

Baffinland 2022 Underwater Acoustic Monitoring

Preliminary analysis of noise from vessel convoys

JASCO Applied Sciences (Canada) Ltd

1 February 2023

Submitted to:

Lou Kamermans
Baffinland Iron Mines

Authors:

Melanie Austin

P001348-016
Version 1.0



Suggested citation:

Austin, M. 2023. Baffinland 2022 Underwater Acoustic Monitoring: Preliminary analysis of noise from vessel convoys. Version 1.0. Technical report by JASCO Applied Sciences for Baffinland Iron Mines.

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

Acronyms	1
Executive Summary	2
1. Introduction	3
2. Methods	5
3. Results	6
4. Discussion	13
5. Summary	16
Appendix A. Summary of 120 dB Exceedance Durations for Individual Vessels Measured by JASCO since 2018	A-1

Figures

- Figure 1. Acoustic monitoring locations along the Northern Shipping Route (AMAR-EFE, AMAR-WFE, and AMAR-MI) for the 2022 shipping season. AMAR-EFE and AMAR-WFE recorded data between 07 Jul 2022 and 07 Aug 2022, AMAR-MI from 13 Aug 2022 through 01 Oct 2022. 3
- Figure 2 Sound Pressure Level (SPL; left axis) as a function of time recorded at (left) AMAR-EFE and (right) AMAR-WFE while three ore carriers and two tugs transited inbound through Eclipse Sound on 31 Jul 2022 (UTC) heading to Milne Port. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μ Pa. Note that Noorderzon is a non-Baffinland vessel. 9
- Figure 3 Sound Pressure Level (SPL; left axis) as a function of time recorded at (left) AMAR-EFE and (right) AMAR-WFE while two ore carriers transited inbound through Eclipse Sound on 01 Aug 2022 heading to Milne Port. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μ Pa. 9
- Figure 4 Sound Pressure Level (SPL; left axis) as a function of time recorded at (left) AMAR-EFE and (right) AMAR-WFE while two ore carriers transited inbound through Eclipse Sound on 03 Aug 2022 heading to Milne Port. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μ Pa. 9
- Figure 5 Sound Pressure Level (SPL; left axis) as a function of time recorded at (left) AMAR-EFE and (right) AMAR-WFE while two ore carriers transited inbound through Eclipse Sound on 06 Aug 2022 heading to Milne Port. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μ Pa. Note that Pierre Radisson is a non-Baffinland vessel. 10
- Figure 6 Sound Pressure Level (SPL; left axis) as a function of time recorded at AMAR-MI while two ore carriers transited through Milne Inlet on (top left) 20 Aug 2022 going inbound, (top right) 22 Aug 2022 going outbound, (mid left) 01 Sep 2022 going inbound, (mid right) 02 Sep 2022 going inbound, (bottom left) 30 Sep 2022 going outbound, and (bottom right) 30 Sep 2022 going inbound. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μ Pa. 11
- Figure 7 Sound Pressure Level (SPL; left axis) as a function of time recorded at AMAR-MI while an ore carrier and a sealift vessel transited outbound through Milne Inlet on 17 Sep 2022. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μ Pa. 12
- Figure A-1 Exceedance durations (120 dB re 1 μ Pa SPL) for individual vessel transits measured in Milne Inlet and Eclipse Sound in 2018 (circles), 2019 (squares), 2020 (triangles), and 2022 (diamonds). Colour indicates vessel speed. Vessel speeds exceeding 9 knots occurred only in 2018, prior to strict implementation of the 9 knot speed restriction mitigation. Vessel speeds in 2019-2022 were 9 knots or less, whereas vessels were allowed to travel between 7-10 knots in 2018. A-1
- Figure A-2 Exceedance durations (120 dB re 1 μ Pa SPL) for individual vessel transits measured in Milne Inlet (red) and Eclipse Sound (blue) in 2018, 2019, 2020, and 2022. A-2
- Figure A-3 Exceedance durations (120 dB re 1 μ Pa SPL) for individual vessel transits measured in Milne Inlet and Eclipse Sound in 2018, 2019, 2020, and 2022. Colour indicates vessel's closest point of approach to the acoustic recorder. A-3
- Figure A-4 Exceedance durations (120 dB re 1 μ Pa SPL) for individual vessel transits measured in Milne Inlet and Eclipse Sound in 2018, 2019, 2020, and 2022, for vessels transiting inbound to Milne Port (blue) and vessel transiting outbound from Milne Port (red). A-4

Tables

Table 1 Deployment locations	4
Table 2. AMAR-EFE: Convoy transits recorded in eastern Eclipse Sound during 2022 early shoulder season and total 120 dB exceedance duration for each transit.	6
Table 3. AMAR-WFE: Convoy transits recorded in western Eclipse Sound during 2022 early shoulder season and total 120 dB exceedance duration for each transit.	7
Table 4 AMAR-MI: Convoy transits recorded in Milne Inlet during 2022 shipping season and total 120 dB exceedance duration for each transit.	8
Table 5 Details for convoy transits measured in 2022, 120 dB exceedance durations for each convoy, and average 120 dB exposure durations for the individual corresponding vessels (averaged). The locations where the convoy were measured are indicated in brackets. Vessel names are followed by (I) for inbound transits and (O) for outbound transits.	15

ዲጋራል ስፔክትሮስኮፒ

AMAR - የጥንቃቄ ስፔክትሮስኮፒ ስርዓት ስርዓት

CPA - የጥንቃቄ ስፔክትሮስኮፒ

LSR - ስርዓት ስፔክትሮስኮፒ ስርዓት

RSA - ስርዓት ስፔክትሮስኮፒ ስርዓት

SPL - ስርዓት ስፔክትሮስኮፒ ስርዓት

Acronyms

AMAR – Autonomous Multichannel Acoustic Recorder

CPA – closest point of approach

LSR – listening space reduction

RSA – regional study area

SPL – sound pressure level

Executive Summary

JASCO Applied Sciences' (JASCO) conducted an Acoustic Monitoring Program for Baffinland Iron Mine Corporation's (Baffinland's) Mary River Project in 2022, in which underwater sound levels were collected at two locations in Eclipse Sound and one location in Milne Inlet. When feasible, in 2022 Baffinland implemented vessel convoys to investigate their effectiveness as a mitigation measure intended to reduce the total amount of noise exposure from shipping within the Regional Study Area (RSA). In this context, a convoy is defined as a transit involving 2 or more Project vessels, transiting in the same direction, within 10 km of each other. It was predicted that the noise footprint for a vessel convoy would be slightly larger than the individual footprint of the loudest vessel in the convoy, but smaller than total footprint for all the convoy vessels individually, and that the noise footprint for a convoy of two similar vessels would be less than two times the footprint for either vessel individually. Thus, the convoy mitigation measure was implemented based on the hypothesis that there would be a reduction of the total amount of sound exposure throughout the shipping season.

