies was from 1 Hz to 24,000 Hz. The received levels were adjusted using spherical spreading law to obtain source levels. The resultant source levels for the drilling with hammering action in 1/3 octave bands are presented on Figure 1 with black line.

The two presented source level spectrums differ by more than 40 dB. It is believed that such a large difference can be attributed to the fact that the hammering action produces more noise than normal rotary drilling and sounds from associated machinery.

Since the type of drilling that will be used is not finalized at the time of this report preparation, both source types were modelled. When the drill method is determined, the results for the more appropriate source can be selected.

The source depth for the modelling of the coring drill was chosen to be 1 m below the sea surface, as it is believed that the loudest noise source for this type of drill rig is the machinery installed on the ice. The source depth for the modelling of the drill with hammering action was chosen to be 1 m above the sea bottom, as it is believed that most of the acoustic energy is emitted at the point of contact of the drill bit with the rock.

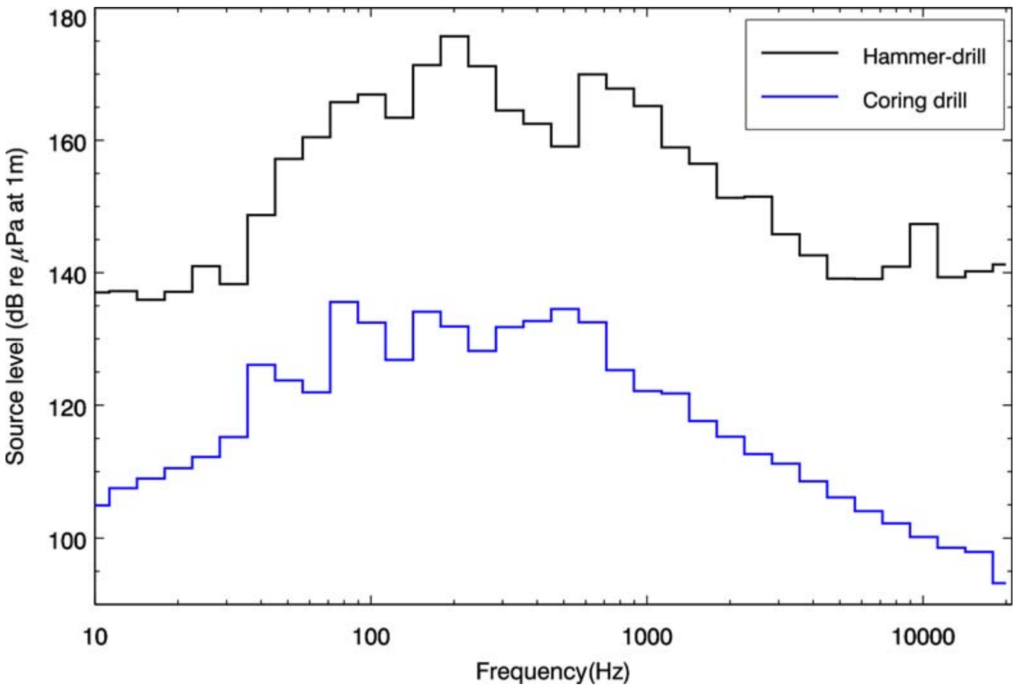

Figure 1: Estimated third-octave band source levels for drilling operation.

2.1.2. Blasting

In-water blasting will likely be carried out during late winter when ice cover is present and marine mammal presence is expected to be lowest. Only ringed seals are expected to be present during that time. Removal of the blast rock will take place during the following open water season. As a result it will be necessary to perform blasting up to 1 m deeper than the target elevation to ensure the required elevation is achieved (Knight Piésold Ltd., 2009, p. 52).

We used Conventional Weapons Effects (ConWep) software to model blast overpressure levels. ConWep was developed by the US Army Engineer Waterways Experimental Station for the US Army Corps of Engineers (Hyde, 1988). It is a collection of conventional weapons effect calculation tools derived from the equations and curves of TM 5-855-1, “Fundamentals of Protective Design for Conventional Weapons.” We employed ConWep v2.0 released in August 1992.

ConWep predicts ground shock overpressures for specified charge sizes and detonation depths below the ground surface (Hyde, 1988). It includes a database of the yield and detonation rates for a number of explosive compounds, including Pentolite and TNT. The code employs a set of empirical equations that were developed based on a large number of experiments conducted by the US Army. In the ground shock modelling mode, ConWep predicts the peak pressure and peak pressure time-history curve (P-T history curve) envelope. The input parameters of ConWep include type and weight of the explosive charge, geometry of the blast (depth of the charge, distance to the target, and depth of the target), and geo-acoustic parameters of the substrate (density, P-wave velocity, and attenuation coefficient).

ConWep predicts the peak pressure in the substrate. In order to obtain the peak pressure values in the water, the pressure transfer coefficient has to be calculated using the impedance values for the water and substrate layers (Wright and Hopky, 1998, Equation A, p. 18).

Almost all input parameters to the ConWep code can be assessed with relatively high accuracy based on the anticipated blasting setup and the geology of the substrate. The attenuation coefficient is site-specific and is the only parameter about which there is considerable uncertainty. The influence of this parameter on the modelling results cannot be ignored, so it has to be estimated with sufficient accuracy.

In a previous blasting noise propagation study conducted by JASCO in an area of reasonably similar bulk geological properties (Zykov, Deveau, and Hannay, 2010), a ground-truthing measurement program combined with ConWep modelling revealed that a ConWep attenuation coefficient of 1.9 is the best choice for this type of geology.

A technique of multiple delay charges is used to improve blast efficiency and also to meet the DFO marine habitat noise guidelines of a maximum 100 kPa waterborne acoustic overpressure. Each charge is detonated after a short delay from its predecessor. This approach avoids the summation of pressures that can arise from simultaneous detonation of multiple charges.

The explosives contractor will design and conduct blasting operations at Mary River to ensure that the 100 kPa waterborne acoustic overpressure threshold zone is limited. A setback distance corresponding to this threshold will be defined based on the specific blast design. A method for calculating setback distance is given in the DFO Guidelines (Wright and Hopky, 1998, Equation D, p. 19).

The final charge sizes and delay sequence are not yet defined. As a starting point for modelling using ConWep, we assume the weight of a single delay charge is 10 kg Pentolite. Charges used for trench blasting in bedrock of the Athabasca River were 8.2 kg (Zykov, Deveau, and Hannay, 2010). The model parameters also assumed charge burial depth of 1.5 m, substrate density of 3.5 g/cm^3 and a compressional sound speed of 2400 m/s. ConWep calculates a setback distance of 37.1 m for the 100 kPa waterborne peak acoustic overpressure with these input parameters. The method of Wright and Hopky (1998) yields a setback distance of just 5 m in this case. The Wright and Hopky method also underestimated the waterborne overpressures measured during the Athabasca River blast.

Explosive charge detonations generate impulsive acoustic events. There is a zone in the immediate vicinity of the blast that is dominated by non-elastic strain, fracture, and bulk material transport within the medium. At some distance from the blast, the acoustic overpressure has sufficiently dissipated so that the medium can retain its integrity and respond elastically to the overpressure disturbance; at greater distances the propagation is described well by linear compressional and shear wave theory. Impulsive acoustic events are characterized by broad frequency band energy. However, as sound propagates away from the source certain frequencies become attenuated (diminished in amplitude) with distance more quickly than others. Sound propagation models can predict the frequency dependence of attenuation. . We carried out sound modelling in third-octave frequency bands with centre frequencies between 10 Hz and 2 kHz.

The ConWep model predicted the 100 kPa (220 dB re 1 µPa) peak overpressure threshold would occur at a horizontal distance of 37.1 m from the source.. This distance was obtained by using ConWep to compute the distance to a threshold of 230 dB re 1 µPa just below the surface of the exposed bedrock . The 10 dB difference represents the level difference between pressure in the seabed and in the water and was predicted using the impedance matching technique from the DFO guidelines (Wright and Hopky, 1998, Equation A, p. 18).

In order to obtain an equivalent source level at 1 m from the source, for the purpose of acoustic propagation modelling, we back-propagated the pressure field according to cylindrical spreading loss, or 10·log(r). The purpose of the back-propagation step is to determine the effective source level at 1 m that is used to initialize the forward acoustic propagation model. The equivalent compressional wave peak overpressure source level in the substrate was 246 dB re 1 µPa @ 1 m.

If it were assumed that the acoustic energy generated by each detonation was equally distributed among the 24 third-octave frequency bands (10 Hz to 2 kHz), the third octave band source levels would be 218 dB re 1 µPa @ 1 m. These source levels would have to be adjusted for charge masses different than 10 kg.

Effect of bubble curtain

Bubble curtains are commonly used to reduce acoustic energy emissions from high-amplitude sources. Bubble curtains can be generated by releasing air through multiple small holes drilled in a hose or manifold deployed on the seabed near the source. The resulting curtain of small air bubbles in the water provides significant attenuation for sound waves propagating through the curtain. The bubble curtain is often use as a mitigation choice for underwater pile driving and blasting activities at construction sites.

Research has been performed to quantify the effectiveness of bubble curtains at attenuating impulsive sounds (eg. Koschinski & Kock, 2009; Schmidtke, 2010; Nützel, 2008). Nützel (2008) established that the reduction of peak pressures of explosion shockwaves depends on the air flow rate. An average of 15.4 dB decrease in the peak pressure was measured with the bubble curtain air flowrate of 20 m^3/min. In another experiment with 25 charges Grunau (2008) estimated the reduction of the peak pressure of the shock wave by as much as 17 dB.

The effect of a bubble curtain was included in the modelling results by applying a flat reduction of 15.4 dB (average of the above-listed attenuations) to the non-mitigated source levels.

2.1.3. Dredging

The construction of the Ore Loading Dock in Steensby Port will involve blasting and dredging of the level pads for the dock caissons and leveling of the seabed at the 25 m contour line. The dredging phase is expected to occur during the open water season, and the dredged material is likely to be contained on barges until future use. However, the exact specification of the dredging equipment was unknown at the time of the study.

There are several types of dredges that could be used here: suction dredges, clamshell bucket dredges, and continuous bucket dredges. It is most likely that a suction dredge or clamshell bucket dredge will be used here.

A clamshell bucket dredge uses a bucket that is being hoisted by a crane. The bucket grabs sediment material from the bottom and dumps it into a barge. One duty cycle of a clamshell bucket dredge lasts 1–2 minutes and involves the following events:

- Bucket striking the bottom
- Bucket digging into the bottom/bucket closing
- Winching up
- Dumping the material from the bucket

Dickerson et al. (2001) identified the "bucket striking the bottom" as the noisiest event of the sequence. They recorded the dredge *Viking* operating in Cook Inlet (Alaska), at a distance of 158 m from the dredging location, where the water depth was 10 m. The reported received levels were back-propagated to 1 m assuming spherical spreading for the first 20 m from the source and the cylindrical spreading thereafter. This event happens once per duty cycle and is very short in duration. The source levels for other events of the clamshell bucket dredge operation are at least 6 dB lower. The next loudest event is winching, which, has the longest duration.

Suction dredges utilize a wide pipe (up to 1 m in diameter) and a high power pump to suck water and loose material from the bottom into a hopper or directly to a discharge location. Often a cutter head is used to help with loosing up the sediments. The intake pipe with the cutter head can be steered by winches or thrusters. The dredge vessel itself can be moved by main thrusters or winches. Cutter-suction dredge operates in more or less continuous mode. The noise sources for the cutter suction dredge include the power plant, the suction pump, the cutter head, and the cutter head thrusters.

A collection of source levels for clamshell bucket and suction dredges are presented on Figures 2 and 3 (various events). Figure 2 shows that the source levels of clamshell bucket dredges are appreciably lower than those of suction dredge at frequencies below 100 Hz and similar levels for higher frequencies. It is assumed that material dumping operation results in the same amount of noise regardless of the type of dredge involved. The noise level from the dumping operation depends on whether the receiving barge is empty or if there is some dredged material already in the barge. The dumping operation is expected to be the loudest if the receiving barge is empty and the dumping material consists of large rocks. The source levels for exactly such event are presented on Figure 2 (*Gerardus Mercator*, dumping).

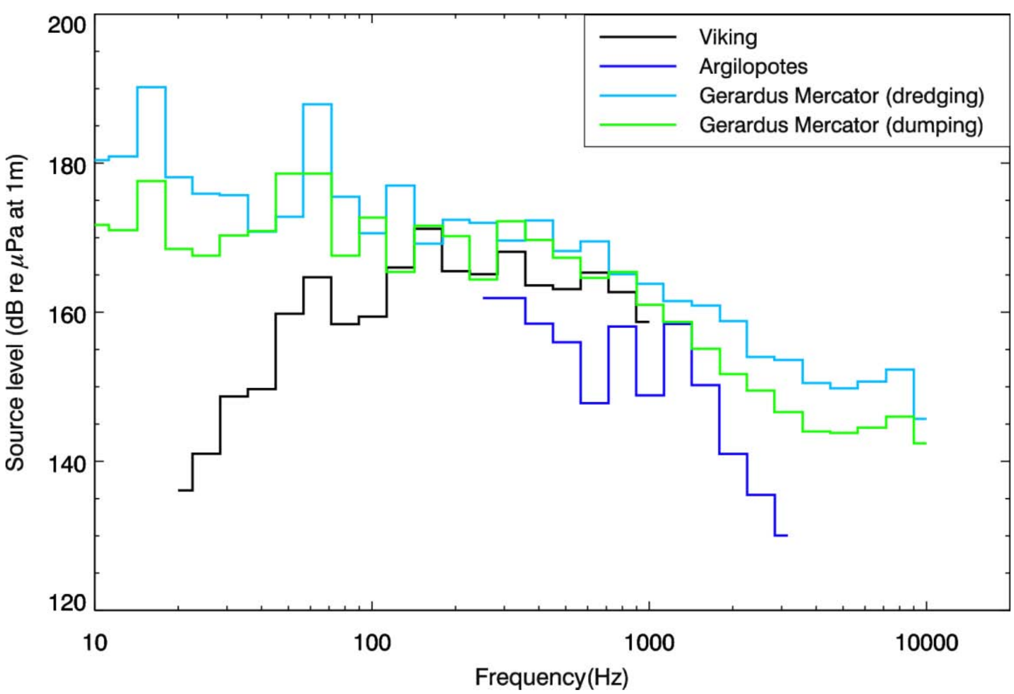

Figure 2: Estimated source levels for clamshell bucket and suction dredges. *Viking* – clamshell dredge, bucket striking bottom event (Dickerson et al. (2001); *Argilopotes* – clamshell dredge (Miles et al., 1987); *Gerardus Mercator* – trailing suction dredge (Hannay et al., 2007).

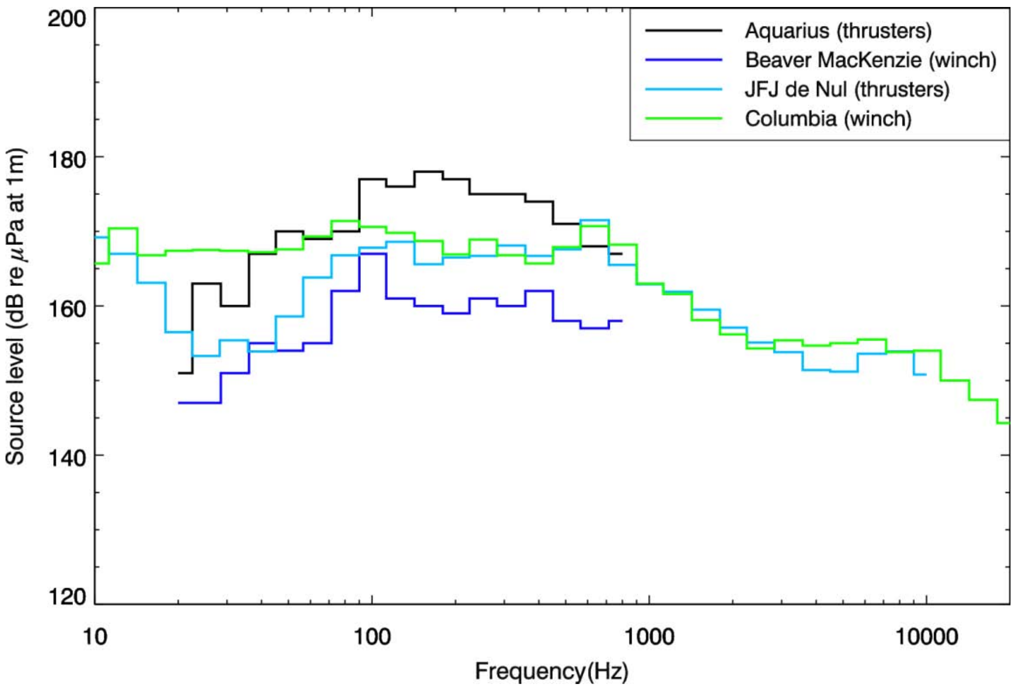

Figure 3: Estimated source levels for cutter-suctions dredges with winch and thruster steering mechanisms. *Aquarius* – thrusters, *Beaver Mackenzie* – winch (Malme et al., 1989); *JFJ de Nul* – thrusters (Hannay et al., 2007); *Columbia* – winch (Zykov et al., 2007).

The noisiest suction dredges are those which use thrusters to steer the intake pipe (Figure 3).

Since the type of dredging for this project has not yet been selected, two surrogate source level spectra were created using the available data for the modelling of the dredging operations. For the clamshell bucket dredge source level the maximum values of the "bucket striking the bottom" levels and the "material dumping" levels were used in each 1/3 octave band to produce a conservative estimate. The vertical position of the source is assumed to be 3 m below the sea surface. For the suction dredge the maximum levels were extracted from the four spectra presented on Figure 3. The vertical position of the source is assumed to be 1 m above the sea floor.

In case the available data did not provide the source levels for higher frequencies, extrapolation was used by taking the level for the highest available band and reducing the value by 10 dB per decade (or 1 dB per 1/3 octave band) as suggested by Ross, 1976. The resultant source levels to be used for modelling of the dredging operation are presented in Figure 4.

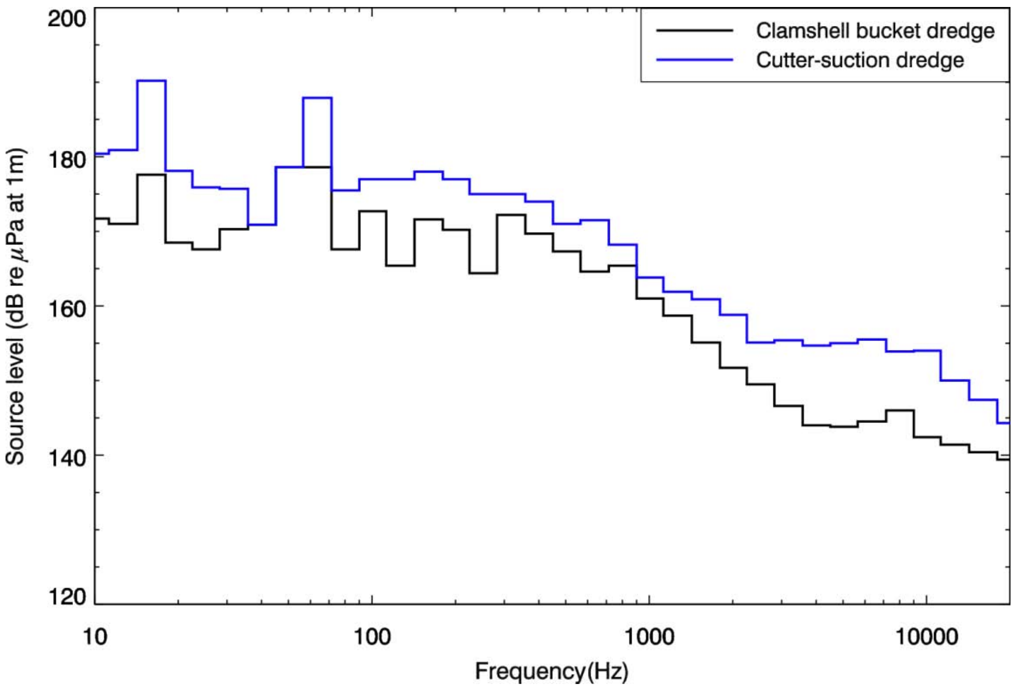

Figure 4: Assumed 1/3-octave band source levels for modelling the dredging operation.

2.1.4. Tugs

Summer (Ice Class 1A) and winter (Polar Class) tugs are expected to operate in the Steensby Port area to assist with the docking operations of the ore carrier fleet as well as in the ice management operations around the dock. The vessel specifications presented in Table 1 were provided by LGL Limited as representative of the vessels expected to perform these operations. We derived surrogate source levels from measurements made by JASCO on tugs performing a variety of typical operations (Hannay et al., 2007). The specifications of the recorded tugs are presented in Table 2.

Table 1: Mary River Project Tugs specifications.

	Summer tug	**Winter tug**
Class	**Ice class 1A**	**Polar class**
Number of screws or thrusters	2	3
Number of propeller blades	4	4
Nozzled?	yes	no
Propeller diameter	2.4 m	2.6 m
Propeller depth	4.0 m	5.5 m
Propeller RPM	190	190
Vessel speed	13.5 kn	14.5 kn

Table 2: Specifications of tugs, for which source level measurements are available.

	Britoil 51	**Katun**	**Kuparuk**
Class	Anchor handling tug	Anchor handling tug	River tug
Length (m)	45	68	19.5
Tonnage (metric tonne)	605	1982	105
Total power (hp)	6600	12240	1095
Number of screws or thrusters	2	2	3
Propeller diameter (m)	3.2	—	1
Vessel speed (kn)	13	13	—
Nozzled	yes	no	no
Number of propeller blades	4	—	5
Propeller RPM	190	—	450
Monitored activity	Anchor pull operation, full speed transit	Anchor pull operation, transit	Barge pushing
Reference	Hannay et al., 2007	Hannay et al., 2007	Zykov et al., 2008

The operating conditions include open water and water covered by thin and thick land-fast ice. The available source level measurements for tugs were only representative of operations in open water. The available measurements for the *Britoil 51*, *Katun*, and *Kuparuk* were compared to the ramming noise levels from the icebreaker *CCGS Henry Larson*, a medium gulf/river icebreaker used by the Canadian Coast Guard (Erbe and Farmer, 2000).

Table 3: *CCGS Henry Larsen* available specifications (www.ccg-gcc.gc.ca).

Class	Medium Gulf/River Icebreaker – Arctic Class 4
Length	100 m
Beam	19.6 m
Draft	7.3 m
Displacement	6,166 tons
Propulsion system	Diesel electric (12,174 kW)
Propellers	2 x fixed pitch
Vessel cruise speed	13.5 kn

In general, there is a direct relation of the produced noise level with the size of the vessel. Larger vessels produce higher sound levels. In case of the tugs however, the relation is different from the one of freight vessels, as tugs are equipped with significantly larger power plants than a freight vessel of the similar size. Tugs performing a docking operation on a large vessel or doing ice management often work at higher power output rates. Moreover, in such conditions the cavitation process at the propeller blades is significantly more extensive. Considering this, tugs can produce noise levels comparable of those from larger vessels, like the *CCGS Henry Larson*.

Erbe and Farmer (2000) defined a ramming-mode of the *CCGS Henry Larson* as “when the ship tried to break the ice-ridge after building up momentum, but failed and was stopped by the ice with the propeller still turning at full speed”. The published 1/12 octave band levels for *CCGS Henry Larson* were for the frequency range 100 Hz to 20 kHz (Figure 5). The levels for frequencies below 100 Hz were assumed to be constant and equal to the one at 100 Hz in the third-octave band spectrum presented, and this is believed to be a conservative assumption.

Figure 5 presents the comparison between spectra from the different tugs and the *CCGS Henry Larsen* engaged in ramming.

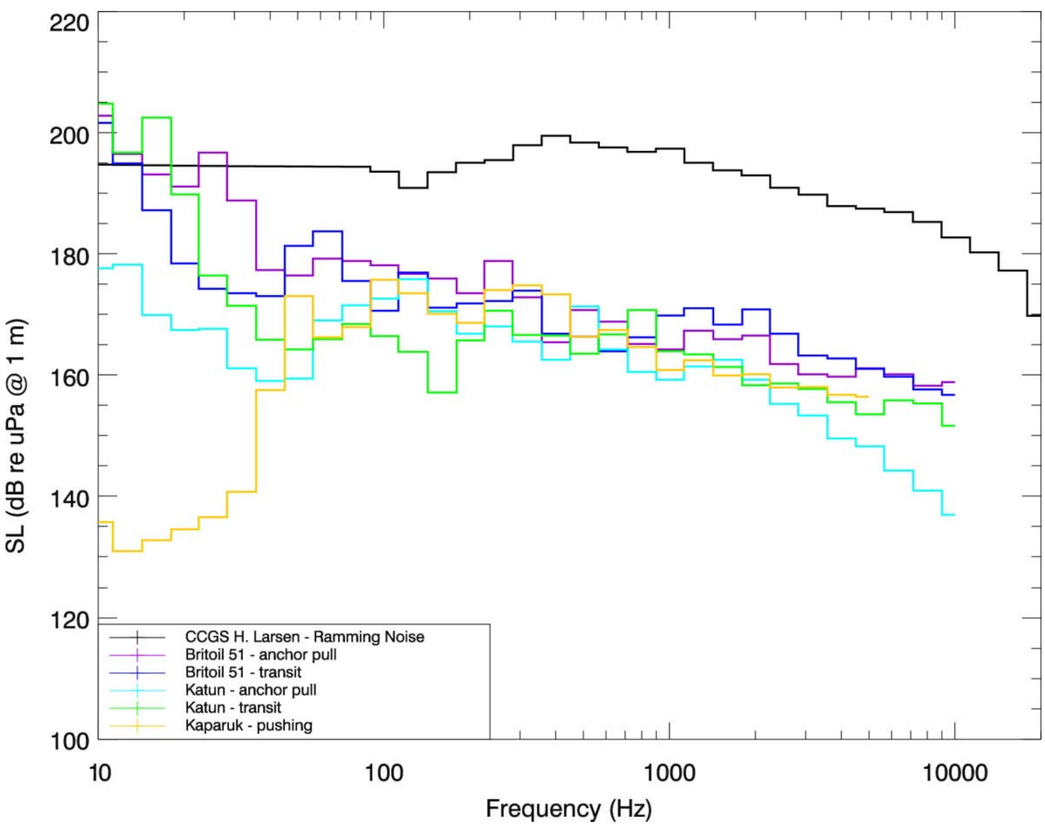

Figure 5: Measured third-octave band source levels for tugs and the icebreaker *CCGS Henry Larsen* engaged in ramming.

The reliability of sound levels at frequencies below 50 Hz is less than for higher frequencies. The reliability also decreases with the distance from which the source was measured. The reduced reliability is attributed to the following factors:

- Higher noise contamination of the recording at low frequencies (e.g. flow noise, self-noise of the system)
- Higher amplification of low frequencies during the back propagation process using transmission loss modelling.

Three separate source level spectra were prepared to represent noise from a tug operating at the port (Figure 6) in three scenarios: open water, presence of thin ice, and presence of thick ice. The open water source levels were calculated as the maximum value of the presented spectra for tugs in each 1/3 octave band. The source levels for the thick ice conditions were calculated as the maximum between the open water source levels and estimated source levels for *CCGS Henry Larsen.* The thin ice source levels were estimated as the mean value of the previous two spectra.

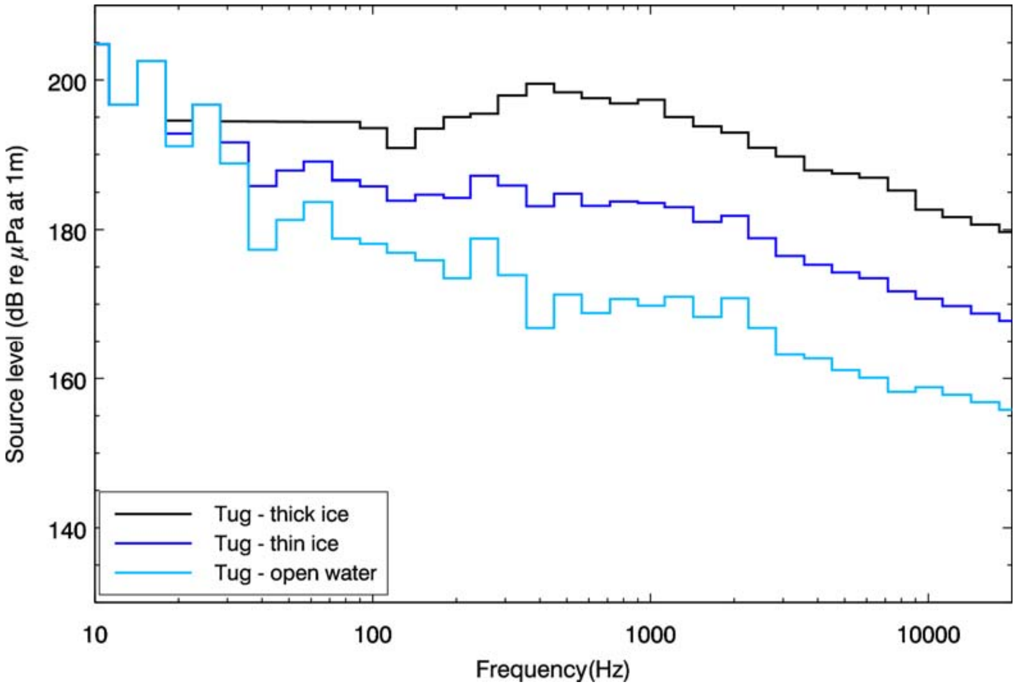

Figure 6: Assumed third-octave band source levels for tugs operating in open water, thin ice, and thick ice conditions.

2.2. Shipping – Icebreaker Ore Carrier in Transit

Ore material is expected to be carried out by a fleet of ore carriers with icebreaking capacity. The vessel conceptual design and specifications were provided by LGL Limited (Table 4).

The vessels' source levels were estimated based on the literature review of the reported measurements of similar ships. Source density spectra were estimated using empirical equations and digitized spectra from several publications.

Table 4: Specifications for a proposed ±190,000 DWT ore carrier with icebreaking capability.

Proposed Icebreaking Ore Carrier Characteristics	
Length overall	329 m
Beam	52 m
Depth	27 m
Draft	20 m
Displacement	248,000 t
Ore Cargo	±190,000 t
Propulsion system	2 x controllable pitch nozzled propellers, 4 blades, 8.3 m diameter.
Propeller / vessel speed	60 rpm / 14 kn (open water) 60 to 78 rpm / 3 to > 7 kn (ice cover)
Depth of the propeller	13.5 m below water line

While in transit, ships emit underwater noise from their various components, including onboard machinery and propellers underwater. Noise spectra from large ships are generally dominated by propeller cavitation noise. Vessels transiting through ice also create noise from the ice breaking process. Ross (1976) has shown that the intensity of propeller cavitation noise depends on the total number of blades, the propeller diameter, and the propeller tip speed. Based on multiple recordings of large merchant ships, he developed an equation to estimate the overall (broadband and omnidirectional) noise level of ships over 100 m in length, operating in calm open waters:

$$L = 175 + 60\log(u/25) + 10\log(B/4), \tag{1}$$

where L is the reference level, u is the propeller tip speed (m/s), and B is the number of propeller blades. This equation gives the total energy produced by the propeller cavitation at frequencies between 100 Hz and 10 kHz. This equation is valid for propeller tip speed between 15 and 50 m/s (Ross, 1976).

Based on Ross' equation and the examination of recorded spectra, Scrimger and Heitmeyer (1991) and Hamson (1997) developed the following equation to provide an estimate source level spectrum for very large merchant ships:

$$SL = SV(f) + 60\log(V/12) + 20\log(Le/300), \tag{2}$$

where V is the vessel speed in knots, Le is the vessel length in feet, and $SV(f)$ is the reference level for merchant ship noise spectrum based on 50 recorded spectra. The reference spectrum was provided in Hamson (1997).

The source levels referred to as "Hamson, 1997" in Figure 8 were obtained as follows. First, the reference spectrum from Hamson (1997) was adjusted to provide the broadband level as calculated with Equation (1) using specified propeller diameter and propeller tip speed. The spectrum was further adjusted for the vessel speed and vessel length using Equation (2).

Another approach for modelling the source levels from large ships transiting in ice-covered waters was proposed by Leggat et al. (1981), which is based on Brown's (1977) formula for prediction of the propeller noise spectrum for a heavily loaded merchant ship:

$$SL_B = 163 + 40\log(D) + 30\log(N) + 10\log(B) - 20\log(f) + 10\log(A_c/A_D), \quad (3)$$

where D is the propeller diameter (meters), N is the propeller revolution rate per second, B is the number of blades, A_c is the area of the blades covered by cavitation, and A_D is the total propeller disc area. Brown's formula applies to frequencies between 100 Hz and 10 kHz, and the density spectrum may be assumed constant at frequencies below 100 Hz. Leggat et al. (1981) tested the validity of this method and showed that Equation (3) should be used with a values of $A_c/A_D = 1.0$. The source levels representing the Ore Carrier transiting in thin- and thick-ice conditions were estimated using Brown's formula with propeller revolution rates of 69 and 78 rpm, respectively.

Measured spectra from large ships presented in several publications were also digitized and translated into third-octave band levels. Table 5 and Figure 7 present a comparison between characteristics and third-octave band source levels from the discussed source levels. Figure 7 also present the spectrum of ice breaking under the weight of the bow of a bulk carrier. This spectrum was derived from recordings on hydrophones positioned close to the bow of the ice-capable concentrate carrier *MV Umiak I* (mentioned in Table 5) transiting in land-fast ice conditions (Sikumiut, 2008).

Table 5: Ships characteristics.

Vessel	Length (m)	Displacement (metric tons)	Speed (knots)	Operation & Condition	source
CCGS Henry Larsen (icebreaker)	100	6,167	variable	ramming	Erbe and Farmer, 2000
Icebreaking bulk carrier MV Umiak I	178	31,992	3	transit in land-fast ice	Sikumiut, 2008
CCGS Louis S. St. Laurent (icebreaker)	120	11,345	14.5	transit in open water	Leggat, 1985
CCGS Louis S. St. Laurent (icebreaker)	120	11,345	10 to 0	deceleration in open water	Leggat, 1985
Container ship *Hanjin Marseilles*	289	62,623	21	transit in open water	Hildebrand, 2006
Cruise ship *Norwegian Wind*	230	50,760	19	transit in open water	Hildebrand, 2006
10 merchant vessel average	89 to 320	3,500 to 201,000	7.5 to 14.6	exiting harbor in open water	Hallet, 2004
Ore Carrier (modelled)	329	248,000	14	transit in open water	Hamson, 1997
Ore Carrier (modelled)	329	248,000	14	transit in open water	Brown, 1977
Ore Carrier (modelled)	329	248,000	14	transit in thin ice	Brown, 1977
Ore Carrier (modelled)	329	248,000	14	transit in thick ice	Brown, 1977

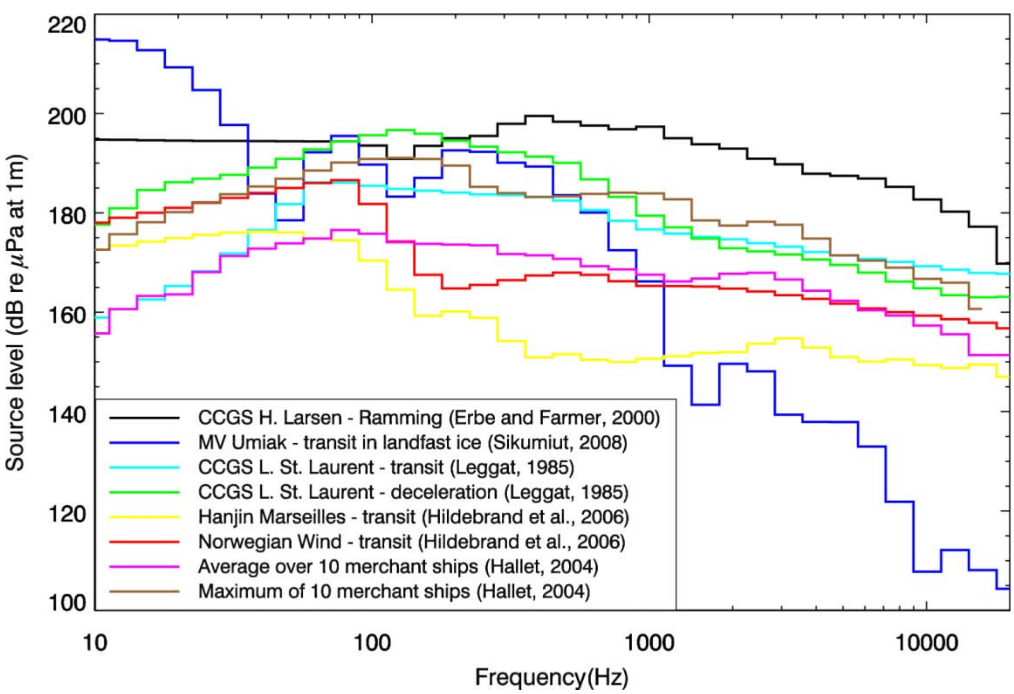

Figure 7: Source levels of large marine vessels based on empirical data. See Table 5 for vessel details.

