MEASUREMENT OF VESSEL UNDERWATER ACOUSTIC SIGNATURE – REPEATABILITY ASSESSED ON THE MARS DATABASE

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1 Introduction

Shipping is the main contributor of anthropogenic noise pollution in the ocean, globally spread and increasing steadily, with adverse effects on marine life. In support for emerging initiatives to reduce shipping noise and mitigate its effects on marine life, the Marine Acoustic Research Station (MARS) applied research project aims to improve measurement, understanding and modeling of underwater noise radiated by ships [1]. A recording station was moored along the St. Lawrence shipping lane during the summer seasons 2021 and 2022. The MARS database contains ~1000 underwater acoustic signatures of ships, representative of the commercial fleet using the St. Lawrence seaway. In this study, we focus on ships that have been measured repeatedly, to demonstrate the reliability of the measurements collected by the MARS station.

2 Method

2.1 The MARS database

The MARS station was specifically designed to collect and process ship noise data following the recommendations of the ANSI/ASA S12.64-2009 [2] and ISO-17208-1 [3] standards, to produce acoustic signatures. Acoustic signatures used in this study are expressed as Monopole Source Level (MSL) on third-octave bands at 1 m. The MSL metric treats the ship's source as a monopole, taking into accounts multiple paths by applying a propagation model [4]. The MARS database consists of about 1000 acoustic signatures measured from 593 individual ships. This database includes a subset of 173 high-quality acoustic signatures from 121 individual ships from participating shipowners, having followed a pre specified measurement protocol to optimize the quality of the acoustic measurement.

2.2 Subset and data analysis

In this study, we focused on the subset of high-quality acoustic signatures. We identified repeated measurements from individual ships, at similar speed, to assess the ability to reproduce the measurement of an acoustic signature.

A preliminary analysis was carried out on four repeated measurements of the same ship, at speeds ranging from 12.6 to 13.7 knots from which we were able to compare the four independent measurements of an acoustic signature.

3 Preliminary observations

The four acoustic signatures collected all share similar features, showing a loud cavitation noise on the 20 – 100 Hz band (Figure 1). The observed spread between the maximum and minimum values of the four signatures is consistent across the 20 – 500 Hz spectrum. For quantification of the spreading between the four acoustic signatures considered and across all the frequency spectrum, we considered the mean signature as the reference for this ship (Figure 1).

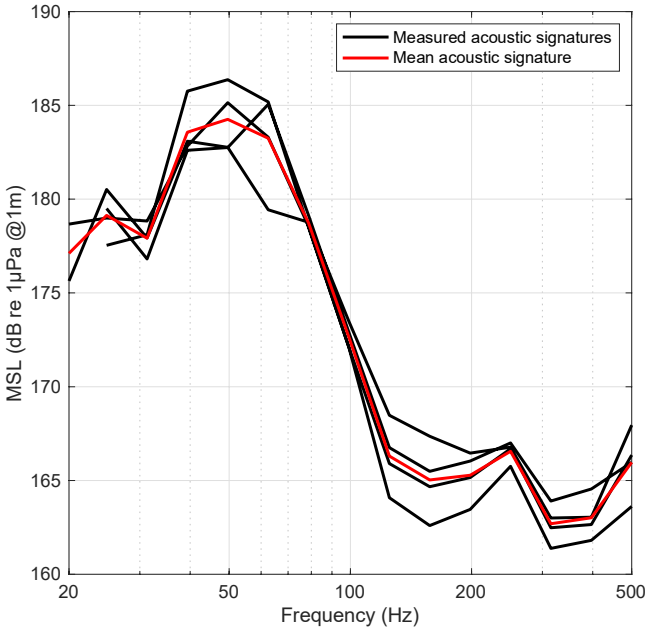

Figure 1: Spectrum of the 4 acoustic signatures collected (black) and mean acoustic signature constructed as a reference (red), expressed in Monopole Source Level (MSL) on third octave bands. Vessel speed ranging from 12.6 to 13.7 knots.

The error was defined as the difference between each acoustic signature and the reference. Analysis of the distribution of the error (Figure 2) shows that 85 % of the observations are within 2 dB from the reference, and the standard deviation of the error is 1.3 dB. Further analysis on an extended dataset including all repeated measurements taken at comparable speed is in progress and will allow to produce robust statistics regarding the expected variability of the acoustic signature measurements taken by the MARS station.

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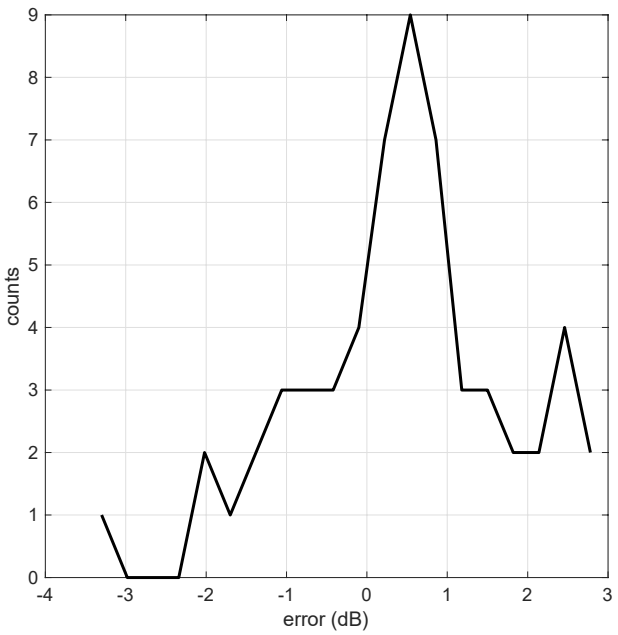

Figure 2: Distribution of the error between each of the 4 acoustic signatures collected and the reference on each third octave bands within 20 – 500 Hz. Associated standard deviation is 1.3 dB.

4 Discussion

The MARS project is building a large dataset of acoustic signatures representative of the underwater noise levels emitted by the St. Lawrence fleet. A significant effort was made to follow the recommendations of the international standards [2,3], and provide high quality acoustic signatures to the scientific community, the industrial actors of the shipping industry, and to the institutions involved in regulation, mitigation, and conservation. The ability to quantify and demonstrate the reliability of our measurements is key to improve acceptability of the decisions based on the MARS database.

This preliminary result is encouraging, regarding the repeatability expected by the ANSI/ASA S12.64-2009 standard [2], of 1.5 dB for the highest grade, and 2 dB and 3 dB for the grades B and C, respectively. Our analysis suggests that 70 % of our observation have an error under 1.5 dB, and 85 % under 2 dB.

It is worth noting that this result was obtained from a ship actively participating in the MARS project, and therefore following a protocol specifically designed to improve accuracy of the measurement. It is expected that data collected from ships being measured without following the protocol will show lower repeatability scores.

5 Conclusion

The design and development of a cutting-edge acoustic recording station, deployed in an ideal environment (bathymetry and proximity from the shipping lane) is a major part of the work carried out by the MARS team. The aim is to collect high-quality measurements and provide the best possible dataset to scientists, industrial partners and regulation and conservation institutions. This preliminary quantification of the repeatability of the measurements suggests that the MARS station will be able to quantify the efficiency of mitigation measures within a 2 dB difference for a ship actively taking part to the measurement process.

Acknowledgments

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References

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