Underwater sound level measurements were collected for convoys in Eclipse Sound between 31 Jul and 7 Aug 2022. The measured convoys included the following configurations:

- 1 measurement of 3 ore carriers and 2 tugs in convoy (inbound)
- 3 measurements of 2 ore carriers in convoy (inbound)

Measurements of convoys in Milne Inlet were collected between 13 Aug and 01 Oct 2022, and included measurements of the following convoy configurations:

- 6 measurements of 2 ore carriers in convoy (4 inbound and 2 outbound)
- 1 measurement of 1 ore carrier and 1 sealift vessel in convoy (outbound)

Sound levels measured during the vessel convoys were compared to previously measured noise footprints for transits of the corresponding vessels on their own. Specifically, JASCO compared the total 120 dB exceedance duration (i.e. the time when the sound pressure level exceeded 120 dB re 1 μ Pa) for each convoy with the total amount of time that the sound level would have exceeded 120 dB re 1 Pa had the vessels in the convoy transited individually (i.e. not in a convoy formation). This analysis was completed for 9 of the 11 measured convoys. The exposure duration analysis could not be completed for the other 2 convoys because the convoy was either too far from the acoustic recorder or because a third vessel transiting in the opposite direction influenced the measurement.

These initial results support the hypothesis that vessel convoys can be an effective means to reduce the overall sound exposure throughout the shipping season. Multiple measurements of individual vessels, and of consistent convoy configurations, reveal a high degree of variability across measurements, particularly within Milne Inlet, due to differences of the vessels' closest point of approach to the acoustic recorders, the vessel's speed, the vessel's heading, and environmental conditions at the time of the measurement such as sea state and current strength. Therefore, in some instances (2 of the 9 considered convoys) the 120 dB exceedance duration for the convoy was greater than the sum of the average 120 dB exceedance duration for the individual vessels in the convoy. This is likely due to situational differences between the measurements. For 7 of the 9 considered convoys, the 120 dB exceedance duration for the convoy was less than the sum of the average 120 dB exceedance durations for the individual vessels in the convoy. Indicating that, overall, the use of convoys is expected to result in a net reduction of sound exposure in the RSA throughout the shipping season.

1. Introduction

Underwater sound level measurements were collected at two locations in Eclipse Sound and one location in Milne Inlet as part of JASCO Applied Sciences' (JASCO) 2022 Acoustic Monitoring Program conducted for Baffinland Iron Mine Corporation's (Baffinland's) Mary River Project (Figure 1, Table 1). In 2022, Baffinland implemented some additional measures intended to mitigate potential narwhal exposure to shipping noise. Specifically, Baffinland committed to delay the start of shipping until there was a clear path with an ice concentration of 3/10ths or less along the entire Northern Shipping Route to avoid use of an icebreaker and, when feasible, Baffinland implemented vessel convoys as a mitigation measure intended to reduce the total amount of noise exposure from shipping within the Regional Study Area (RSA). In this context, a convoy is defined as a transit involving multiple Project vessels, transiting in the same direction, within 10 km of each other.

Measured underwater sound levels were used to characterize the noise footprint for the vessel convoys, in comparison to the noise footprint for transits of the individual vessels on their own. It was predicted that the noise footprint for a vessel convoy would be slightly larger than the individual footprint of the loudest vessel in the convoy, but smaller than total footprint for all the convoy vessels individually, and that the footprint for a convoy of two similar vessels would be less than two times the footprint for either vessel individually. Thus, the convoy mitigation measure was implemented based on the hypothesis that there would be a reduction of the total amount of ensonification throughout the shipping season.

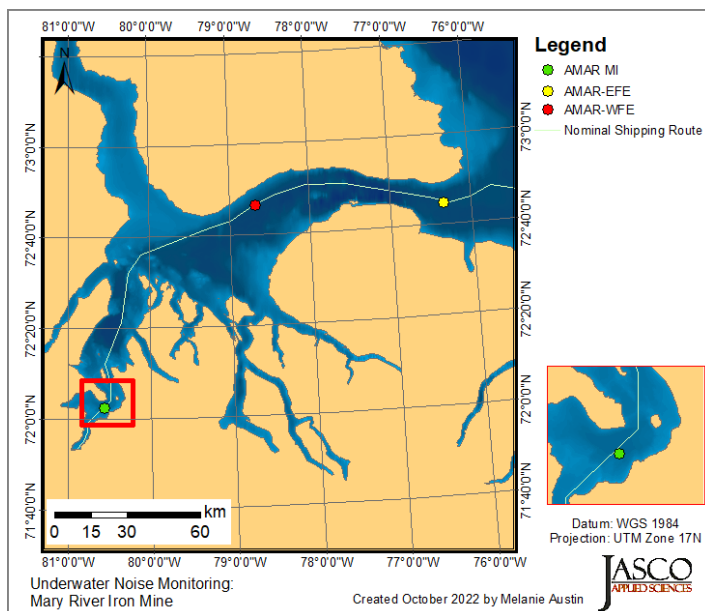


Figure 1. Acoustic monitoring locations along the Northern Shipping Route (AMAR–EFE, AMAR–WFE, and AMAR-MI) for the 2022 shipping season. AMAR-EFE and AMAR-WFE recorded data between 07 Jul 2022 and 07 Aug 2022, AMAR-MI from 13 Aug 2022 through 01 Oct 2022.

Table 1 Deployment locations

Location	Latitude	Longitude	Depth (m)
AMAR-WFE	72° 46.400' N	78° 40.223' W	-575
AMAR-EFE	72° 44.455' N	76° 19.730' W	-650
AMAR-MI	72° 02.187' N	080° 33.366' W	-275

2. Methods

Underwater acoustic data were collected in Eclipse Sound between 7 Jul and 7 Aug 2022 and in Milne Inlet between 13 Aug and 01 Oct 2022, using JASCO's Autonomous Multichannel Acoustic Recorders (AMARs). Baffinland vessels first entered the RSA on 30 Jul local time (31 Jul UTC). This preliminary report focuses exclusively on convoy vessel transits recorded starting 31 Jul (UTC), with the primary objective of characterizing a preliminary analysis of the underwater noise levels generated by vessels transiting in convoys. A comprehensive analysis of all underwater sound levels recorded at these locations will be presented in a separate acoustic monitoring report that will document the spatial and temporal variability of the recorded underwater sounds, marine mammal vocalization occurrence, and results of a Listening Space Reduction (LSR) analysis.

The analysis for this preliminary report involved processing acoustic data from AMAR-EFE, a recorder located near the mouth of Baffin Bay at the entrance of Eclipse Sound; AMAR-WFE, located west of Pond Inlet in Eclipse Sound; and AMAR-MI, located in Milne Inlet. All recorder locations overlap with the nominal shipping route (Figure 1). The acoustic analysis considered segments of data recorded within 1 hour before and after the closest points of approach (CPA) to the acoustic recorder for all Project-vessel transits in this period. In this preliminary analysis, the data were analyzed to determine the 120 dB exceedance duration for the measured convoys in comparison to the exceedance duration for individual transits of the vessels comprising the convoys. Here we use a sound pressure level (SPL) of 120 dB re 1 μ Pa to define the exceedance duration because this threshold has been used for indicating noise levels where there is potential marine mammal behavioural disturbance. When vessels travelled in convoys, this analysis considered the combined noise from all vessels in the convoy and the exceedance duration is the total time when the SPL exceeded 120 dB re 1 μ Pa during the passage of all vessels in the convoy past the corresponding acoustic recorder.