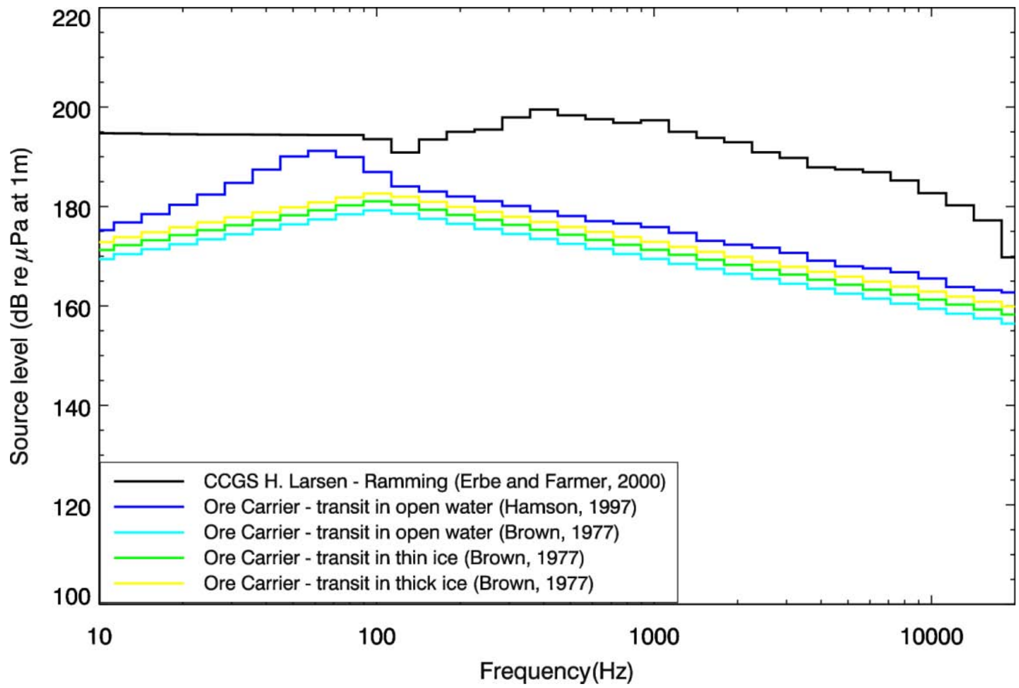

Figure 8: Source levels of large marine vessels calculated using empirical equations (except for CCGS H. Larsen provided for easier comparison between the two figures). See Table 5 for vessel details.

Figure 7 shows that the source levels of land-fast ice breaking at the bow of a large carrier are much lower than the source levels from propeller cavitation. Consequently, in estimating the source levels for the proposed Ore Carrier transiting in ice-covered water, only the sound from the ship propulsion system was considered.

Figure 7 also shows that Brown's formula, Equation (3), produce estimates of sound levels (pink, brown, and mustard line) comparable to those of the *Hanjin Marseilles* (yellow line) and the *Norwegian Wind* (red line), although this is a much larger, heavily-loaded vessel, transiting in open and ice-covered waters. It was therefore assumed that Brown's formula underestimates the expected source levels of the proposed icebreaker ore carrier and was not used in estimating the final ore carrier sound levels.

Table 5 and Figure 7 show that (smaller) vessels with icebreaking capability produce higher sound levels then much larger vessels. For example, the transiting container ship *Hanjin Marseilles* (yellow line) and the cruise ship *Norwegian Wind* (red line) produce lower source levels than the much smaller *CCGS Louis St. Laurent* (light blue line) at all frequencies, and the smaller icebreaker carrier *MV Umiak* (dark blue line) at frequencies below 1 kHz.

Hamson's equation, Equation (2), produces estimated source levels (fuchsia line) higher than Brown's equation. It is therefore believed that Hamson's equation produces a better estimate of source levels representing the Mary River ore carrier transiting in open water.

In studying reactions from marine mammals to ice-breaking ships, Finley et al. (1990) estimated that higher source levels are produced when ships operates in "backing-up" mode. He pointed out that the *MV Arctic*, a icebreaking carrier approximately half the size of the proposed ore carrier, produces broadband source levels 7 dB higher in backing-up than in ramming mode. Leggat (1985) reported on the recordings of the *CCGS Louis S. St. Laurent* while operating in various modes. Although the recordings were done in open water, the different modes were set to represent icebreaking operations, *e.g.* high propeller revolution rate while making no headway, rapid acceleration, and rapid deceleration. This study agrees with Finley's (1990) statement by showing that the source levels from the *CCGS Louis S. St. Laurent* are higher in deceleration mode than for high propeller revolution rate while making no headway. There are no measurements for the source levels of the *CCGS Louis S. St. Laurent* in backing-up mode. However, the highest source levels at frequencies above 200 Hz were produced by the *CCGS Henry Larsen*, recorded by Erbe and Farmer (2000). It is believed that this is due to more extensive cavitation process, much more than during a normal transit, occurring due to higher rpm of the propellers and, at the same time, slower vessel forward movement.

2.2.1. Modelled Source Levels

The source levels from the Ore Carrier had to be estimated for operations in three different conditions: transiting in open water, thin ice, and thick ice condition. Figure 9 presents the final source levels for the Mary River Ore Carrier transiting under these three conditions.

The source levels for open water were modelled using combination of equations by Ross (1976) and Hamson (1997), Equations (1) and (2) respectively, for operating parameters as presented in Table 4 (open water conditions).

It is believed that thick-ice conditions will lead to using higher rpm on the propellers while the vessel velocity will be reduced by the ice resistance. To account for all the additional factors, the source levels of the Ore Carrier transiting in thick-ice conditions was assumed to be the maximum value of all presented levels, *i.e.* the maximum values of the measured levels from the *CCGS Louis S. St. Laurent* in deceleration mode, the *MV Umiak* transiting in land-fast ice, and the *CCGS Henry Larsen* in ramming mode.

Finally, the source level of the Ore Carrier transiting in thin-ice conditions was modelled as the mean between the thick-ice levels, and the calculated levels using Equations (1) and (2) for operating parameters as presented in Table 4 (iced conditions).

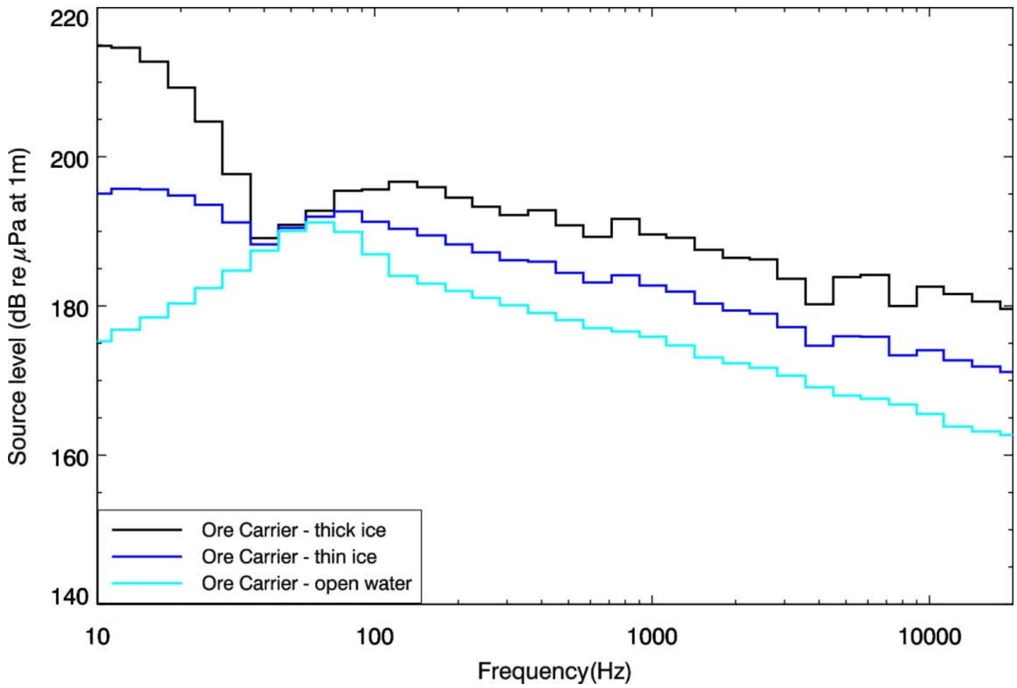

Figure 9: Assumed third-octave band source levels for the Mary River ore carrier transiting through open water, thin ice, and thick ice conditions.

3. Modelling Sound Propagation

3.1. Modelling Locations

Underwater sound resulting from construction and operations related to the Mary River Iron Mine was modelled at the Steensby Intel Port Facility and along the nominal shipping route. More specifically, the sound resulting from the drilling, blasting, and dredging operations was modelled at the expected ore loading dock construction site; the sound levels resulting from various tug operations were modelled approximately 450 m southwest of the drilling, blasting, and dredging location; shipping noise was modelled at 3 locations along the shipping route through Steensby Inlet, Foxe Basin and Hudson Strait (Table 6, Figure 10, and Figure 11).

Table 6: Modelling Locations.

Activities	Locations			Water Depth(m)
Drilling, blasting, and dredging	Ore Loading Dock	70°16'47.18" N	78°33'01.92" W	20
Tug operations	In the vicinity of the Ore Loading Dock	70°16'54.93" N	78°32'24.17" W	65
Ore Carrier in transit	Southern Steensby Inlet	70°06'57.46" N	78°17'22.53" W	74
	Central Foxe Basin	66°51'17.01" N	79°20'00.00" W	70
	Hudson Strait	64°02'24.80" N	76°08'47.78" W	115

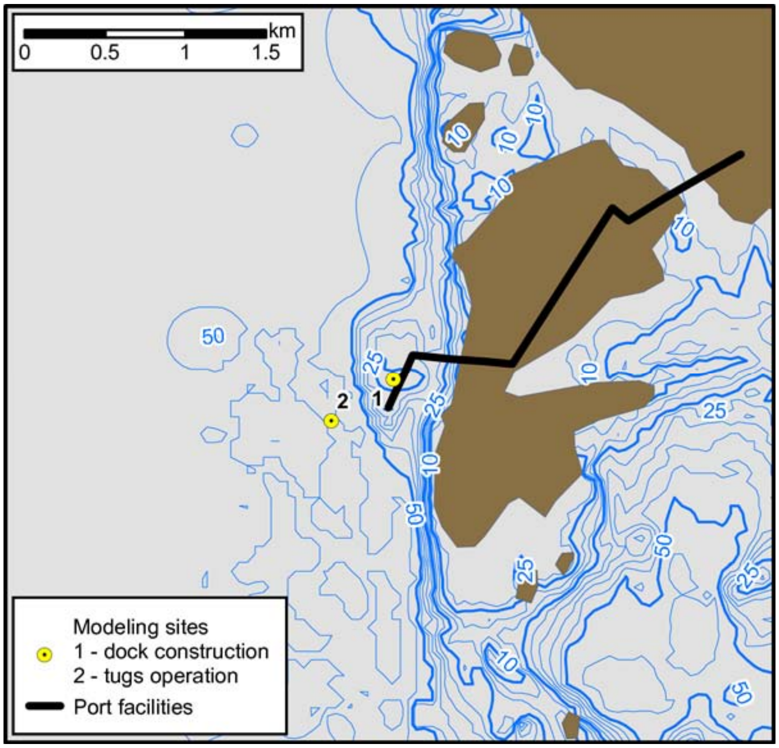

Figure 10: Modelling sites at the Steensby Port.

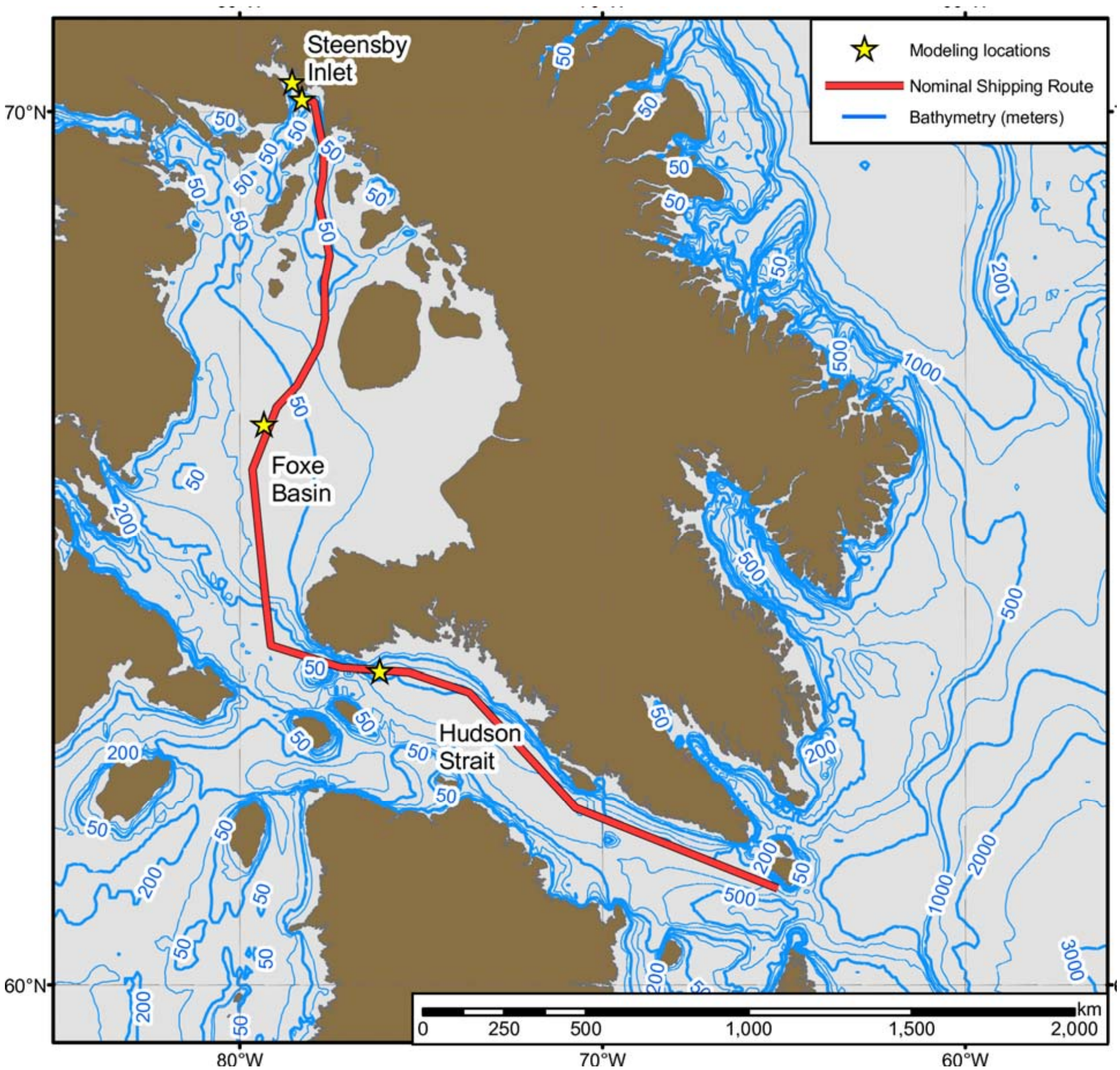

Figure 11: Overview of modelling locations along the shipping route.

Bathymetry data for the Foxe Basin and Hudson Strait areas were obtained from a data series referred to as SRTM 30+, version 6.0 (Becker et al., 2009). The resolution of this bathymetry grid is 30 geographical seconds or approximately 900 x 300 m at the study location. The bathymetric data in the vicinity of the Steensby Port combines the SRTM30+ version 6.0 data with higher resolution single-beam and multi-beam data provided by LGL Limited.

The area is characterized by shallow depths (approximately 50 m) from Steensby Inlet to central Foxe Basin; depth increases to 100 m in the central part of Foxe Basin and to 200 m at the entrance to Hudson Strait. The water depths in Hudson Strait vary 200 m in the west part to 500 m at the mouth of the strait.

The first site along the shipping route is located in the southern area of Steensby Inlet. This region of the route is characterized by relatively shallow waters and close proximity to the shoreline which allows the presence of land-fast ice in the winter and spring months. The second site is located in central Foxe Basin where the bathymetry slowly increases from 50 m to 200 m in a northeast-southwest direction. The third site is located where the shipping route presents its closest point of approach to the shoreline, approximately 20 km southeast of Cape Dorset.

3.2. Environment Sea-Ice Cover

The study area is nearly completely covered by ice between the months of November and June and is ice-free in late summer and early fall (Saucier et al., 2004). Figure 12 (b) from Saucier et al. (2004) presents modelled ice thickness in the region at different time of year, which compares very well to observed sea-ice coverage from the 1996-97 seasons. These results, presented in Figure 12, were used to estimate the ice coverage at the modelling locations.

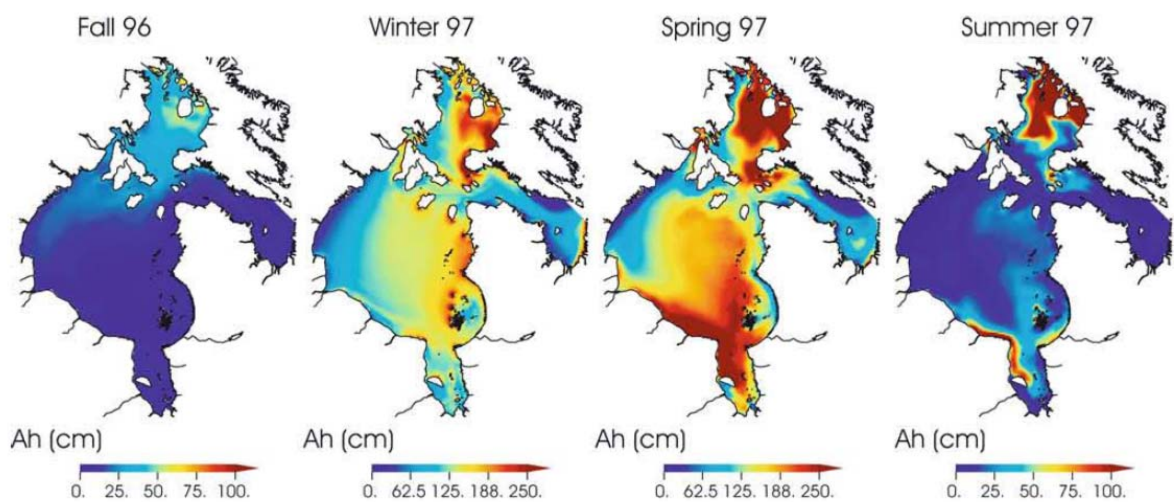

Figure 12: Modelled seasonal averaged sea-ice, 1996-1997 (Figure 12(b), Saucier et al., 2004).

For all modelling locations the maximum ice thickness is reached in early May, after which the amount of solar radiation rapidly increases in the regions and ice starts to melt. In August open water conditions develop throughout the area. In October-November ice start slowly forming on the sea surface reaching the highest growth rate in February.

At Steensby Port and in the northern section of Foxe Basin, land-fast ice grows on average up to 2 m thick and may reach a thickness of 2.5 m in the Inlet (Saucier et al., 2004; Knight Piésold Ltd., 2009). In central Foxe Basin, pack ice thickness can also reach 2 m, but this number decreases towards the southwest. The chosen modelling location in Hudson Strait, south of Cape Dorset, accumulates the thickest ice-coverage in the Strait, which can also reach 2 to 2.5 m in the spring.

3.2.1. Geoacoustics

Drillhole logs from the Steensby Inlet area were provided by LGL Limited. The logs suggest that the surficial sediment in the vicinity of Steensby Port is composed of silty sand, transitioning to mainly gravel and cobbles with increasing depth below the seafloor (bsf). This information is consistent with the data from Deck41 (NGDC, 2003), which suggests that the surficial sediments in Foxe Basin consist of stilt and sand. A top layer of silty sand is found throughout Foxe Basin, increasing in thickness with increasing range from Steensby Inlet. This layer changes to silty clay to the south of Foxe Basin and in Hudson Strait (St-Onge and Lajeuness, 2007), where it covers a layer of glacial drift (MacLean et al., 1991).

At Steensby Port, the provided drillhole logs show that granite and granitic gneiss is found at less than 10 metres below seafloor (mbsf). Information about the geological characteristics of the deeper (Cretaceous to pre-Cambrian) layers found in Foxe Basin and Hudson Strait are described by Sanford and Grant (2000). Following the described stratification, P-wave velocity and attenuation for the surficial layers were estimate using Hamilton (1980), Ellis and Hughes (1989), and Buckingham (2005); P-wave velocity and attenuation for the deeper layers were estimated using Barton (2007) and Ellis and Hughes (1989); S-wave velocity and attenuation were estimated based on the sediment type and porosity values through the grain-shearing model (Buckingham, 2005). The estimated geo-acoustic parameters representing the four modelling locations are presented in Tables 7 to 10.

Table 7: Geoacoustic parameters – Steensby Port Area.

Layers	Depth [m bsf]	P-wave velocity [m/s]	Density [g/cm^3]	P-attenuation [dB/λ]	S-wave velocity [m/s]	S-attenuation [dB/λ]
silty sand to gravel to cobles	0 – 5	1650 – 2000	1.8 – 2.1	0.85 – 1.00	150	1.5
granitic gneiss	5 – 330	3500 – 5000	2.4 – 2.6	0.35	-	-
pre-Cambrian basement	>330	5500	2.6	0.275	-	-

Table 8: Geoacoustic parameters – Southern Steensby Inlet.

Layers	Depth [m bsf]	P-wave velocity [m/s]	Density [g/cm^3]	P-attenuation [dB/λ]	S-wave velocity [m/s]	S-attenuation [dB/λ]
silty sand to gravel to cobles	0 – 5	1650 – 2000	1.8 – 2.1	0.85 – 1.0	200	1.6
granitic gneiss	5 – 330	3500 – 5000	2.4 – 2.6	0.35	-	-
pre-Cambrian basement	>330	5500	2.6	0.275	-	-

Table 9: Geoacoustic parameters – Central Foxe Basin.

Layers	Depth [m bsf]	P-wave velocity [m/s]	Density [g/cm^3]	P-attenuation [dB/λ]	S-wave velocity [m/s]	S-attenuation [dB/λ]
silty sand to gravel to cobles	0 – 20	1566 – 2000	1.8 – 2.1	0.2 – 1.0	200	1.6
Cambrio-Sillurian limestone to granitic gneiss	20 – 330	3200 – 5000	2.4 – 2.6	0.35	-	-
pre-Cambrian basement	>330	5500	2.6	0.275	-	-

Table 10: Geoacoustic parameters – Hudson Strait.

Layers	Depth [m bsf]	P-wave velocity [m/s]	Density [g/cm^3]	P-Attenuation [dB/λ]	S-wave velocity [m/s]	S-Attenuation [dB/λ]
silty clay	0 – 5	1566 – 1725	1.8 – 2.0	0.200 – 0.525	200	0.1
sand to gravel	5 – 30	1725	2.0 – 21	0.525 – 1.000	-	-
glacial drift	30 – 130	1725 – 2000	2.1 – 2.3	1.00 – 0.23	-	-
Evens formation (stanstonce – cretaceous)	130 – 360	2000 – 3200	2.3 – 2.4	0.23 – 0.35	-	-
Cambrio-Sillurian limestone to granitic gneiss	630 – 880	3200 – 5000	2.4 – 2.6	0.35	-	-
pre-Cambrian basement	>880	5500	2.6	0.275	-	

3.2.2. Sound Speed Profile

Sound speed profiles for the different modelling locations were obtained from the U.S. Naval Oceanographic Office’s Generalized Digital Environmental Model (GDEM) database (Teague et al. 1990). The latest release of the GDEM database (version 3.0, October 2003) (Naval Oceanographic Office, 2003) provides average monthly profiles of temperature and salinity for the World’s oceans on a latitude/longitude grid with 0.25° resolution. Profiles in GDEM are provided at 78 fixed depth points up to a maximum depth of 6800 m. The profiles in GDEM are based on historical observations of global temperature and salinity from the U.S. Navy’s Master Oceanographic Observational Data Set (MOODS).

Temperature/salinity profiles were extracted from the GDEM database for the every month of the year and converted to speed of sound in seawater using the equations of Coppens (1981):

$$\begin{aligned} c(z,T,S) &= 1449.05 + 45.7T - 5.21t^2 - 0.23t^3 \\ &\quad + (1.333 - 0.126t + 0.009t^2)(S-35) + \Delta \\ \Delta &= 16.3Z + 0.18Z^2 \\ Z &= (z/1000)(1 - 0.0026\cos(2\phi)) \\ t &= T/10 \end{aligned} \quad , \qquad (4)$$

where z is depth in meters, T is temperature in degrees Celsius, S is salinity in psu, and ϕ is latitude (in radians). Resulting monthly sound speed profiles for the four modelling locations are presented in Figure 13.

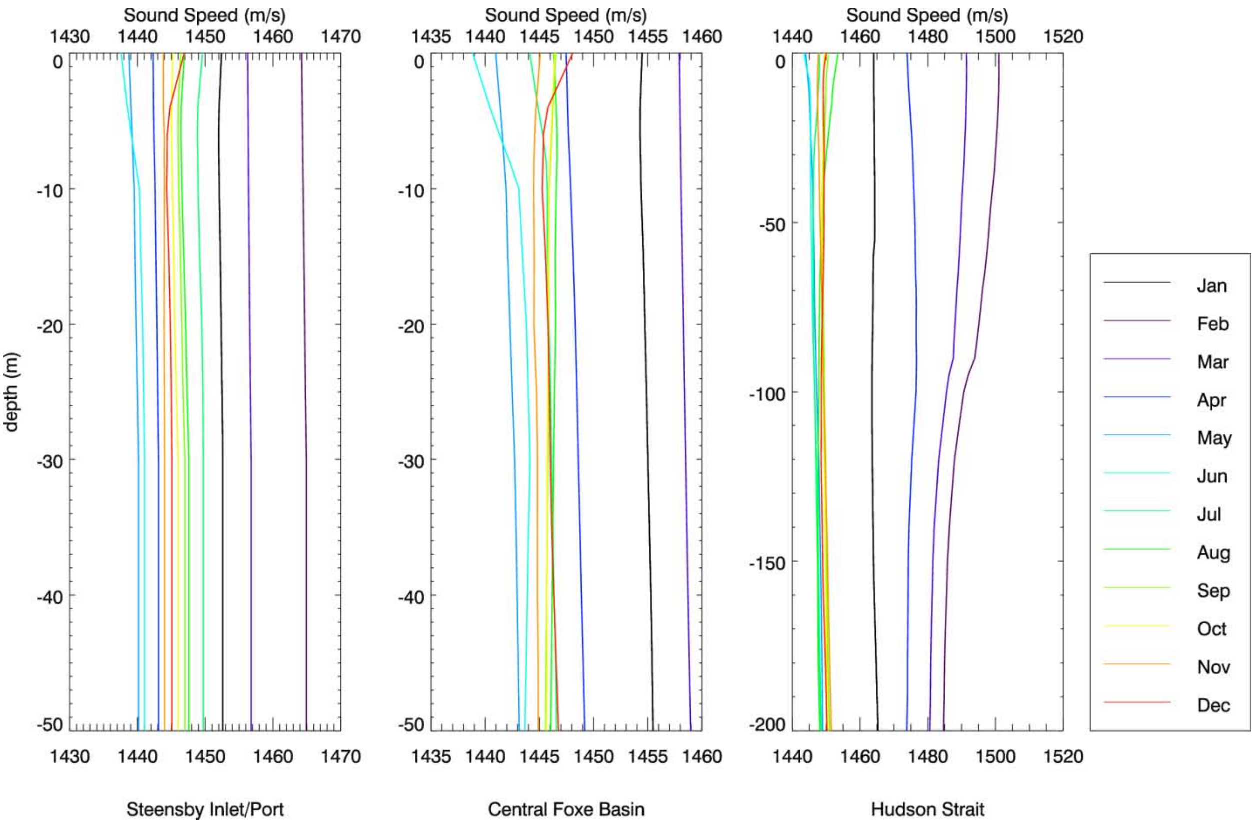

Figure 13: Monthly averaged sound speed profiles for the Steensby Inlet and Port area, the central Foxe Basin area, and Hudson Strait.

All profiles present nearly isothermal conditions, which are favorable for sound propagation. There is a large decrease in sound speed (between 18 and 60 m/s) between the months of February and May.

In accordance with the ice thickness study (Saucier et al., 2004), the sound speed profile for the month of August was used to model sound propagation during the time of year when open water prevails over the studied area, the month of February when thin ice covers the area, and the month of May when thick ice covers the area.

3.3. Sound Propagation Modelling

3.3.1. Vessel and construction noise

The acoustic propagation model used to model the acoustic sources at frequencies below 10 kHz is JASCO's Marine Operations Noise Model (MONM). MONM computes received Sound Exposure Levels (SEL) for impulsive sources if SEL source levels are input. For a continuous source, such as a vessel, dredge or drill rig, MONM outputs RMS levels.

MONM treats sound propagation in range-varying acoustic environments through a wide-angled parabolic equation (PE) solution to the acoustic wave equation. The parabolic equation code used by MONM is based on a version of the Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for an elastic seabed. The Parabolic Equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins, 1993).

MONM computes acoustic fields in three dimensions by modelling transmission loss along evenly spaced 2-D radial traverses covering a 360° swath from the source, an approach commonly referred to as N×2-D. The model fully accounts for depth and/or range dependence of several environmental parameters including bathymetry and sound speed profiles in the water column and the sub-bottom. It also accounts for the additional reflection loss at the seabed that is due to partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces. It includes wave attenuations in all layers. The acoustic environment is sampled at a fixed range step along radial traverses.

MONM treats frequency dependence by computing acoustic transmission loss at the center frequencies of 1/3-octave bands between 10 Hz and 10 kHz. This frequency range includes the important bandwidth of noise emissions for the operating vessel or construction activity. 1/3-octave band received levels are computed by subtracting band transmission loss values from the corresponding directional source levels. Broadband received levels are then computed by summing the received band levels. MONM's sound level predictions have been extensively validated against experimental data (Hannay & Racca, 2005).

The modelling of the sources at frequencies from 10 kHz to 20 kHz was done using the BELLHOP acoustic raytrace model (Porter and Liu, 1994). BELLHOP also computes received Sound Exposure Levels (SEL).

BELLHOP models transmission loss in the ocean using the Gaussian beam tracing technique. In addition to other types of attenuation, BELLHOP accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water (Fisher and Simmons, 1977). This type of attenuation is significant for frequencies higher than 5 kHz and cannot be neglected without noticeable effect on the modelling results at longer distances from the source.

Similar to MONM, BELLHOP computes sound propagation along a single 2-D radial profile in range and depth. In order to obtain the 3-D spatial distribution of the sound field around the source, a series of 2-D profiles is projected from the source covering a 360° swath in azimuth.

The acoustic models take into account the variability of the sound levels emitted in different directions from the source. This variability is referred to as source directivity. Source directivity is specified to the model as a function of both azimuthal and depression angle where azimuthal angle is the sideways direction relative to north, and depression angle is the vertical angle relative to horizontal. The BELLHOP modelling code estimates sound pressure levels at various horizontal distances from the source as well as at different depths.

3.3.2. Blasting

The current DFO guidelines suggest that an fish exposes to instantaneous pressure change of 100 kPa is expected to lead to 50% fish mortality (Wright and Hopky, 1998). A Pentolite equivalent charge weight of 10 kg was used for source modelling, with a burial depth of 1.5 m (assuming rock as the substrate).

Detonation of a buried explosive generates an in-ground pressure shock wave, which propagates through the substrate and into the water column. The blast effects model ConWep (Hyde, 1992) was used to predict the shape of the in-ground shock wave pressure at distance from the detonation site. ConWep produces a pressure-time history function at some distance from the source for a given explosive type and weight, source-receiver geometry, and substrate.

Because the physics of explosive detonation are complex in the immediate vicinity of the blast, a blast effects model such as ConWep cannot be used to directly yield sound levels at or very near the source. Instead, ConWep was run for a range well outside the non-linear region near the detonation, and the equivalent third-octave band source levels (similar to those presented in the preceding sections) were back-propagated using a sound propagation model. The specific steps were:

- ConWep was run using the explosive setup and geometry described above, for a horizontal range of 37.1 m. This was the setback distance for which ConWep produced a peak waterborne overpressure of 100 kPa for a 10 kg charge weight.
- Third-octave band SPLs at a range of 1 m were computed by back-propagating the peak pressure from 37.1 m to 1 m under a cylindrical spreading assumption and equally dividing the resultant equivalent broadband source level into 24 third-octave bands (i.e., $BL = SL - 20 \cdot \log(24)$, in dB) assuming that an impulse (pressure delta function) equally excites all frequencies.
- The sound propagation model MONM (discussed in Section 3.3.1) was used to compute the transmission loss in each third-octave band, to a maximum range of up to 200 km for receivers in the water column. The blasting equivalent acoustic source depth was set to 1 m above the sea floor for an equivalent in-water acoustic source.

The equivalent source levels: 218 and 208 dB re 1 µPa at 1 m respectively for sources in the substrate and in the water column, are not the actual levels that would be measured at the detonation site; rather, they represent “equivalent” source levels, which when forward-propagated in a realistic acoustic environment (as outlined in Section 3.3.1) yield the same received levels at a horizontal range of 37.1 m as is predicted using ConWep.

3.4. Attenuation of Sound

As sound waves propagate they interact at a molecular level with the constituents of sea water through a range of mechanisms, resulting in absorption of some of the sound energy (Thorp, 1965; Fisher and Simmons, 1977; Francois and Garrison, 1982a,b; Medwin, 2005). This occurs even in completely particulate-free waters and is in addition to energy losses from scattering by objects such as zooplankton or suspended sediments. The absorption of sound energy by absorption is quantified by the attenuation coefficient in units of decibels per kilometer (dB/km).

This absorption coefficient is computed from empirical equations and increases generally with the square of frequency.

The present study used the equation developed by Fisher and Simmons (1977) for the propagation of sound in open water:

$$
\begin{aligned}
&a = 8.686\left[\frac{A_1 f_1 f^2}{f_1^2 + f^2} + \frac{A_2 P_2 f_2 f^2}{f_2^2 + f^2} + A_3 P_3 f^2\right],\\
&\textit{where}\\
&A_1 = 1.03\times10^{-8} + 2.36\times10^{-10}T - 5.22\times10^{-12}T^2,\\
&f_1 = 1.32\times10^{3}(T + 273.1)\exp[-1700/(T + 273.1)],\\
&A_2 = 5.62\times10^{-8} + 7.52\times10^{-10}T,\\
&f_2 = 1.55\times10^{7}(T + 273.1)\exp[-3052/(T + 273.1)],\\
&P_2 = 1 - 10.3\times10^{-4}P + 3.7\times10^{-7}P^2,\\
&A_3 = (55.9 - 2.37T + 4.77\times10^{-2}T^2 - 3.48\times10^{-4}T^3)\times10^{-15},\\
&\textit{and}\\
&P_3 = 1 - 3.84\times10^{-4}P + 7.57\times10^{-8}P^2.
\end{aligned}
\quad , \qquad (5)
$$

where, f is the frequency in Hz, T is the temperature in degrees centigrade, and P is the pressure in atmospheres.

Thiele et al. (1990) later developed a general equation for the attenuation coefficient which applies to propagation of sound in ice-covered water.

$$
a = \frac{0.235 f^3}{0.0023 + f^3} + \frac{0.11 f^2}{1.0 + f^2} + \frac{43.7 f^2}{4{,}100 + f^2} \quad , \qquad (6)
$$

where, a is the attenuation coefficient, f is the frequency in kHz. This equation was used in the present study to calculate loss from scattering and absorption of sound propagation under a thin or a thick ice cover. Figure 14 compares the attenuation coefficient values in open water and ice conditions using equations (5) and (6). In this example water temperature was set to 1°C and the results represent the coefficient value at 15 m depth.

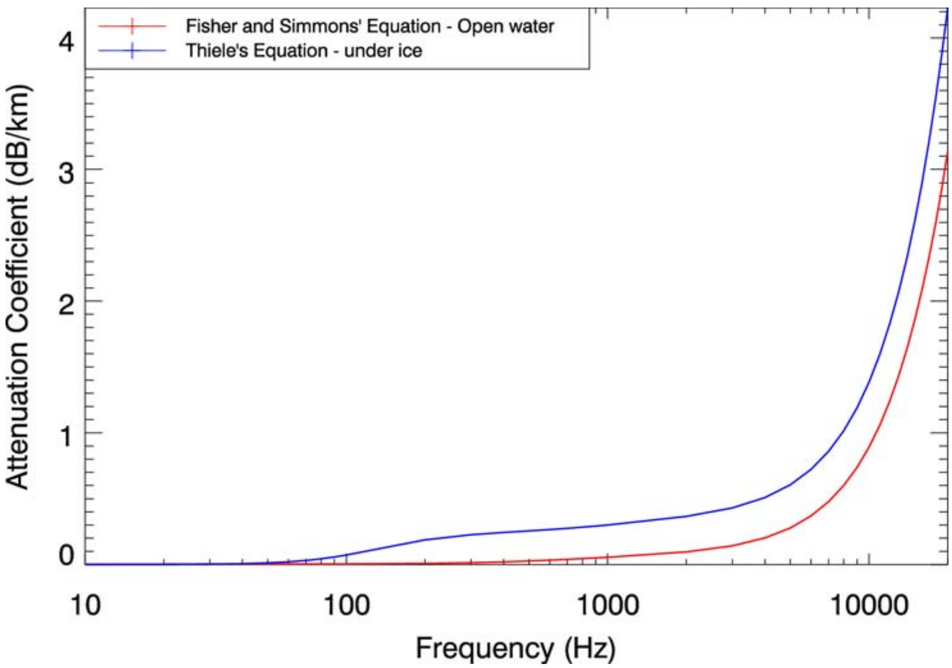

Figure 14: Comparison between attenuation coefficients for propagation in water with no ice cover (Fisher and Simmons, 1977) and with ice cover (Thiele, 1990). This example was produced for a water temperature of 1°C and a water depth of 15 m.

3.5. M-weighting

The potential for seismic survey noise to affect marine species depends on how well the species can hear the sounds produced (Martin et al., 2010). Noises are less likely to disturb animals if they are at frequencies that the animal cannot hear well. An exception is when the sound pressure is so high that it can cause physical injury. For non-injurious sound levels, frequency weighting curves based on audiograms may be applied to weight the importance of sound levels at particular frequencies in a manner reflective of the receiver's sensitivity to those frequencies (Nedwell and Turnpenny, 1998).

A NMFS-sponsored Noise Criteria Committee has proposed standard frequency weighting curves — referred to as M-weighting filters — for use with marine mammal species (Gentry et al., 2004). M-weighting filters are band-pass filter networks that are designed to reduce the importance of inaudible or less-audible frequencies for four broad classes of marine mammals:

1. Low-frequency cetaceans,
2. Mid-frequency cetaceans,
3. High-frequency cetaceans, and
4. Pinnipeds.

The amount of discount applied by M-weighting filters for less-audible frequencies is not as great as would be indicated by the corresponding audiograms for these groups of species. The rationale for applying a smaller discount than would be suggested by the audiogram is in part due to an observed characteristic of mammalian hearing that perceived equal loudness curves increasingly have less rapid roll-off outside the most sensitive hearing frequency range as sound levels increase. This is the reason that C-weighting curves for humans, used for assessing very loud sounds such as blasts, are flatter than A-weighting curves used for quiet to mid-level sounds. Additionally, out-of-band frequencies, though less audible, can still cause physical injury if pressure levels are very high. The M-weighting filters therefore are primarily intended to be applied at high sound levels where effects such as temporary or permanent hearing threshold shifts may occur. The use of M-weighting should be considered precautionary (in the sense of overestimating the potential for an effect) when applied to lower level effects such as onset of behavioral response. Figure 15 shows the decibel frequency weighting of the four standard underwater M-weighting filters.