Underwater sound was recorded with Autonomous Multichannel Acoustic Recorders—Generation 4 (AMAR G4, JASCO). Each AMAR was fitted with an M36-V35-100 omnidirectional hydrophone (GeoSpectrum Technologies Inc., -165 ± 3 dB re 1 V/ μ Pa sensitivity). All devices were calibrated to within 1 dB using a pistonphone calibrator in JASCO's laboratory before shipping, and in the field immediately before deployment and upon retrieval. The AMAR hydrophones were protected by a hydrophone cage, which was covered with a shroud to minimize noise artifacts from water flow. JASCO's moorings are designed to be silent to prevent any mooring noise that could contaminate the acoustic recordings; all metal mooring components were isolated and/or rubber coated to avoid metal-on-metal contact that could generate underwater noise, and no chains were used in the mooring. The AMARs recorded with a duty cycle of 14 minutes continuously at 64,000 samples per second with 6 dB gain for a recording bandwidth of 10 Hz to 32 kHz then for 1 continuous minute at 512,000 samples per second for a recording bandwidth of 10 Hz to 256 kHz.

Received SPLs during each transit were computed in 1-second, Hann-weighted, time windows with 50% overlap. These time-stamped SPL data were compared to the distance of each vessel from the AMAR at the respective times. We computed the distances in the forward and aft directions (i.e., measured as the vessels approached the AMAR and as the vessels moved away from the AMAR, respectively) where the measured SPL was at or above 120 dB re 1 μ Pa. We plotted the SPL and distance data as a function time and determined the total amount of time during which received sound levels exceeded 120 dB re 1 μ Pa for each of the analyzed transits.

3. Results

The analyzed data at AMAR-EFE and AMAR-WFE included one convoy with 5 vessels (3 ore carriers and 2 tugs) and three transits with 2 ore carriers in convoy, all transiting toward Milne Port (inbound) at the start of the 2022 shipping season. The 5-vessel convoy was the first group of vessels, and was the only transit to occur on that first day of Baffinland shipping on 31 Jul. This convoy included two tugs, which only transit through the RSA on the first and on the last day of the shipping season. The analyzed data at AMAR-MI included 3 inbound convoys of 2 ore carriers, 3 outbound convoys of 2 ore carriers, and 1 outbound convoy with an ore carrier and a sealift vessel. The vessels in all measured convoys were spaced less than 3.5 km from each other during the measurements, conforming with the definition of a convoy for this analysis. Details about the analyzed convoys are provided in Table 2 (AMAR-EFE), Table 3 (AMAR-WFE), and Table 4 (AMAR-MI), along with the total duration when the recorded SPL exceeded 120 dB re 1 μ Pa for each convoy transit.

Figures 2 through 5 are plots of the broadband SPL (on the left axis) as a function of time recorded when the convoys transited past AMAR-EFE (left) and AMAR-WFE (right). Figure 6 and Figure 7 are plots of the data from convoy transits at AMAR-MI. The right hand axis of each figure shows the distances between each vessel and the AMARs through time.

Table 2. AMAR-EFE: Convoy transits recorded in eastern Eclipse Sound during 2022 early shoulder season and total 120 dB exceedance duration for each transit.

Lead vessel CPA time (UTC)	Vessels in convoy						Total duration SPL > 120 dB (min)
	Inbound/Outbound	Horizontal Range to AMAR at CPA (m)	Name	Vessel type	Distance from forward vessel (km)	Speed (kn)	
31 Jul 2022 01:50	Inbound	NA [†]	<i>Nordic Olympic</i>	Ore carrier	-	NA [†]	32.1
		831	<i>Nordic Siku</i>	Ore carrier	3.2	8	
		987	<i>Nordic Odin</i>	Ore carrier	1.7	8.5	
		1191	<i>Ocean Tundra</i>	Tug	1.2	8.1	
		1128	<i>Ocean Taiga</i>	Tug	0.7	8.3	
01 Aug 2022 00:30	Inbound	1246	<i>Nordic Sanngjuq</i>	Ore carrier	-	8.2	94.1*
		1245	<i>Nordic Odyssey</i>	Ore carrier	2.1	8.3	
03 Aug 2022 04:48	Inbound	NA [†]	<i>Arkadia</i>	Ore carrier	-	NA ^{††}	0.0
		861	<i>Nordic Qinnua</i>	Ore carrier	3.4	7.0	
06 Aug 2022 11:49	Inbound	1030	<i>Nordic Orion</i>	Ore carrier	-	8.1	0.0
		1004	<i>Golden Opal</i>	Ore carrier	2.1	8.6	

[†]AIS data for *Nordic Olympic* was too sparse during this time to compute these values.

^{††}AIS data for *Arkadia* was too sparse during this time to compute these values.

*High background levels at this time, see Figure 3 left.

CPA = Closest Point of Approach; SPL = sound pressure level; AMAR = Autonomous Multichannel Acoustic Recorder

Table 3. AMAR-WFE: Convoy transits recorded in western Eclipse Sound during 2022 early shoulder season and total 120 dB exceedance duration for each transit.

Lead vessel CPA time (UTC)	Vessels in convoy						Total duration SPL > 120 dB (min)
	Inbound/Outbound	Horizontal Range to AMAR at CPA (m)	Name	Vessel type	Distance from forward vessel (km)	Speed (kn)	
31 Jul 2022 07:19	Inbound	323	<i>Nordic Olympic</i>	Ore carrier	-	7.5	50.7
		357	<i>Nordic Siku</i>	Ore carrier	2.6	7.7	
		243	<i>Nordic Odin</i>	Ore carrier	1.9	7.8	
		279	<i>Ocean Tundra</i>	Tug	1.7	8.2	
		219	<i>Ocean Taiga</i>	Tug	1.0	8.1	
01 Aug 2022 05:42	Inbound	424	<i>Nordic Sanngjuq</i>	Ore carrier	-	8.3	10.3
		336	<i>Nordic Odyssey</i>	Ore carrier	2.2	8.2	
03 Aug 2022 10:06	Inbound	259	<i>Arkadia</i>	Ore carrier	-	7.8	45.1*
		411	<i>Nordic Qinnua</i>	Ore carrier	3.4	8.1	
06 Aug 2022 16:54	Inbound	390	<i>Nordic Orion</i>	Ore carrier	-	8.6	0.0
		398	<i>Golden Opal</i>	Ore carrier	2.4	8.0	

* *Nordic Siku* was passing the convoy in the opposite direction during this transit, travelling outbound, which extended the 120 dB duration for this period. See Figure 4, right.

CPA = Closest Point of Approach; SPL = sound pressure level; AMAR = Autonomous Multichannel Acoustic Recorder

Table 4 AMAR-MI: Convoy transits recorded in Milne Inlet during 2022 shipping season and total 120 dB exceedance duration for each transit.