These filters have unity gain (0 dB) through the pass band and their high and low frequency roll off is approximately –12 dB per octave. The amplitude response of the M-weighting filters is defined in the frequency domain by the following function:

$$G(f) = -20\log_{10}\left[\left(1+\frac{f_{lo}^2}{f^2}\right)\left(1+\frac{f^2}{f_{hi}^2}\right)\right] \quad , \tag{7}$$

The roll off and pass band of these filters are controlled by the two parameters f_{lo} and f_{hi}; the parameter values that are used for the four different standard M-weighing curves are given in Table 11.

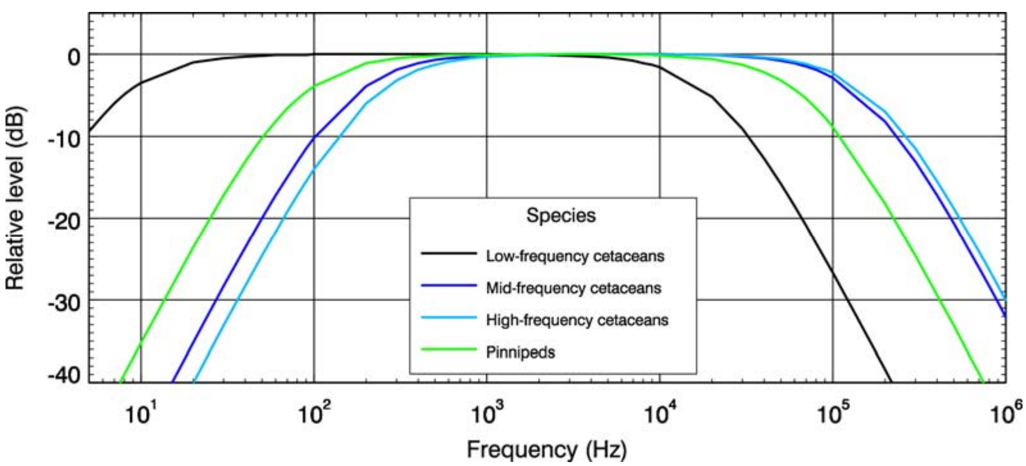

Figure 15: Plot of standard M-weighting curves for low-frequency, mid-frequency, and high-frequency cetaceans and for pinnipeds in water.

Table 11: Low frequency and high frequency cutoff parameters for standard marine mammal M-weighting curves.

M-weighting filter	f_{lo} (Hz)	f_{hi} (Hz)
Low frequency cetaceans	7	22 000
Mid-frequency cetaceans	150	160 000
High-frequency cetaceans	200	180 000
Pinnipeds underwater	75	75 000

4. Results

Sound propagation modelling was performed using two geographic coverage methods : (a) areal coverage over a 200 km x 200 km zone centered on each modelling location, using a 5 m modelling step size in horizontal range, for frequencies between 10 Hz and 2 kHz, and (b) along three individual profiles in the direction of the maximum sound field extension (as determined with the results from the areal modelling) up to the distance where the broad band levels drop below 100 dB re µPa for frequencies between 10 Hz and 20 kHz. The regime (a) provides high resolution area map of the sound field around each source, while regime (b) provides a full-band, high resolution assessment of the sound field in the directions of maximum sound propagation. The extent of the frequency range used in regime (b) would make the modelling at all azimuths around the source too computationally intensive for approach (a).

Processing of the output data from the modelling code involved gridding of the data points in horizontal planes corresponding to multiple receiver depths. The resulting stack of grids was collapsed to a single grid using a maximum-over-depth rule; that is, the sound level at each geographic location was taken to be the maximum value that occurred over all modelled depths for that location.

Four M-weighting filters (Table 11) were applied to the modelled sound fields by weighting the modelled sound levels according to Equation (7). M-weighting is applied to each third-octave band separately. After the filter is applied the individual values in each band are summed to compute the broadband sound levels.

The presented maps of ensonification levels were calculated using the results from the geographic approach (a). Consequently, these maps represent the maximum-over-depth levels in the 10 to 2000 Hz band.

The calculations of maximum distances to specific broadband sound levels were performed based on the grids of the broadband (10 – 2000 Hz) levels from areal modelling results complemented with modelling along three profiles if the threshold level extended beyond the modelling area. Since the source levels for frequencies higher than 2000 Hz are significantly lower than the ones for lower frequencies, the usage of reduced band (only up to 2000 Hz, rather than 20,000 Hz) for calculation of the broadband levels did not affect the results.

For each level, two distances are reported: (1) R_{max} – the maximum distance at which the specific sound level was registered in the modelled field; (2) $R_{95\%}$ – the maximum distance to a grid point at which the specific sound level was registered after exclusion of 5% furthest points.

The calculations of maximum-over-depth sound levels in each third-octave band at specific distances were performed using the results of the modelling along three extended profile exclusively for the full frequency range (from 10 Hz to 20,000 Hz). These threshold levels are reported in Appendix B (separate document).

4.1. Drilling

Drilling sound levels were modelled at 20 depths between 1 m and 150 m below the surface. The modelling was performed using a source depth of 2 m below the surface, representing coring drilling, and a source depth of 19 m, representing drilling using hammering action as discussed in Section 2.1.1. The associated source levels are presented in Figure 1.

The maximum distances to specific sound levels produced by the coring drilling and hammer-drilling operations are presented in Table 12. The resultant sound field maps are presented in Figures A-1 and A-2. The black lines in these figures originating at the source location indicate the direction of the modelling profiles (modelling of frequencies between 10 and 20,000 Hz using geographic method (b)). Tables B-1 and B-2 present the R_{max} and $R_{95\%}$ distances calculated with and without M-weighting filters applied for each sources.

Table 12: Threshold distances from drilling operations at the Ore Loading Dock, calculated from broadband (10 – 2000 Hz) sound fields.

RMS SPL (dB re 1 µPa)	Drilling operation Maximum distance (m)	
	Coring drilling	Hammer-drilling
170		< 10
160		20
150		130
140		800
130	< 10	3,800
120	20	18,000
110	170	28,500
100	1,125	74,500

4.2. Blasting

Sound levels from blasting were modelled at 20 receiver depths between 1 m to 150 m below the surface. This modelling was performed using a source location at 1 m above the bottom (or 19 m below the sea surface).

Radii are shown in Table 13 for blasting in the area of the Ore Loading Dock of the Mary River port upgrading project; the corresponding sound field is mapped in Figure A-3 and Figure A-4. As expected given the source levels presented in Section 2.1.2, the radii for this activity are greater than those for the other port construction operations analyzed in this report. There is significant sound transmission through the sea bottom as well as through the water.

As discussed in Section 2.1.2, the scenario described below is illustrative of a single charge of 10 kg and an offset distance of 37.1 m results from the DFO 100 kPa overpressure guideline (Wright and Hopky, 1998). In practice, various approaches may be used to reduce the effect for a given overall explosive charge, including sub-dividing a large charge into a series of smaller, time-delayed charges or using additional mitigation measures such as bubble curtains (Wright and Hopky, 1998).

The accuracy of the prediction for the actual sound field produced by the proposed blasting operation is not high because the assumptions regarding charge weights and blast design are not yet determined (and therefore not available). Generic specifications were selected as the input for the model based on our previous experience at modelling and measuring an underwater blasting operation. The results provided here can be adjusted later to account for differences between the assumed parameter values and finalized blasting specifications once those are available. The assumptions used here are provided in Section 2.1.2. A bubble curtain attenuation factor of 15.4 dB was applied. If the actual bubble curtain effectiveness differs from this value then that difference should be taken into account.

Table 13: Threshold distances from blasting operations at the Ore Loading Dock, calculated from broadband (10 – 2000 Hz) sound fields.

RMS SPL (dB re 1 µPa)	Blasting operation	
	no curtain	with curtain
200	25	
190	170	< 10
180	885	45
170	3,650	460
160	14,000	1,680
150	26,000	7,300
140	60,000	20,700
130	80,500	43,900
120	85,600	75,000
110	86,000	80,500
100	86,250	85,600

4.3. Dredging

Sound levels from dredging were modelled at 20 receiver depths between 1 m to 150 m below the surface. This modelling was performed using a source depth of 3 m below the surface, representing the dumping of material into an empty barge, and for a source depth of 19 m, representing cutter-suction dredging with thrusters.

The maximum distances to specific sound levels produced by dredging operations are presented in Table 14. The resulting ensonification field maps are presented in Figures A-5 and A-6. Again the black lines in these figures indicate the direction of the geographic method (b) extended frequency band modelling profiles. Tables A-5 and A-6 present the R_{max} and $R_{95\%}$ distances calculated with and without M-weighting filters applied for each source.

Table 14: Threshold distances from dredging operations at the Ore Loading Dock, calculated from broadband (10 – 2000 Hz) sound fields.

RMS SPL (dB re 1 µPa)	Dredging operation Maximum distances (m)	
	Basket	Cutter
180		< 10
170	< 10	35
160	15	260
150	130	1,700
140	900	5,800
130	5,300	16,500
120	16,500	29,000
110	43,000	75,000
100	80,500	80,500

4.4. Port Operation – Tugs

The sound levels produced by tug operations were modelled at 20 depths between 1 m and 150 m below the sea surface. This modelling was performed using a source depth of 3 m below the surface, in the vicinity of the ore loading dock, during open water, thin-ice, and thick-ice conditions.

The maximum distances to specific sound levels produced by tug operations in different water conditions are presented in Table 15. The resulting ensonification field maps are presented in Figures A-7 to A-9. The black lines in these figures indicate the directions of the geographic method (b) extended bandwidth modelling profiles. Tables A-7 to A-9 present the R_{max} and $R_{95\%}$ distances calculated with and without M-weighting filters applied for each source.

Table 15: Threshold distances from tugs operating in the vicinity of the Ore Loading Dock, calculated from broadband (10 – 2000 Hz) sound fields.

RMS SPL (dB re 1 µPa)	Tug operations maximum radius (meter)		
	Open water	Thin ice cover	Thick ice cover
200			< 10
190		< 10	15
180	< 10	15	35
170	25	30	450
160	100	250	1,750
150	800	1,500	5,800
140	3,600	5,100	17,000
130	9,200	13,500	43,000
120	20,000	25,000	75,500
110	75,500	58,000	107,500
100	109,000	81,000	109,000

4.5. Shipping – Icebreaker Ore Carrier

Shipping and icebreaker sound levels were modelled at 20, 26, and 31 different depths, ranging from 1 m to 700 m below the surface, depending on the modelling location. The modelling was performed using a source depth of 9 m below the surface, representing the icebreaking ore carrier draft during transit through Steensby Inlet, Foxe Basin, and Hudson Strait, during open water, thin-ice, and thick-ice conditions.

The maximum distances to specific sound levels produced by the ore carrier transiting through the three modelling locations, in different water conditions are presented in Table 16. The resulting ensonification field maps are presented in Figures I-10 to I-18. The black lines in these figures indicate the directions of the extended bandwidth modelling profiles. Tables J-10 to J-18 present the R_{max} and $R_{95\%}$ distances calculated with and without M-weighting filters applied for each source.

Table 16: Threshold distances from Ore Carrier transiting at the 3 modelled locations, calculated from broadband (10 – 2000 Hz) sound fields.

RMS SPL (dB re 1 μPa)	Steensby Inlet maximum radius (meter)			Foxe Basin maximum radius (meter)			Hudson Strait maximum radius (meter)		
	Open water	Thin ice cover	Thick ice cover	Open water	Thin ice cover	Thick ice cover	Open water	Thin ice cover	Thick ice cover
200			< 10			< 10			< 10
190		< 10	20		< 10	20		< 10	20
180	< 10	15	60	< 10	15	85	< 10	15	70
170	35	55	450	35	60	720	35	55	280
160	290	450	3,500	270	450	3,500	125	350	2,100
150	1,700	2,700	11,000	1,700	3,000	9,500	1,000	2,000	7,500
140	7,000	10,500	27,500	6,200	7,000	20,500	6,000	8,300	23,000
130	23,500	26,500	48,000	15,000	20,500	38,500	21,000	26,000	91,500
120	70,000	51,500	70,500	40,000	47,500	85,500	97,000	132,000	153,000
110	178,500	84,500	105,500	108,000	104,000	123,500	215,000	239,000	> 250,000
100	> 250,000	108,500	142,500	> 250,000	150,000	208,000	240,000	> 250,000	

5. Discussion

There are several factors that define the difference in the ensonification field between the open water and ice seasons. First, the vessel source levels for the thin and thick ice conditions are much higher than for the open water season due to the additional power required to break ice. In case of the Ore Carrier the most notable increases (by up to 40 dB) occur for frequencies below 30 Hz. A second factor is the additional attenuation of acoustic energy due to ice cover. This attenuation is greatest for higher frequencies: 7.5 dB per 100 km at 100 Hz, 30 dB per 100 km at 1000 Hz. The attenuation due to ice cover has virtually no effect for frequencies below 30 Hz.

Tables 15 and 16 show that in Steensby Inlet, broadband threshold distances for sound pressure levels of 120 dB re 1 µPa and less can be greater during open water conditions (120 dB - 70 km; 110 dB – 178 km) than in thin- (120 dB - 51 km; 110 dB – 84 km) or thick-ice (120 dB - 70 km; 110 dB – 105 km) conditions.

Although the vessels have higher source levels while operating in ice versus open water conditions, additional attenuation for frequencies above 100 Hz due to presence of ice on the sea surface leads to marked reduction at long ranges (more than 50 km) of the received sound levels and threshold distances in thin and thick ice conditions relative to open water conditions. The shallow depth and hard bottom in Steensby Inlet do not support propagation of low frequencies. Higher levels of low frequency acoustic energy for thick-ice conditions do not contribute enough to affect the extent of the broadband threshold distances. On the other hand, the deeper depths in Hudson Strait allow long-range propagation of frequencies below 50 Hz which do influence the broadband threshold distances. These low frequencies are less affected than high frequencies by sound energy absorption in the water and attenuation due to ice cover. The increase of the acoustic energy in the lower frequencies for the thick-ice conditions leads to a large increase in the threshold distances for Hudson Strait modelling location. The increase can be as much as 17 times: 160 dB re 1 µPa at 125 m open water; at 350 m thin ice; 2100 m thick ice. Such a dramatic increase in the threshold distance at this location can be attributed exclusively to the increase in the levels for the frequency bands below 30 Hz (Figure 9).

Propagation conditions in Hudson Strait for the month of February (thin ice) and May (thick ice) are slightly different due to variation in the sound speed profile. For February the profile is downward refracting and directs the acoustic energy into the bottom. In May the sound speed profile is slightly upward refracting, i.e. promotes better sound propagation by avoiding bottom reflections.

The effect of M-weighting on broadband threshold distances depends directly on the long-range propagating frequencies. Thus, the effect of M-weighting depends on the locations of the source and the water conditions.

Because of large attenuation levels at high frequencies, acoustic energy at frequencies above 5000 Hz has a limited contribution to the broadband threshold distances. Consequently, the high frequency cutoff parameters for M-weighting filters have little to no effect on the calculated broadband threshold distances.

Again, because of the water depth and the seabed geology, long-range propagating frequencies in Steensby Inlet and Foxe Basin are mainly found above 100 Hz. Thus, at this location, the low frequency cutoff parameters for M-weighting filters contribute to slightly reduce the broadband threshold distances. For example, in Steensby Inlet, the frequency bands propagating farthest from the ore carrier during transit in thin-ice conditions extends from 63 to 1000 Hz, while in thick-ice condition the corresponding bands are from 400 to1000 Hz, and from 600 to 1000 Hz in open water conditions. Consequently, the ore carrier broadband threshold distances for 110 dB re 1 μPa are reduced by up 24% in thin-ice conditions (Table A-11), 4% in thick-ice conditions (Table A-12) and 3% in open water (Table A-10).

In Hudson Strait, however, the M-weighting filters do cut off long-range propagating frequencies and result in a greater reduction of the broadband threshold distances. Consequently, the ore carrier broadband threshold distances for 110 dB re 1 μPa are reduced by up 66% in thin-ice conditions (Table A-17), 50% in thick-ice conditions (Table A-18) and 30% in open water (Table A-16).

The modelled sound field maps representing the operations in vicinity of the port indicate that some acoustic energy can be detected behind land masses. This energy is real and results from propagation through the ground and back to the water column on the far side of the land mass.

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Appendix A.

A.1. Unweighted Sound Fields – Drilling operations

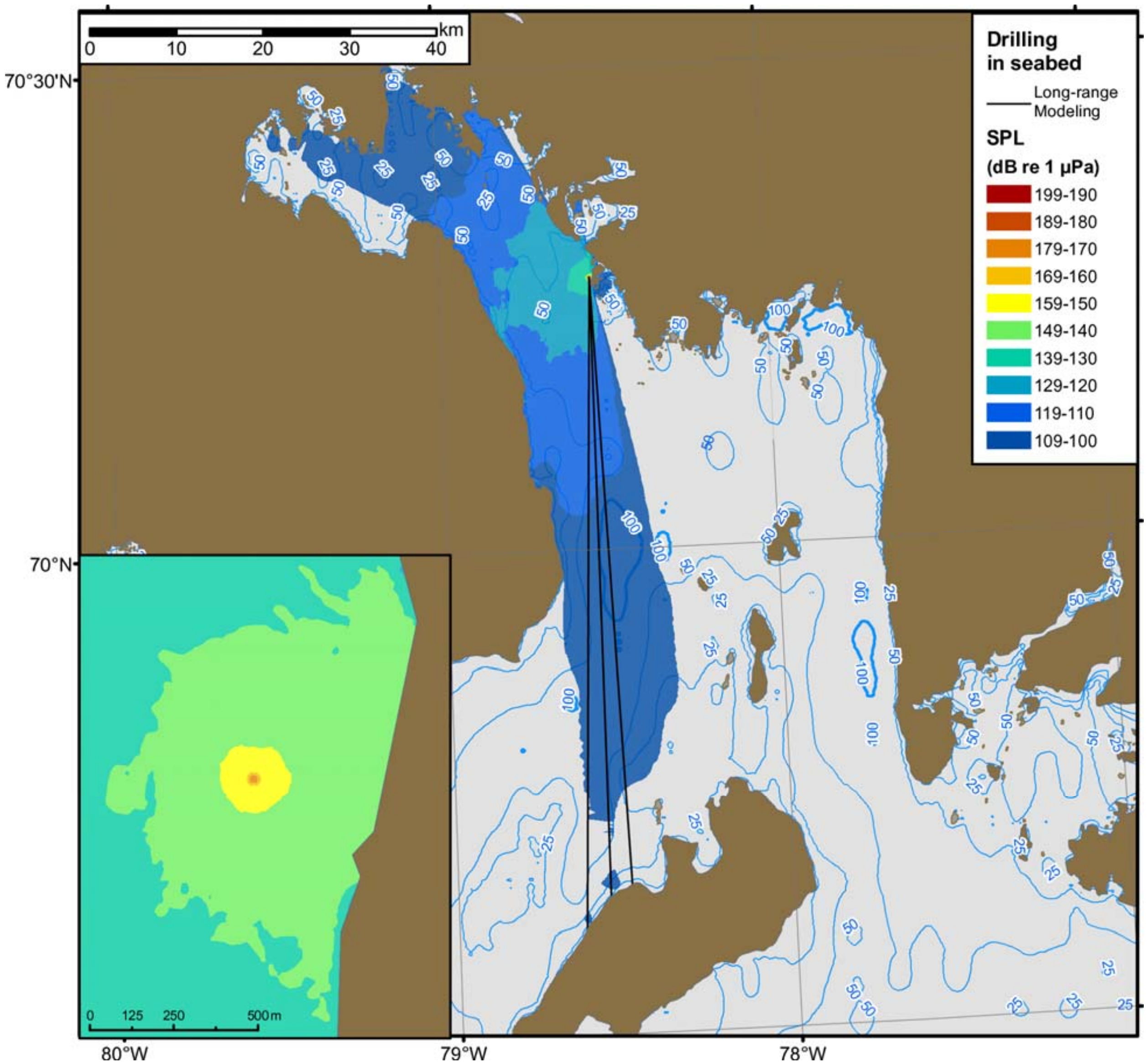

Figure A-1: Estimated broadband (10 – 2000 Hz) sound pressure levels around hammer-drilling operations in the seabed at the Ore Loading Dock, in open water conditions.

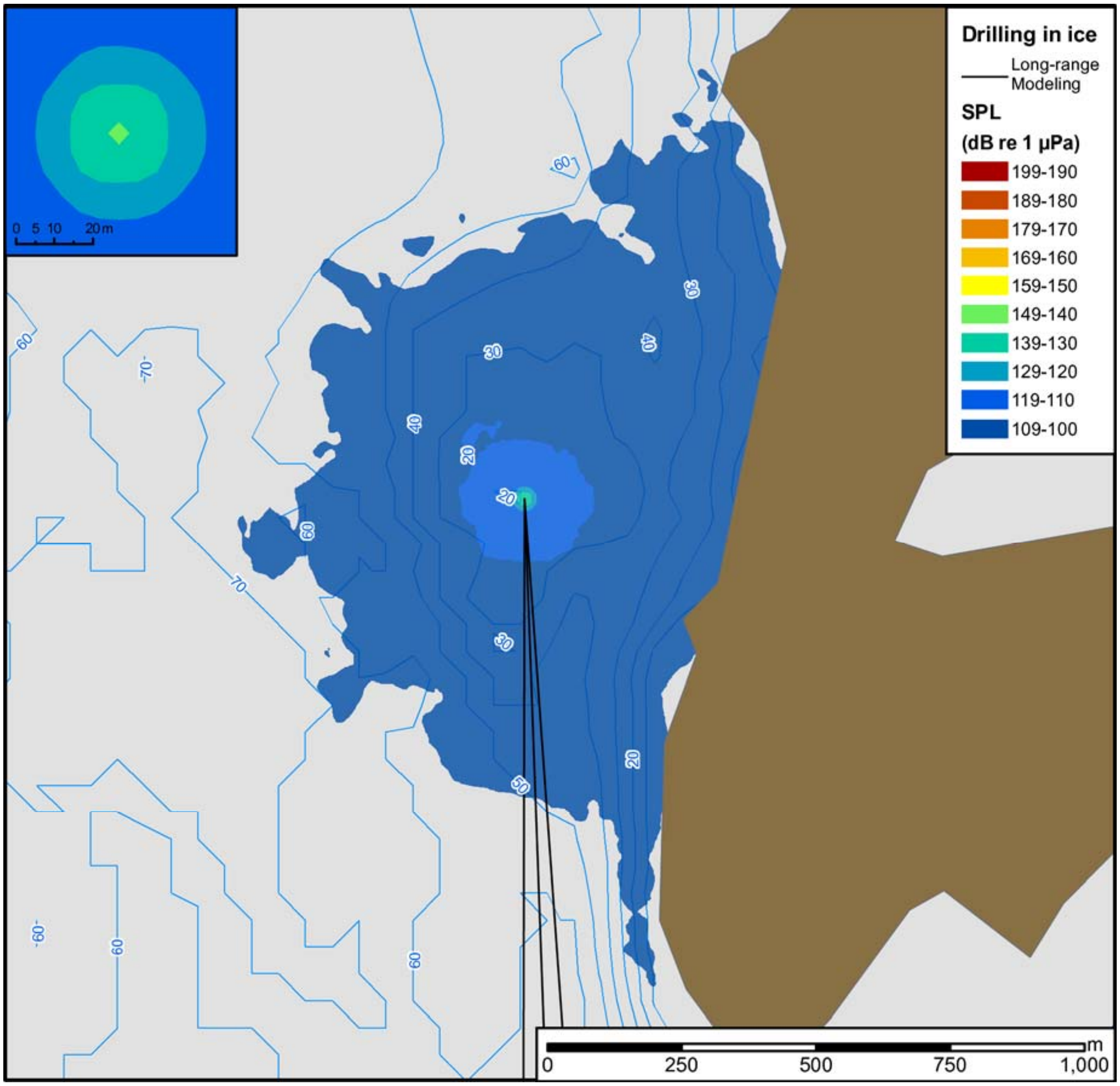

Figure A-2: Estimated broadband (10 – 2000 Hz) sound pressure levels around drilling operations in the surface ice at the Ore Loading Dock, in open water conditions.

A.2. Threshold Distances – Drilling operations

Table A-1: Comparison between predicted m-weighted and unweighted threshold distances from drilling operations in the seabed at the Ore Loading Dock, in open water conditions. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 μPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
170	< 10	< 10	< 10	< 10					< 10	< 10
160	20	20	20	20	< 10	< 10	< 10	< 10	15	15
150	130	110	130	110	75	65	60	50	100	90
140	800	600	800	600	510	400	460	350	730	500
130	3,800	2,600	3,800	2,600	3,200	1,400	1,650	1,200	3,400	2,100
120	18,000	11,500	18,000	11,000	12,500	7,000	8,000	6,000	16,500	9,000
110	28,500	23,000	28,500	22,500	26,500	20,000	24,500	18,000	27,000	22,000
100	74,500	54,500	74,500	54,000	57,000	42,500	52,500	38,000	74,000	52,000

Table A-2: Comparison between predicted m-weighted and unweighted threshold distances from drilling operations in the surface ice at the Ore Loading Dock, in open water conditions. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 μPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
130	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
120	20	20	20	20	15	15	15	15	20	15
110	170	130	170	130	165	105	155	85	165	120
100	1,125	625	1,125	625	910	565	885	520	1,125	625

A.3. Unweighted Sound Fields – Blasting operations

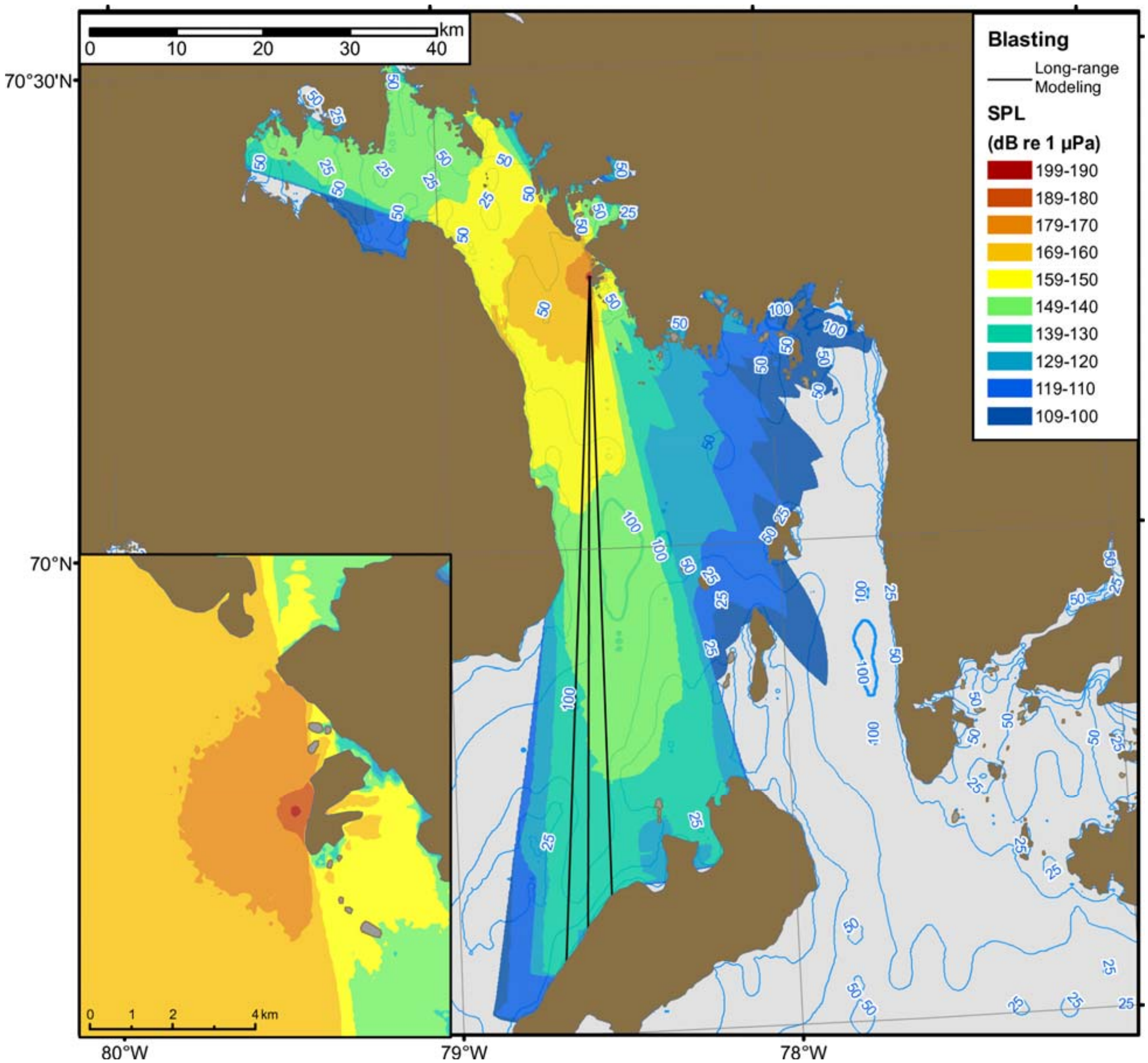

Figure A-3: Estimated broadband (10 – 2000 Hz) sound pressure levels around blasting operations in the seabed at the Ore Loading Dock, in open water conditions.

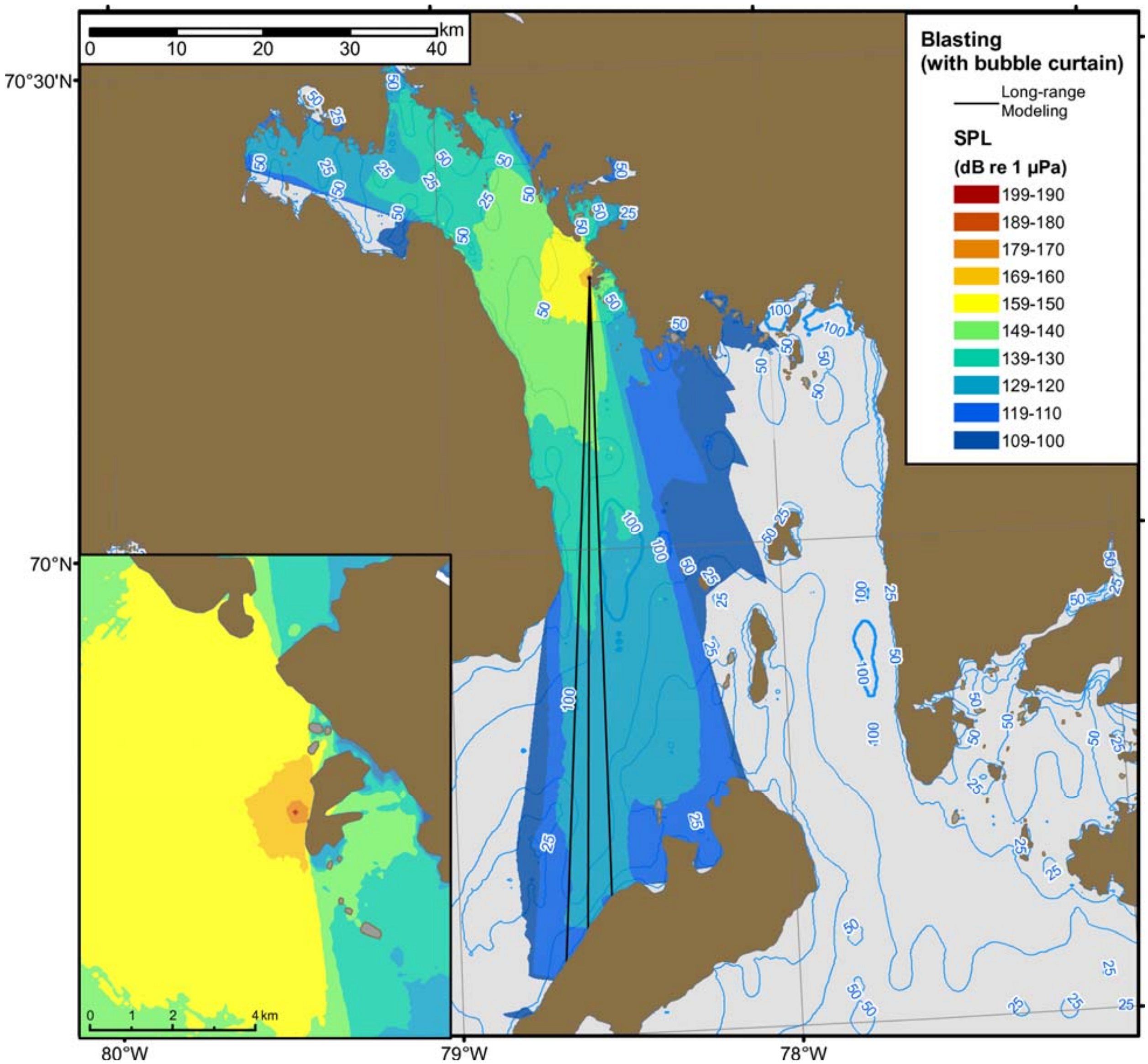

Figure A-4: Estimated broadband (10 – 2000 Hz) sound pressure levels around blasting operations in the seabed at the Ore Loading Dock, in open water conditions, using a bubble curtain.

A.4. Threshold Distances – Blasting operations

Table A-3: Comparison between predicted m-weighted and unweighted threshold distances from drilling operations in the seabed at the Ore Loading Dock, in open water conditions. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	25	25	25	25	< 20	< 20	< 20	< 20	< 20	< 20
190	170	130	165	120	65	55	55	50	75	65
180	885	640	850	625	520	400	480	365	600	460
170	3,650	2,800	3,650	2,675	1,880	1,300	1,600	1,200	3,200	1,500
160	14,000	10,400	14,000	10,100	9,000	7,000	8,650	6,400	13,000	7,900
150	26,000	24,300	26,000	24,300	27,000	20,200	24,600	19,500	27,000	21,300
140	60,000	56,900	60,000	56,900	57,250	42,800	47,000	40,700	57,600	46,000
130	80,500	68,500	80,500	68,500	80,500	68,000	80,500	67,700	80,500	68,500
120	85,600	70,000	85,600	70,000	85,600	70,000	85,600	70,000	85,600	70,000
110	86,000	73,500	86,000	73,500	86,000	73,500	86,000	73,500	86,000	73,000
100	86,250	75,000	86,250	75,000	86,250	74,400	86,250	74,750	86,250	73,600

Table A-4: Comparison between predicted m-weighted and unweighted threshold distances from drilling operations in the seabed at the Ore Loading Dock, in open water conditions, using a bubble curtain. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
180	45	45	45	45	25	25	25	25	30	30
170	460	340	450	300	200	150	200	130	220	170
160	1,680	1,225	1,600	1,180	1,100	700	950	650	1,300	800
150	7,300	6,000	7,200	5,900	5,500	3,000	5,500	2,700	5,800	4,000
140	20,700	16,300	24,000	16,000	19,600	12,100	19,600	11,800	19,600	13,500
130	43,900	30,800	42,800	30,700	37,600	27,200	37,000	24,500	42,700	29,200
120	75,000	63,000	75,000	63,000	74,900	60,500	74,900	59,000	74,900	62,500
110	80,500	69,000	80,500	69,200	80,500	69,600	80,500	69,500	80,500	69,600
100	85,600	70,700	85,600	69,700	85,600	70,700	85,600	70,700	85,600	70,600

A.5. Unweighted Sound Fields – Dredging operations

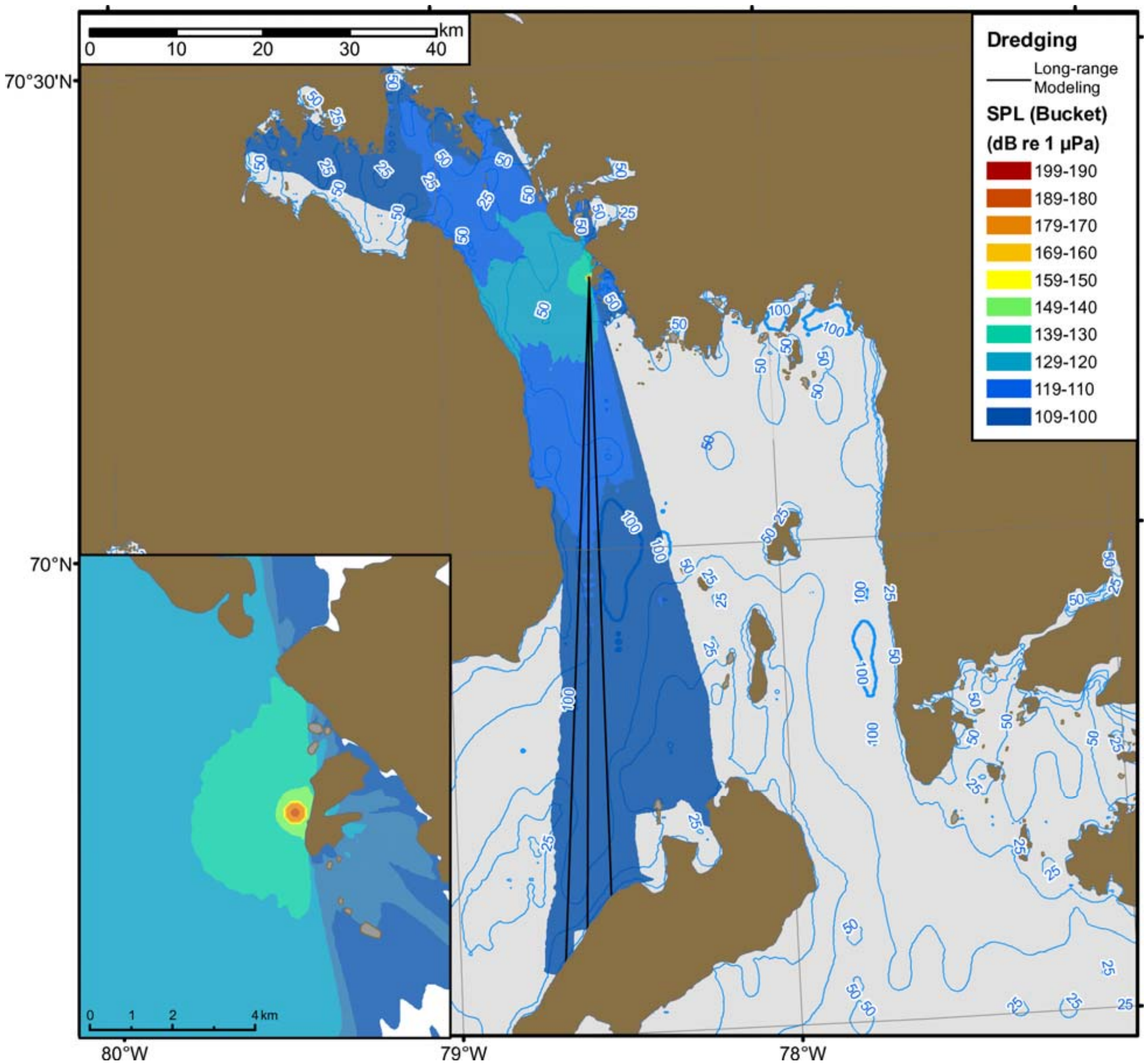

Figure A-5: Estimated broadband (10 – 2000 Hz) sound pressure levels around dredging operation (basket) at the Ore Loading Dock, in open water conditions.