Lead vessel CPA time (UTC)	Vessels in convoy						Total duration SPL > 120 dB (min)
	Inbound/ Outbound	Horizontal Range to AMAR at CPA (m)	Name	Vessel type	Distance from forward vessel (km)	Speed (kn)	
20 Aug 2022 03:47	Inbound	266	<i>Golden Ruby</i>	Ore carrier	-	7.3	25.5
		216	<i>Golden Amber</i>	Ore carrier	1.7	8.0	
22 Aug 2022 14:06	Outbound	110	<i>Golden Ruby</i>	Ore carrier	-	7.9	49.6
		105	<i>Golden Amber</i>	Ore carrier	1.8	7.7	
01 Sep 2022 02:47	Inbound	43	<i>Golden Freeze</i>	Ore carrier	-	8.7	28.1
		12	<i>Nordic Olympic</i>	Ore carrier	2.4	8.5	
02 Sep 2022 17:28	Inbound	48	<i>Nordic Siku</i>	Ore carrier	-	8.1	28.5
		73	<i>Nordic Orion</i>	Ore carrier	2.5	8.4	
17 Sep 2022 21:00	Outbound	225	<i>Golden Diamond</i>	Ore carrier	-	8.1	43.2
		138	<i>Rosaire A. Desgagnes</i>	Sealift	1.3	8.5	
30 Sep 2022 07:59	Outbound	230	<i>M.V. Golden Brilliant</i>	Ore carrier	-	8.0	42.0
		451	<i>Golden Fast</i>	Ore carrier	1.7	8.0	
30 Sep 2022 11:23	Inbound	167	<i>Golden Bull</i>	Ore carrier	-	8.1	14.4
		221	<i>Golden Furious</i>	Ore carrier	1.9	8.1	

CPA = Closest Point of Approach; SPL = sound pressure level; AMAR = Autonomous Multichannel Acoustic Recorder

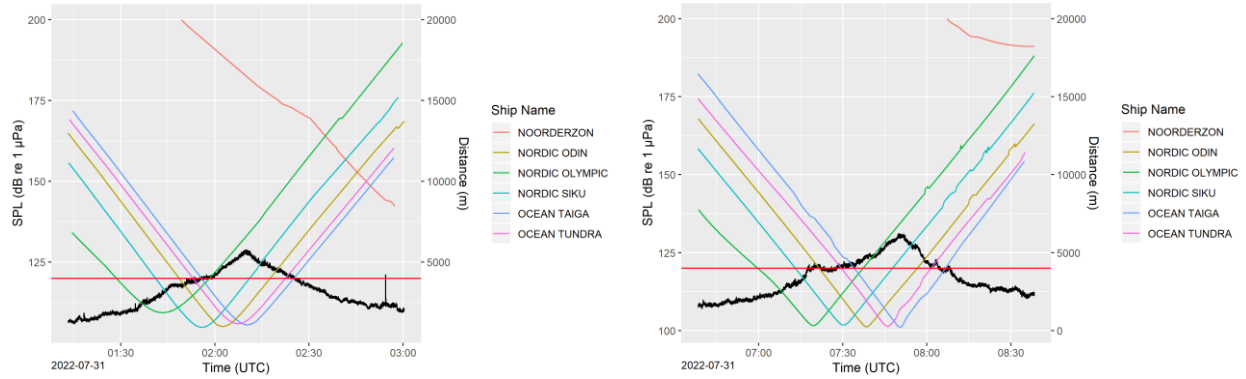


Figure 2 Sound Pressure Level (SPL; left axis) as a function of time recorded at (left) AMAR-EFE and (right) AMAR-WFE while three ore carriers and two tugs transited inbound through Eclipse Sound on 31 Jul 2022 (UTC) heading to Milne Port. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μ Pa. Note that Noorderzon is a non-Baffinland vessel.

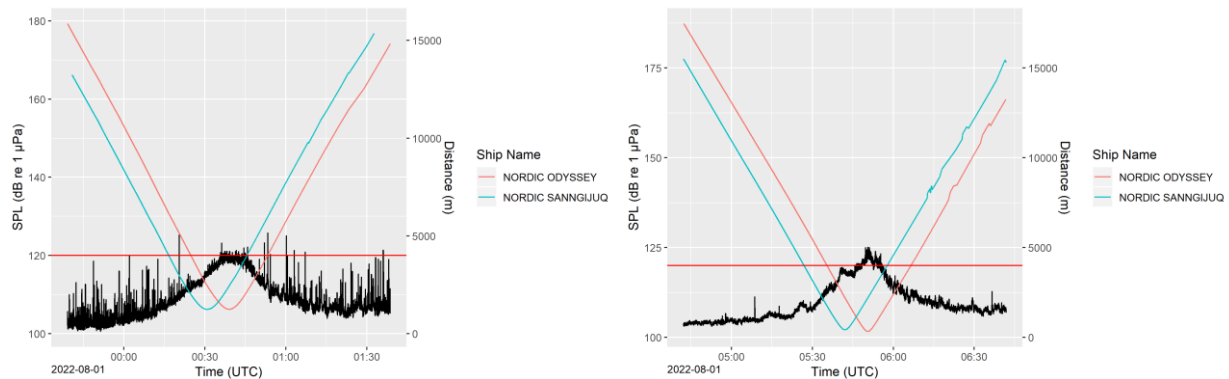


Figure 3 Sound Pressure Level (SPL; left axis) as a function of time recorded at (left) AMAR-EFE and (right) AMAR-WFE while two ore carriers transited inbound through Eclipse Sound on 01 Aug 2022 heading to Milne Port. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μ Pa.

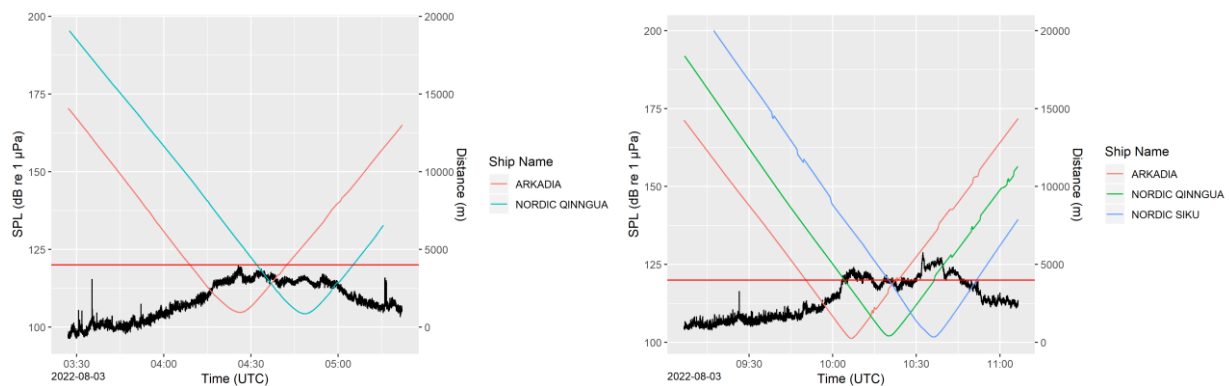


Figure 4 Sound Pressure Level (SPL; left axis) as a function of time recorded at (left) AMAR-EFE and (right) AMAR-WFE while two ore carriers transited inbound through Eclipse Sound on 03 Aug 2022 heading to Milne Port. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μ Pa.