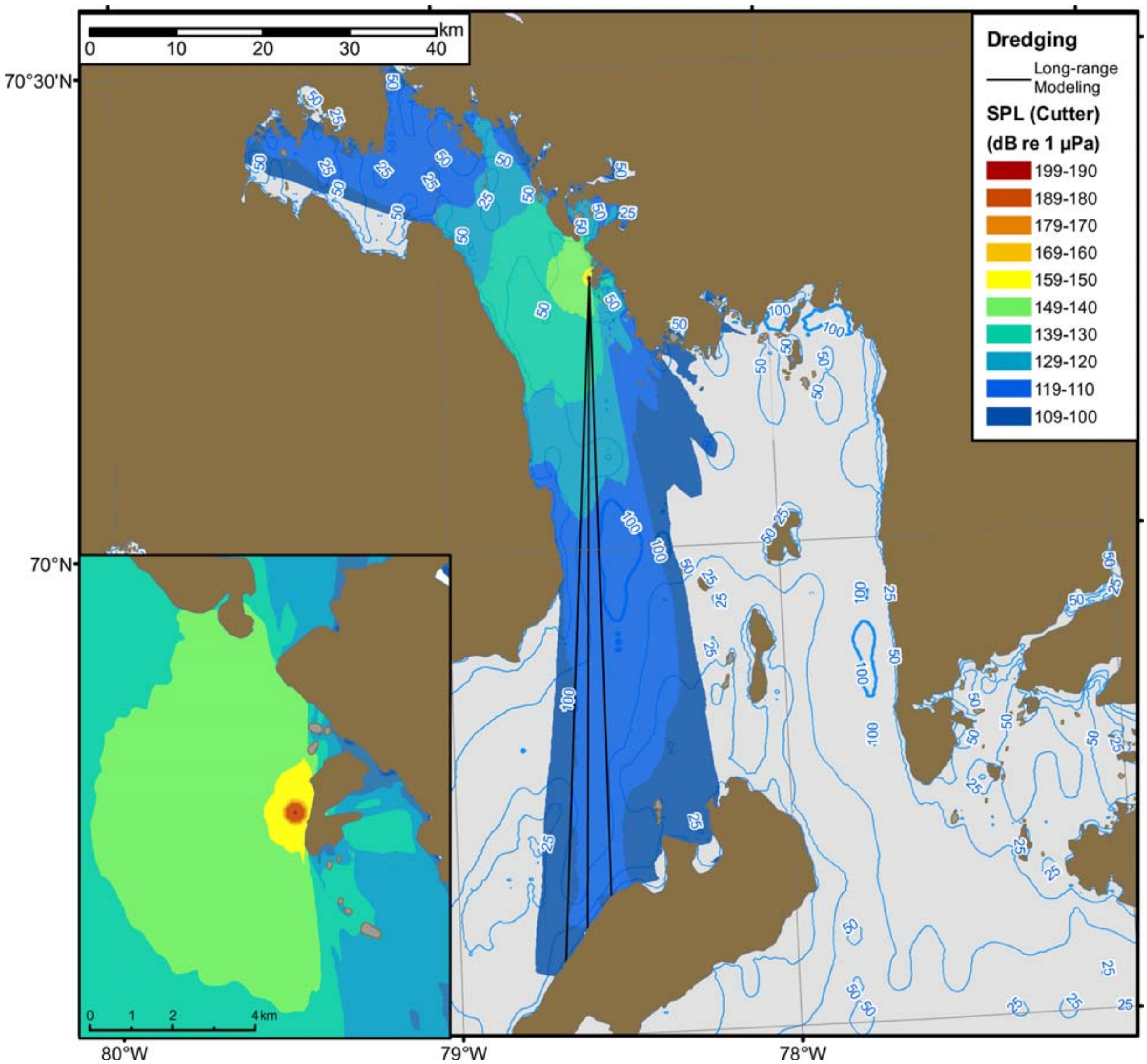

Figure A-6: Estimated broadband (10 – 2000 Hz) sound pressure levels around dredging operation (cutter) at the Ore Loading Dock, in open water conditions.

A.6. Threshold Distances – Dredging operations

Table A-5: Comparison predicted between m-weighted and unweighted threshold distances from dredging operations (basket) at the Ore Loading Dock, in open water conditions. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
170	< 10	< 10	< 10	< 10	< 10	< 10			< 10	< 10
160	15	15	15	15	10	10	< 10	< 10	10	10
150	130	120	130	120	65	60	50	50	85	75
140	900	600	900	600	500	350	400	250	750	450
130	5,300	2,700	5,300	2,600	3,000	1,300	1,650	1,150	3,400	1,800
120	16,500	12,000	16,000	12,000	14,500	8,000	13,500	3,500	15,000	12,000
110	43,000	27,000	43,000	27,000	34,000	23,000	32,500	21,500	40,000	25,500
100	80,500	74,500	80,500	74,500	80,500	74,000	80,500	74,000	80,500	74,500

Table A-6: Comparison predicted between m-weighted and unweighted threshold distances from dredging operations (cutter) at the Ore Loading Dock, in open water conditions. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
180	< 10	< 10	< 10	< 10						
170	35	35	30	30	< 10	< 10	< 10	< 10	< 10	< 10
160	260	230	250	200	30	30	20	20	50	50
150	1,700	1,100	1,400	950	200	150	130	100	450	350
140	5,800	4,800	5,600	4,500	1,100	700	850	600	1,650	1,200
130	16,500	13,000	16,500	13,000	5,600	3,500	3,500	2,400	12,500	6,000
120	29,000	22,500	28,500	22,500	24,000	14,500	24,000	12,000	26,500	19,500
110	75,000	62,000	75,000	62,000	75,000	45,000	74,500	36,000	75,000	60,000
100	80,500	75,000	80,500	75,000	80,500	75,000	80,500	75,000	80,500	75,000

A.7. Unweighted Sound Fields – Tug operations

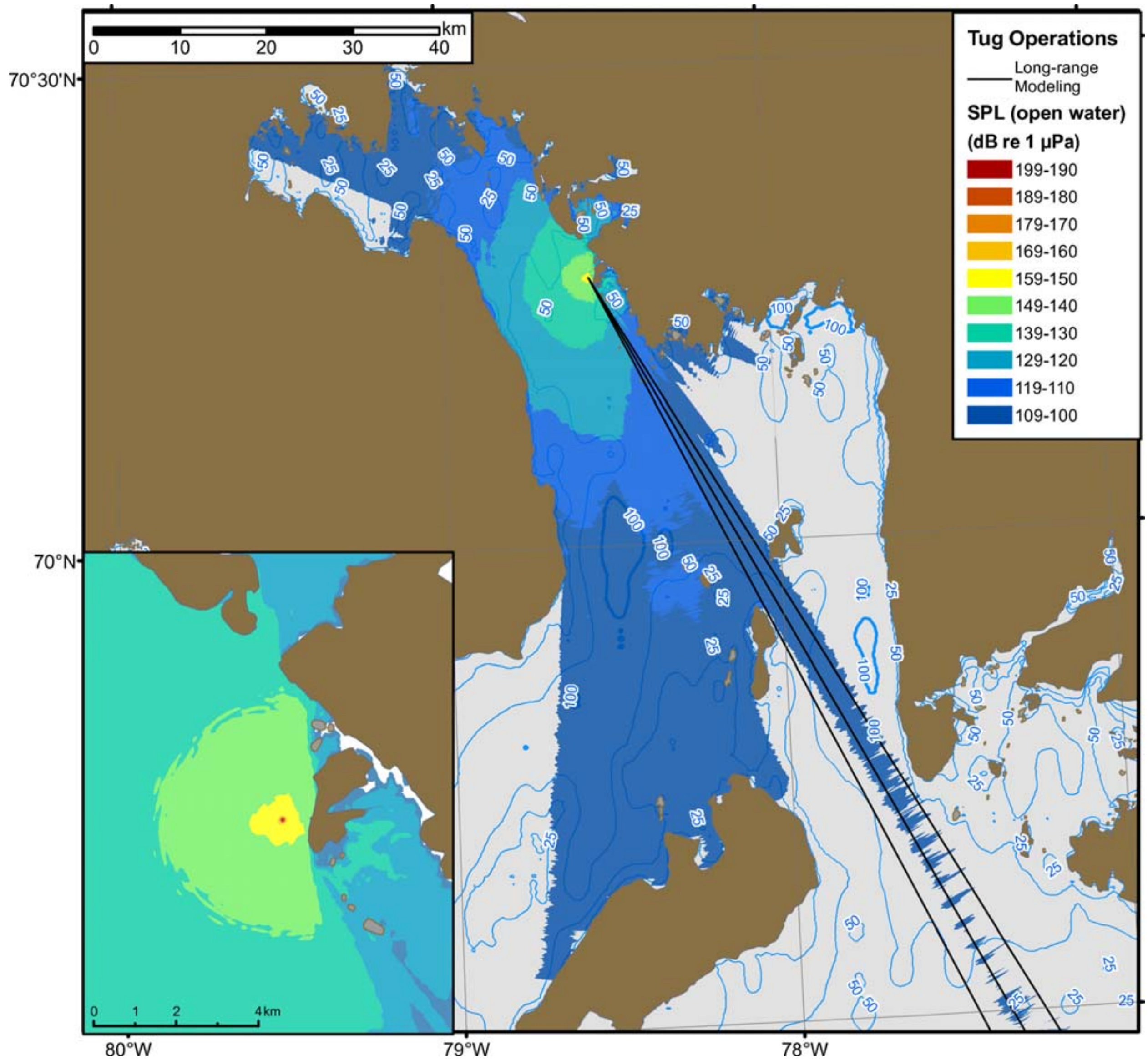

Figure A-7: Estimated broadband (10 – 2000 Hz) sound pressure levels around a tug operating in the vicinity of the Ore Loading Dock, in open water conditions.

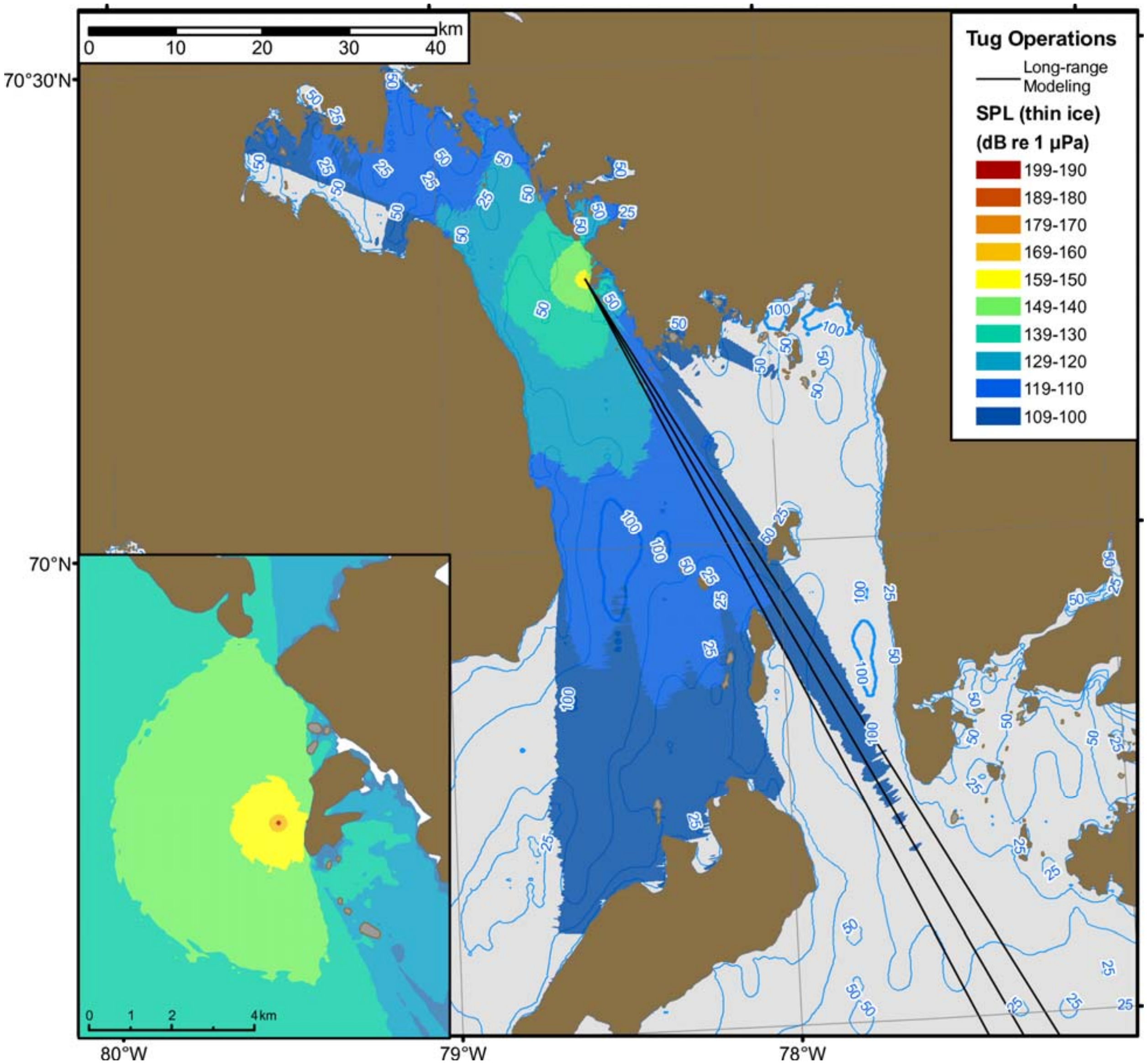

Figure A-8: Estimated broadband (10 – 2000 Hz) sound pressure levels around a tug operating in the vicinity of the Ore Loading Dock, in thin ice conditions.

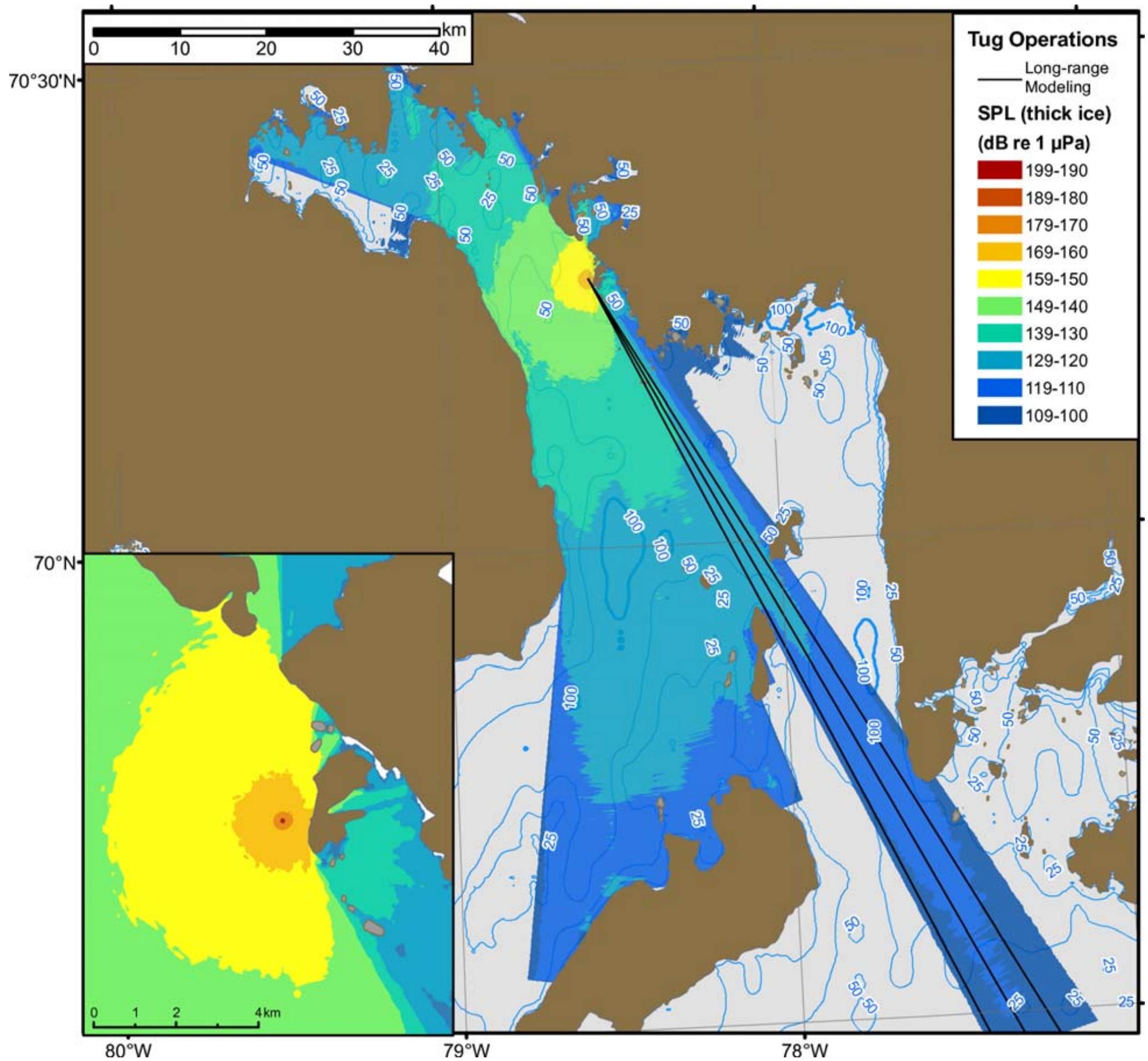

Figure A-9: Estimated broadband (10 – 2000 Hz) sound pressure levels around a tug operating in the vicinity of the Ore Loading Dock, in thick ice conditions.

A.8. Threshold Distances – Tug Operations

Table A-7: Comparison between predicted m-weighted and unweighted threshold distances from the tugs operating in the vicinity of the Ore Loading Dock, in open water conditions. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 μPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
180	< 10	< 10	< 10	< 10						
170	25	25	20	20	< 10	< 10	< 10	< 10	< 10	< 10
160	100	100	90	90	20	20	15	15	20	20
150	800	700	800	600	120	100	100	50	160	150
140	3,600	3,000	2,800	2,300	950	550	650	450	1,200	800
130	9,200	7,500	7,700	6,500	3,400	2,200	2,650	1,900	3,800	2,800
120	20,000	16,000	16,500	13,800	12,500	7,000	13,000	6,400	13,500	7,500
110	75,500	34,000	75,500	30,000	75,500	24,500	75,500	34,000	75,500	26,500
100	109,000	105,500	109,000	105,500	109,000	105,500	109,000	105,500	109,000	105,500

Table A-8: Comparison between predicted m-weighted and unweighted threshold distances from the tugs operating in the vicinity of the Ore Loading Dock, in thin ice conditions. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 μPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	< 10	< 10	< 10	< 10						
180	15	15	15	15	< 10	< 10	< 10	< 10	< 10	< 10
170	30	30	30	30	20	20	20	20	25	25
160	250	200	250	200	150	125	120	80	170	150
150	1,500	1,100	1,300	1,000	1,100	650	950	550	1,200	800
140	5,100	4,000	4,600	3,600	3,500	2,500	3,500	2,200	3,900	2,800
130	13,500	9,400	13,500	8,500	12,500	7,000	12,500	7,000	13,000	7,500
120	25,000	20,500	25,000	20,000	24,000	19,000	24,500	18,500	25,000	20,000
110	58,000	43,000	58,000	43,000	50,500	42,000	50,500	41,000	51,000	43,000
100	81,000	65,000	81,000	65,000	81,000	65,000	81,000	65,000	81,000	65,000

Table A-9: Comparison between predicted m-weighted and unweighted threshold distances from the tugs operating in the vicinity of the Ore Loading Dock, in thick ice conditions. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	< 10	< 10	< 10	< 10						
190	15	15	15	15	< 10	< 10	< 10	< 10	< 10	< 10
180	35	35	35	35	30	30	30	30	35	35
170	450	250	450	250	370	180	360	170	425	225
160	1,750	1,200	1,750	1,200	1,500	1,000	1,350	950	1,700	1,100
150	5,800	4,500	5,800	4,500	5,500	3,800	5,500	3,700	5,700	4,200
140	17,000	12,000	17,000	12,000	17,000	11,500	17,000	11,500	17,000	11,500
130	43,000	26,000	43,000	26,000	38,000	24,500	38,000	24,000	40,000	25,500
120	75,500	54,000	75,500	54,000	75,500	53,000	75,500	52,500	75,500	54,000
110	107,500	97,000	107,500	97,000	107,500	95,000	107,500	90,500	107,500	97,000

A.9. Unweighted Sound Fields – Ore Carrier Transiting

A.9.1. Steensby Inlet

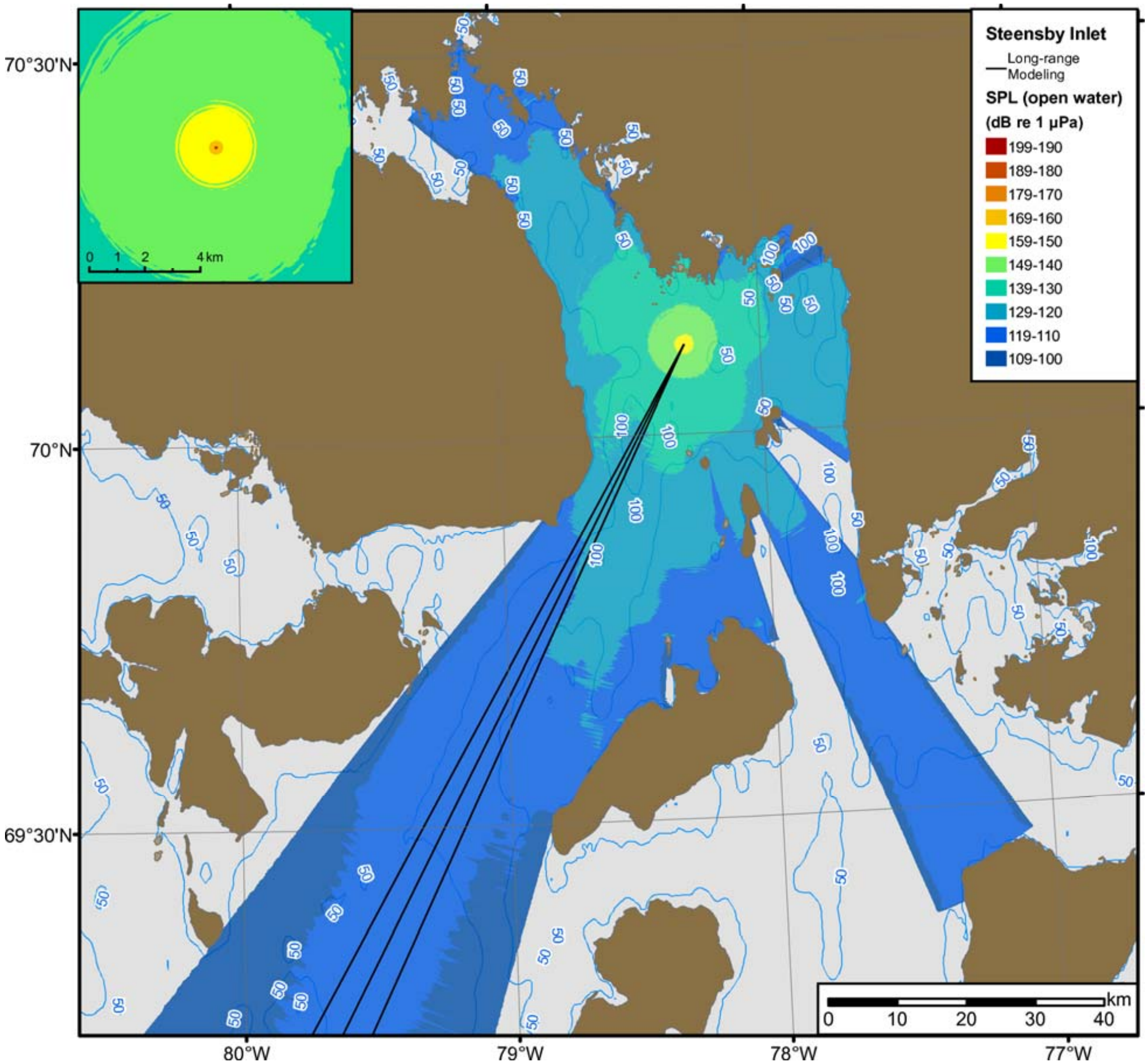

Figure A-10: Estimated broadband (10 – 2000 Hz) sound pressure levels around the Ore Carrier transiting in Steensby Inlet, in open water conditions.

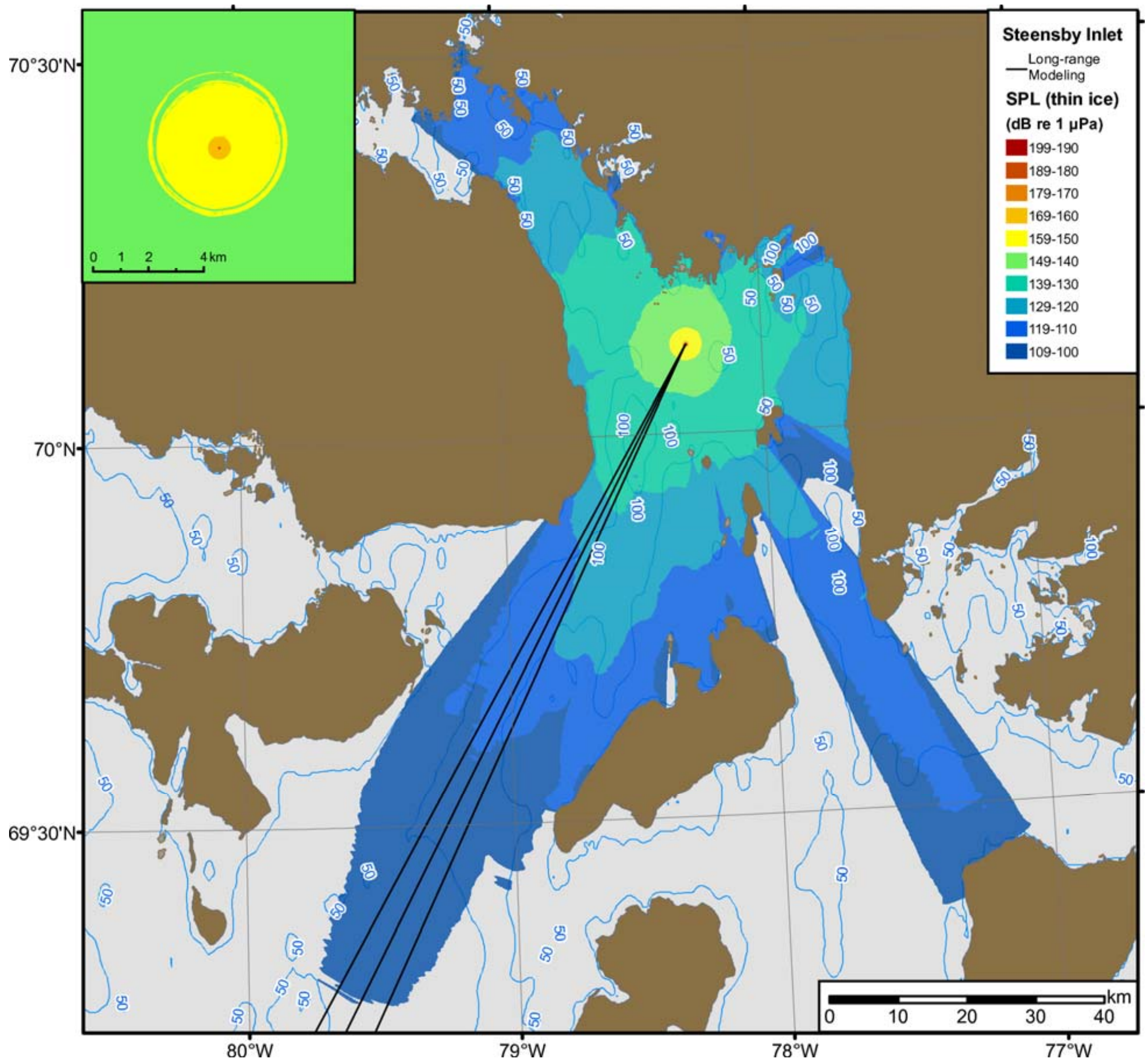

Figure A-11: Estimated broadband (10 – 2000 Hz) sound pressure levels around the Ore Carrier transiting in Steensby Inlet, in thin ice conditions.

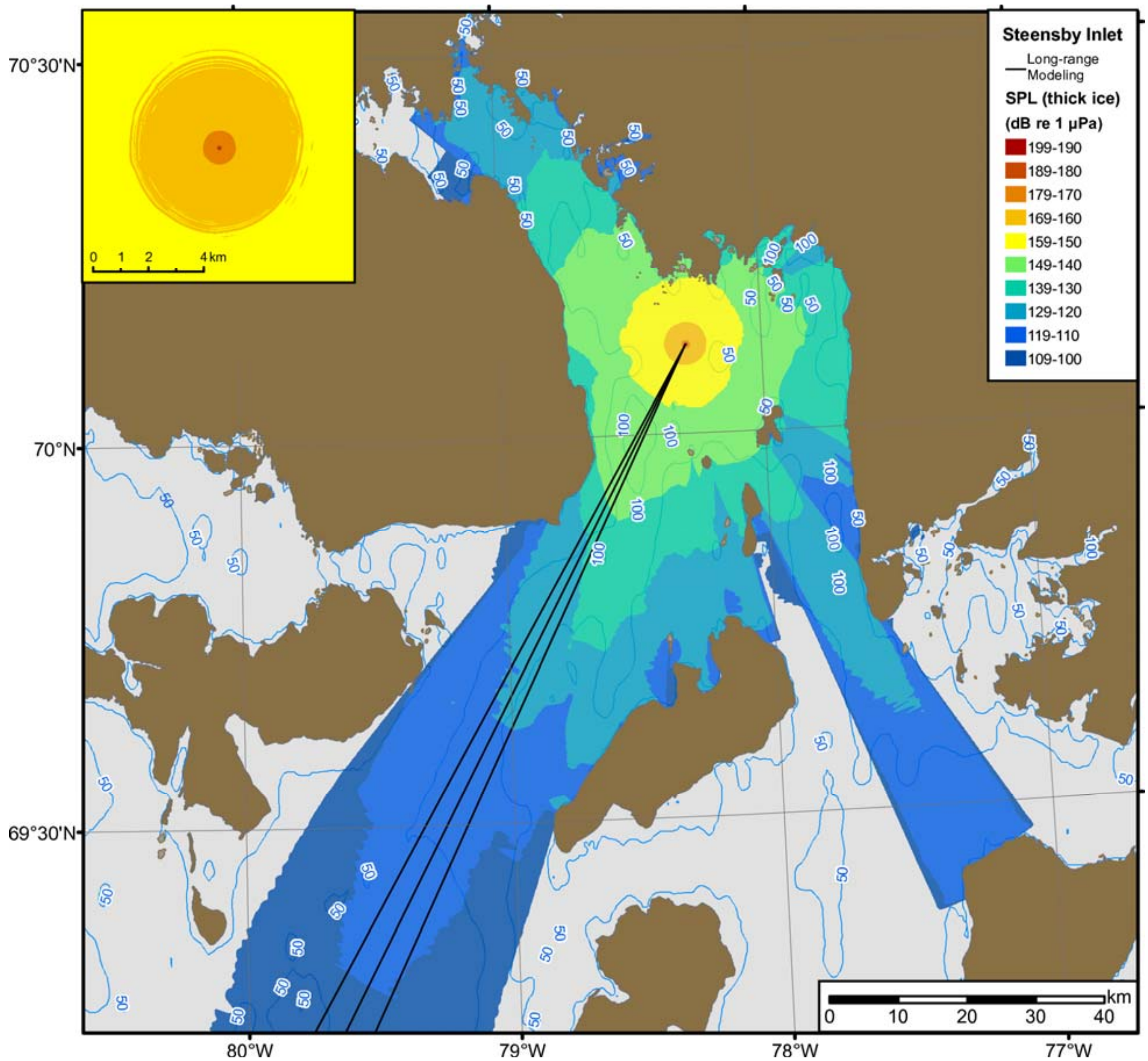

Figure A-12: Estimated broadband (10 – 2000 Hz) sound pressure levels around the Ore Carrier transiting in Steensby Inlet, in thick ice conditions.

A.9.2. Foxe Basin

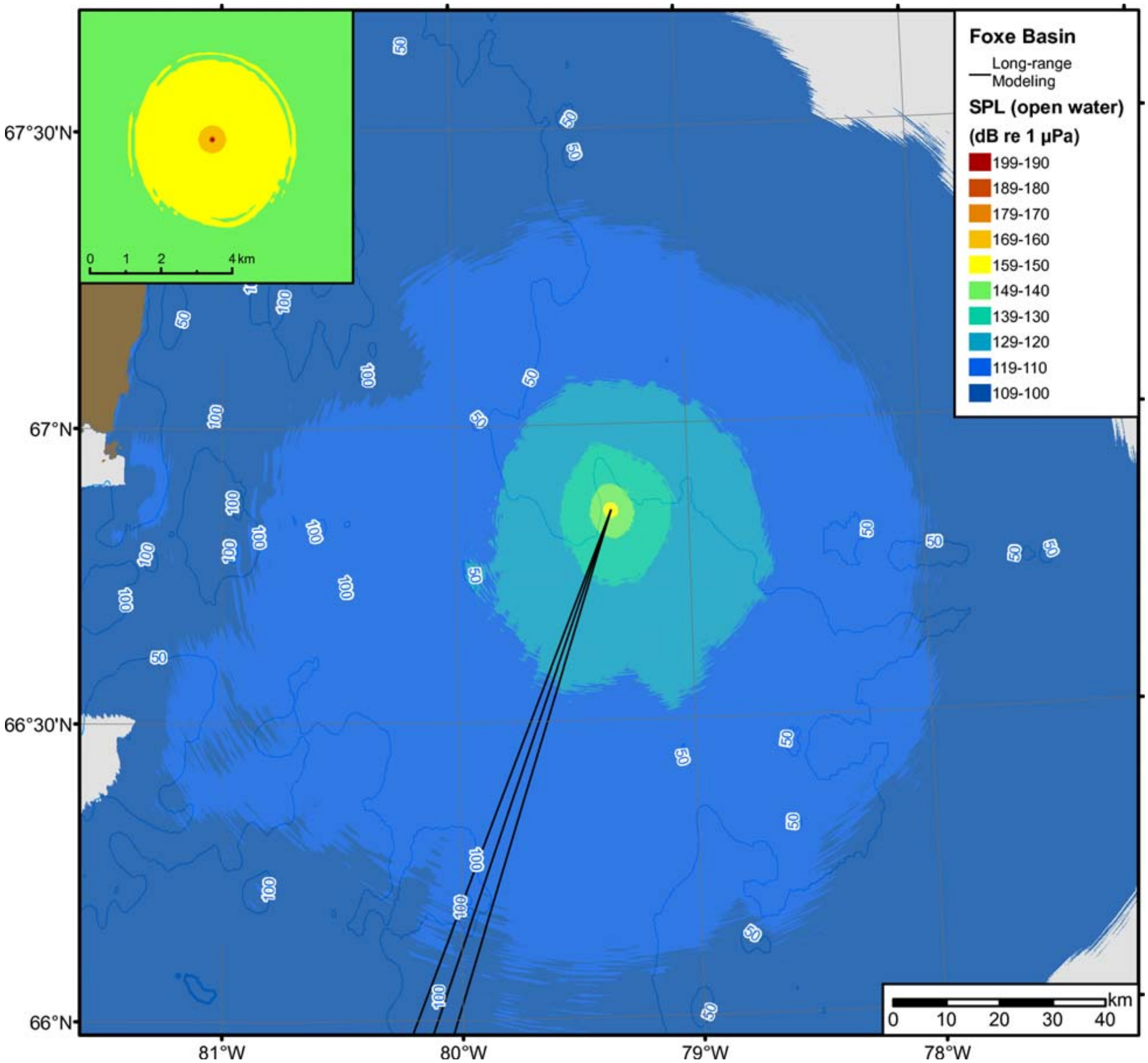

Figure A-13: Estimated broadband (10 – 2000 Hz) sound pressure levels around the Ore Carrier transiting in Foxe Basin, in open water conditions.

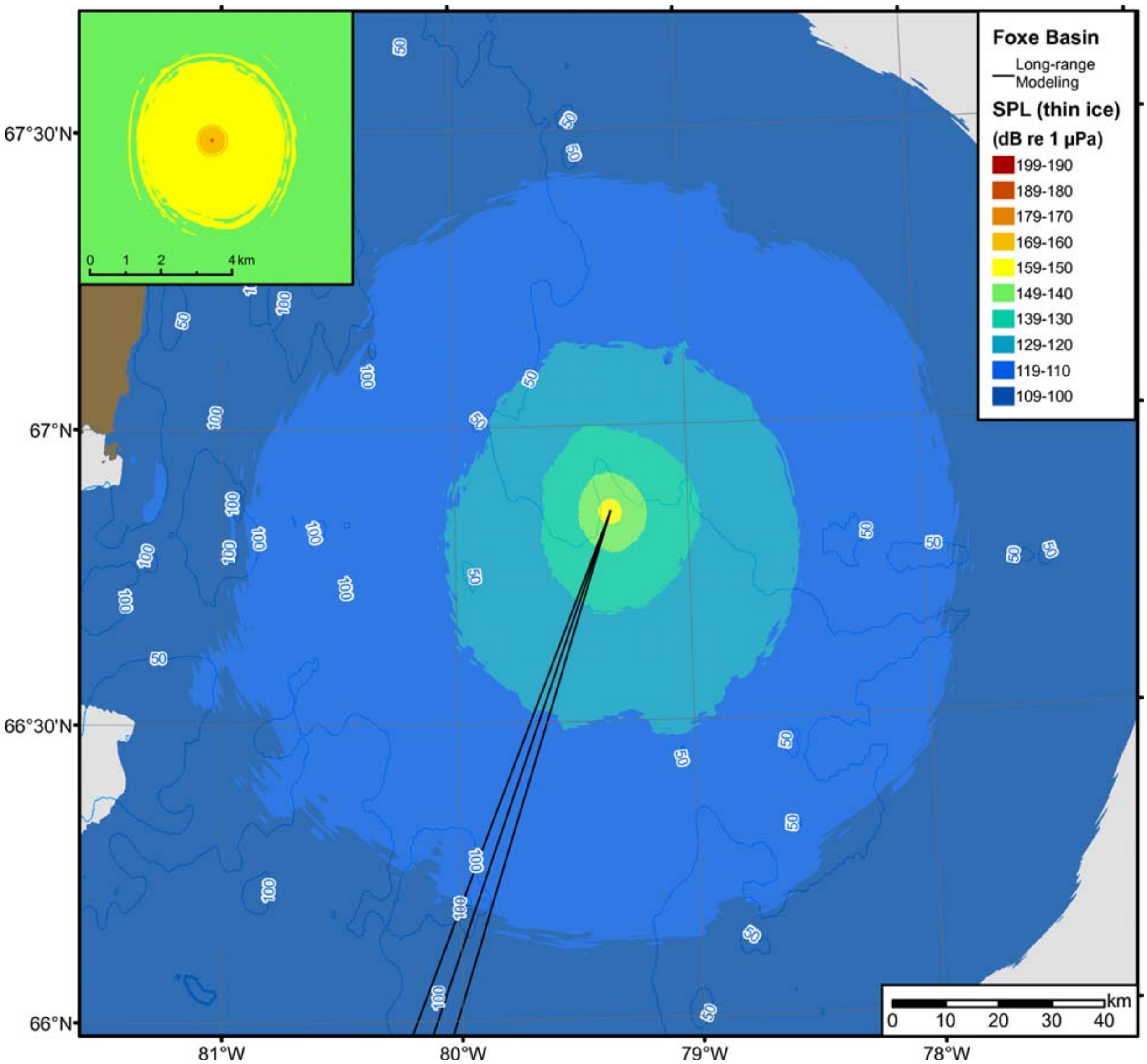

Figure A-14: Estimated broadband (10 – 2000 Hz) sound pressure levels around the Ore Carrier transiting in Foxe Basin, in thin ice conditions.

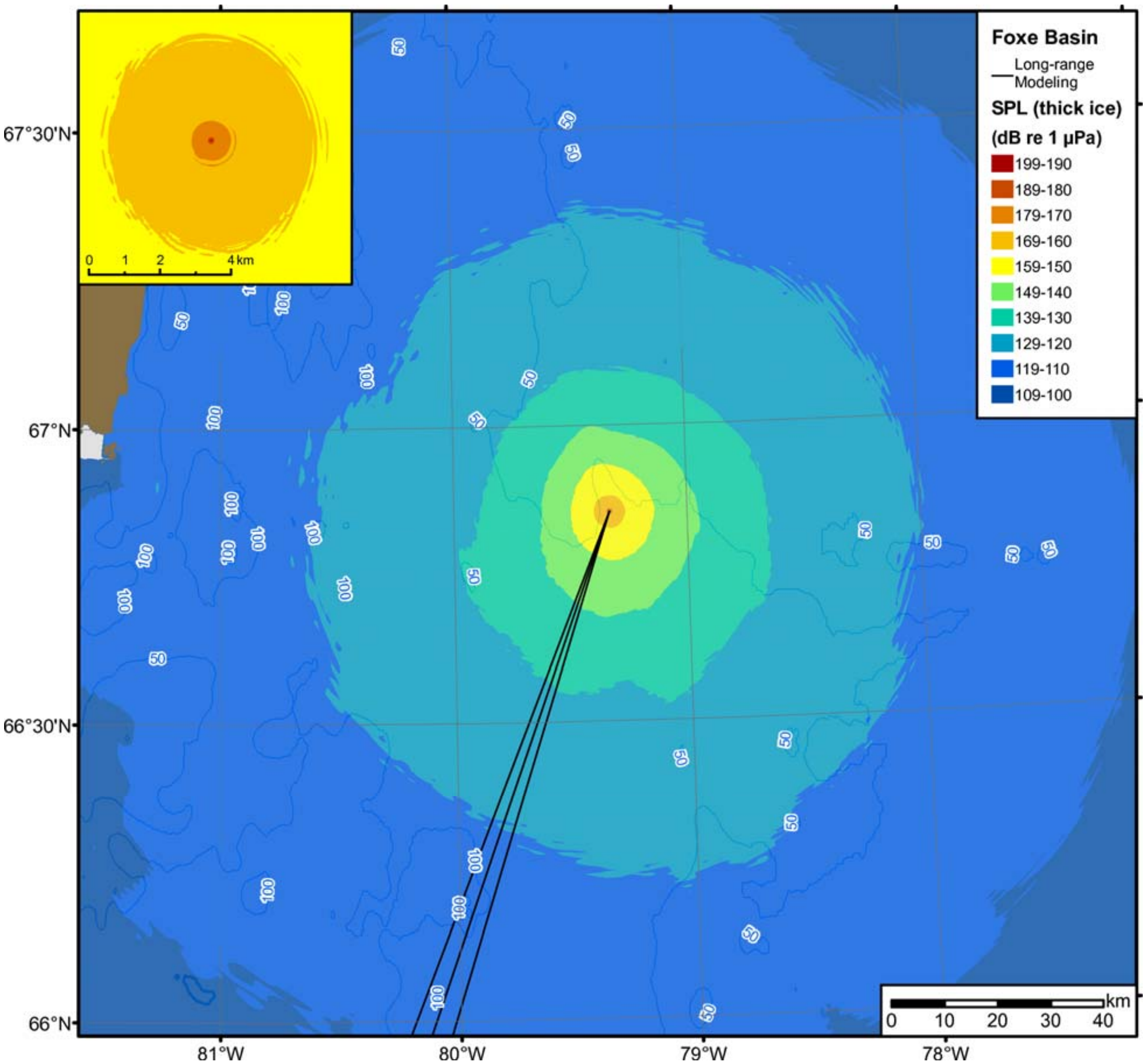

Figure A-15: Estimated broadband (10 – 2000 Hz) sound pressure levels around the Ore Carrier transiting in Foxe Basin, in thick ice conditions.

A.9.3. Hudson Strait

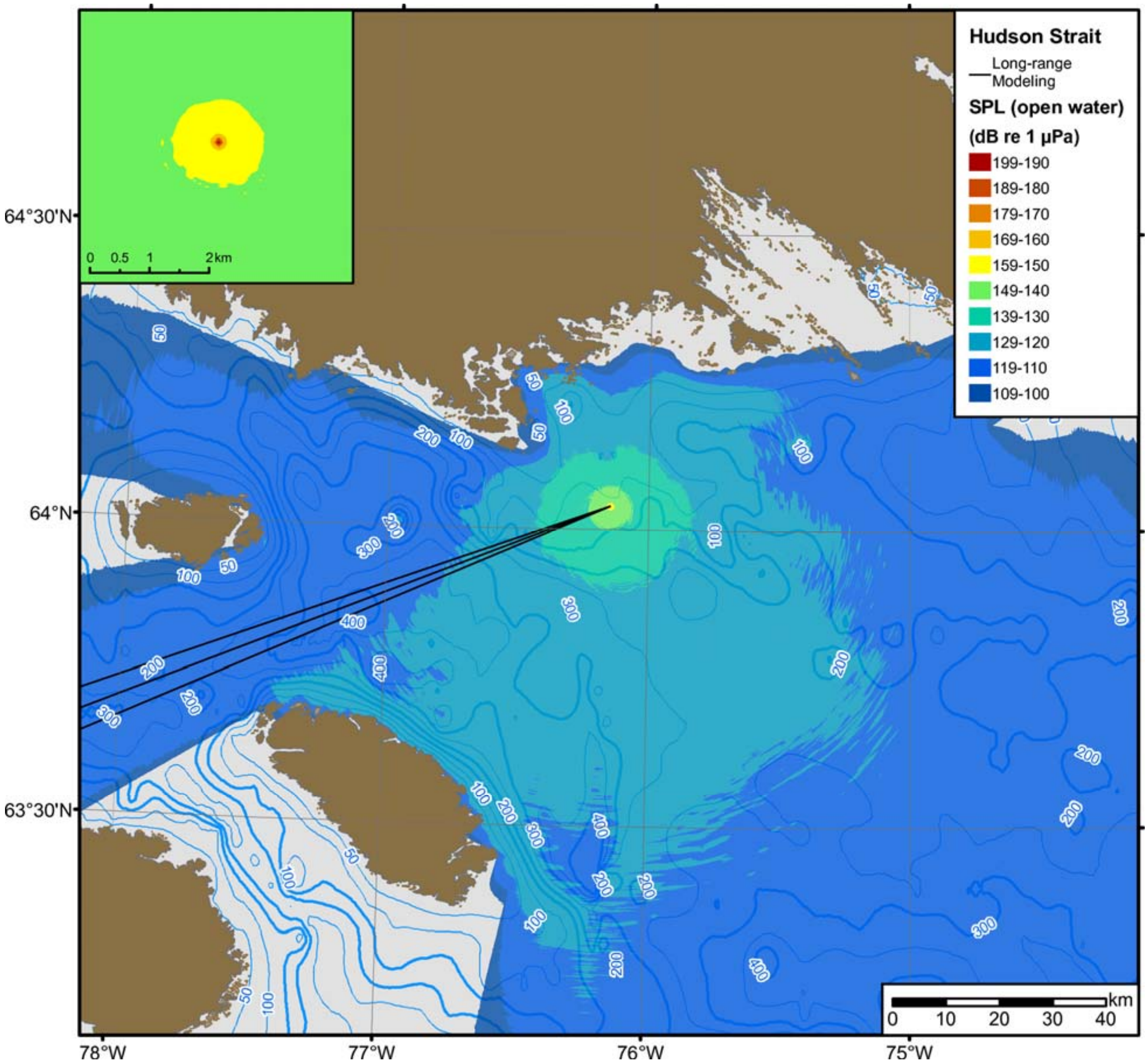

Figure A-16: Estimated broadband (10 – 2000 Hz) sound pressure levels around the Ore Carrier transiting in Hudson Strait, in open water conditions.

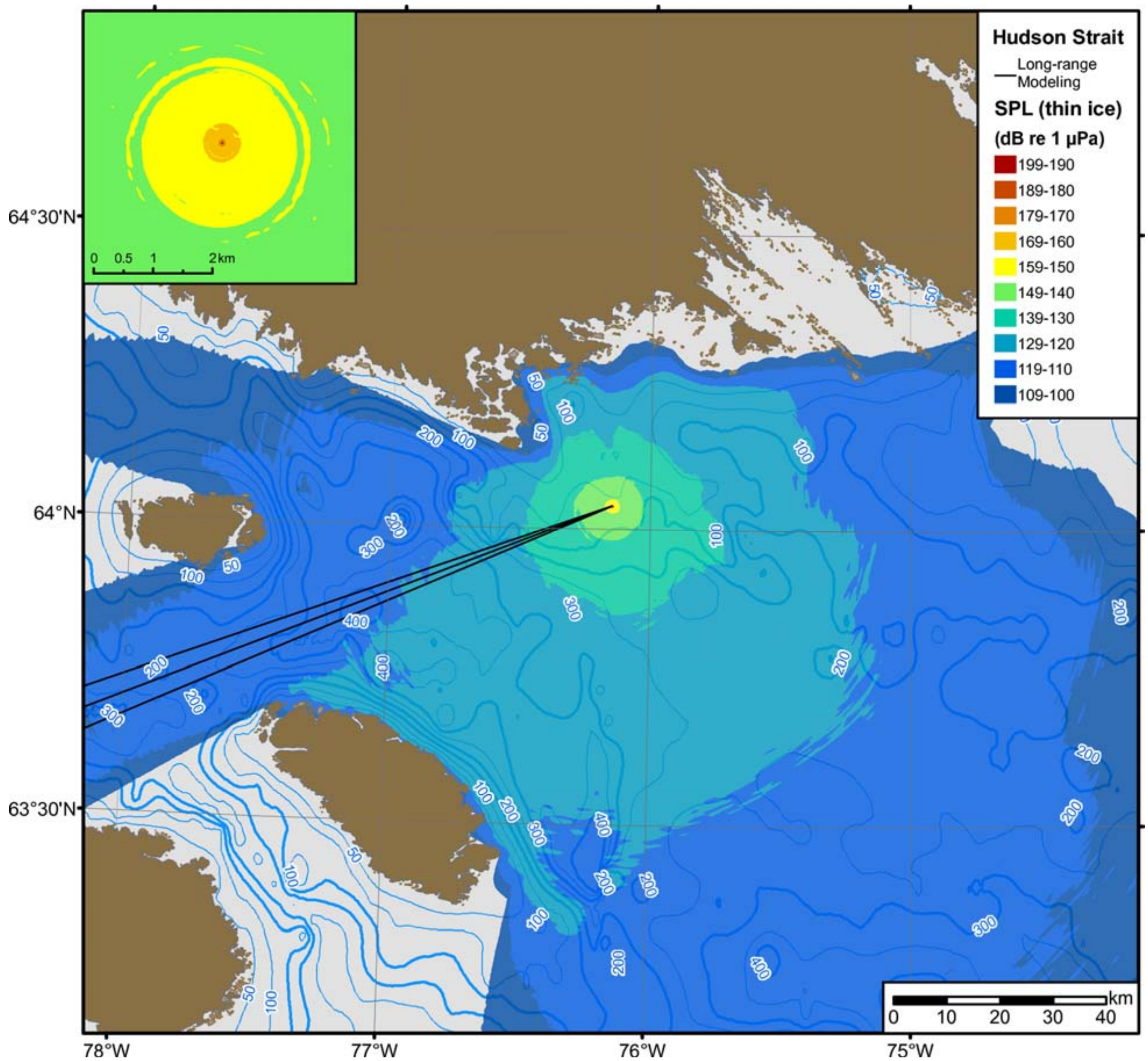

Figure A-17: Estimated broadband (10 – 2000 Hz) sound pressure levels around the Ore Carrier transiting in Hudson Strait, in thin ice conditions.

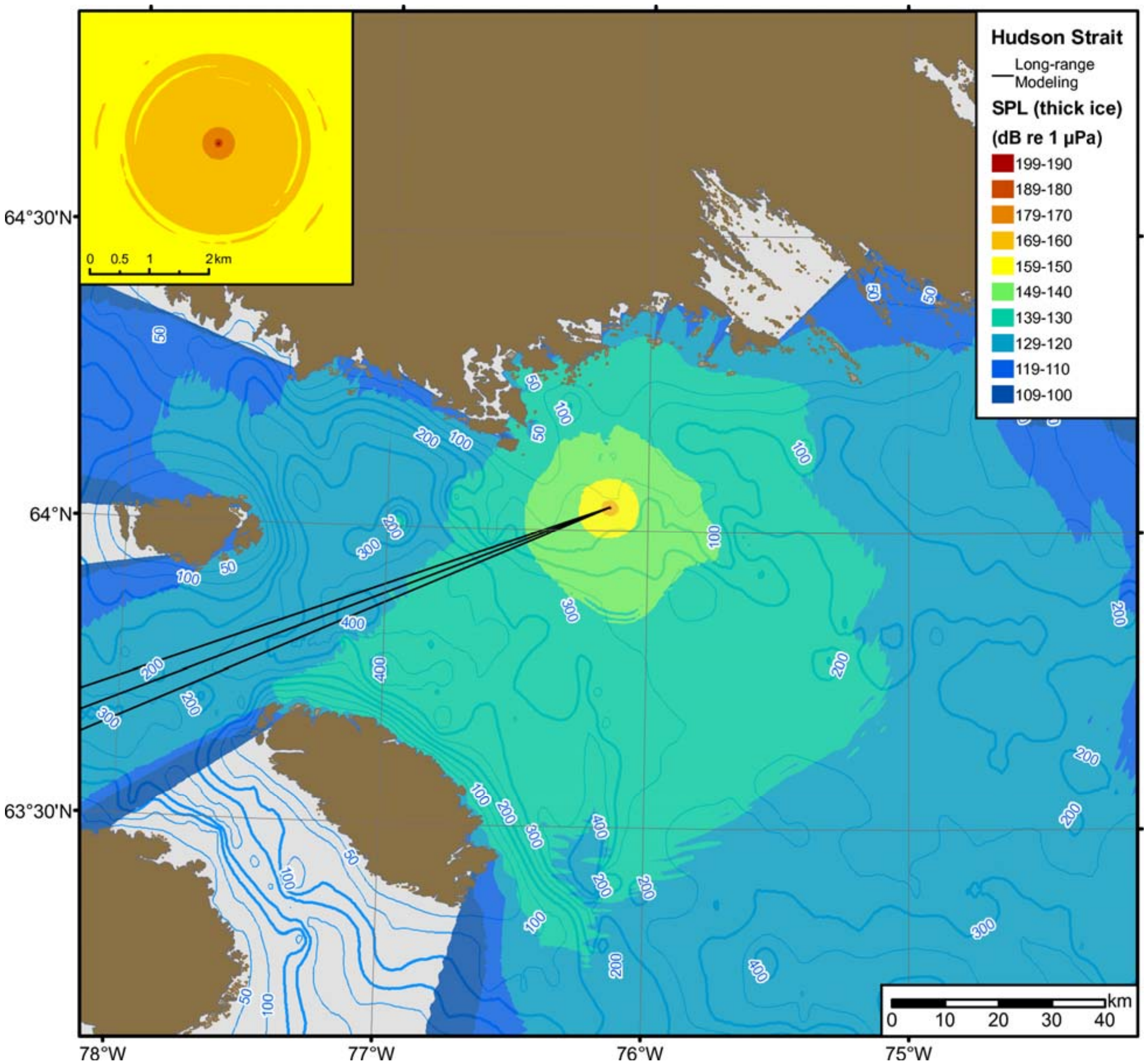

Figure A-18: Estimated broadband (10 – 2000 Hz) sound pressure levels around the Ore Carrier transiting in Hudson Strait, in thick ice conditions.

A.10. Threshold Distances – Shipping Operation

A.10.1. Steensby Inlet

Table A-10: Comparison between predicted m-weighted and unweighted threshold distances from the Ore Carrier transiting in Steensby Inlet, in open water conditions. Distances are calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
180	< 10	< 10	< 10	< 10					< 10	< 10
170	35	35	35	35	< 10	< 10	< 10	< 10	15	15
160	290	280	290	280	40	40	30	30	60	60
150	1,700	1,550	1,700	1,550	225	200	200	200	500	500
140	7,000	5,000	7,000	5,000	1,700	1,350	1,200	950	3,350	2,800
130	23,500	16,000	23,500	16,000	13,500	7,500	11,000	6,000	18,500	10,500
120	70,000	41,000	70,000	41,000	62,000	29,500	55,000	29,000	69,000	36,500
110	178,500	139,000	178,500	139,000	173,500	137,000	172,000	136,000	178,500	138,500
100	> 250,000	244,000	> 250,000	244,000	> 250,000	244,000	> 250,000	244,000	> 250,000	244,000

Table A-11: Comparison between predicted m-weighted and unweighted threshold distances from the Ore Carrier transiting in Steensby Inlet, in thin ice conditions. Distances are calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	< 10	< 10	< 10	< 10						
180	15	15	15	15	< 10	< 10	< 10	< 10	< 10	< 10
170	55	55	55	55	25	25	20	20	35	35
160	450	400	400	360	85	85	75	75	220	210
150	2,700	2,400	2,700	2,400	650	600	500	450	1,600	1,200
140	10,500	8,000	10,000	7,500	4,500	3,600	3,900	2,700	6,100	5,000
130	26,500	20,500	26,500	20,000	19,000	13,000	18,500	11,500	22,000	16,500
120	51,500	39,000	51,500	38,500	48,000	30,000	45,000	29,000	49,000	35,500
110	84,500	65,500	84,500	65,000	65,000	60,000	64,500	58,500	69,500	61,500
100	108,500	104,000	108,500	104,000	106,000	102,000	105,000	101,000	108,500	103,500

Table A-12: Comparison between predicted m-weighted and unweighted threshold distances from the Ore Carrier transiting in Steensby Inlet, in thick ice conditions. Distances calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	< 10	< 10	< 10	< 10						
190	20	20	20	20	< 10	< 10	< 10	< 10	< 10	< 10
180	60	60	60	60	15	15	15	15	20	20
170	450	400	450	400	55	55	50	50	80	80
160	3,500	3,000	3,000	2,500	330	300	280	260	550	500
150	11,000	9,000	10,000	8,000	2,700	2,000	2,000	1,600	4,000	3,300
140	27,500	21,000	26,000	19,500	13,500	9,000	13,500	8,200	16,000	11,500
130	48,000	35,000	48,000	34,000	45,000	26,000	32,000	24,500	45,000	28,500
120	70,500	54,500	70,500	54,500	70,500	51,500	70,500	50,500	70,500	53,000
110	105,500	103,000	105,500	102,000	103,000	98,000	102,500	95,500	105,000	101,000
100	142,500	136,000	142,500	136,000	140,000	135,500	139,500	135,000	140,000	136,000

A.10.2. Foxe Basin

Table A-13: Comparison between predicted m-weighted and unweighted threshold distances from the Ore Carrier transiting in Foxe Basin, in open water conditions. Distances are calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
180	< 10	< 10	< 10	< 10					< 10	< 10
170	35	35	35	35	< 10	< 10	< 10	< 10	20	20
160	270	260	270	260	40	40	30	30	65	65
150	1,700	1,500	1,700	1,500	250	225	200	200	580	480
140	6,200	4,800	6,200	4,700	2,000	1,600	1,350	1,050	3,400	2,700
130	15,000	12,500	15,000	12,000	8,000	6,500	7,000	5,500	11,500	9,000
120	40,000	34,500	40,000	34,500	27,500	24,000	26,500	21,000	34,000	28,500
110	108,000	100,000	108,000	99,500	93,000	69,000	70,000	67,000	99,000	90,000
100	> 250,000	230,000	> 250,000	230,000	233,000	204,000	212,000	199,000	> 250,000	207,000

Table A-14: Comparison between predicted m-weighted and unweighted threshold distances from the Ore Carrier transiting in Foxe Basin, in thin ice conditions. Distances are calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	< 10	< 10	< 10	< 10						
180	15	15	15	15	< 10	< 10	< 10	< 10	< 10	< 10
170	60	60	55	50	25	25	20	20	35	35
160	450	450	450	425	100	85	75	75	200	200
150	3,000	2,400	2,700	2,300	725	575	550	500	1,500	1,250
140	7,000	6,000	7,000	6,000	4,500	3,500	3,800	3,000	6,000	5,000
130	20,500	17,000	19,500	16,500	13,500	11,500	12,500	10,500	17,000	14,000
120	47,500	37,500	47,500	37,500	38,000	29,500	34,000	27,500	39,500	33,500
110	104,000	76,500	101,500	76,000	94,000	61,000	85,500	58,500	96,000	66,500
100	150,000	144,500	150,000	144,500	123,000	100,500	123,000	99,000	126,500	119,500

Table A-15: Comparison between predicted m-weighted and unweighted threshold distances from the Ore Carrier transiting in Foxe Basin, in thick ice conditions. Distances are calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 µPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	< 10	< 10	< 10	< 10						
190	20	20	15	15	< 10	< 10	< 10	< 10	< 10	< 10
180	85	85	65	60	15	15	10	10	20	20
170	720	680	450	380	55	55	50	50	80	70
160	3,500	3,000	3,000	2,300	350	300	275	250	580	480
150	9,500	8,500	8,500	7,500	3,000	2,200	2,300	1,700	4,000	3,200
140	20,500	17,500	19,000	16,000	10,500	8,500	9,500	7,500	13,000	10,500
130	38,500	32,000	37,500	31,000	31,000	24,000	28,500	22,500	33,500	27,000
120	85,500	61,000	85,500	61,000	65,500	52,500	61,500	50,500	85,500	57,000
110	123,500	101,000	123,000	101,000	119,500	95,000	119,500	93,000	123,000	106,000
100	208,000	181,000	208,000	180,500	155,000	148,000	152,000	143,500	177,000	161,000

A.10.3. Hudson Strait

Table A-16: Comparison between predicted m-weighted and unweighted threshold distances from the Ore Carrier transiting in Hudson Strait, in open water conditions. Distances are calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 μPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
180	< 10	< 10	< 10	< 10					< 10	< 10
170	35	35	35	35	< 10	< 10	< 10	< 10	15	15
160	125	110	125	110	40	40	30	30	60	60
150	1,000	900	1,000	900	150	125	100	100	380	360
140	6,000	4,300	6,000	4,200	1,200	1,000	960	750	3,000	2,300
130	21,000	14,500	21,000	14,500	9,500	6,000	6,200	4,500	12,500	10,000
120	97,000	68,000	97,000	68,000	67,500	21,500	28,000	18,000	80,000	39,000
110	215,000	171,500	214,500	171,000	155,000	147,000	151,000	91,500	176,000	153,000
100	240,000	234,000	239,500	233,500	239,500	233,500	239,500	233,500	239,500	233,500

Table A-17: Comparison between predicted m-weighted and unweighted threshold distances from the Ore Carrier transiting in Hudson Strait, in thin ice conditions. Distances are calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 μPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	< 10	< 10	< 10	< 10						
180	15	15	15	15	< 10	< 10	< 10	< 10	< 10	< 10
170	55	55	50	50	20	20	20	20	35	35
160	350	300	325	300	80	80	70	70	100	100
150	2,000	1,500	2,000	1,500	500	450	400	375	900	750
140	8,300	6,600	8,300	6,500	4,000	3,000	3,500	2,200	6,000	4,500
130	26,000	19,500	25,500	19,500	14,500	11,500	13,000	10,500	20,500	14,500
120	89,000	60,500	84,000	60,000	40,000	30,500	38,000	26,500	69,000	41,500
110	127,500	104,000	127,500	103,500	90,000	68,000	83,500	61,500	106,000	85,500
100	207,500	184,000	207,500	183,500	131,000	111,000	114,200	98,000	160,000	151,500

Table A-18: Comparison between predicted m-weighted and unweighted threshold distances from the Ore Carrier transiting in Hudson Strait, in thick ice conditions. Distances are calculated from broadband (10 – 2000 Hz) sound field.

RMS SPL (dB re 1 μPa)	Threshold distances (meters)									
	No weighting applied		Cetaceans						Pinnipeds	
			Low-frequency		Mid-frequency		High-frequency			
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	< 10	< 10	< 10	< 10						
190	20	20	15	15	< 10	< 10	< 10	< 10	< 10	< 10
180	70	70	50	50	15	15	10	10	20	20
170	280	260	250	250	55	55	50	50	70	70
160	2,100	1,500	1,500	1,200	325	300	150	150	450	400
150	7,500	5,700	6,000	5,000	2,100	1,500	1,500	1,200	4,000	2,500
140	23,000	19,000	22,500	16,500	14,000	9,500	10,500	7,500	15,500	12,000
130	91,500	65,500	84,000	60,000	36,000	28,500	35,000	27,500	63,000	34,000
120	153,000	147,500	151,000	135,000	90,000	68,000	83,500	62,500	102,000	82,000
110	> 250,000	221,000	239,000	217,000	150,500	122,000	119,500	100,500	175,500	157,000
100		234,000	> 250,000	233,500	216,000	197,000	185,500	173,000	> 250,000	234,000

Table1a. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during open water conditions.

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	161	153	145	154	149	153	149	140	145	149	145	145	147	147	145	150	143	136	142	138	140	138	139	135	139	134	130	129	127	126	124	123	122	121	120
300	155	149	140	146	144	148	145	133	140	143	140	140	141	140	139	144	139	130	135	134	135	134	136	133	136	133	128	126	124	124	121	119	117	116	115
1,000	149	144	135	140	136	142	135	126	131	136	132	131	134	133	132	138	135	128	131	128	130	128	130	127	130	126	122	123	120	118	116	112	111	109	107
3,000	135	134	123	122	123	125	125	109	116	118	115	112	114	116	117	118	115	112	117	115	115	114	118	114	119	112	111	111	109	107	105	101	99	96	91
10,000	122	118	107	117	110	111	106	94	97	105	101	99	102	104	105	107	106	102	106	105	105	105	110	107	111	105	104	104	103	102	101	88	81	71	58
30,000	112	101	89	87	93	95	92	82	85	96	92	91	96	96	100	101	100	96	101	99	102	101	105	101	105	101	99	100	99	99	96	60	44	16	
100,000	108	25	17	20	24	33	37	31	40	56	61	68	79	79	86	92	91	90	94	88	95	96	102	100	102	100	96	99	97	97	93				

Table 1b. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during open water conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	160	150	142	152	148	152	149	139	145	149	145	145	147	147	145	150	143	136	142	138	140	138	139	135	138	134	130	128	127	126	123	122	120	118	115
300	154	145	138	144	143	147	144	133	140	143	140	140	141	140	139	144	139	130	135	134	135	134	136	133	136	133	128	126	124	123	120	117	115	112	110
1,000	147	141	133	139	135	142	135	126	131	136	132	131	134	133	132	138	135	128	131	128	130	128	130	127	130	125	121	123	119	117	115	111	108	105	101
3,000	133	130	121	120	122	125	124	109	116	118	114	112	114	116	117	118	115	112	117	115	115	114	118	114	119	112	111	111	109	106	104	100	97	92	86
10,000	121	115	105	116	109	110	106	94	97	105	101	99	102	104	105	107	106	102	106	105	105	105	110	107	110	105	104	104	102	101	100	86	79	67	52
30,000	112	98	87	86	92	94	91	81	85	96	92	91	96	96	100	101	100	96	101	99	102	101	105	101	105	101	98	100	99	98	95	59	41	12	
100,000	108	22	15	18	23	33	37	31	40	55	61	68	79	79	86	92	91	90	94	88	95	96	102	100	102	100	96	99	97	97	91				

Table 1c. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during open water conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	152	106	102	115	114	122	122	116	125	132	132	135	139	141	141	147	142	135	141	138	140	138	139	135	139	134	130	129	127	126	124	123	122	121	120
300	146	102	98	107	109	116	117	110	120	126	127	130	133	135	135	141	137	129	135	133	135	134	136	133	136	133	128	126	124	124	121	118	117	116	115
1,000	140	97	93	101	101	111	108	103	111	119	119	121	126	128	128	135	133	127	130	128	130	128	130	127	130	126	122	123	120	118	116	112	111	109	106
3,000	125	87	81	83	88	94	97	85	96	102	101	102	106	110	113	115	114	111	117	114	115	114	118	114	119	112	111	111	109	107	105	101	99	96	91
10,000	116	71	64	78	74	79	79	71	77	89	88	89	94	99	102	105	104	100	106	105	105	105	110	107	110	105	104	104	103	102	101	88	81	71	57
30,000	111	54	47	48	58	63	65	58	65	80	79	81	88	90	96	98	98	95	100	98	102	101	105	101	105	101	99	100	99	99	96	60	44	15	
100,000	108					2	10	7	20	39	48	58	71	74	82	89	89	89	93	88	95	96	101	100	102	100	96	99	97	97	93				

Table 1d. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during open water conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	150	101	97	110	109	117	117	111	120	128	128	131	136	138	139	146	140	134	140	137	139	138	139	135	138	134	130	129	127	126	124	123	122	121	120
300	145	97	93	102	104	112	113	105	115	122	123	126	130	132	133	139	136	128	134	133	135	134	136	133	136	133	128	126	124	124	121	118	117	116	115
1,000	139	92	88	96	96	106	103	98	107	115	115	117	123	125	126	134	132	126	130	127	130	128	130	127	130	126	122	123	120	118	116	112	111	109	106
3,000	124	82	76	78	83	89	93	81	91	97	97	98	103	107	111	113	112	110	116	114	115	114	118	114	119	112	111	111	109	107	105	101	99	96	91
10,000	116	66	59	73	69	74	74	66	73	84	84	85	91	96	99	103	103	100	105	104	104	105	110	107	110	105	104	104	103	102	101	88	81	71	57
30,000	111	49	42	43	53	59	60	53	60	75	74	77	85	87	94	97	97	94	100	98	102	101	105	101	105	101	99	100	99	99	96	60	44	16	
100,000	108						5	3	16	35	44	54	68	71	80	88	88	88	93	88	95	96	101	100	102	100	96	99	97	97	93				

Table 1e. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during open water conditions - Pinnipeds M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	154	118	114	127	125	133	133	127	135	141	140	141	144	145	144	149	143	136	141	138	140	138	139	135	139	134	130	129	127	126	124	123	122	121	120
300	148	114	109	119	120	128	128	120	130	135	135	136	138	139	138	143	138	130	135	134	135	134	136	133	136	133	128	126	124	124	121	118	117	116	114
1,000	142	109	105	113	113	122	119	113	121	128	127	127	131	132	131	137	134	127	131	128	130	128	130	127	130	126	122	123	120	118	116	112	111	108	106
3,000	126	99	93	95	100	105	108	96	106	110	109	108	111	114	116	117	115	111	117	115	115	114	118	114	119	112	111	111	109	107	105	101	99	95	90
10,000	116	83	76	90	86	91	90	81	87	98	95	95	99	102	104	107	105	101	106	105	105	105	110	107	111	105	104	104	103	102	101	88	81	71	57
30,000	111	66	59	60	69	75	76	69	75	88	86	87	93	94	99	100	99	96	101	99	102	101	105	101	105	101	99	100	99	99	96	60	43	15	
100,000	108					13	21	18	30	48	56	64	76	77	85	91	90	90	94	88	95	96	102	100	102	100	96	99	97	97	92				

Table 2a. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thin ice conditions.

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	166	153	145	153	150	153	152	148	152	154	153	153	154	156	156	158	155	153	155	152	153	152	151	148	149	146	143	141	141	140	138	135	134	133	132
300	161	149	140	146	145	148	147	142	147	148	148	147	147	150	150	152	150	147	148	148	148	147	148	144	148	143	141	139	137	136	133	130	129	127	126
1,000	154	144	135	141	138	142	138	135	138	142	141	139	140	142	142	146	146	143	144	142	143	142	141	139	140	137	134	134	132	130	129	123	121	119	115
3,000	139	133	123	127	124	124	124	118	120	124	122	120	120	122	126	125	126	128	130	128	128	128	127	125	127	124	121	122	121	119	119	111	107	102	95
10,000	126	117	107	117	110	111	108	102	102	111	106	105	108	109	115	112	114	116	118	114	116	119	117	115	116	113	112	112	113	110	107	91	82	66	46
30,000	117	100	89	93	92	94	92	88	91	101	96	97	100	99	107	102	106	109	109	107	108	109	108	106	107	104	103	102	100	99	93	49	23		
100,000	99	26	18	25	24	27	34	36	44	55	62	69	76	76	84	86	88	93	91	85	92	92	93	89	91	86	84	79	75	66	50				

Table 2b. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thin ice conditions - Low-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	166	150	142	151	149	152	151	147	151	154	153	153	154	156	156	158	155	153	155	152	153	152	151	148	149	146	143	141	140	139	137	134	132	129	127
300	161	145	138	144	144	147	146	141	146	148	148	147	147	150	150	152	150	147	148	148	148	147	148	144	148	143	141	139	137	135	132	128	126	124	121
1,000	154	141	133	139	137	141	138	134	138	142	141	139	140	142	142	146	146	143	144	142	143	142	141	139	140	137	133	133	131	129	128	122	119	115	110
3,000	138	130	120	125	123	123	124	118	120	124	122	120	120	122	126	125	126	128	130	128	127	128	127	125	127	124	121	122	120	119	118	109	105	98	90
10,000	126	114	105	116	109	110	108	102	102	111	106	105	108	109	115	112	114	116	118	114	116	118	117	115	116	113	112	112	112	109	106	89	79	63	41
30,000	117	96	87	92	91	93	92	88	90	101	96	97	100	99	107	102	106	109	109	107	108	109	108	106	107	104	103	102	100	98	92	47	21		
100,000	99	23	16	24	23	26	34	36	44	55	62	69	76	76	84	86	88	93	91	85	92	92	93	89	90	86	83	79	74	66	49				

Table 2c. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thin ice conditions - Mid-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	163	106	102	114	115	122	125	124	132	138	140	143	146	151	152	156	153	152	154	151	153	151	150	148	149	146	143	141	141	140	138	135	134	133	132
300	157	102	98	107	110	117	119	118	127	131	135	137	139	144	146	149	149	146	147	147	147	147	148	144	148	143	141	139	137	136	133	130	129	127	126
1,000	151	97	93	102	103	111	111	111	118	126	128	128	133	137	138	144	144	142	143	141	142	142	141	139	140	137	134	133	132	130	129	123	121	119	115
3,000	136	86	80	88	88	93	97	95	100	108	109	110	112	117	122	122	125	127	129	127	127	127	127	125	127	124	121	122	120	119	119	111	107	102	95
10,000	125	70	64	78	75	80	81	78	82	94	93	95	100	104	111	109	113	115	117	113	116	118	117	115	116	113	112	112	113	110	107	91	82	66	46
30,000	116	53	47	54	57	62	65	65	71	84	83	87	92	94	103	99	105	108	109	106	108	109	108	106	107	104	103	102	100	99	93	49	23		
100,000	98						7	12	24	38	49	58	68	71	80	83	86	92	90	84	92	92	93	89	91	86	84	79	75	66	50				

Table 2d. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thin ice conditions - High-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	162	101	97	109	110	117	120	119	127	133	136	139	143	148	150	154	152	151	154	151	152	151	150	148	149	146	143	141	141	140	138	135	134	133	132
300	156	97	93	102	105	112	115	113	122	127	130	133	136	141	144	148	147	145	147	147	147	147	148	144	148	143	141	139	137	136	133	130	129	127	126
1,000	151	92	88	97	98	106	106	106	113	121	124	125	129	134	136	142	143	141	143	141	142	142	141	139	140	137	134	133	132	130	129	123	121	119	115
3,000	135	81	75	83	83	88	92	90	96	103	105	106	109	114	120	120	123	126	129	127	127	127	127	125	127	124	121	122	120	119	119	111	107	102	95
10,000	125	65	59	73	70	75	76	74	78	90	89	91	97	101	109	107	111	114	117	113	116	118	116	115	116	113	112	112	113	110	107	91	82	66	46
30,000	116	48	42	49	52	57	60	60	66	80	79	83	89	91	101	98	104	107	108	106	108	108	108	106	107	104	103	102	100	99	93	49	23		
100,000	98						2	8	19	34	45	55	65	68	78	81	85	91	89	84	91	92	93	89	90	86	84	79	75	66	50				

Table 2e. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thin ice conditions - Pinnipeds M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	164	118	114	126	127	133	136	135	141	146	148	149	151	154	155	157	154	152	155	152	153	152	151	148	149	146	143	141	141	140	138	135	134	133	131
300	159	114	109	119	122	128	130	128	136	140	142	144	145	148	149	151	150	147	148	147	147	147	148	144	148	143	141	139	137	136	133	130	128	127	125
1,000	152	109	105	114	114	122	122	122	128	134	135	135	138	140	141	146	145	143	144	142	143	142	141	139	140	137	134	133	132	130	129	123	121	118	115
3,000	136	98	92	100	100	104	108	105	110	117	117	116	117	121	125	124	126	127	130	127	127	128	127	125	127	124	121	122	120	119	119	111	107	101	94
10,000	125	82	76	90	86	91	92	89	92	103	101	101	105	107	114	111	114	116	118	114	116	118	117	115	116	113	112	112	112	110	107	91	82	66	45
30,000	117	64	58	66	69	74	76	75	80	93	90	93	97	98	106	101	106	109	109	106	108	109	108	106	107	104	103	102	100	99	93	48	23		
100,000	99				1	7	18	23	34	47	57	65	74	75	83	85	87	93	90	85	92	92	93	89	91	86	84	79	75	66	50				

Table 3a. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thick ice conditions.