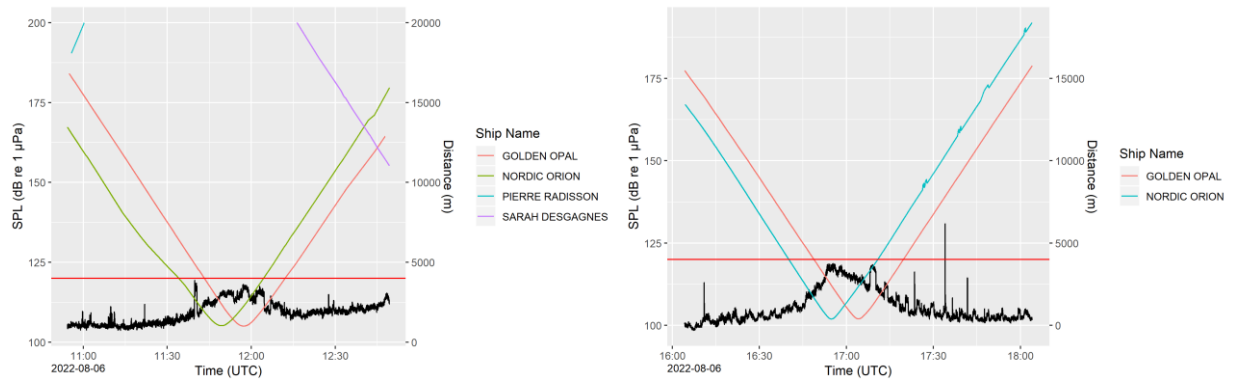


Figure 5 Sound Pressure Level (SPL; left axis) as a function of time recorded at (left) AMAR-EFE and (right) AMAR-WFE while two ore carriers transited inbound through Eclipse Sound on 06 Aug 2022 heading to Milne Port. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 μPa. Note that Pierre Radisson is a non-Baffinland vessel.

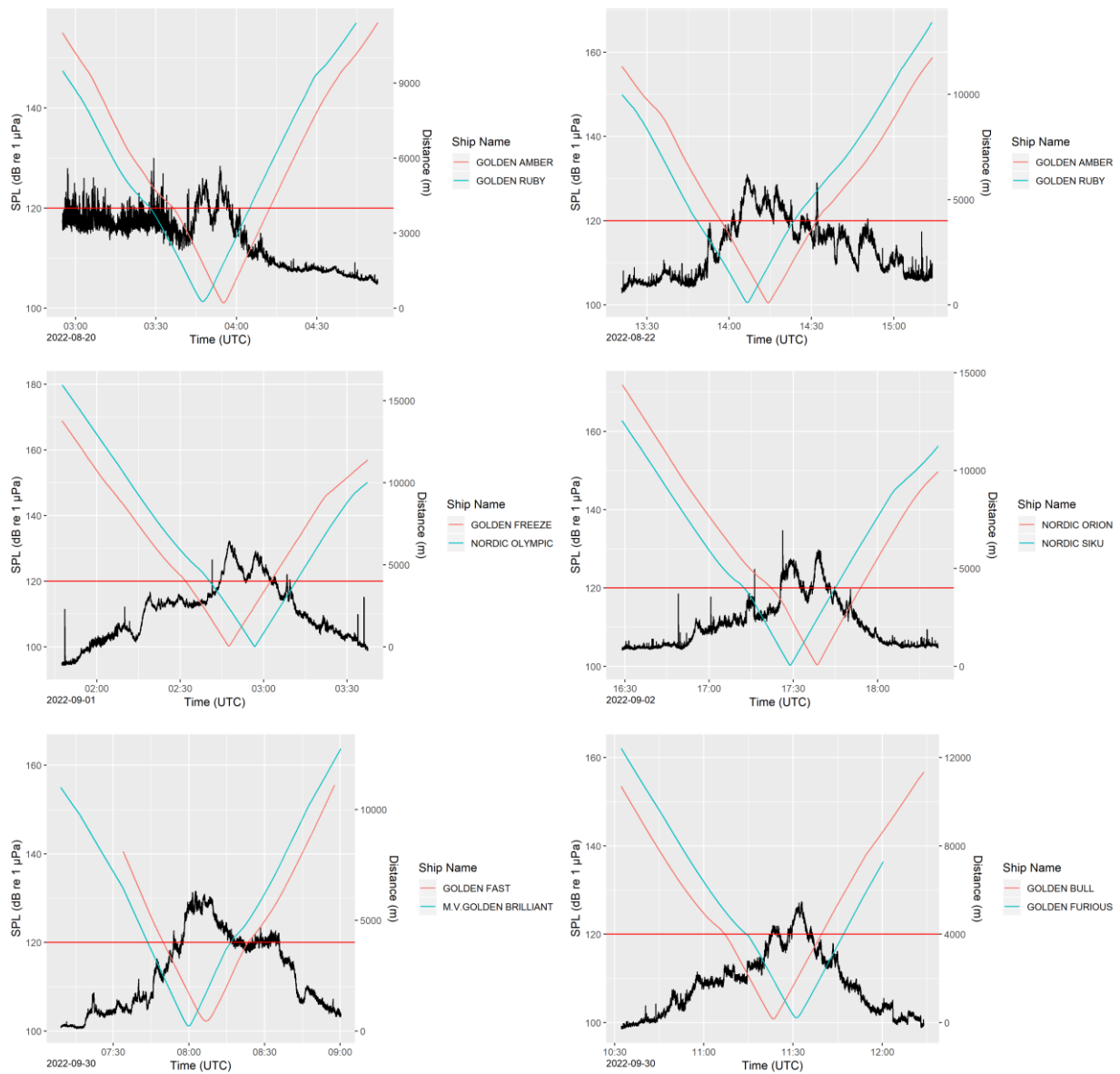


Figure 6 Sound Pressure Level (SPL; left axis) as a function of time recorded at AMAR-MI while two ore carriers transited through Milne Inlet on (top left) 20 Aug 2022 going inbound, (top right) 22 Aug 2022 going outbound, (mid left) 01 Sep 2022 going inbound, (mid right) 02 Sep 2022 going inbound, (bottom left) 30 Sep 2022 going outbound, and (bottom right) 30 Sep 2022 going inbound. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 µPa.

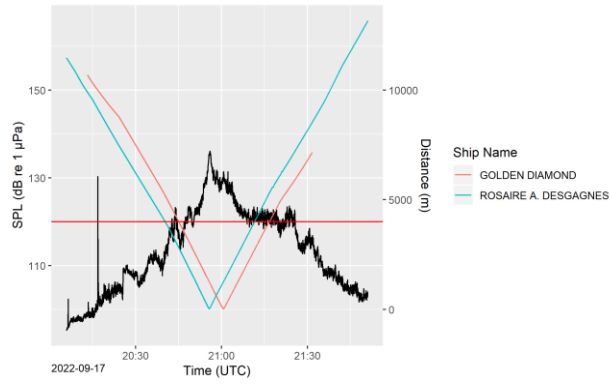


Figure 7 Sound Pressure Level (SPL; left axis) as a function of time recorded at AMAR-MI while an ore carrier and a sealift vessel transited outbound through Milne Inlet on 17 Sep 2022. The distances (right axis) between the vessels and the recorder are plotted in colour. A solid red horizontal line marks 120 dB re 1 µPa.

4. Discussion

During the vessel convoys, the SPL rises to its highest level at the vessels' CPA. The width and steepness of this peak of the SPL versus time is in part dependent on the CPA to the AMAR; this peak being broader and rounder when the vessels are further from the AMAR and steeper at closer approach distances. For some of the convoys, the CPA was greater than the distance where the SPL exceeded 120 dB re 1 μ Pa and therefore sound levels above the 120dB threshold were not recorded on the AMAR (e.g. convoys past AMAR-EFE on 03 and 06 Aug 2022).