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	177	153	145	154	152	153	155	157	158	160	161	161	160	164	167	166	167	168	168	167	166	166	163	161	161	158	157	154	154	153	152	147	146	145	144
300	171	149	140	146	147	148	151	150	153	154	156	155	155	158	160	160	163	162	162	162	161	162	160	159	159	155	154	152	152	150	147	142	141	140	138
1,000	165	144	135	140	140	142	141	144	144	148	147	147	148	150	153	154	158	160	158	156	155	157	154	152	151	150	148	146	146	145	143	136	135	132	129
3,000	151	134	123	124	127	126	130	126	130	129	130	128	128	133	138	136	140	143	144	143	141	142	141	140	141	138	137	138	136	136	134	124	121	115	109
10,000	140	119	107	118	114	110	111	112	109	115	116	114	116	121	126	125	129	131	132	132	131	132	132	129	130	129	129	129	128	128	122	105	96	80	59
30,000	132	101	89	89	96	95	97	100	98	106	107	106	108	111	119	116	120	124	124	124	122	124	123	120	122	120	120	118	116	114	103	62	37		
100,000	114	28	16	17	26	32	41	48	54	66	77	80	88	89	97	97	102	108	107	104	105	108	107	104	104	103	101	96	92	82	48				

Table 3b. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thick ice conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	177	150	142	153	151	152	155	157	158	159	161	161	160	164	167	166	167	168	168	167	166	166	163	161	160	158	157	154	153	152	150	146	144	141	139
300	171	145	138	144	146	147	150	150	153	153	156	155	155	158	160	160	163	162	162	162	161	162	160	159	159	155	154	151	151	150	146	141	139	136	133
1,000	165	141	133	139	139	142	141	143	144	148	147	147	148	150	153	154	158	160	158	156	155	157	154	152	151	149	148	146	146	144	142	135	132	128	124
3,000	151	130	121	122	126	125	130	126	130	129	130	128	128	133	138	136	140	143	144	143	141	141	141	140	141	137	136	138	136	136	132	123	118	112	104
10,000	140	115	105	116	113	110	111	112	109	114	116	114	116	121	126	125	129	131	132	132	131	132	132	129	130	129	129	128	128	127	121	103	93	77	54
30,000	132	98	87	88	95	94	96	100	98	106	107	105	108	111	119	116	120	124	124	124	122	124	123	120	122	120	120	118	116	114	102	61	34		
100,000	114	24	14	16	25	31	41	47	54	66	76	80	88	88	97	97	102	108	107	104	105	108	107	104	104	103	101	96	91	81	47				

Table 3c. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thick ice conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	175	106	102	115	117	122	128	133	138	143	148	151	152	159	163	163	166	167	168	166	166	166	163	161	160	158	157	154	154	153	152	147	146	145	144
300	170	102	98	107	112	116	123	127	133	137	143	145	147	152	156	158	161	161	161	161	161	162	160	159	159	155	154	152	152	150	147	142	141	140	138
1,000	164	97	93	101	105	111	114	120	124	131	134	137	140	145	149	152	156	159	157	155	155	156	154	152	151	149	148	146	146	145	143	136	135	132	129
3,000	150	87	81	85	92	95	103	103	110	112	117	118	120	128	134	133	138	142	143	142	141	141	141	140	141	137	136	138	136	136	133	124	121	115	109
10,000	140	72	65	79	78	79	84	89	89	98	103	104	108	116	122	122	127	130	131	131	130	132	132	129	130	129	129	129	128	128	122	105	96	80	59
30,000	131	54	47	50	61	63	69	76	78	89	94	95	100	106	115	114	118	123	123	123	122	124	123	120	122	120	120	118	116	114	103	62	37		
100,000	114					1	14	24	34	49	63	70	80	83	93	94	101	106	107	104	105	108	106	104	104	103	101	96	92	82	48				

Table 3d. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thick ice conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	174	101	97	110	112	117	123	129	133	139	144	147	149	156	161	162	164	166	167	166	166	166	163	161	160	158	157	154	154	153	152	147	146	145	144
300	169	97	93	102	107	111	119	122	129	133	139	141	144	150	154	156	160	160	161	161	160	162	160	159	159	155	154	152	152	150	147	142	141	140	138
1,000	163	92	88	96	100	106	109	115	120	127	130	133	137	142	147	150	155	158	157	155	155	156	154	152	151	149	148	146	146	145	143	136	135	132	129
3,000	150	82	76	80	87	90	98	98	105	108	113	114	117	125	132	131	137	141	142	142	141	141	141	140	141	137	136	138	136	136	133	124	121	115	109
10,000	139	67	60	74	73	74	79	84	85	94	99	100	105	113	120	121	126	129	131	131	130	132	132	129	130	129	129	129	128	128	122	105	96	80	59
30,000	131	49	42	46	56	58	65	72	73	85	90	92	97	103	113	112	117	122	123	123	122	124	123	120	122	120	120	118	116	114	103	62	37		
100,000	114						9	19	29	45	59	66	77	80	91	93	100	106	106	104	105	108	106	104	104	103	101	96	92	82	48				

Table 3e. Estimated sound levels at set radii from the Tug operating in the vicinity of the Ore Loading Dock, during thick ice conditions - Pinnipeds M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	176	118	114	127	129	133	139	144	148	152	155	157	157	162	166	165	167	168	168	166	166	166	163	161	161	158	157	154	154	153	151	147	146	145	143
300	171	114	109	119	124	128	134	137	143	146	151	151	152	156	159	159	162	162	162	162	161	162	160	159	159	155	154	152	152	150	147	142	141	139	138
1,000	165	109	105	113	116	122	125	131	134	140	142	143	145	149	152	154	158	159	158	155	155	157	154	152	151	150	148	146	146	145	143	136	134	132	128
3,000	150	99	92	97	104	106	114	113	119	121	125	124	125	132	137	135	139	143	143	143	141	141	141	140	141	137	136	138	136	136	133	124	121	115	108
10,000	140	84	76	91	90	90	95	99	99	107	111	110	113	119	125	124	128	131	132	132	131	132	132	129	130	129	129	129	128	128	122	105	95	80	59
30,000	132	66	59	62	73	75	80	87	87	98	102	102	106	110	118	116	120	124	124	124	122	124	123	120	122	120	120	118	116	114	103	62	36		
100,000	114				2	12	25	34	43	58	71	76	85	87	96	96	102	107	107	104	105	108	107	104	104	103	101	96	92	82	48				

Table 1a. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during open water conditions.

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	164	130	131	141	143	145	148	150	157	159	156	153	151	150	149	148	147	146	145	145	144	142	141	139	138	138	137	135	134	134	132	130	128	127	126
300	161	126	128	136	139	141	145	148	154	156	154	149	147	147	145	143	143	141	141	139	139	139	137	136	135	134	133	132	130	129	128	123	121	120	119
1,000	154	120	121	130	133	137	140	144	148	149	149	145	143	141	138	138	137	136	135	135	133	133	132	132	131	131	129	126	126	126	125	117	115	113	112
3,000	147	114	116	122	125	129	133	137	140	141	141	139	136	134	133	133	132	132	130	130	130	130	129	127	127	125	124	123	121	122	121	110	107	104	99
10,000	137	104	107	110	113	116	120	124	127	131	130	129	127	126	126	125	125	124	124	122	122	122	121	120	119	119	117	117	116	115	114	96	89	79	66
30,000	128	89	92	95	97	101	105	110	115	116	119	116	116	117	117	118	118	118	117	118	117	116	115	114	114	113	112	111	111	109	109	68	50	22	
100,000	117	19	17	24	33	42	53	66	78	85	91	95	97	98	101	103	104	106	107	108	108	108	107	105	106	106	105	104	103	103	100				
150,000	112							17	37	50	64	73	81	83	92	93	97	99	101	103	104	104	104	102	102	102	101	101	99	100	96				
200,000	111									19	39	54	67	74	84	88	93	96	99	101	102	103	103	101	100	101	100	99	99	100	94				
250,000	109										19	36	53	66	77	83	90	94	97	100	101	102	101	100	99	100	99	98	97	97	91				

Table 1b. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during open water conditions - Low-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	164	127	129	140	142	144	147	150	156	158	156	153	151	150	149	148	147	146	145	145	144	142	141	139	138	137	136	135	133	133	131	128	125	123	121
300	161	122	125	134	138	141	145	148	154	156	154	149	147	147	145	143	143	141	141	139	139	139	137	136	135	133	133	132	130	129	127	121	118	116	114
1,000	154	117	119	129	132	136	139	144	148	149	149	145	143	141	138	138	137	136	135	135	133	133	132	132	131	131	128	126	126	125	124	115	112	110	107
3,000	147	111	114	120	124	128	132	137	140	141	141	139	136	134	133	133	132	132	130	130	130	130	129	127	127	125	124	123	121	121	119	109	105	100	94
10,000	137	101	104	108	112	116	119	123	127	131	130	128	127	126	126	125	125	124	124	122	122	122	121	120	119	119	117	117	115	114	113	94	86	75	60
30,000	128	86	90	93	96	100	105	109	114	116	119	116	116	117	117	118	118	118	117	118	117	116	115	114	114	113	112	111	110	108	108	66	48	18	
100,000	116	15	15	22	32	41	53	66	78	85	91	95	97	98	101	103	104	106	107	108	108	108	107	105	105	105	105	104	102	102	99				
150,000	112							17	37	50	64	73	81	83	92	93	97	99	101	103	104	104	104	102	102	102	101	101	99	99	95				
200,000	110									19	39	54	67	74	84	88	93	96	99	101	102	103	103	101	100	101	100	99	98	99	93				
250,000	109										19	36	53	66	77	83	90	94	97	100	101	101	101	100	99	100	99	98	97	96	89				

Table 1c. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during open water conditions - Mid-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	156	83	89	102	107	114	121	126	137	142	143	143	144	145	145	145	146	145	144	144	144	142	141	139	138	137	137	135	134	134	132	130	128	127	126
300	151	79	85	97	104	110	118	125	134	140	141	139	139	142	141	141	141	140	140	139	139	139	137	136	135	134	133	132	130	129	128	123	121	120	119
1,000	145	73	79	91	98	106	113	121	128	133	136	135	135	135	134	135	135	134	135	135	133	133	132	132	131	131	129	126	126	126	125	117	115	113	112
3,000	140	67	73	83	90	97	105	113	120	125	128	129	128	129	129	130	130	130	130	130	130	129	129	127	127	125	124	123	121	122	120	110	107	104	99
10,000	132	57	64	71	78	85	92	100	107	114	117	118	119	121	122	123	124	123	123	122	122	122	121	119	119	119	117	117	116	115	114	96	89	79	65
30,000	126	42	49	56	62	70	78	86	95	100	106	106	109	112	113	116	116	117	116	117	116	115	115	114	114	113	112	111	111	109	109	68	50	22	
100,000	116					10	26	43	58	69	78	85	89	93	97	100	103	105	106	107	108	108	107	105	106	106	105	104	103	103	100				
150,000	112								17	34	51	63	73	77	88	90	95	98	100	102	104	104	104	102	102	102	101	101	99	100	96				
200,000	110									2	26	43	59	69	80	85	92	95	98	100	102	103	103	101	100	101	100	99	99	100	94				
250,000	109										6	25	46	60	73	81	89	93	96	99	100	101	101	100	99	100	99	98	97	97	90				

Table 1d. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during open water conditions - High-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	154	78	84	97	103	109	116	122	132	138	139	139	140	142	143	144	144	144	144	144	144	142	141	139	138	137	137	135	134	134	132	130	128	127	126
300	149	74	80	92	99	105	113	120	130	136	137	135	136	139	139	139	140	139	140	139	138	139	137	136	135	133	133	132	130	129	128	123	121	120	119
1,000	144	68	74	86	93	101	108	116	123	128	132	131	132	133	132	134	134	134	134	134	133	133	132	131	131	131	129	126	126	126	125	117	115	113	112
3,000	138	62	68	78	85	92	100	109	116	120	124	125	125	126	127	129	129	130	129	129	130	129	129	127	127	125	124	123	121	122	120	110	107	104	99
10,000	131	52	59	66	73	80	88	95	103	110	113	115	116	118	120	121	123	122	122	121	122	122	121	119	119	119	117	117	116	115	114	96	89	79	66
30,000	125	37	44	51	57	65	73	81	90	95	102	102	105	109	111	114	115	116	116	117	116	115	115	114	114	113	112	111	111	109	109	68	50	22	
100,000	116					5	21	38	53	64	74	81	86	90	95	99	101	104	106	107	108	108	107	105	105	105	105	104	103	103	100				
150,000	112								12	29	47	59	70	75	86	88	94	97	100	102	103	104	104	102	102	102	101	101	99	100	96				
200,000	110										22	40	56	66	78	84	90	94	98	100	102	103	103	101	100	101	100	99	99	100	94				
250,000	109										2	22	42	58	71	79	87	92	96	99	100	101	101	100	99	100	99	98	97	97	90				

Table 1e. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during open water conditions - Pinnipeds M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	159	95	101	114	119	125	132	137	146	151	151	149	149	148	148	147	147	146	145	144	144	142	141	139	138	138	137	135	134	133	132	129	128	127	126
300	155	91	97	109	115	121	129	135	144	149	148	145	144	145	143	143	143	141	141	139	139	139	137	136	135	134	133	132	130	129	128	123	121	120	119
1,000	149	85	91	103	110	117	124	131	138	141	143	141	140	139	137	137	136	135	135	135	133	133	132	132	131	131	129	126	126	126	125	116	114	113	111
3,000	143	79	85	95	102	109	116	124	130	134	135	135	133	132	132	132	132	131	130	130	130	130	129	127	127	125	124	123	121	122	120	110	107	103	99
10,000	134	69	76	83	89	96	103	111	117	123	125	125	124	125	125	125	125	124	123	122	122	122	121	120	119	119	117	117	116	115	114	95	88	78	65
30,000	127	54	61	67	73	81	89	97	104	109	114	112	114	115	116	118	118	118	117	117	117	116	115	114	114	113	112	111	111	109	109	68	50	21	
100,000	116				10	22	37	53	68	78	86	91	94	96	100	102	104	106	107	108	108	108	107	105	106	106	105	104	103	103	100				
150,000	112							4	26	43	59	69	79	81	91	92	96	99	101	103	104	104	104	102	102	102	101	101	99	100	96				
200,000	110									11	33	50	64	72	83	87	93	96	99	101	102	103	103	101	100	101	100	99	98	100	94				
250,000	109										14	32	51	64	76	83	90	94	97	100	101	101	101	100	99	100	99	98	97	97	90				

Table 2a. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thin ice conditions.

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	169	150	150	158	157	156	154	151	157	160	159	157	158	157	155	154	154	153	151	150	151	150	148	146	146	145	143	141	142	142	139	138	137	136	135
300	165	146	146	152	153	152	152	148	155	158	157	154	153	153	151	149	149	148	147	145	146	146	144	142	141	140	139	136	138	137	134	131	129	128	127
1,000	158	140	140	147	148	148	146	146	148	150	152	149	148	147	144	143	142	142	141	140	141	140	140	138	137	137	135	132	133	134	129	123	121	119	116
3,000	151	134	134	139	140	139	138	136	140	141	143	143	142	140	139	139	137	138	137	136	137	135	133	132	133	130	130	127	128	127	125	115	111	106	100
10,000	141	124	125	126	127	127	126	124	127	131	133	132	132	131	131	129	130	129	127	126	127	126	125	125	123	123	120	118	119	118	115	95	86	71	51
30,000	130	109	110	111	111	112	112	109	114	117	120	118	120	120	119	120	119	121	119	118	118	117	116	115	114	114	111	107	108	105	98	53	27		
100,000	106	38	35	39	43	49	56	64	74	81	88	92	92	95	94	96	95	97	97	97	98	98	96	94	91	90	87	80	77	69	53				
150,000	92							11	29	44	57	66	71	77	77	78	80	81	83	84	85	84	84	81	78	75	71	64	58	46	23				
200,000	82									8	28	42	52	61	64	69	69	72	73	75	76	75	74	71	67	64	59	49	41	26					
250,000	73										5	20	35	46	51	58	59	62	63	66	66	66	64	61	57	53	45	35	24	4					

Table 2b. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thin ice conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	168	147	148	157	156	155	153	151	157	159	159	157	158	157	155	154	154	153	151	150	151	149	148	146	145	144	143	140	141	141	138	136	134	132	129
300	165	142	144	151	152	151	151	148	154	157	157	154	153	153	151	149	149	148	147	145	146	146	144	142	141	140	139	136	137	136	133	129	127	125	122
1,000	158	137	138	145	147	147	146	146	148	150	152	149	148	147	144	143	142	142	141	140	141	140	140	138	137	137	135	131	133	133	128	121	118	115	111
3,000	151	131	132	137	139	138	137	136	140	141	143	143	142	140	139	139	137	138	137	136	137	135	133	132	133	130	130	127	128	127	124	113	109	103	95
10,000	141	120	123	125	126	126	126	124	127	131	133	132	132	131	131	129	130	129	127	126	127	126	125	125	123	123	120	118	119	117	114	93	83	67	46
30,000	130	105	108	110	110	111	111	109	114	117	120	118	120	120	119	120	119	121	119	118	118	117	116	115	114	113	110	107	108	104	97	51	24		
100,000	106	34	32	37	42	48	55	63	74	81	88	92	92	95	94	96	95	97	97	97	98	98	96	94	91	90	87	80	77	68	52				
150,000	92							11	29	44	57	66	71	77	77	78	80	81	83	84	85	84	84	80	78	75	70	64	58	46	22				
200,000	82									8	28	42	52	61	64	69	69	72	73	75	76	75	74	71	67	64	58	48	41	25					
250,000	73										5	20	35	46	51	58	59	62	63	66	66	66	64	61	57	53	45	35	24	3					

Table 2c. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thin ice conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	162	103	108	119	122	124	127	128	137	143	146	147	150	151	151	151	152	152	150	150	151	149	148	146	145	144	143	141	142	142	139	138	136	135	134
300	157	99	104	113	118	121	124	125	135	141	144	144	146	148	147	146	147	147	147	144	146	146	144	142	141	140	139	136	138	137	134	131	129	128	127
1,000	151	93	98	108	113	116	119	122	128	134	139	139	141	141	140	141	140	141	140	140	141	140	139	138	137	137	135	132	133	134	129	123	121	119	116
3,000	145	87	92	100	105	108	111	112	120	125	130	132	134	135	135	136	135	136	136	136	137	135	133	132	133	130	130	127	128	127	125	115	111	106	100
10,000	136	77	82	87	92	96	99	100	107	115	120	122	124	126	127	127	128	128	126	126	127	126	125	125	123	123	120	118	119	118	115	95	85	71	51
30,000	127	62	68	72	76	80	84	85	94	100	107	108	113	114	115	117	117	120	118	117	118	117	116	115	114	114	111	107	108	105	98	53	27		
100,000	105				8	17	28	40	54	65	75	82	85	89	90	94	93	96	96	96	98	98	96	94	91	90	87	80	77	69	53				
150,000	91								9	27	44	56	63	71	73	76	78	80	82	83	84	84	84	80	78	75	71	64	58	46	23				
200,000	82										15	32	44	55	60	67	68	71	72	75	76	75	74	71	67	64	59	49	41	26					
250,000	72											10	27	41	47	55	57	61	62	65	66	66	64	61	57	53	45	35	24	4					

Table 2d. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thin ice conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	161	98	103	114	117	120	122	123	133	139	142	143	147	148	149	150	151	151	150	149	150	149	148	146	145	144	143	141	142	142	139	138	136	135	135
300	156	94	99	108	113	116	119	120	130	137	140	140	142	145	145	145	146	146	146	144	146	146	143	142	141	140	139	136	138	137	134	131	129	128	127
1,000	149	88	93	103	108	111	114	118	124	129	135	135	137	139	138	139	139	141	140	140	141	139	139	138	137	137	135	132	133	134	129	123	121	119	116
3,000	144	82	87	95	100	103	106	108	115	120	126	129	131	132	133	134	134	136	135	135	136	135	133	132	133	130	130	127	128	127	125	115	111	106	100
10,000	135	72	78	83	87	91	94	95	103	110	116	118	121	123	125	125	127	127	126	126	127	126	125	124	123	123	120	118	119	118	115	95	86	71	51
30,000	126	57	63	67	71	76	79	81	89	96	103	104	109	112	113	115	116	119	118	117	118	117	116	115	114	114	111	107	108	105	98	53	27		
100,000	104				3	13	24	35	50	60	71	79	81	87	88	92	92	95	96	96	98	98	96	94	91	90	87	80	77	69	53				
150,000	91								5	23	40	52	60	69	71	74	77	79	82	83	84	84	84	80	78	75	70	64	58	46	23				
200,000	81										11	28	41	53	58	65	66	70	72	74	76	75	74	71	67	64	59	49	41	26					
250,000	72											6	24	38	45	54	56	60	62	65	66	65	64	61	57	53	45	35	24	4					

Table 2e. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thin ice conditions - Pinnipeds M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	164	115	119	131	133	136	138	138	147	152	154	153	155	155	153	153	153	153	151	150	151	149	148	146	145	145	143	141	142	142	139	138	136	135	134
300	160	111	116	125	130	132	135	135	144	150	151	150	151	151	150	148	149	148	147	145	146	146	144	142	141	140	139	136	138	137	134	131	129	128	126
1,000	154	105	110	119	124	128	130	133	138	142	146	145	146	145	143	143	142	142	141	140	141	140	140	138	137	137	135	132	133	134	129	123	121	118	115
3,000	148	99	104	111	116	119	122	123	130	134	137	139	139	138	138	138	137	137	137	136	137	135	133	132	133	130	130	127	128	127	125	115	111	106	99
10,000	138	89	94	99	104	107	110	111	117	124	127	128	129	130	130	129	129	129	127	126	127	126	125	125	123	123	120	118	119	118	115	95	85	70	50
30,000	128	74	80	84	87	92	95	96	104	109	115	114	118	118	118	119	118	121	119	118	118	117	116	115	114	114	111	107	108	105	98	53	27		
100,000	106	3	4	12	20	29	39	51	64	73	83	89	90	93	93	96	94	97	97	97	98	98	96	94	91	90	87	80	77	69	53				
150,000	92								19	36	52	62	68	75	76	78	79	80	83	83	85	84	84	80	78	75	71	64	58	46	23				
200,000	82										23	38	49	59	62	69	69	72	73	75	76	75	74	71	67	64	59	49	41	26					
250,000	72											16	32	44	49	57	59	62	63	66	66	66	64	61	57	53	45	35	24	4					

Table 3a. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thick ice conditions.

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	180	170	169	175	172	167	161	151	157	160	162	162	164	163	162	161	160	160	158	157	157	157	155	153	152	152	149	146	150	150	145	147	145	144	143
300	175	166	166	170	168	164	158	150	155	158	159	158	159	160	157	156	155	155	153	152	154	153	152	151	148	148	146	142	146	146	142	140	138	137	135
1,000	169	160	159	165	162	159	153	146	149	151	154	154	155	153	150	150	150	150	148	148	148	146	146	145	144	146	142	139	141	142	138	133	131	128	125
3,000	162	154	154	157	155	151	145	138	141	143	147	148	149	147	146	145	144	145	143	143	145	142	142	141	139	138	136	134	137	137	133	124	121	116	109
10,000	151	144	144	144	142	139	133	126	128	133	136	137	139	138	138	137	136	137	136	133	135	134	133	132	130	131	128	123	127	127	120	104	95	80	60
30,000	139	129	130	129	126	123	118	112	116	118	124	124	127	128	127	128	127	128	126	125	127	125	125	123	121	121	118	113	115	113	101	63	37		
100,000	115	59	56	59	63	65	67	69	79	86	95	101	103	103	103	103	104	106	106	105	108	105	104	101	100	98	94	87	86	78	46				
150,000	101						10	21	38	52	67	77	85	87	86	88	88	92	92	92	96	94	92	90	86	85	78	71	68	54	7				
200,000	92									20	42	57	68	74	76	78	80	83	84	83	87	84	83	79	76	74	66	58	50	34					
250,000	83										22	38	52	61	64	68	71	75	75	74	78	75	73	68	64	61	54	41	33	11					

Table 3b. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thick ice conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	178	166	167	174	171	167	161	151	157	160	162	161	164	163	162	161	160	160	158	157	157	157	155	153	152	152	149	146	149	149	144	145	143	141	138
300	173	162	163	169	167	163	158	150	155	158	159	158	159	160	157	156	155	155	153	152	154	153	152	151	148	148	146	142	145	145	141	138	136	133	130
1,000	168	157	157	163	161	159	153	146	149	151	154	154	155	153	150	150	150	150	148	148	148	146	146	144	144	146	142	138	140	141	137	131	128	125	120
3,000	161	150	152	155	154	150	145	138	141	143	147	148	149	147	146	145	144	145	143	143	145	142	142	141	139	138	136	134	137	136	132	123	119	112	104
10,000	150	140	142	143	141	138	132	125	128	132	136	137	139	138	138	137	136	137	136	133	135	134	133	132	130	131	128	123	127	126	119	103	93	76	55
30,000	138	126	128	127	125	123	118	111	115	117	124	124	127	127	127	128	127	128	126	125	127	125	125	123	121	120	118	113	114	112	100	61	35		
100,000	115	56	53	57	62	65	67	68	79	86	95	101	103	103	103	103	104	106	106	105	108	105	104	101	100	98	94	87	85	77	45				
150,000	101						10	20	38	51	67	77	85	87	86	88	88	92	92	92	96	94	92	90	86	85	78	70	67	53	6				
200,000	92									20	42	57	68	74	76	78	80	83	84	83	87	84	83	79	76	74	66	58	49	33					
250,000	83										22	38	52	61	64	68	71	75	75	74	78	75	73	68	64	61	54	41	33	11					

Table 3c. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thick ice conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	168	123	127	137	136	136	134	128	137	143	149	151	156	158	158	158	159	159	157	156	157	157	155	153	152	152	149	146	150	150	145	146	145	144	143
300	164	118	123	131	132	133	131	127	135	141	146	148	152	155	153	153	154	154	152	152	153	153	152	151	148	148	146	142	146	146	142	140	138	137	135
1,000	157	113	117	126	127	128	126	122	129	135	141	144	147	148	147	147	148	149	148	147	148	146	146	144	144	146	142	139	141	142	138	133	131	128	125
3,000	152	107	111	118	119	119	118	115	121	127	134	137	141	141	142	143	142	144	142	142	144	142	142	141	139	138	136	134	137	137	133	124	121	116	109
10,000	143	97	102	105	107	107	106	102	108	116	123	127	131	133	134	134	134	135	135	133	135	134	133	132	130	131	128	123	127	127	120	104	95	80	60
30,000	134	82	87	90	91	92	91	88	96	101	111	114	120	122	123	125	125	127	126	124	127	125	124	123	121	121	118	113	115	113	101	63	37		
100,000	114	12	13	20	28	34	40	45	59	70	82	91	95	98	99	101	102	105	105	105	108	105	104	101	100	98	94	87	86	78	46				
150,000	101								18	35	54	67	77	82	82	85	87	91	91	92	95	94	92	90	86	85	78	71	68	54	7				
200,000	92									4	29	47	60	68	72	75	78	82	83	83	86	84	83	79	76	74	66	58	50	34					
250,000	82										9	28	44	55	60	65	69	74	74	74	77	75	73	68	64	61	54	41	33	11					

Table 3d. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thick ice conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	167	118	122	132	132	131	129	123	133	139	145	148	153	155	156	156	157	158	156	156	157	157	155	153	152	152	149	146	150	150	145	147	145	144	143
300	163	113	118	126	128	128	126	122	131	137	142	144	148	152	151	151	152	153	152	152	153	153	152	150	148	148	146	142	146	146	142	140	138	137	135
1,000	156	108	112	121	122	123	121	118	124	130	137	140	144	145	144	146	147	148	147	147	148	146	146	144	144	146	142	139	141	142	138	133	131	128	125
3,000	151	102	106	113	114	114	113	110	117	122	130	134	138	139	140	141	141	143	142	142	144	141	142	141	139	138	136	134	137	137	133	124	121	116	109
10,000	142	92	97	100	102	102	101	97	104	112	119	123	128	130	132	132	133	135	135	133	135	133	133	132	130	131	128	123	127	127	120	104	95	80	60
30,000	134	77	82	85	86	87	86	83	91	97	107	110	116	119	121	123	124	126	125	124	126	125	124	123	121	121	118	113	115	113	101	63	37		
100,000	113	7	8	15	23	29	35	40	54	65	78	87	92	95	97	99	101	104	105	105	107	105	104	101	100	98	94	87	86	78	46				
150,000	100								14	31	50	63	74	79	80	84	86	90	91	91	95	94	92	89	86	85	78	71	68	54	7				
200,000	91										25	43	57	65	70	73	77	81	83	83	86	84	83	79	76	74	66	58	50	34					
250,000	82										4	24	41	53	58	63	68	73	74	73	77	75	73	68	64	61	54	41	33	11					

Table 3e. Estimated sound levels at set radii from the Ore Carrier transiting in Steensbe Inlet, during thick ice conditions - Pinnipeds M-weighting applied

Range	broad	Frequency (Hz)																														
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	171	135	138	148	148	147	145	138	147	152	157	158	161	162	160	160	160	160	157	157	157	157	155	153	152	152	149	146	150	150	145	146	145	144	143
300	166	130	135	143	144	144	142	137	145	150	154	154	157	158	156	155	155	155	153	152	153	153	152	151	148	148	146	142	146	146	142	140	138	137	135
1,000	160	125	129	138	139	139	137	133	139	144	149	150	152	151	149	149	149	150	148	148	148	146	146	145	144	146	142	139	141	142	138	132	131	128	125
3,000	154	119	123	129	131	131	129	125	131	135	141	144	146	145	145	144	143	144	143	143	144	142	142	141	139	138	136	134	137	137	133	124	121	116	109
10,000	145	109	114	117	119	119	117	113	118	125	131	133	136	136	136	136	136	136	136	133	135	134	133	132	130	131	128	123	127	127	120	104	95	79	59
30,000	136	94	99	102	102	103	102	99	105	110	118	120	125	126	126	127	126	128	126	125	127	125	125	123	121	121	118	113	115	113	101	63	37		
100,000	114	24	25	31	40	45	51	56	69	78	90	97	100	101	102	102	103	106	106	105	108	105	104	101	100	98	94	87	86	78	46				
150,000	101							8	28	44	62	73	82	86	85	87	88	92	92	92	95	94	92	90	86	85	78	71	68	54	7				
200,000	92									12	36	53	65	72	75	77	80	83	84	83	86	84	83	79	76	74	66	58	50	34					
250,000	83										16	34	49	59	63	67	70	74	75	74	78	75	73	68	64	61	54	41	33	11					

Table 4a. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during open water conditions.

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	165	131	133	141	144	145	148	153	158	159	157	153	152	151	149	149	148	147	147	145	143	143	141	140	139	138	137	135	134	133	133	130	128	127	127
300	161	127	128	135	139	142	145	148	153	155	154	150	146	147	145	144	143	141	142	140	140	139	138	136	134	135	134	131	131	130	129	123	121	120	119
1,000	155	121	122	130	133	135	140	146	147	150	150	145	141	141	139	140	137	135	136	137	134	133	134	131	131	130	128	127	126	125	124	116	114	112	110
3,000	148	115	116	121	126	129	132	136	139	142	142	139	137	135	133	135	133	132	131	129	130	129	127	126	127	125	124	122	122	120	120	108	105	102	97
10,000	135	104	105	108	109	113	118	122	125	128	129	127	126	125	124	124	125	122	123	121	122	121	119	118	117	117	116	115	114	114	112	94	87	77	64
30,000	125	84	86	89	92	96	101	108	112	115	116	115	113	115	115	116	115	115	115	115	114	113	112	111	110	111	109	107	107	106	105	64	46	19	
100,000	114	40	45	52	59	67	77	86	93	99	101	102	99	102	102	103	104	104	105	104	104	104	103	102	102	102	100	98	98	98	95				
150,000	111	22	29	37	46	56	67	79	87	94	97	98	95	99	99	100	100	101	102	101	102	101	100	99	98	99	98	97	95	94	91				
200,000	109	8	15	25	35	46	58	72	82	88	94	94	94	98	99	99	99	100	101	100	101	101	100	98	97	97	97	94	94	92	86				
250,000	103	2	10	21	31	43	55	71	78	87	91	92	90	91	94	94	94	95	96	95	95	96	94	92	92	92	91	90	89	88	80				

Table 4b. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during open water conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	165	128	130	139	143	144	148	152	157	159	157	153	152	151	149	149	148	147	147	145	143	143	141	140	139	138	137	135	134	133	131	128	126	124	122
300	160	123	125	134	138	142	144	148	153	155	154	150	146	147	145	144	143	141	142	140	140	139	138	136	134	135	134	131	130	130	127	121	118	116	114
1,000	155	118	120	128	132	134	140	146	147	150	150	145	141	141	139	140	137	135	136	137	134	133	134	131	130	130	128	126	125	125	123	114	111	108	105
3,000	147	112	114	119	125	128	132	135	139	141	142	139	137	135	133	135	133	132	131	129	130	129	127	126	126	125	123	122	121	120	119	107	103	98	92
10,000	135	100	103	107	108	113	117	121	125	128	129	127	126	125	124	124	125	122	123	121	122	121	119	118	117	117	116	115	113	113	111	92	84	74	59
30,000	125	80	84	88	91	95	101	107	111	115	116	115	113	115	115	116	115	114	115	115	114	113	112	111	110	111	109	107	106	105	104	62	44	15	
100,000	114	37	43	51	58	66	76	86	93	99	101	102	99	102	102	103	104	104	105	104	104	104	103	102	102	102	100	98	97	97	94				
150,000	111	18	26	35	45	55	67	79	87	94	97	98	95	99	99	100	100	101	102	101	102	101	100	99	98	99	98	97	95	93	90				
200,000	109	4	13	24	34	46	58	72	82	88	94	94	94	98	99	99	99	100	101	100	101	101	100	98	97	97	97	94	93	91	85				
250,000	103		8	19	30	43	55	70	78	87	90	92	90	91	94	94	94	95	96	95	95	96	94	92	92	92	91	89	88	87	79				

Table 4c. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during open water conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	156	84	90	102	108	114	121	129	138	143	144	143	144	146	146	147	146	146	146	145	143	143	141	140	139	138	137	135	134	133	133	130	128	127	127
300	151	80	85	96	104	111	117	125	133	139	141	139	139	142	141	141	141	140	141	139	139	139	138	136	134	135	134	131	131	130	129	123	121	120	119
1,000	146	74	79	91	98	103	113	122	127	133	137	135	133	136	135	137	136	134	135	136	134	133	134	130	131	130	128	127	126	125	124	116	114	112	110
3,000	140	68	74	82	90	97	105	112	119	125	129	128	130	129	129	133	131	131	130	129	129	128	127	126	127	125	124	122	122	120	120	108	105	102	97
10,000	130	57	62	69	74	82	91	98	105	112	116	117	118	120	120	121	123	121	122	121	121	120	119	118	117	117	116	115	114	114	112	94	87	77	64
30,000	122	37	44	50	57	65	74	84	92	99	103	104	105	109	111	113	114	113	115	114	114	112	112	111	110	111	109	107	107	106	105	64	46	18	
100,000	112		3	13	24	36	49	63	73	83	88	91	91	97	98	100	102	103	105	103	104	104	103	102	102	102	100	98	98	98	95				
150,000	109				11	24	40	56	67	78	84	88	87	93	95	98	99	99	101	101	102	101	100	99	98	99	98	97	95	94	91				
200,000	108					15	31	49	62	71	81	83	86	92	95	96	97	99	100	100	101	101	100	98	97	97	97	94	94	92	86				
250,000	102					12	28	47	58	71	77	82	82	86	90	92	92	93	95	94	95	96	94	92	92	92	91	90	89	88	80				

Table 4d. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during open water conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	155	79	85	97	103	109	116	124	133	138	140	139	141	143	143	145	145	145	146	144	143	143	141	140	139	138	137	135	134	133	133	130	128	127	127
300	150	75	80	91	99	106	112	120	129	134	137	136	135	139	139	139	140	139	141	139	139	139	137	136	134	135	134	131	131	130	129	123	121	120	119
1,000	144	69	74	86	93	98	108	118	123	129	133	131	130	133	133	135	135	133	135	136	133	133	134	130	130	130	128	127	126	125	124	116	114	112	110
3,000	138	63	69	77	86	92	100	107	115	121	125	125	126	127	127	131	130	130	129	128	129	128	127	126	126	125	124	122	122	120	120	108	105	102	97
10,000	129	52	57	64	69	77	86	93	100	107	112	113	115	117	118	120	122	120	121	121	121	120	119	118	117	117	116	115	114	114	112	94	87	77	64
30,000	121	32	39	45	52	60	69	79	87	94	98	101	102	107	109	111	112	113	114	114	113	112	112	111	110	111	109	107	107	106	105	64	46	18	
100,000	112			8	19	31	45	58	69	78	84	88	88	94	96	99	101	102	104	103	103	104	103	102	102	102	100	98	98	98	95				
150,000	109				6	19	35	51	62	73	80	84	84	90	93	96	98	99	100	101	102	101	100	99	98	99	98	97	95	94	91				
200,000	108					10	26	44	57	67	77	80	83	90	93	94	96	98	99	100	100	100	100	98	97	97	97	94	94	92	86				
250,000	102					7	23	42	54	66	73	78	79	83	88	90	91	93	95	94	95	95	94	92	92	92	91	90	89	88	80				

Table 4e. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during open water conditions - Pinnipeds M-weighting applied

Range (m)	broad band	Frequency (Hz)																															
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	160	96	102	114	120	125	132	139	147	151	151	149	150	149	148	149	148	146	147	145	143	143	141	140	139	138	137	135	134	133	132	130	128	127	126
300	155	91	97	108	115	122	128	135	143	147	149	146	144	145	144	143	143	141	142	139	140	139	138	136	134	135	134	131	131	130	128	123	121	120	119
1,000	150	86	91	102	110	115	124	133	137	142	145	141	138	140	138	139	137	135	136	136	134	133	134	131	131	130	128	127	126	125	124	116	114	112	110
3,000	143	80	86	93	102	109	116	123	129	134	136	135	135	133	132	135	132	132	131	129	130	129	127	126	127	125	124	122	122	120	120	108	105	101	97
10,000	132	69	74	81	86	93	102	109	115	121	123	123	123	123	123	123	124	122	122	121	122	120	119	118	117	117	116	115	114	114	112	94	87	77	64
30,000	124	49	55	62	69	76	85	95	101	107	110	111	110	113	114	115	115	114	115	115	114	112	112	111	110	111	109	107	107	106	105	64	46	18	
100,000	113	5	15	25	36	47	60	73	83	91	96	98	96	101	101	102	104	104	105	104	104	104	103	102	102	102	100	98	98	98	95				
150,000	110			9	22	36	51	66	77	87	92	94	92	97	98	100	100	100	101	101	102	101	100	99	98	99	98	97	95	94	91				
200,000	109				12	26	42	59	72	80	88	90	91	96	98	98	99	100	100	100	101	101	100	98	97	97	97	94	94	92	86				
250,000	103				8	23	39	58	68	79	85	88	87	90	93	94	94	94	96	95	95	96	94	92	92	92	91	90	89	88	80				

Table 5a. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thin ice conditions.