It is difficult to directly compare the 120 dB exceedance durations across transits because the CPA was not consistent for all transits. The 120 dB exceedance duration will also depend on the vessels' speeds, vessels' headings (since sound levels may differ for inbound vessels that are unladen and outbound vessels that are laden), but also on environmental metrics such as ocean current and sea state at the time of measurement. Therefore, the 120 dB exceedance durations are quite variable across transits, even for multiple transits of the same vessel and for transits with similar convoy configurations. As such, it is difficult to compare 120 dB exceedance durations for a convoy transit with transits of the corresponding vessels individually, since they are measured at different times with slight differences in the influencing parameters of CPA distance, speed, heading, currents, and sea state.

In an effort to understand the variability in the data, we examined the 120 dB exceedance durations as a function of these influencing parameters for all analyzed vessel transits measured by JASCO since 2018 (Appendix A). Counterintuitively, there was not a consistent trend noted in the 120 dB exceedance duration with CPA distance, speed, heading, or measurement location. These results lead us to hypothesize that undefined environmental factors may be influencing the degree of variability in the measurements. This is noted particularly in the data collected in Milne Inlet, where the vessels maneuver to follow the turn of the shipping route as they pass Poirier Island (Qikiqtatannak). The typical expectation, all conditions being equal, is for sound levels to decrease with increasing vessel range from the AMAR. But, during some transits the sound level versus range data level off (or sometimes increase) for a time as the vessels make this turn (e.g. bottom left panel of Figure 6 and Figure 7). For some transits, this has the effect of extending the 120 db duration. This trend of the SPL data versus range is not consistent for all transits and therefore may be a function of the power required by the vessel's engines at the time of making the turn at Poirier Island. Perhaps due to the situational weather conditions, the vessel's loading, or other navigational factors such as the rate of turn.

The variability of the 120 dB exceedance durations (due to differences of the influencing parameters at the times of measurement) confound a comparison between convoy transits and individual transits of the corresponding vessels. Since there were no discernible trends between the 120 dB exceedance duration and the influencing parameters (Appendix A), for this analysis we considered the average 120 dB exceedance duration for each individual vessel that was part of a convoy in 2022, averaged over all available measurements collected since 2018, regardless of the measurement conditions (i.e. including measurements with influencing parameters that differ from the conditions during the convoy). The resulting average 120 dB exceedance durations for each vessel were then compared to the 120 dB exceedance durations for the corresponding convoy transits (Table 5). Table 5 excludes the two convoys for which a 120 dB exceedance duration could not be computed (i.e. the convoy with *Arkadia* and the *Nordic Qinnua* from 3 Aug, since noise from the *Nordic Siku* impacted that measurement, and the convoy from 6 Aug with the *Golden Opal* and the *Nordic Orion* since their CPAs exceeded the 120 dB distances for the vessels).

In seven of the nine convoys (78%) included in the comparative analysis in Table 5, the 120 dB exceedance duration for the convoy was less than the sum of the 120 dB durations for the

individual vessels comprising the convoy. This supports the hypothesis that convoys can be an effective mitigation measure to reduce the overall sound exposure throughout the shipping season in comparison to the total sound exposure that would occur if all vessels transited individually.

Table 5 Details for convoy transits measured in 2022, 120 dB exceedance durations for each convoy, and average 120 dB exposure durations for the individual corresponding vessels (averaged). The locations where the convoy were measured are indicated in brackets. Vessel names are followed by (I) for inbound transits and (O) for outbound transits.

Lead vessel CPA time (UTC)	Vessels in convoy							Corresponding Vessels travelling alone, Averaged over all available measurements		
	Name	Vessel type	Vessel Length (m)	Range from forward vessel (km)	Speed (kn)	Horizontal Range to AMAR at CPA(m)	Total duration SPL > 120 dB (min)	Mean Duration SPL > 120 dB (min)	Number of measurements in average	Sum of durations for individual vessels
31 Jul 2022 01:50	<i>Nordic Olympic (I)</i>	Ore carrier	225	-	NA	NA	32.1 - 50.7 (EFE) (WFE)	36.4	6	186.5
	<i>Nordic Siku (I)</i>	Ore carrier	229	3.2	8	831		25.9	2	
	<i>Nordic Odin (I)</i>	Ore carrier	225	1.7	8.5	987		13.8	5	
	<i>Ocean Tundra (I)</i>	Tug	36	1.2	8.1	1191		55.2	1	
	<i>Ocean Taiga (I)</i>	Tug	36	0.7	8.3	1128				
01 Aug 2022 00:30	<i>Nordic Sanngijjuq (I)</i>	Ore carrier	229	-	8.2	1246	10.3 (WFE)	12.8	1	57.8
	<i>Nordic Odyssey (I)</i>	Ore carrier	225	2.1	8.3	1245		45.0	4	
20 Aug 2022 03:47	<i>Golden Ruby (I)</i>	Ore carrier	225	-	7.3	266	25.5 (MI)	20.5	6	34.8
	<i>Golden Amber (I)</i>	Ore carrier	225	1.7	8.0	216		14.3	4	
22 Aug 2022 14:06	<i>Golden Ruby (O)</i>	Ore carrier	225	-	7.9	110	49.6 (MI)	20.5	6	34.8
	<i>Golden Amber (O)</i>	Ore carrier	225	1.8	7.7	105		14.3	4	
01 Sep 2022 02:47	<i>Golden Freeze (I)</i>	Ore carrier	225	-	8.7	43	28.1 (MI)	50.0	1	86.4
	<i>Nordic Olympic (I)</i>	Ore carrier	225	2.4	8.5	12		36.4	6	
02 Sep 2022 17:28	<i>Nordic Siku (I)</i>	Ore carrier	229	-	8.1	48	28.5 (MI)	25.9	2	53.3
	<i>Nordic Orion (I)</i>	Ore carrier	225	2.5	8.4	73		27.4	5	
17 Sep 2022 21:00	<i>Golden Diamond (O)</i>	Ore carrier	225	-	8.1	225	43.2 (MI)	23.1	4	44.3
	<i>Rosaire A. Desgagnes (O)</i>	Sealift	138	1.3	8.5	138		21.2	1	
30 Sep 2022 07:59	<i>M.V. Golden Brilliant (O)</i>	Ore carrier	225	-	8.0	230	42.0 (MI)	17.5	8	27.4
	<i>Golden Fast (O)</i>	Ore carrier	229	1.7	8.0	451		9.9	2	
30 Sep 2022 11:23	<i>Golden Bull (I)</i>	Ore carrier	225	-	8.1	167	14.4 (MI)	22.0	5	37.5
	<i>Golden Furious (I)</i>	Ore carrier	229	1.9	8.1	221		15.5	2	

5. Summary

This preliminary report summarizes an analysis of underwater sound levels measured during transits of convoys and individual vessels during Baffinland's 2022 shipping season. Measurements were collected for convoys including:

- 3 ore carriers and 2 tugs
- 2 ore carriers
- 1 ore carrier and 1 sealift vessel

It was not possible in 2022 to collect measurements of a convoy involving a fuel tanker due to timing logistics. Convoys including an icebreaker were intentionally avoided for this pilot study because data for icebreaker convoys are already available from previous measurements. Baffinland also avoided the use of an icebreaker at the start of the shipping season, when the acoustic data were collected.