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	169	151	152	158	158	156	154	154	157	160	160	157	158	158	155	155	155	154	152	151	152	149	148	147	146	145	143	141	142	142	139	138	137	136	135
300	164	146	147	152	153	153	151	149	154	156	157	154	153	152	151	149	148	148	147	145	146	145	145	143	142	141	139	136	138	137	134	131	129	128	127
1,000	159	141	141	147	147	146	146	146	147	150	153	149	147	148	144	145	144	142	142	142	141	139	141	138	137	136	135	132	133	134	130	124	121	119	116
3,000	151	135	135	137	140	140	138	136	139	142	144	142	143	141	138	140	138	138	136	136	137	136	134	133	135	131	129	127	128	128	125	115	111	107	100
10,000	139	123	124	125	124	123	124	122	125	128	130	130	130	130	129	128	129	128	127	126	127	126	124	123	122	122	120	117	117	117	113	96	86	72	52
30,000	127	103	105	106	106	107	107	107	111	115	117	117	117	118	118	117	117	117	116	116	117	116	115	113	113	112	109	106	106	104	96	53	26		
100,000	110	59	63	68	72	76	81	85	91	98	101	101	100	100	100	99	99	99	99	98	99	97	96	94	91	90	87	81	78	69	53				
150,000	103	40	46	52	58	64	71	77	84	92	96	96	94	93	92	91	91	91	90	88	89	88	85	83	80	78	73	65	60	47	25				
200,000	97	26	33	41	47	55	61	70	79	85	91	90	89	87	85	82	82	83	81	80	81	78	76	72	69	67	60	50	42	26					
250,000	92	20	28	36	43	52	59	68	75	83	86	87	84	79	77	75	74	75	73	73	72	70	67	63	59	55	47	36	25	5					

Table 5b. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thin ice conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	169	148	149	156	157	155	154	153	157	160	160	157	158	158	155	155	155	154	152	151	152	149	148	147	146	145	143	141	142	141	138	137	135	132	130
300	164	143	144	150	152	152	150	149	153	156	157	154	153	152	151	149	148	148	147	145	146	145	145	143	142	141	139	136	137	137	133	129	127	124	122
1,000	159	137	139	146	146	145	146	146	147	150	152	149	147	148	144	145	144	142	142	142	141	139	141	138	137	136	135	132	133	133	129	122	119	115	111
3,000	151	132	133	136	139	139	138	136	139	141	144	142	143	141	138	140	138	138	136	136	137	136	134	133	134	131	129	127	127	127	124	114	109	103	95
10,000	139	120	122	124	123	123	123	122	124	128	130	130	130	130	129	128	129	128	127	126	127	126	124	123	122	122	120	117	117	116	112	94	84	68	47
30,000	127	100	102	105	105	106	107	107	110	114	117	117	117	118	118	117	117	117	116	116	117	116	115	113	113	112	109	106	106	103	95	51	24		
100,000	110	56	61	67	71	76	80	84	91	97	101	101	100	100	100	99	99	99	99	98	99	97	95	94	91	90	87	80	78	69	52				
150,000	103	37	44	51	57	64	71	77	84	92	96	96	94	93	92	91	91	91	90	88	89	88	85	83	80	78	73	64	60	46	24				
200,000	97	22	30	39	46	54	61	70	78	85	91	90	89	87	85	82	82	83	81	80	81	78	76	72	69	67	60	50	41	25					
250,000	92	17	26	35	42	51	58	68	75	83	86	87	84	79	77	75	74	75	73	73	72	70	67	63	59	55	47	36	25	4					

Table 5c. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thin ice conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	162	104	109	119	123	125	127	130	137	143	147	147	151	152	151	153	153	153	151	150	152	149	148	147	146	145	143	141	142	142	139	138	137	136	135
300	157	99	104	113	118	121	124	125	134	139	144	144	145	147	147	146	147	147	146	145	146	144	145	142	142	141	139	136	138	137	134	131	129	128	127
1,000	151	94	98	108	112	115	119	123	127	133	139	138	139	142	140	143	142	141	141	141	141	139	141	138	137	136	135	132	133	134	130	124	121	119	116
3,000	145	88	93	98	105	108	111	113	119	125	131	132	135	135	135	137	136	137	135	136	136	136	134	133	134	131	129	127	128	128	125	115	111	107	100
10,000	135	76	81	86	88	92	96	98	105	112	117	120	122	124	125	126	127	127	126	125	127	126	124	123	122	122	120	117	117	117	113	96	86	72	52
30,000	125	56	62	67	71	75	80	84	91	98	104	106	109	112	114	114	115	116	115	115	117	116	115	113	113	112	109	106	106	104	96	52	26		
100,000	107	12	21	29	37	45	54	61	71	81	88	91	92	95	96	97	97	98	98	98	99	97	95	94	91	90	87	81	78	69	53				
150,000	98		3	13	23	33	44	54	64	76	83	86	86	87	88	88	89	90	89	88	89	87	85	83	80	78	73	65	60	47	25				
200,000	90			2	12	24	34	46	59	69	78	80	81	82	81	79	80	81	80	79	81	78	76	72	69	67	60	50	42	26					
250,000	84				8	21	31	45	55	66	73	76	76	74	74	73	73	73	72	72	72	70	67	63	59	55	47	36	25	5					

Table 5d. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thin ice conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	161	99	104	114	118	120	122	125	133	139	143	143	147	149	149	151	152	152	151	150	151	149	148	146	146	145	143	141	142	142	139	138	137	136	135
300	156	94	99	108	113	117	119	121	129	135	140	140	142	144	145	145	145	146	146	144	146	144	145	142	142	141	139	136	138	137	134	131	129	128	127
1,000	150	89	94	103	107	110	114	118	122	129	135	135	136	140	138	141	141	140	141	141	141	139	141	138	137	136	135	132	133	134	130	124	121	119	116
3,000	144	83	88	93	100	103	106	108	115	121	127	128	132	133	132	135	135	136	135	135	136	136	134	133	134	131	129	127	128	128	125	115	111	107	100
10,000	134	71	76	81	83	87	92	94	100	107	113	116	119	122	123	124	126	126	126	125	126	126	124	123	122	122	120	117	117	117	113	96	86	72	52
30,000	124	51	57	62	66	71	75	79	86	94	100	103	106	109	112	113	114	116	115	115	117	116	114	113	113	112	109	106	106	104	96	53	26		
100,000	106	7	16	24	32	40	49	56	66	77	84	87	89	92	94	95	96	97	98	97	99	97	95	94	91	90	87	81	78	69	53				
150,000	96			9	18	28	39	49	60	71	79	82	83	85	86	86	88	89	89	87	89	87	85	83	80	78	73	65	60	47	25				
200,000	88				7	19	29	42	54	64	74	77	78	79	79	78	79	81	80	79	80	78	76	72	69	67	60	50	42	26					
250,000	82				3	16	27	40	51	62	69	73	73	71	71	71	72	73	72	72	72	69	66	63	59	55	47	36	25	5					

Table 5e. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thin ice conditions - Pinnipeds M-weighting applied

Range (m)	broad band	Frequency (Hz)																																	
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	165	116	121	131	134	136	138	141	147	152	154	154	156	156	154	155	155	154	152	151	152	149	148	147	146	145	143	141	142	142	139	138	137	136	134
300	160	111	116	124	130	133	135	136	143	148	151	150	150	150	150	148	148	148	147	145	146	145	145	143	142	141	139	136	138	137	134	131	129	128	126
1,000	154	106	110	120	123	126	130	133	137	142	147	145	144	146	143	144	143	142	142	142	141	139	141	138	137	136	135	132	133	134	130	123	121	119	116
3,000	148	100	105	110	116	120	122	123	129	134	138	138	140	139	137	139	137	138	136	136	136	136	134	133	135	131	129	127	128	128	125	115	111	106	100
10,000	137	88	93	98	100	103	107	109	114	121	125	126	127	128	128	127	128	127	127	126	127	126	124	123	122	122	120	117	117	117	113	96	86	71	51
30,000	126	68	74	79	82	87	91	94	100	107	111	113	114	116	117	116	117	117	116	116	117	116	115	113	113	112	109	106	106	104	96	52	26		
100,000	108	24	32	41	48	56	65	71	81	90	96	98	97	99	98	99	98	99	99	98	99	97	95	94	91	90	87	81	78	69	53				
150,000	100	5	15	25	35	44	55	64	74	84	90	92	91	91	91	90	90	91	90	88	89	88	85	83	80	78	73	65	60	47	25				
200,000	94		2	13	24	35	45	57	68	77	86	87	86	85	84	81	81	82	81	80	81	78	76	72	69	67	60	50	42	26					
250,000	88			9	20	32	42	55	65	75	81	83	81	78	76	75	74	74	73	73	72	70	67	63	59	55	47	36	25	5					

Table 6a. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thick ice conditions.

Range (m)	broad band	Frequency (Hz)																																	
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	180	171	170	175	173	168	161	154	158	161	162	162	165	164	162	162	160	160	160	157	158	157	156	154	153	152	150	147	150	150	146	147	146	145	144
300	175	166	166	169	168	165	158	150	154	157	160	158	159	160	157	156	155	155	155	152	155	153	152	150	149	150	146	144	146	147	142	140	138	137	135
1,000	169	161	160	164	162	157	153	148	148	151	156	154	154	155	151	152	149	149	149	149	149	148	148	146	146	144	142	139	143	142	138	133	131	129	126
3,000	162	155	154	155	155	151	145	137	140	143	147	147	150	148	145	147	145	146	144	143	145	143	142	141	141	140	137	133	136	137	131	125	122	116	110
10,000	150	143	143	143	138	136	131	124	126	130	134	135	138	138	136	135	136	135	134	132	135	134	133	131	130	130	128	123	127	126	121	104	95	79	58
30,000	135	123	124	123	121	118	115	110	113	117	121	123	125	126	125	126	125	126	125	122	125	123	123	121	120	119	117	113	115	112	102	61	35		
100,000	117	80	83	86	88	90	90	88	94	101	106	108	108	108	107	107	106	107	106	105	108	105	105	103	100	98	93	88	85	77	53				
150,000	110	62	67	71	75	79	81	81	88	95	101	103	101	102	99	98	98	99	97	96	98	95	94	91	88	86	80	71	68	56	20				
200,000	103	47	53	60	65	69	72	74	83	88	96	97	96	96	91	90	88	90	88	86	88	85	83	80	76	75	66	56	50	35					
250,000	96	42	49	56	61	66	69	73	78	86	91	92	90	87	83	82	79	81	79	78	79	77	74	70	65	63	55	42	34	13					

Table 6b. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thick ice conditions - Low-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																	
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	179	167	168	174	172	167	161	154	158	161	162	162	165	164	162	162	160	160	160	157	158	157	156	154	153	152	150	146	150	149	145	145	143	141	138
300	174	163	163	168	167	164	157	150	154	157	160	158	159	160	157	156	155	155	155	152	155	153	152	150	149	150	146	143	146	146	141	138	136	133	130
1,000	168	157	158	162	161	156	153	147	148	151	156	154	154	155	151	152	149	149	149	149	149	147	148	146	146	144	142	139	143	141	137	132	129	125	121
3,000	161	152	152	154	154	150	144	137	140	143	147	147	150	148	145	147	145	146	144	143	145	143	142	141	141	139	137	133	136	137	130	123	119	113	105
10,000	149	140	141	141	137	135	130	123	126	130	134	135	138	138	136	135	136	135	134	132	135	134	133	131	130	130	127	123	127	125	120	103	92	75	53
30,000	135	120	122	122	120	118	114	110	112	117	121	123	125	126	125	126	125	126	125	122	125	123	123	121	120	119	117	112	115	111	101	60	33		
100,000	117	77	81	85	87	89	90	88	94	100	106	108	108	108	107	107	106	107	106	105	108	105	104	102	100	98	93	87	85	76	52				
150,000	110	58	64	70	74	78	81	81	88	95	101	103	101	102	99	98	98	99	97	96	98	95	94	91	87	85	80	71	67	55	19				
200,000	103	44	51	58	64	69	71	74	82	88	96	97	96	96	91	90	88	90	88	86	88	85	83	80	76	75	66	56	50	34					
250,000	96	38	46	54	60	65	69	73	78	86	91	92	90	87	83	82	79	81	79	78	79	77	74	70	65	63	55	42	33	12					

Table 6c. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thick ice conditions - Mid-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																	
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	169	124	128	136	137	136	134	131	138	144	149	152	157	158	158	159	159	159	159	157	158	156	156	154	153	152	150	147	150	150	146	147	146	145	143
300	164	119	123	131	133	133	130	126	134	140	147	148	151	155	153	154	154	154	154	151	154	153	152	150	149	150	146	144	146	147	142	140	138	137	135
1,000	158	114	117	125	127	126	126	124	128	135	143	143	146	149	147	149	148	148	148	148	148	147	148	146	146	144	142	139	143	142	138	133	131	129	126
3,000	153	108	112	116	120	120	118	114	120	127	134	137	142	142	141	145	143	145	143	143	145	143	142	141	141	140	137	133	136	137	131	125	121	116	110
10,000	143	96	100	104	103	104	104	100	106	114	121	125	130	132	132	132	134	134	133	131	134	134	133	131	130	130	128	123	127	126	121	104	94	79	58
30,000	132	76	81	84	86	87	87	86	93	101	108	113	117	121	122	123	123	125	124	121	125	123	122	121	120	119	117	113	115	112	102	61	35		
100,000	114	33	41	48	53	58	63	65	74	84	93	98	100	103	104	105	104	106	105	104	108	105	104	102	100	98	93	88	85	77	53				
150,000	105	15	24	32	40	47	54	58	68	79	88	93	94	96	95	95	96	97	96	95	98	95	94	91	87	86	80	71	68	56	20				
200,000	97		11	21	30	38	45	51	63	72	83	87	89	91	88	87	87	89	88	85	88	85	83	80	76	75	66	56	50	35					
250,000	89		6	17	26	35	42	49	58	69	78	82	82	82	79	79	78	80	79	77	79	77	74	70	65	63	55	42	34	13					

Table 6d. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thick ice conditions - High-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																	
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	168	119	123	131	132	131	129	126	134	140	145	148	154	156	156	157	158	158	158	157	158	156	156	154	153	152	150	147	150	150	146	147	146	145	143
300	163	114	118	126	128	128	125	122	129	136	143	144	148	152	151	152	153	154	154	151	154	153	152	150	149	150	146	144	146	147	142	140	138	137	135
1,000	157	109	112	120	122	121	121	119	124	130	138	140	143	146	145	148	147	147	148	148	148	147	148	146	146	144	142	139	143	142	138	133	131	129	126
3,000	152	103	107	111	115	115	113	109	116	122	130	133	139	140	139	143	142	144	142	142	145	143	142	141	141	140	137	133	136	137	131	125	121	116	110
10,000	142	91	95	99	98	100	99	95	101	109	117	122	127	129	130	130	133	133	133	131	134	134	133	131	130	130	128	123	127	126	121	104	94	79	58
30,000	131	71	76	79	81	82	83	81	88	96	104	109	114	118	119	121	122	124	123	121	125	123	122	121	120	119	117	113	115	112	102	61	35		
100,000	113	28	36	43	48	54	58	60	70	80	89	94	97	100	101	103	103	105	104	104	107	105	104	102	100	98	93	88	85	77	53				
150,000	104	10	19	27	35	43	49	53	63	75	84	89	90	93	93	93	95	97	96	95	98	95	94	91	87	86	80	71	68	56	20				
200,000	96		6	16	25	33	40	46	58	68	79	83	85	88	85	85	86	88	87	85	88	85	83	80	76	75	66	56	50	35					
250,000	87		1	12	21	30	37	45	54	65	74	78	79	79	77	77	77	79	78	77	79	76	74	69	65	63	55	42	34	13					

Table 6e. Estimated sound levels at set radii from the Ore Carrier transiting in Foxe Basin, during thick ice conditions - Pinnipeds M-weighting applied

Range (m)	broad band	Frequency (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	171	136	140	148	149	148	145	141	148	153	157	158	162	162	161	161	160	160	160	157	158	157	156	154	153	152	150	147	150	150	146	147	146	144	143
300	166	131	135	142	144	145	141	137	144	149	154	154	156	158	156	155	155	155	155	152	155	153	152	150	149	150	146	144	146	147	142	139	138	137	135
1,000	160	125	129	137	139	137	137	135	138	144	150	150	151	153	150	151	149	149	149	149	148	147	148	146	146	144	142	139	143	142	138	133	131	129	125
3,000	155	120	124	128	131	131	128	124	130	135	142	143	147	146	144	146	145	146	143	143	145	143	142	141	141	140	137	133	136	137	131	125	121	116	109
10,000	144	108	112	115	115	116	115	111	116	123	129	132	135	136	135	134	135	135	134	132	135	134	133	131	130	130	128	123	127	126	121	104	94	78	58
30,000	133	88	93	96	98	98	98	97	102	109	116	119	122	125	124	125	124	126	124	122	125	123	123	121	120	119	117	113	115	112	102	61	35		
100,000	116	45	53	59	65	70	74	75	84	93	100	104	105	107	106	107	106	107	105	105	108	105	104	103	100	98	93	88	85	77	53				
150,000	108	26	36	44	52	59	65	68	77	88	95	99	99	100	98	97	97	98	97	96	98	95	94	91	88	86	80	71	68	56	20				
200,000	101	12	23	33	41	49	56	61	72	81	91	93	94	94	90	89	88	90	88	86	88	85	83	80	76	75	66	56	50	35					
250,000	93	7	18	28	37	46	53	60	68	78	86	88	87	86	82	81	79	81	79	77	79	77	74	70	65	63	55	42	34	13					

Table 7a. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during open water conditions.

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	163	133	134	138	141	146	150	153	155	157	155	152	151	150	149	147	147	146	145	143	143	142	141	139	139	138	137	135	134	134	132	132	128	127	127
300	158	119	124	130	131	138	140	145	150	151	152	149	146	144	143	143	142	140	139	139	139	137	136	134	134	133	132	130	128	127	127	124	119	118	118
1,000	152	113	117	123	126	128	134	139	143	146	145	143	139	137	136	137	135	135	133	132	133	131	130	130	128	128	127	126	125	124	122	122	112	111	109
3,000	145	109	113	116	120	121	129	133	135	139	141	137	134	133	132	132	131	131	129	129	129	126	125	124	125	123	122	120	119	119	119	117	108	105	100
10,000	138	100	102	106	111	114	120	124	129	132	132	132	129	127	127	127	125	124	124	124	122	121	121	119	118	118	117	115	114	114	113	111	90	80	68
30,000	125	84	87	90	95	99	104	109	114	118	117	117	115	116	113	114	113	113	110	111	111	112	108	107	108	106	107	105	103	103	102	97	49	21	
100,000	120	74	79	83	88	92	98	103	108	111	112	111	110	110	109	109	109	108	107	106	106	105	105	104	103	102	100	99	98	97	95	83			
150,000	118	68	74	80	86	90	96	101	107	109	110	111	108	110	110	110	109	108	108	107	107	107	106	103	102	103	101	99	97	97	95	76			
200,000	113	54	62	71	78	83	91	95	100	103	103	104	104	104	106	105	105	104	103	101	101	102	101	99	98	99	97	95	94	94	90	67			
250,000	112	40	51	63	71	79	87	92	97	100	100	101	101	101	103	102	102	100	101	100	99	100	98	97	96	96	94	92	91	92	86	60			

Table 7b. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during open water conditions - Low-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	163	129	132	137	140	145	149	153	155	156	155	152	151	149	149	147	147	146	145	143	143	142	141	139	139	138	137	135	134	133	131	130	126	124	121
300	158	116	122	129	130	138	139	145	150	151	152	149	146	144	143	143	142	140	139	139	139	137	136	134	134	133	132	129	128	127	126	123	117	115	113
1,000	152	110	115	122	125	128	133	139	143	146	145	143	139	137	136	137	135	135	133	132	133	131	130	130	128	128	127	126	125	123	121	120	110	107	103
3,000	145	106	111	114	119	121	128	132	135	139	141	137	134	133	132	132	131	131	129	129	129	126	125	124	125	122	122	120	119	118	118	115	105	101	95
10,000	138	96	100	105	110	113	120	123	128	132	132	132	129	127	127	127	125	124	124	124	122	121	121	119	118	117	116	115	113	113	112	109	87	77	62
30,000	125	80	85	89	94	99	104	109	114	118	117	117	115	116	113	114	113	113	110	111	111	112	108	107	108	106	107	104	102	102	101	95	47	17	
100,000	120	70	77	82	87	92	97	103	108	111	112	111	110	110	109	109	109	108	107	106	106	105	105	104	103	102	100	99	98	97	94	82			
150,000	118	64	72	78	85	90	95	101	107	109	110	111	108	110	110	110	109	108	108	107	107	107	106	103	102	102	101	99	97	96	94	75			
200,000	113	50	60	69	77	82	90	95	100	103	103	104	104	104	106	105	105	103	103	101	101	102	101	99	98	99	96	95	94	94	89	65			
250,000	112	37	49	61	70	78	87	92	96	100	100	101	101	101	103	102	102	100	101	100	99	100	98	97	96	95	94	92	91	91	85	58			

Table 7c. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during open water conditions - Mid-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	155	86	91	99	106	114	122	129	135	140	142	142	143	144	145	145	146	145	144	143	143	142	141	139	139	138	137	135	134	134	132	132	128	127	127
300	149	72	82	91	96	107	112	122	130	135	139	139	138	138	139	140	140	139	138	139	138	137	136	134	134	133	132	130	128	127	127	124	119	118	118
1,000	143	66	74	85	91	97	107	116	123	130	132	133	131	132	132	134	133	134	133	131	133	131	130	130	128	128	127	126	125	124	122	122	112	111	109
3,000	138	62	70	77	85	90	101	109	115	122	128	126	126	127	128	130	129	130	128	129	129	126	125	124	125	123	122	120	119	119	119	117	108	105	100
10,000	132	53	60	67	76	82	93	100	109	116	119	121	121	122	123	124	124	123	123	123	122	121	121	119	118	117	117	115	114	114	113	111	90	80	67
30,000	120	37	44	51	59	68	77	85	94	102	104	106	107	110	109	111	112	112	110	110	111	111	108	107	108	106	107	105	103	103	102	97	49	21	
100,000	115	27	36	44	53	61	71	80	88	95	98	100	103	105	105	107	107	107	106	106	106	105	105	104	103	102	100	99	98	97	95	83			
150,000	115	21	31	41	50	59	69	78	87	93	97	101	100	104	106	107	107	107	107	107	106	106	106	103	102	103	101	99	97	97	95	76			
200,000	110	7	20	32	42	51	63	72	80	87	90	94	97	99	102	102	103	102	102	100	101	102	101	99	98	99	97	95	94	94	90	67			
250,000	110		9	24	36	47	60	69	77	84	87	91	94	96	99	99	100	99	100	99	98	100	98	97	96	96	94	92	91	92	86	60			

Table 7d. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during open water conditions - High-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	154	81	86	94	101	109	117	125	131	136	138	138	140	141	143	143	144	144	143	142	142	142	141	139	139	138	137	135	134	134	132	132	128	127	127
300	148	67	77	86	91	102	108	117	125	130	135	135	135	136	136	138	139	138	137	138	138	136	136	134	134	133	132	130	128	127	127	124	119	118	118
1,000	142	61	69	80	86	92	102	111	119	125	128	129	128	129	130	133	132	133	132	131	133	131	130	130	128	128	127	126	125	124	122	122	112	111	109
3,000	137	57	65	72	80	85	96	104	111	118	124	123	123	125	126	128	128	129	128	128	129	126	125	124	124	123	122	120	119	119	119	117	108	105	100
10,000	131	48	55	62	71	77	88	95	104	111	115	118	118	119	121	122	122	122	123	123	122	121	121	119	118	117	117	115	113	114	113	111	90	80	67
30,000	119	32	39	46	55	63	72	81	89	97	100	103	104	107	107	110	111	111	109	110	111	111	108	107	108	106	107	105	103	103	102	97	49	21	
100,000	114	22	31	39	48	56	66	75	84	91	94	97	99	102	103	105	106	106	106	106	106	105	104	104	103	102	100	99	98	97	95	83			
150,000	114	16	26	36	45	54	64	73	83	88	93	97	97	102	104	105	106	106	107	106	106	106	106	103	102	103	101	99	97	97	95	76			
200,000	109	2	15	27	38	47	59	67	76	83	86	90	93	96	100	100	102	102	102	100	101	102	101	99	98	99	97	95	94	94	90	67			
250,000	109		4	19	31	42	55	64	72	80	83	87	90	93	97	98	99	98	99	99	98	100	98	97	96	96	94	92	91	92	86	60			

Table 7e. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during open water conditions - Pinnipeds M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	159	98	103	111	117	126	133	140	145	149	150	149	149	148	148	147	147	145	145	143	143	142	141	139	139	138	137	135	134	134	132	131	128	127	126
300	153	84	94	103	108	118	123	132	140	144	146	145	144	142	141	142	141	140	138	139	139	137	136	134	134	133	132	130	128	127	127	124	119	118	117
1,000	147	78	86	96	103	108	118	126	133	139	140	139	136	135	134	136	134	135	133	131	133	131	130	130	128	128	127	126	125	124	122	122	112	110	108
3,000	141	74	82	89	97	101	112	119	125	131	135	133	131	131	131	132	130	130	129	129	129	126	125	124	125	123	122	120	119	119	119	117	108	104	100
10,000	135	65	71	79	87	94	104	110	118	125	127	128	126	125	126	126	125	124	124	123	122	121	121	119	118	117	117	115	113	114	113	111	90	80	67
30,000	122	49	56	63	71	79	88	96	104	110	112	113	112	114	112	113	113	113	110	111	111	111	108	107	108	106	107	105	103	103	102	97	49	21	
100,000	117	39	48	56	65	72	82	90	98	104	106	107	108	108	108	109	109	108	107	106	106	105	105	104	103	102	100	99	98	97	95	83			
150,000	117	33	43	53	62	70	80	88	97	102	105	107	105	108	109	109	108	108	108	107	107	107	106	103	102	103	101	99	97	97	95	76			
200,000	112	19	32	44	54	63	74	82	90	96	98	100	102	103	105	104	105	103	103	101	101	102	101	99	98	99	97	95	94	94	90	67			
250,000	111	5	21	35	48	59	71	79	86	93	95	97	99	100	102	101	101	100	101	100	99	100	98	97	96	96	94	92	91	92	86	60			

Table 8a. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait during thin ice conditions.

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	168	152	153	152	155	157	155	153	155	157	158	156	156	156	155	154	153	153	151	150	150	149	148	146	146	145	143	141	142	142	139	138	137	136	135
300	161	138	141	145	145	147	145	145	150	152	153	152	152	150	147	146	148	146	144	144	144	141	141	139	139	138	135	132	133	133	130	129	127	126	124
1,000	154	133	135	139	139	139	139	135	141	144	147	147	145	144	141	142	141	142	138	138	139	137	136	135	134	134	131	128	129	129	126	119	116	114	112
3,000	149	128	131	131	134	132	134	130	134	140	143	140	140	141	137	137	136	136	134	134	136	132	132	129	127	128	126	123	124	124	121	112	108	102	96
10,000	141	119	120	121	124	123	124	124	128	131	134	134	135	133	132	132	130	130	128	127	127	126	125	124	122	121	119	117	118	116	112	94	84	69	49
30,000	127	102	103	105	107	108	109	108	113	115	118	118	120	118	117	117	116	115	114	113	114	112	110	108	108	108	104	102	100	98	90	48	23		
100,000	115	90	94	96	98	100	100	100	105	108	110	109	110	107	105	103	101	100	100	96	96	93	91	90	88	86	82	76	72	62	46				
150,000	111	83	87	92	94	96	96	96	101	104	107	105	104	101	96	95	93	91	90	86	87	84	82	79	77	73	68	59	53	41	18				
200,000	102	67	74	81	83	86	90	91	95	97	99	97	94	90	87	85	80	79	77	75	75	72	68	65	61	59	50	42	31	15					
250,000	96	51	60	70	76	80	83	85	89	91	93	90	87	83	77	75	71	70	67	64	65	59	56	53	50	43	36	26	12						

Table 8b. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait during thin ice conditions - Low-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	168	149	150	151	154	156	155	153	155	157	158	156	156	156	155	154	153	153	151	150	150	149	148	146	146	145	143	141	142	141	138	137	134	132	130
300	161	134	139	144	144	146	145	145	149	152	153	152	152	150	147	146	148	146	144	144	144	141	141	139	139	138	135	132	132	132	129	127	125	122	119
1,000	154	129	133	137	138	138	139	135	141	144	147	146	145	144	141	142	141	142	138	138	139	137	136	135	134	133	131	127	129	128	125	117	114	110	106
3,000	149	124	129	130	133	132	133	130	134	140	143	140	140	141	137	137	136	136	134	134	136	132	132	129	127	128	126	123	124	123	120	110	105	99	90
10,000	141	116	117	119	123	123	124	123	128	131	134	134	135	133	132	132	130	130	128	127	127	126	125	124	122	121	119	117	118	115	111	92	82	66	44
30,000	127	98	101	104	106	107	108	108	113	115	118	118	120	118	117	117	116	115	114	113	114	112	110	108	108	108	104	101	100	97	88	47	21		
100,000	115	87	91	95	97	99	99	100	105	108	110	109	110	107	105	103	101	100	100	96	96	93	91	90	88	85	82	75	72	62	45				
150,000	111	79	85	90	93	95	96	96	101	104	107	105	104	101	96	95	93	91	90	86	87	84	82	79	77	73	68	59	52	40	17				
200,000	102	63	72	79	82	85	89	90	95	97	98	97	94	90	87	85	80	79	77	75	75	72	68	65	61	59	50	42	30	14					
250,000	96	47	58	68	75	79	83	85	89	91	93	90	87	83	77	75	71	70	67	64	65	59	56	53	49	43	36	25	12						

Table 8c. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait during thin ice conditions - Mid-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	162	105	110	113	120	125	128	130	135	141	145	146	149	151	151	152	151	151	151	149	150	149	148	146	146	145	143	141	142	142	139	138	137	136	135
300	154	91	99	106	110	116	118	122	130	135	140	142	144	145	143	144	146	145	144	143	144	141	140	139	139	138	135	132	133	133	130	129	127	126	124
1,000	149	86	92	100	104	108	112	112	121	128	134	136	137	138	137	139	139	141	137	138	139	137	136	135	134	134	131	128	129	129	126	119	116	114	111
3,000	143	81	89	92	99	101	107	106	114	123	130	130	132	136	134	135	134	134	133	133	135	132	132	129	127	128	126	123	124	124	121	112	108	102	96
10,000	137	72	77	82	89	92	97	100	108	115	121	124	127	128	128	129	128	129	128	127	127	126	125	124	122	121	119	117	118	116	112	94	84	69	49
30,000	122	55	61	66	71	77	81	85	93	98	105	108	112	113	113	114	114	114	114	112	114	112	110	108	108	108	104	102	100	98	90	48	23		
100,000	108	43	51	57	63	69	73	76	85	92	97	98	102	102	102	100	99	99	99	95	96	93	91	90	88	86	82	75	72	62	46				
150,000	101	36	45	53	59	64	69	73	81	87	94	95	96	96	92	92	91	90	89	86	87	84	82	79	77	73	68	59	53	41	18				
200,000	91	20	31	42	48	55	62	67	75	80	85	87	86	85	83	82	79	78	76	75	75	72	68	65	61	59	50	42	30	15					
250,000	91	4	18	31	40	49	56	62	69	75	80	80	79	77	73	73	69	69	67	63	65	59	56	53	49	43	36	26	12						

Table 8d. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait during thin ice conditions - High-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	161	100	105	108	115	120	123	125	131	136	141	142	145	148	149	150	150	151	150	149	150	149	148	146	146	145	143	141	142	142	139	138	137	136	135
300	153	86	94	101	105	111	113	117	125	131	136	138	141	142	141	142	145	144	143	143	143	141	140	139	139	138	135	132	133	133	130	129	127	126	124
1,000	147	81	87	95	99	103	107	107	117	124	130	133	134	135	135	137	138	140	136	137	139	137	136	135	134	134	131	128	129	129	126	119	116	114	111
3,000	142	76	84	87	94	96	102	102	110	119	125	126	129	133	131	133	133	134	133	133	135	132	132	129	127	128	126	123	124	124	121	112	108	102	96
10,000	135	67	72	77	84	87	92	95	103	111	117	120	124	125	126	127	127	129	127	126	127	126	125	124	122	121	119	117	118	116	112	94	84	69	49
30,000	121	50	56	61	66	72	77	80	89	94	101	104	109	110	111	113	113	113	113	112	113	112	110	108	108	108	104	102	100	98	90	48	23		
100,000	105	38	46	52	58	64	68	72	80	87	93	95	99	99	99	98	98	98	99	95	96	93	91	90	88	86	82	75	72	62	46				
150,000	99	31	40	48	54	59	64	68	76	83	89	91	93	93	90	91	90	89	88	86	87	84	81	79	77	73	68	59	53	41	18				
200,000	88	15	26	37	43	50	58	62	70	76	81	83	83	82	81	80	77	77	76	75	75	72	68	65	61	59	50	42	30	15					
250,000	91		13	26	36	44	51	57	65	70	76	76	76	75	71	71	68	68	66	63	65	59	56	53	49	43	36	26	12						

Table 8e. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait during thin ice conditions - Pinnipeds M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	164	117	122	125	131	137	139	140	145	149	153	153	154	154	154	154	152	152	151	150	150	149	148	146	146	145	143	141	142	142	139	138	136	135	134
300	157	103	111	118	121	127	129	132	139	144	148	148	150	148	146	146	147	146	144	143	144	141	141	139	139	138	135	132	133	133	130	129	127	125	124
1,000	151	98	104	111	115	119	123	122	131	137	141	143	142	142	140	141	140	141	137	138	139	137	136	135	134	134	131	128	129	129	125	118	116	114	111
3,000	146	93	101	104	111	112	118	117	124	132	137	136	137	139	136	137	136	135	134	134	136	132	132	129	127	128	126	123	124	124	121	112	107	102	95
10,000	139	84	89	93	100	103	108	111	118	124	129	130	132	131	130	131	130	130	128	127	127	126	125	124	122	121	119	117	118	116	112	94	84	69	49
30,000	124	67	73	78	83	88	92	95	103	107	112	114	117	117	116	116	115	115	114	113	114	112	110	108	108	108	104	102	100	98	89	48	23		
100,000	112	55	63	69	75	80	84	87	95	100	105	105	107	105	104	102	101	100	100	95	96	93	91	90	88	86	82	75	72	62	46	-89			
150,000	106	48	57	64	70	76	80	83	91	96	101	101	101	99	95	94	93	91	89	86	87	84	82	79	77	73	68	59	53	41					
200,000	97	32	43	53	59	66	73	78	85	89	93	93	91	88	86	84	80	79	77	75	75	72	68	65	61	59	50	42	30	15					
250,000	93	16	30	43	52	60	67	72	79	84	88	86	84	81	76	75	71	70	67	64	65	59	56	53	50	43	36	26	12						

Table 9a. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during thick ice conditions.

Range	broad	Frequency (Hz)																															
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	179	173	172	172	170	168	162	155	156	158	161	161	164	162	161	160	159	159	157	155	158	156	155	154	153	152	150	147	150	150	146	148	146	145	143
300	170	158	162	164	161	161	153	147	151	153	157	157	159	156	155	154	154	153	152	150	153	152	151	148	147	147	144	140	143	142	137	139	136	135	133
1,000	164	153	155	158	155	152	147	141	145	148	151	152	152	150	148	149	148	148	147	145	148	145	145	144	142	142	139	136	139	139	134	137	130	128	125
3,000	158	149	151	151	150	144	142	134	137	141	147	146	147	146	144	144	141	144	142	140	142	143	141	137	139	138	134	132	135	136	130	132	121	115	108
10,000	150	140	140	141	140	136	133	127	130	134	139	141	143	140	139	138	137	138	136	134	137	135	135	134	132	132	129	125	128	126	121	121	97	82	61
30,000	136	124	125	125	125	123	118	112	115	120	125	126	129	127	127	124	123	125	123	123	125	123	123	121	119	120	117	111	114	112	102	92	37		
100,000	127	114	117	118	117	116	111	105	111	115	118	119	119	118	115	113	111	112	110	108	110	107	107	104	102	101	95	89	87	80	59	31			
150,000	124	108	113	115	114	113	110	104	109	113	116	115	116	113	110	108	105	105	102	100	102	100	97	94	91	89	83	74	70	58	29				
200,000	116	95	101	106	106	107	102	97	102	107	108	109	108	104	100	97	97	95	92	89	92	88	87	83	79	76	69	59	53	36					
250,000	111	82	91	99	102	103	99	95	98	104	105	105	103	97	92	91	88	87	85	82	83	79	78	73	69	65	57	44	35	17					

Table 9b. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during thick ice conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																															
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	177	169	169	170	169	167	162	154	156	158	161	161	163	162	161	160	159	159	157	155	158	156	155	154	153	152	150	146	150	149	145	147	143	141	138
300	170	155	160	162	160	160	152	147	151	153	157	157	159	156	155	154	154	153	152	150	153	152	151	148	147	147	144	140	142	141	136	138	134	131	128
1,000	163	150	153	157	154	151	147	141	144	148	151	152	152	150	148	149	148	148	147	145	148	145	145	144	142	141	138	136	139	138	133	135	128	124	119
3,000	157	146	149	149	149	143	142	134	137	141	147	146	147	146	144	144	141	144	142	140	142	143	141	137	139	138	134	132	135	135	129	130	118	111	103
10,000	149	137	138	140	139	136	133	126	130	134	139	141	143	140	139	138	137	138	136	134	137	135	135	134	132	132	129	124	128	126	120	119	95	78	55
30,000	136	120	123	124	123	122	118	111	115	120	125	126	129	127	127	124	123	125	123	123	125	123	123	121	119	119	116	111	114	111	101	90	34		
100,000	126	111	115	117	116	115	111	105	111	115	118	119	119	117	115	113	111	112	110	108	110	107	107	104	102	100	95	88	87	79	58	30			
150,000	123	105	110	114	113	113	109	104	109	112	115	115	116	113	110	108	105	105	102	100	102	100	97	94	91	89	83	74	69	58	28				
200,000	115	91	99	105	105	107	102	97	101	107	108	109	108	104	100	97	97	95	92	89	92	88	87	83	79	76	69	59	52	36					
250,000	111	78	89	97	101	103	99	94	98	104	105	105	103	97	92	91	88	87	85	82	83	79	78	73	69	65	57	44	35	16					

Table 9c. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during thick ice conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																															
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	168	126	129	133	134	137	135	131	136	141	148	151	156	157	157	157	157	158	157	155	158	156	155	154	153	152	150	147	150	150	146	148	146	144	143
300	162	111	120	125	125	129	126	123	131	136	144	147	151	151	151	152	152	152	151	150	153	152	151	148	147	147	144	140	143	142	137	139	136	135	133
1,000	156	106	112	119	120	120	120	118	125	131	138	142	144	144	144	146	146	147	146	144	148	145	145	144	142	142	139	136	139	139	134	137	130	128	124
3,000	151	102	108	112	115	113	115	111	117	124	134	135	139	141	140	141	140	143	141	139	141	143	141	137	139	138	134	132	135	136	130	132	121	115	108
10,000	145	93	97	102	105	105	106	103	110	118	126	130	135	135	135	135	135	137	136	134	136	135	134	134	132	132	129	125	128	126	121	120	97	82	60
30,000	132	77	83	86	89	91	91	88	95	104	111	116	121	121	123	121	121	124	122	122	124	123	123	121	119	119	117	111	114	112	102	92	37		
100,000	119	67	75	79	82	84	84	81	91	99	105	109	111	112	111	111	109	111	109	107	110	107	107	104	102	100	95	89	87	80	59	31			
150,000	113	61	70	76	79	82	82	80	89	96	102	105	109	107	106	105	103	104	101	99	101	100	97	94	91	89	83	74	70	58	29				
200,000	105	48	59	67	71	76	75	74	82	91	95	99	100	99	96	95	95	94	91	89	92	88	86	83	79	76	69	59	53	36					
250,000	100	35	49	60	66	72	72	71	78	88	92	95	95	92	88	88	86	86	84	82	82	78	77	73	69	65	57	44	35	17					

Table 9d. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during thick ice conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																															
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	167	121	124	128	129	132	130	126	131	137	144	147	152	154	155	155	156	157	156	155	158	156	155	154	153	152	150	147	150	150	146	148	146	144	143
300	161	106	115	120	120	124	121	119	126	132	140	143	148	148	149	150	151	151	151	149	153	152	151	148	147	147	144	140	143	142	137	139	136	135	133
1,000	155	101	107	114	115	115	115	113	120	127	134	138	141	141	142	144	145	146	145	144	147	145	145	144	142	142	139	136	139	139	134	137	130	128	124
3,000	150	97	103	107	110	108	110	106	112	120	130	132	136	138	138	139	139	142	141	139	141	143	140	137	139	138	134	132	135	136	130	132	121	115	108
10,000	144	88	93	97	100	100	101	98	106	114	122	127	132	132	133	134	134	136	135	133	136	135	134	133	132	132	129	125	128	126	121	121	97	82	60
30,000	131	72	78	81	84	87	86	83	91	99	107	112	118	118	121	119	120	123	122	122	124	123	123	121	119	119	117	111	114	112	102	92	37		
100,000	117	62	70	74	77	79	79	77	87	94	101	105	108	109	109	109	108	110	108	107	109	107	107	104	102	100	95	89	87	80	59	31			
150,000	111	56	65	71	74	77	78	76	84	92	98	101	105	105	104	103	102	103	101	99	101	100	97	93	91	89	83	74	70	58	29				
200,000	102	43	54	62	66	71	70	69	77	86	91	95	97	96	94	93	94	93	91	89	92	88	86	83	79	76	69	59	53	36					
250,000	97	30	44	55	62	67	67	66	74	83	88	91	92	89	86	86	85	85	84	81	82	78	77	72	69	65	57	44	35	17					

Table 9e. Estimated sound levels at set radii from the Ore Carrier transiting in Hudson Strait, during thick ice conditions - Pinnipeds M-weighting applied

Range (m)	broad band	Frequency (Hz)																																
		10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	170	138	141	145	146	148	146	141	146	150	155	157	161	161	160	159	159	159	157	155	158	156	155	154	153	152	150	147	150	150	146	148	145	144	143
300	164	123	132	137	137	141	137	134	140	145	152	154	156	155	154	154	154	153	152	150	153	152	151	148	147	147	144	140	143	142	137	139	136	135	133
1,000	158	118	124	131	132	132	131	128	134	140	146	148	149	148	147	148	148	148	146	144	148	145	145	144	142	142	139	136	139	139	134	137	130	127	124
3,000	153	114	120	123	127	124	126	121	127	133	141	142	144	145	143	143	141	144	142	140	142	143	141	137	139	138	134	132	135	136	130	131	120	115	108
10,000	146	105	109	114	117	116	117	114	120	127	133	137	140	139	138	137	137	138	136	134	137	135	135	134	132	132	129	125	128	126	121	120	97	81	60
30,000	133	89	94	98	101	103	102	99	105	113	119	122	126	125	126	123	122	125	123	123	124	123	123	121	119	119	117	111	114	112	102	92	37		
100,000	122	79	86	91	94	96	95	92	101	107	113	115	116	116	114	113	110	112	109	108	110	107	107	104	102	100	95	89	87	80	59	31			
150,000	118	73	82	88	91	93	93	91	99	105	110	112	114	111	109	107	104	105	102	100	101	100	97	94	91	89	83	74	70	58	29				
200,000	110	60	71	79	83	87	86	84	91	99	102	106	105	102	99	96	97	95	92	89	92	88	87	83	79	76	69	59	53	36					
250,000	105	47	60	72	78	83	83	82	88	96	99	101	100	96	91	90	88	87	85	82	83	79	78	73	69	65	57	44	35	17					

Table1a. Estimated sound levels at set radii from Dredging (basket) operations at the Ore Loading Dock, during open water conditions.

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	153	106	117	135	129	129	131	131	144	146	136	139	136	145	142	139	144	143	140	137	136	132	130	126	121	121	118	116	115	115	117	111	110	109	108
300	146	103	110	131	124	123	125	125	138	140	130	135	131	138	138	132	137	134	132	131	130	127	125	120	119	115	114	108	108	110	111	104	102	101	100
1,000	139	96	102	121	114	114	117	117	129	132	121	127	124	130	128	123	132	129	126	124	124	121	117	115	110	108	105	103	102	104	104	96	95	93	91
3,000	132	91	96	115	109	108	111	112	123	125	115	122	118	124	122	119	126	124	121	119	121	115	115	109	106	104	101	97	97	99	98	88	86	82	78
10,000	123	78	84	104	97	96	100	101	110	112	105	112	107	115	113	109	117	114	111	111	112	108	106	102	99	98	94	91	90	90	92	74	67	57	43
30,000	114	56	62	80	75	76	80	83	93	98	92	102	98	106	102	100	107	107	105	105	106	100	99	95	93	91	87	85	85	86	86	46	29		
80,000	106			16	15	19	28	36	51	60	62	76	82	94	87	83	97	102	99	97	99	95	95	90	90	88	86	84	84	84	84				

Table 1b. Estimated sound levels at set radii from Dredging (basket) operations at the Ore Loading Dock, during open water conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	153	103	114	134	128	128	130	131	144	146	136	139	136	145	142	139	144	143	140	137	136	132	130	126	120	121	118	116	114	114	116	109	107	105	103
300	146	99	107	129	123	122	124	125	138	139	130	135	131	138	138	132	137	134	132	131	130	127	125	120	119	114	113	108	108	109	110	102	100	97	95
1,000	138	93	100	120	113	113	116	117	129	132	121	127	123	130	128	123	132	129	126	124	124	121	117	115	109	108	105	102	101	103	103	94	92	89	85
3,000	132	87	94	114	108	107	111	112	123	125	115	122	118	124	122	119	126	124	121	119	120	115	115	109	106	104	100	97	97	98	97	87	84	79	72
10,000	123	74	81	102	96	96	99	100	110	112	105	112	107	115	113	109	117	114	111	111	112	108	106	102	99	98	94	91	90	89	91	72	65	53	38
30,000	114	52	60	79	74	75	80	82	93	98	92	102	98	106	102	100	107	107	105	105	106	100	99	95	93	91	87	84	84	85	85	44	26		
80,000	106			15	14	19	27	35	50	60	62	76	82	94	87	83	97	102	99	97	99	95	95	90	90	88	86	83	83	83	83				

Table 1c. Estimated sound levels at set radii from Dredging (basket) operations at the Ore Loading Dock, during open water conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	149	59	74	96	94	97	104	108	124	130	123	129	129	139	139	136	142	142	140	136	136	132	130	126	120	121	118	116	115	114	117	111	110	109	108
300	141	56	67	92	88	91	98	102	118	123	117	125	123	133	134	130	135	133	132	130	130	127	125	120	119	115	114	108	108	110	111	103	102	101	100
1,000	134	49	59	82	79	82	89	94	109	115	108	117	116	124	124	121	130	128	125	124	124	121	117	114	110	108	105	103	102	104	104	96	94	93	91
3,000	128	44	53	76	74	77	84	89	103	108	102	112	110	118	118	116	124	123	120	119	120	115	115	109	106	104	101	97	97	99	98	88	86	82	77
10,000	120	31	41	65	62	65	72	77	90	96	92	102	100	109	109	107	116	113	111	111	112	108	106	102	99	98	94	91	90	90	92	74	67	57	43
30,000	112	9	19	41	39	44	53	59	73	81	79	92	90	100	98	98	105	106	104	105	105	100	99	95	93	91	87	85	85	86	86	46	29		
80,000	105						0	12	31	43	49	66	74	88	83	81	95	100	98	96	99	95	95	90	90	88	86	84	84	84	84				

Table 1d. Estimated sound levels at set radii from Dredging (basket) operations at the Ore Loading Dock, during open water conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	147	54	69	91	89	92	99	103	119	125	119	125	125	137	136	135	141	142	139	136	135	132	130	126	120	121	118	116	115	114	117	111	110	109	108
300	140	51	62	87	83	86	93	97	113	119	113	121	120	130	132	128	134	132	131	130	130	126	125	120	119	115	114	108	108	110	111	103	102	101	100
1,000	133	44	54	77	74	78	85	89	104	111	104	113	112	122	122	119	129	127	125	123	123	121	117	114	109	108	105	103	102	104	104	96	94	93	91
3,000	127	39	48	71	69	72	79	84	98	104	98	108	107	116	116	114	123	122	120	118	120	115	115	109	106	104	101	97	97	99	98	88	86	82	78
10,000	119	26	36	60	57	60	68	72	86	92	87	98	96	107	107	105	115	113	110	111	112	107	105	102	99	98	94	91	90	90	92	74	67	57	43
30,000	111	4	14	36	35	39	48	54	68	77	75	88	87	98	96	96	104	105	103	104	105	100	99	95	93	91	87	85	85	86	86	46	29		
80,000	105							7	26	39	45	62	71	85	81	79	94	100	97	96	99	94	95	90	90	88	86	84	84	84	84				

Table 1e. Estimated sound levels at set radii from Dredging (basket) operations at the Ore Loading Dock, during open water conditions - Pinnipeds M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	150	71	86	108	106	109	115	118	134	138	130	135	134	143	141	138	143	143	140	137	136	132	130	126	120	121	118	116	115	114	117	111	110	109	107
300	144	67	79	103	100	103	109	112	128	132	125	131	128	137	137	132	136	133	132	131	130	127	125	120	119	115	114	108	108	110	111	103	102	101	99
1,000	136	61	71	94	91	94	100	104	119	124	116	123	121	128	127	123	131	129	126	124	124	121	117	115	110	108	105	103	102	104	104	96	94	92	90
3,000	130	55	65	88	85	88	95	99	112	117	109	118	115	122	121	118	126	124	121	119	120	115	115	109	106	104	101	97	97	99	98	88	86	82	77
10,000	121	43	53	76	73	76	83	88	100	105	99	108	105	113	112	109	117	114	111	111	112	108	106	102	99	98	94	91	90	90	92	74	67	57	43
30,000	113	21	31	53	51	56	64	70	83	90	87	98	95	104	100	100	106	106	104	105	106	100	99	95	93	91	87	85	85	86	86	46	29		
80,000	106						11	23	40	52	56	72	79	92	85	83	96	101	99	96	99	95	95	90	90	88	86	84	84	84	84				

Table2a. Estimated sound levels at set radii from Dredging (cutter) operations at the Ore Loading Dock, during open water conditions.

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	165	129	140	161	152	149	148	142	149	161	149	148	150	150	149	146	147	146	142	143	141	137	135	133	129	127	126	124	126	126	123	125	118	115	112
300	160	126	134	157	146	143	142	136	144	154	141	142	144	145	144	142	141	141	138	137	134	131	129	127	124	121	120	121	121	121	118	118	112	109	106
1,000	151	120	126	147	137	134	133	128	136	146	134	135	135	136	136	133	134	131	129	130	127	122	120	120	118	114	113	113	113	115	112	115	103	99	95
3,000	145	114	120	141	131	128	128	123	131	141	127	129	130	132	131	129	128	127	125	125	122	119	116	115	113	109	108	108	107	108	107	107	95	89	83
10,000	135	101	108	130	119	117	117	112	120	130	116	118	121	121	122	120	119	120	116	117	114	110	108	106	106	100	101	101	100	102	99	97	76	64	49
30,000	121	79	86	106	97	96	97	94	106	117	103	106	109	109	111	112	112	111	109	110	108	103	102	100	96	93	94	94	94	95	92	82	38	8	
80,000	112	6	7	42	37	40	45	47	63	82	74	82	89	96	102	104	104	103	104	105	100	97	98	94	93	90	90	91	91	92	89	57			

Table 2b. Estimated sound levels at set radii from Dredging (cutter) operations at the Ore Loading Dock, during open water conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	165	126	138	160	151	149	147	142	149	160	148	148	150	150	149	146	147	146	142	143	141	137	135	132	129	127	126	123	126	125	121	123	115	111	106
300	159	123	132	155	145	142	141	136	144	154	141	142	144	145	144	142	141	141	138	137	134	131	129	127	124	120	120	121	121	120	117	117	109	105	100
1,000	150	117	124	146	136	134	133	128	136	146	134	135	135	136	136	133	134	131	129	130	127	122	120	120	117	114	112	112	112	114	110	114	101	96	90
3,000	144	111	118	140	130	128	128	123	130	141	127	129	130	132	131	129	128	127	125	125	122	119	116	115	113	109	108	108	107	107	106	105	92	86	77
10,000	134	98	106	128	118	116	116	112	120	130	116	118	121	121	122	120	119	120	116	117	114	110	108	106	106	100	101	101	100	101	98	95	73	60	43
30,000	121	76	84	105	96	95	97	94	105	117	103	106	109	109	111	112	112	111	109	110	108	103	102	100	96	93	94	94	93	95	91	81	36	4	
80,000	112	3	5	41	36	39	44	47	63	81	74	82	89	96	102	104	104	103	104	105	100	97	98	94	93	90	90	91	91	92	88	55			

Table 2c. Estimated sound levels at set radii from Dredging (cutter) operations at the Ore Loading Dock, during open water conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	154	82	98	122	116	118	121	119	129	144	135	138	142	145	145	143	145	144	142	143	140	137	135	132	129	127	126	124	126	126	123	125	117	115	111
300	148	79	91	118	111	112	115	113	124	138	128	132	136	139	140	139	139	139	137	136	134	130	129	127	124	121	120	121	121	121	118	118	112	109	105
1,000	139	73	84	108	102	103	106	104	116	130	121	124	127	131	132	130	132	130	129	130	127	122	120	120	117	114	113	113	113	115	112	115	103	99	95
3,000	134	67	78	102	96	97	101	100	111	124	114	118	123	126	127	127	126	126	124	125	122	119	116	115	113	109	108	108	107	108	107	106	94	89	83
10,000	125	54	65	91	84	86	90	88	100	114	103	108	113	116	118	117	117	119	115	116	114	110	108	106	106	100	101	101	100	102	99	97	75	64	48
30,000	117	32	44	67	62	65	70	70	86	100	90	95	101	104	108	109	110	110	109	110	107	102	102	100	96	93	94	94	93	95	92	82	38	7	
80,000	110			3	2	8	17	23	43	65	61	72	81	90	98	102	102	102	103	104	100	96	98	94	93	90	90	91	91	92	89	57			

Table 2d. Estimated sound levels at set radii from Dredging (cutter) operations at the Ore Loading Dock, during open water conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	152	77	93	117	112	113	116	114	125	140	131	134	139	142	143	142	144	144	141	143	140	137	135	132	129	127	126	124	126	126	123	125	117	115	111
300	146	74	86	113	106	107	110	108	119	133	124	128	133	137	138	138	138	139	136	136	134	130	129	127	124	121	120	121	121	121	118	118	112	109	105
1,000	137	68	79	104	97	98	101	100	111	125	117	121	124	128	130	128	131	129	128	129	127	122	120	120	117	114	113	113	113	115	112	115	103	99	95
3,000	132	62	73	97	91	92	96	95	106	120	110	115	119	123	125	125	125	125	123	125	122	119	115	115	113	109	108	108	107	108	107	106	94	89	83
10,000	124	49	60	86	79	81	85	84	96	110	99	104	110	113	116	115	116	118	114	116	114	110	108	106	106	100	101	101	100	102	99	97	76	64	48
30,000	116	27	39	62	57	60	65	66	81	96	86	92	98	101	105	107	109	109	108	109	107	102	102	100	96	93	94	94	93	95	92	82	38	7	
80,000	109					4	13	19	38	61	57	68	78	88	96	100	101	101	102	104	99	96	98	94	93	90	90	91	91	92	89	57			

Table 2e. Estimated sound levels at set radii from Dredging (cutter) operations at the Ore Loading Dock, during open water conditions - Pinnipeds M-weighting applied

Range	broad	Frequency (Hz)																																
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	158	94	110	134	128	129	132	129	139	153	143	145	147	149	148	145	147	145	142	143	140	137	135	132	129	127	126	124	126	126	122	124	117	114	111
300	151	91	103	130	122	123	126	123	134	146	136	138	142	143	143	141	141	140	137	137	134	130	129	127	124	121	120	121	121	120	118	118	112	109	105
1,000	143	85	96	120	113	114	117	115	126	139	128	131	133	135	135	132	133	131	129	130	127	122	120	120	118	114	113	113	113	115	111	115	103	99	94
3,000	138	79	90	114	108	108	112	110	120	133	122	125	128	130	130	129	127	126	124	125	122	119	116	115	113	109	108	108	107	108	107	106	94	89	82
10,000	128	66	77	103	96	97	100	99	110	123	111	115	118	119	121	119	119	119	116	116	114	110	108	106	106	100	101	101	100	102	99	97	75	64	48
30,000	119	44	55	79	74	76	81	81	95	109	98	102	106	108	110	111	111	111	109	110	108	102	102	100	96	93	94	94	93	95	92	82	38	7	
80,000	111			15	14	20	28	34	53	74	69	78	87	94	101	104	103	103	103	105	100	97	98	94	93	90	90	91	91	92	89	56			

Table 1a. Estimated sound levels at set radii from drilling through ice operations at the Ore Loading Dock, during open water conditions.

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	113	39	51	63	68	70	72	83	86	86	101	98	95	105	102	102	104	105	107	106	98	93	92	89	87	84	83	80	77	75	73	70	67	66	62
300	107	32	43	59	62	64	66	77	80	80	95	93	89	99	98	94	97	99	101	98	90	88	88	84	82	79	77	75	72	69	66	64	59	58	53
1,000	99	26	35	49	53	54	58	69	71	72	86	84	82	90	87	86	91	92	94	91	83	80	80	76	75	73	70	67	66	63	61	56	52	50	44
3,000	93	20	29	43	47	49	53	64	65	65	80	79	75	84	82	80	86	86	88	87	78	76	76	72	68	66	64	61	58	57	54	47	40	36	26
10,000	84	8	17	32	35	38	41	52	52	53	69	69	64	74	71	70	76	77	78	77	69	66	67	62	60	56	55	52	50	48	43	27	15		
30,000	72			8	13	17	22	35	35	38	56	58	54	63	58	58	63	65	67	66	57	56	56	52	49	46	45	41	38	33	22				
75,000	63							7	12	19	40	45	44	55	43	44	51	55	58	57	48	49	48	43	41	37	35	31	25	16					

Table 1b. Estimated sound levels at set radii from drilling through ice operations at the Ore Loading Dock, during open water conditions - Low-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	113	35	49	62	67	69	72	83	86	86	101	98	95	105	102	102	104	105	107	106	98	93	92	89	87	84	83	80	77	74	72	69	64	63	56
300	107	29	41	57	61	63	66	77	79	80	95	93	89	99	98	94	97	99	101	98	90	88	88	84	82	79	77	75	71	68	65	63	57	55	48
1,000	99	23	33	48	52	54	58	69	71	72	86	84	82	90	87	86	91	92	94	91	83	80	80	76	74	73	69	67	65	63	60	55	50	46	38
3,000	93	17	27	42	46	48	53	64	65	65	80	79	75	84	82	80	86	86	88	87	78	76	76	72	68	66	64	61	58	57	53	45	38	32	20
10,000	84	4	14	30	34	37	40	52	52	53	69	69	64	74	71	70	76	77	78	77	69	66	67	62	60	56	55	52	50	47	42	25	12		
30,000	72			6	12	16	21	34	34	38	56	58	54	63	58	58	63	65	67	66	57	56	56	52	49	46	45	41	37	33	21				
75,000	63							7	11	19	40	45	44	55	42	44	51	55	58	57	48	49	48	43	40	37	35	31	25	16					

Table 1c. Estimated sound levels at set radii from drilling through ice operations at the Ore Loading Dock, during open water conditions - Mid-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	112		8	24	33	39	45	59	66	70	88	87	87	100	98	99	102	104	106	106	98	93	92	89	87	84	83	80	77	75	73	70	67	66	61
300	105			20	27	32	39	54	60	63	82	82	82	94	94	91	95	98	100	98	90	88	88	84	82	79	77	75	72	69	66	64	59	58	53
1,000	97			10	17	23	31	46	51	55	73	74	74	85	83	83	90	91	93	90	83	79	80	76	74	73	70	67	66	63	61	56	52	50	44
3,000	91			4	12	18	26	41	45	49	67	68	68	79	78	77	84	85	87	86	78	76	76	72	68	66	64	61	58	57	54	47	40	36	25
10,000	82				0	6	14	29	32	36	56	58	57	68	67	67	74	76	78	77	69	66	67	62	60	56	55	52	50	48	43	27	14		
30,000	70							11	15	22	43	48	46	58	54	55	61	64	66	66	56	56	55	52	49	46	45	41	38	33	22				
75,000	61									3	27	34	36	49	39	41	50	54	58	57	48	49	48	43	40	37	35	31	25	16					

Table 1d. Estimated sound levels at set radii from drilling through ice operations at the Ore Loading Dock, during open water conditions - High-frequency cetaceans M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	111		3	19	28	34	40	55	61	65	84	84	84	97	96	98	101	103	106	105	98	93	92	89	87	84	83	80	77	75	73	70	67	66	62
300	104			15	22	27	34	49	55	59	78	79	78	91	92	90	94	97	100	97	90	87	88	84	82	79	77	75	72	69	66	64	59	58	53
1,000	96			5	12	18	26	41	47	51	69	70	71	82	81	81	88	90	92	90	83	79	80	76	74	73	70	67	66	63	61	56	52	50	44
3,000	91				7	13	21	36	40	45	63	65	64	76	76	76	83	84	87	86	77	76	76	72	68	66	64	61	58	57	54	47	40	36	25
10,000	81					1	9	24	27	32	52	55	53	66	65	66	73	75	77	77	69	66	67	62	60	56	55	52	50	48	43	27	14		
30,000	69							6	10	17	39	44	43	55	52	53	60	63	66	65	56	56	55	52	49	46	45	41	37	33	22				
75,000	61										23	31	33	47	36	40	49	53	57	57	48	49	48	43	40	37	35	31	25	16					

Table 1e. Estimated sound levels at set radii from drilling through ice operations at the Ore Loading Dock, during open water conditions - Pinnipeds M-weighting applied

Range	broad	Frequency (Hz)																																	
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	113	4	20	36	44	50	56	70	76	79	96	94	92	104	101	101	104	105	107	106	98	93	92	89	87	84	83	80	77	75	73	70	67	66	61
300	106		12	32	38	44	50	64	69	72	90	89	87	97	97	93	96	99	101	98	90	88	88	84	82	79	77	75	72	69	66	64	59	58	53
1,000	98		4	22	29	34	42	56	61	64	81	81	79	88	86	85	91	92	93	91	83	80	80	76	75	73	70	67	66	63	61	56	52	50	43
3,000	92			16	24	29	37	51	55	58	75	75	73	82	81	79	85	86	88	86	78	76	76	72	68	66	64	61	58	57	54	47	40	35	25
10,000	83			4	11	18	25	39	42	45	64	65	62	72	70	69	76	77	78	77	69	66	67	62	60	56	55	52	50	48	43	27	14		
30,000	71						5	22	24	30	51	54	51	62	57	57	63	65	67	66	57	56	56	52	49	46	45	41	37	33	22				
75,000	62								1	12	35	41	41	53	41	43	51	55	58	57	48	49	48	43	41	37	35	31	25	16					

Table 2a. Estimated sound levels at set radii from drilling through the seabed operations at the Ore Loading Dock, during open water conditions.

Range (m)	broad band	Frequency (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	152	88	98	107	111	114	110	120	128	133	139	138	136	143	147	143	137	134	130	142	140	139	132	128	123	123	117	113	110	109	109	118	107	108	108
300	146	83	91	103	105	108	104	114	122	127	132	132	130	138	142	138	131	129	125	135	133	132	126	122	117	117	113	108	106	103	106	112	101	102	102
1,000	137	77	83	93	95	99	96	106	114	118	124	125	122	128	134	130	123	120	117	129	127	123	117	116	109	111	104	100	98	98	97	104	91	90	89
3,000	132	71	77	87	90	94	91	101	109	113	118	119	118	125	130	126	117	114	113	122	121	120	113	109	104	105	98	95	91	89	91	94	80	77	72
10,000	122	58	64	75	78	82	79	90	99	102	106	107	107	114	118	114	106	105	103	113	113	110	104	100	94	96	90	86	82	80	79	75	55		
30,000	111	36	43	52	56	61	60	72	84	88	93	92	94	100	107	103	96	94	93	102	102	100	93	90	82	83	78	73	67	66	61	37			
75,000	102			13	19	27	30	45	61	70	77	78	83	92	99	95	88	84	85	93	94	91	84	80	73	73	66	62	53	49	29				
80,000	25								17	23	21	16																							

Table 2b. Estimated sound levels at set radii from drilling through the seabed operations at the Ore Loading Dock, during open water conditions - Low-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	152	85	96	106	110	114	110	120	128	133	139	138	136	143	147	143	137	134	130	142	140	139	132	128	123	123	117	113	109	109	108	116	104	104	103
300	146	80	89	101	104	107	104	114	122	126	132	132	130	138	142	138	131	129	125	135	133	132	125	122	117	117	113	108	105	103	105	110	98	98	97
1,000	137	73	81	91	94	98	95	106	114	118	124	125	122	128	134	130	123	120	117	129	127	123	117	116	109	111	103	99	97	97	96	103	88	86	84
3,000	132	67	75	86	89	93	91	101	109	113	118	119	118	125	130	126	117	114	113	122	121	120	112	109	104	105	98	95	90	89	90	93	78	73	67
10,000	122	55	62	74	77	81	78	89	99	102	106	107	107	114	118	114	106	105	103	113	113	110	104	100	94	96	89	85	81	79	78	74	52	38	19
30,000	111	33	40	50	55	61	59	72	84	88	93	92	94	100	107	103	96	94	93	102	102	100	92	90	82	83	77	73	67	66	60	35			
75,000	102			11	18	26	29	45	61	70	77	78	83	92	99	95	88	84	85	93	94	91	84	80	73	73	66	62	52	48	28				
80,000	25								16	22	21	16																							

Table 2c. Estimated sound levels at set radii from drilling through the seabed operations at the Ore Loading Dock, during open water conditions - Mid-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	149	41	56	68	76	83	83	96	108	117	126	128	128	138	144	140	135	133	130	141	140	139	132	128	123	123	117	113	110	109	109	118	107	107	108
300	142	36	48	64	70	77	77	90	102	110	119	122	122	133	138	136	129	128	125	135	133	132	125	122	117	117	113	108	106	103	106	112	101	101	102
1,000	134	30	40	54	60	67	69	82	94	102	111	114	114	123	130	127	121	119	117	128	126	122	117	116	109	111	104	100	98	98	97	104	91	90	89
3,000	129	24	34	48	55	62	64	78	89	97	104	108	110	119	126	123	116	113	112	122	121	120	112	109	104	105	98	95	91	89	91	94	80	77	72
10,000	119	11	22	36	43	51	52	66	79	86	93	97	99	108	115	111	105	104	103	112	113	110	103	100	94	96	90	86	82	80	79	75	55	42	24
30,000	108			13	21	30	33	48	64	72	80	82	86	95	103	100	95	93	92	101	102	100	92	90	82	83	78	73	67	66	61	37			
75,000	100						2	21	41	53	64	68	76	87	95	93	86	83	84	93	94	91	83	80	73	73	66	62	52	49	29				
80,000	11									6	8	6																							

Table 2d. Estimated sound levels at set radii from drilling through the seabed operations at the Ore Loading Dock, during open water conditions - High-frequency cetaceans M-weighting applied

Range (m)	broad band	Frequency (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	147	36	51	63	71	78	78	92	103	112	122	124	125	135	141	139	134	132	129	141	140	138	132	128	122	123	117	113	110	109	109	118	107	107	108
300	141	31	43	59	65	72	72	86	98	106	114	118	119	130	136	134	128	127	124	134	133	131	125	122	117	117	113	108	106	103	106	112	101	101	102
1,000	133	25	35	49	55	63	64	77	90	97	107	111	111	120	128	126	120	118	116	128	126	122	116	115	109	111	104	100	98	98	97	104	91	90	89
3,000	128	19	29	43	50	57	59	73	85	92	100	105	107	116	124	121	114	112	111	122	121	120	112	109	104	105	98	95	91	89	91	94	80	77	72
10,000	118	6	17	31	38	46	47	61	74	81	89	93	96	105	112	110	103	103	102	112	112	110	103	100	94	96	90	86	82	80	79	75	55	42	24
30,000	107			8	16	25	28	44	59	68	76	78	83	92	101	98	93	92	92	101	102	99	92	90	82	83	78	73	67	66	61	37			
75,000	99							17	37	49	60	64	72	84	93	91	85	82	84	92	94	90	83	80	73	73	66	62	52	49	29				
80,000	7									2	3	2																							

Table 2e. Estimated sound levels at set radii from drilling through the seabed operations at the Ore Loading Dock, during open water conditions - Pinnipeds M-weighting applied

Range (m)	broad band	Frequency (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	151	53	67	80	87	94	94	107	118	125	133	134	133	142	146	142	136	134	130	142	140	139	132	128	123	123	117	113	110	109	109	118	107	107	108
300	145	48	60	75	81	88	88	101	112	119	126	128	127	136	141	137	130	129	125	135	133	132	125	122	117	117	113	108	106	103	106	112	101	101	101
1,000	136	42	52	66	72	79	80	93	104	111	119	121	119	127	133	129	122	120	117	129	127	123	117	116	109	111	104	100	98	98	97	104	91	90	89
3,000	131	36	46	60	67	74	75	88	99	106	112	115	115	123	129	125	117	114	112	122	121	120	112	109	104	105	98	95	90	89	91	94	80	76	71
10,000	121	23	34	48	54	62	63	76	89	95	101	103	104	112	117	113	106	105	103	113	113	110	104	100	94	96	90	85	82	80	79	75	55	41	23
30,000	110	1	12	25	33	41	44	59	74	81	88	88	91	99	106	102	96	93	93	101	102	100	92	90	82	83	78	73	67	66	61	37			
75,000	101					7	13	32	51	62	72	74	81	91	97	94	87	84	85	93	94	91	84	80	73	73	66	62	52	49	29				
80,000	19								6	15	15	12																							

Table1a. Estimated sound levels at set radii from Blasting operations at the Ore Loading Dock, during thick ice conditions.

Range	broad	Frequency (Hz)																															
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	194	159	169	179	182	181	180	179	179	181	181	179	180	180	180	180	180	179	179	180	180	182	182	180	179	180	179	179	179	178	177	178	175	175	175
300	188	154	162	175	176	175	174	173	173	174	174	173	174	175	175	175	174	175	174	173	173	175	175	173	174	173	175	174	175	172	173	173	170	169	169
1,000	179	148	154	165	166	166	166	165	165	166	166	166	167	165	166	167	166	165	166	167	167	165	166	167	166	167	166	165	167	167	164	165	159	158	156
3,000	174	142	148	159	161	161	161	160	160	161	160	160	162	161	162	162	161	160	162	160	161	163	162	161	161	161	160	160	159	158	159	155	149	145	139
10,000	163	129	135	148	149	149	149	149	150	150	149	148	151	150	151	151	150	151	152	151	153	153	153	151	151	152	152	151	151	149	146	136	124	110	91
30,000	151	107	113	124	127	128	130	131	135	136	135	133	138	137	139	139	140	139	142	140	142	143	142	142	139	139	140	138	136	135	128	98	64	22	
80,000	139	21	23	41	47	48	56	72	86	97	102	103	121	123	127	130	130	122	133	125	133	130	131	130	128	125	126	124	119	113	90				

Table 1b. Estimated sound levels at set radii from Blasting operations at the Ore Loading Dock, during thick ice conditions - with bubble curtain

Range	broad	Frequency (Hz)																															
(m)	band	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
100	179	144	154	164	167	166	165	164	164	166	166	164	165	165	165	165	165	164	164	165	165	167	167	165	164	165	164	164	164	163	162	163	160	160	160
300	173	139	147	160	161	160	159	158	158	159	159	158	159	160	160	160	159	160	159	158	158	160	160	158	159	158	160	159	160	157	158	158	155	154	154
1,000	164	133	139	150	151	151	151	150	150	151	151	151	152	150	151	152	151	150	151	152	152	150	151	152	151	152	151	150	152	152	149	150	144	143	141
3,000	159	127	133	144	146	146	146	145	145	146	145	145	147	146	147	147	146	145	147	145	146	148	147	146	146	146	145	145	144	143	144	140	134	130	124
10,000	148	114	120	133	134	134	134	134	135	135	134	133	136	135	136	136	135	136	137	136	138	138	138	136	136	137	137	136	136	134	131	121	109	95	76
30,000	136	92	98	109	112	113	115	116	120	121	120	118	123	122	124	124	125	124	127	125	127	128	127	127	124	124	125	123	121	120	113	83	49	7	
80,000	125	6	8	26	32	33	41	57	71	82	87	88	106	108	112	115	115	107	118	110	118	115	116	115	113	110	111	109	104	98	75				