These initial results support the hypothesis that vessel convoys can be an effective means to reduce the overall sound exposure throughout the shipping season. This analysis has highlighted the variability in the sound footprint for vessel transits, particularly within Milne Inlet, due to differences of the vessels' closest point of approach to the acoustic recorder, the vessel's speed, the vessel's heading, and environmental conditions at the time of the measurement. Therefore, in some instances (2 of the 9 considered convoys, see Table 5) the 120 dB exceedance duration for the convoy was greater than the sum of the average 120 dB exceedance duration for the individual vessels in the convoy, likely due to situational differences between the measurements. For 7 of the 9 considered convoys, the 120 dB exceedance duration for the convoy was less than the sum of the average 120 dB exceedance durations for the individual vessels in the convoy.

Appendix A. Summary of 120 dB Exceedance Durations for Individual Vessels Measured by JASCO since 2018

The following plots present 120 dB exceedance durations measured for the individual vessels that were involved in convoys during Baffinland shipping in 2022. These data were collected during individual vessel transits in Milne Inlet in 2018, 2019, and 2020 as well as either in Milne Inlet or in Eclipse Sound in 2022. The plots include the same data, but presented with different visualizations to examine the effect of the following influencing parameters:

- Figure Figure A-2: speed (separated by year)
- Figure Figure A-3: closest points of approach to the acoustic recorder
- Figure Figure A-4: direction (i.e. inbound vs outbound vessels)
- Figure Figure A-1: location (Milne Inlet or Eclipse Sound)

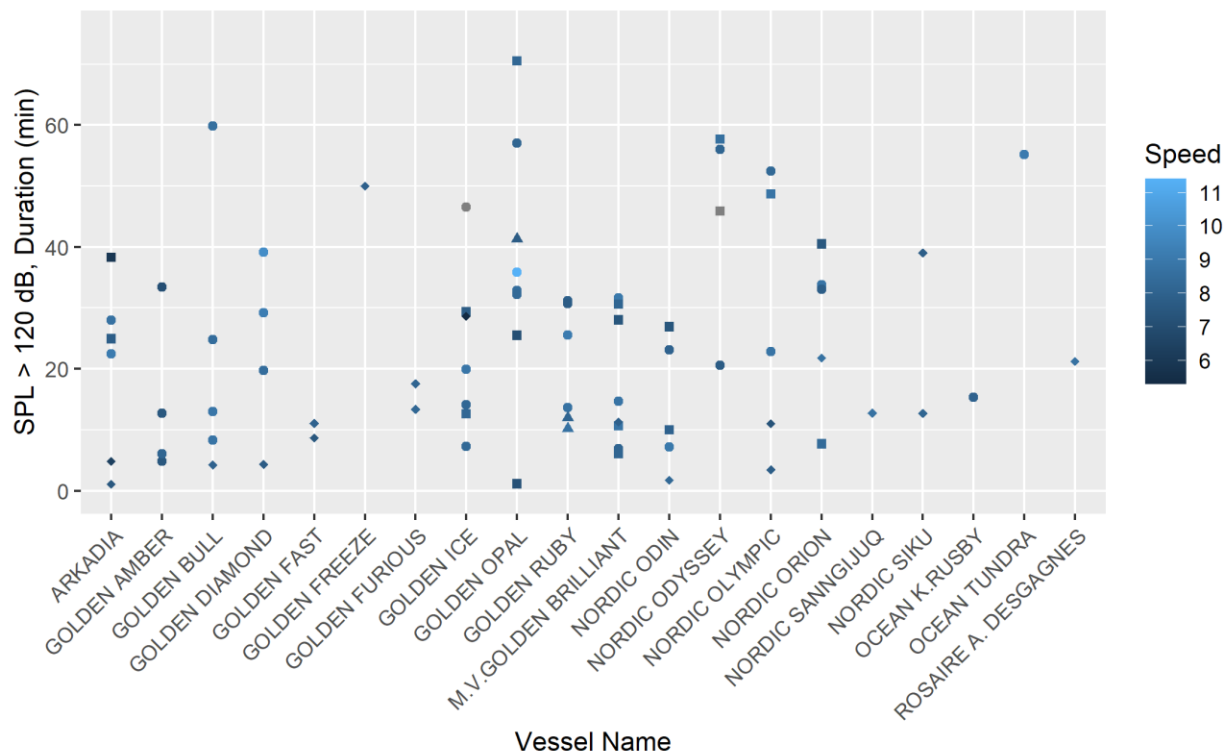


Figure A-1 Exceedance durations (120 dB re 1 μ Pa SPL) for individual vessel transits measured in Milne Inlet and Eclipse Sound in 2018 (circles), 2019 (squares), 2020 (triangles), and 2022 (diamonds). Colour indicates vessel speed. Vessel speeds exceeding 9 knots occurred only in 2018, prior to strict implementation of the 9 knot speed restriction mitigation. Vessel speeds in 2019-2022 were 9 knots or less, whereas vessels were allowed to travel between 7-10 knots in 2018.

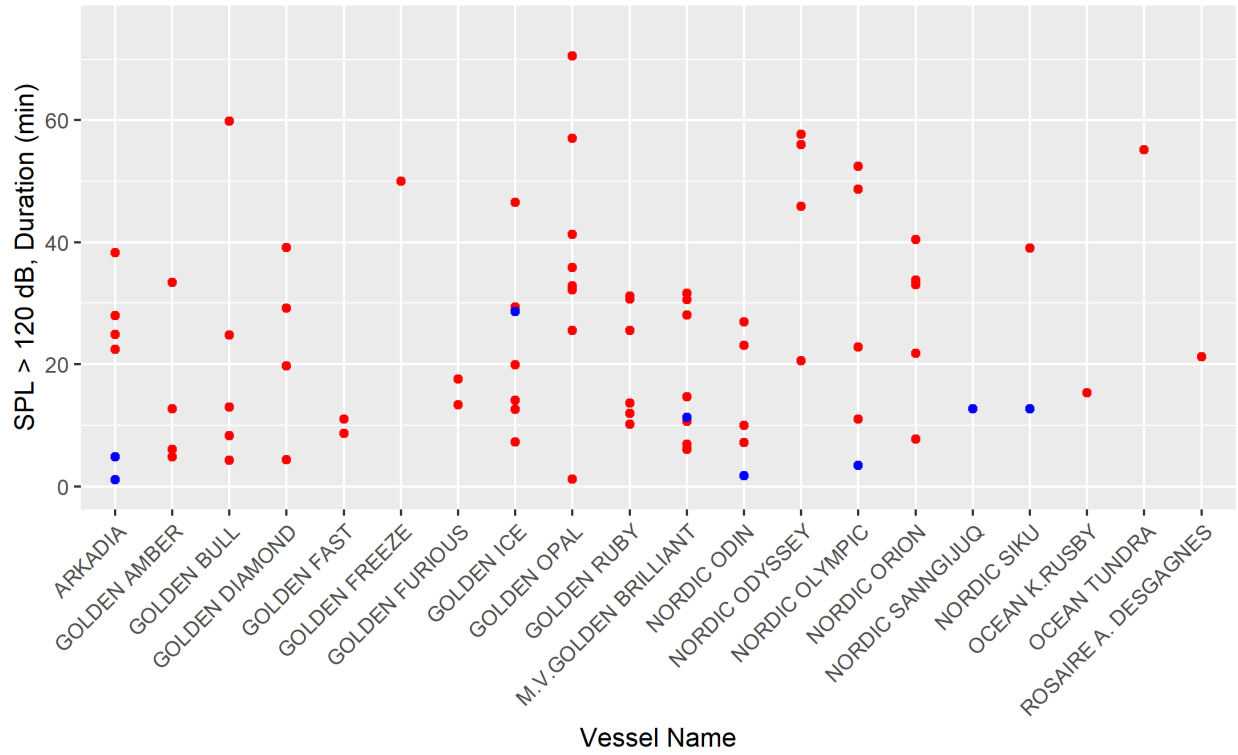


Figure A-2 Exceedance durations (120 dB re 1 μ Pa SPL) for individual vessel transits measured in Milne Inlet (red) and Eclipse Sound (blue) in 2018, 2019, 2020, and 2022.

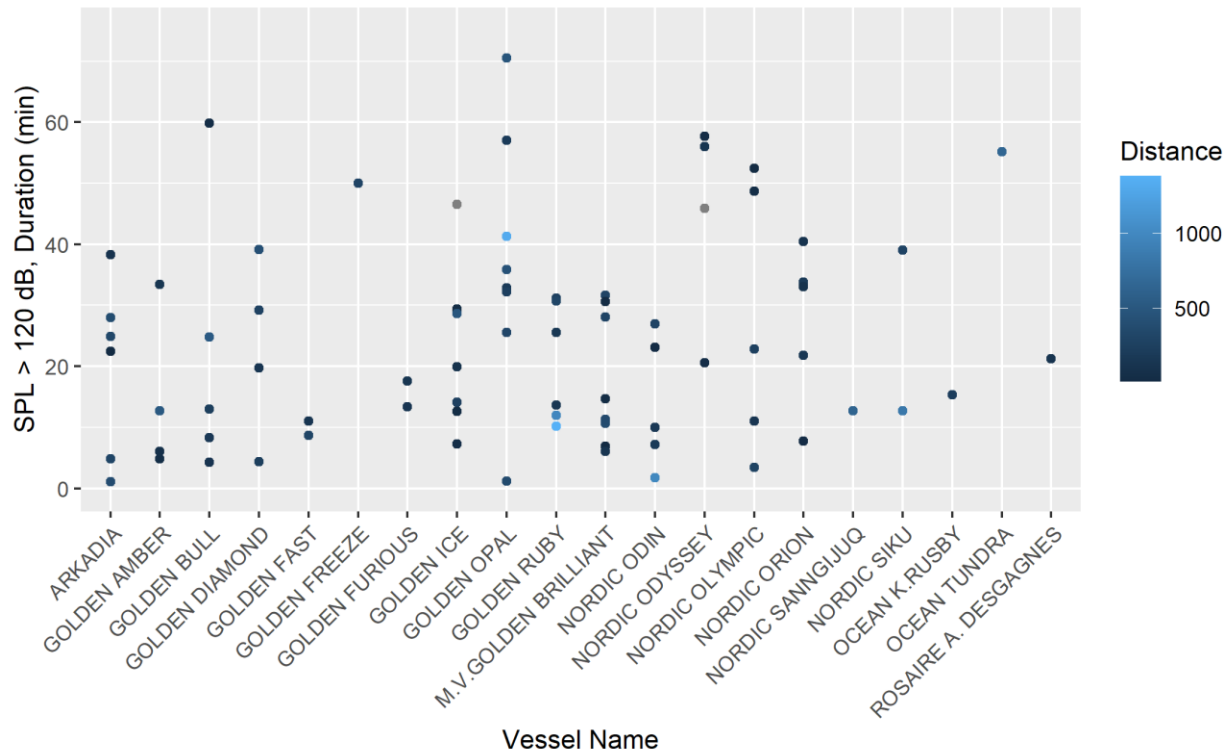


Figure A-3 Exceedance durations (120 dB re 1 μ Pa SPL) for individual vessel transits measured in Milne Inlet and Eclipse Sound in 2018, 2019, 2020, and 2022. Colour indicates vessel's closest point of approach to the acoustic recorder.

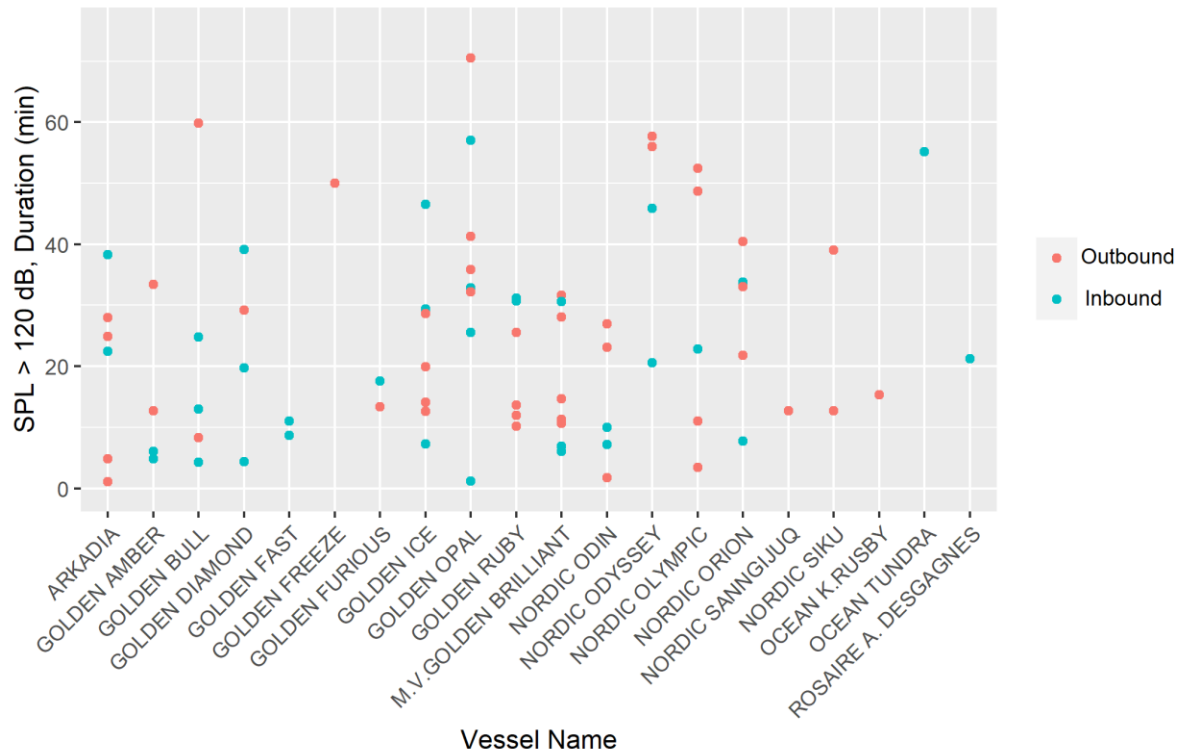


Figure A-4 Exceedance durations (120 dB re 1 μ Pa SPL) for individual vessel transits measured in Milne Inlet and Eclipse Sound in 2018, 2019, 2020, and 2022, for vessels transiting inbound to Milne Port (blue) and vessel transiting outbound from Milne Port (red).