Quantifying the effects of mitigation measures on North Sea shipping noise

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Introduction

The EU Interreg North Sea Region project DEMASK (Development and Evaluation of noise MAnagement Strategies to Keep the North Sea healthy) aims to help maritime policymakers and other stakeholders, evaluate future scenarios and set priorities for a well-managed soundscape. Scenarios to mitigate the underwater noise from ships are evaluated via modelled statistical sound maps, enabling the study of the potential impact on the habitat of selected aquatic species. The effect of mitigation measures is first studied in generic local scenarios, so that the most promising measures can be selected before quantifying their effect in large-scale sound maps.

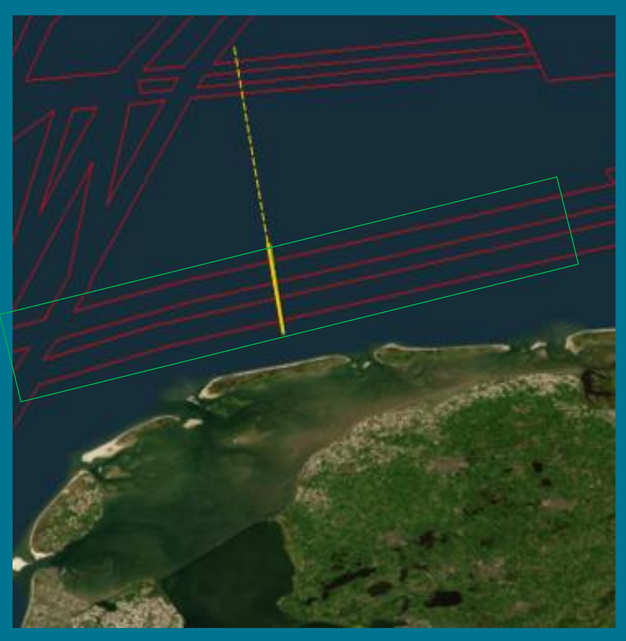

Fig. 1: Synthetic shipping lane.

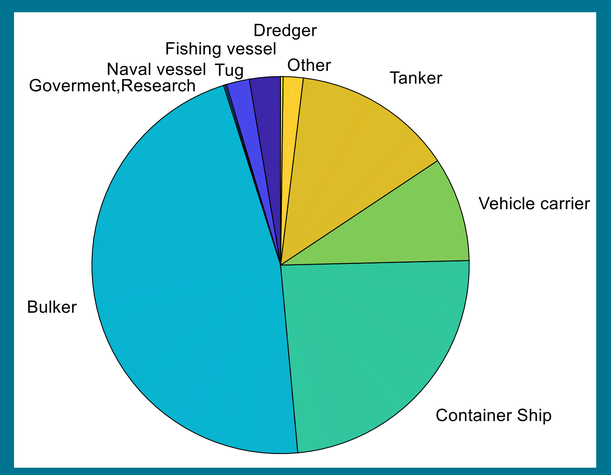

Fig. 2: Ship class distribution.

Synthetic shipping lane modelling

A synthetic shipping lane scenario is developed to study the effects of mitigation measures to reduce the underwater noise from ship traffic. The scenario is designed using recorded AIS (automatic identification system) data for ships passing through a shipping lane (yellow solid line, 24 km wide, Fig. 1) north of the Dutch Wadden Islands in January 2020. The study focuses on four primary categories of vessels: bulk carriers, container ships, vehicle carriers, and tankers (Fig. 2). Assuming that the selected ships sail at constant speed along a straight shipping lane (200 km length, green polygon) in a uniform environment, the monthly statistics of the broadband (16 Hz to 20 kHz) sound pressure level (SPL) are calculated as a function of the distance to the shipping lane (Fig. 5). Ship source levels (Fig. 3) are calculated using the JOMOPANS-ECHO ship source level model (Mac Gillivray & de Jong, 2021). Propagation loss (Fig. 4) is calculated using a RAM parabolic equation model (Colins 1993).

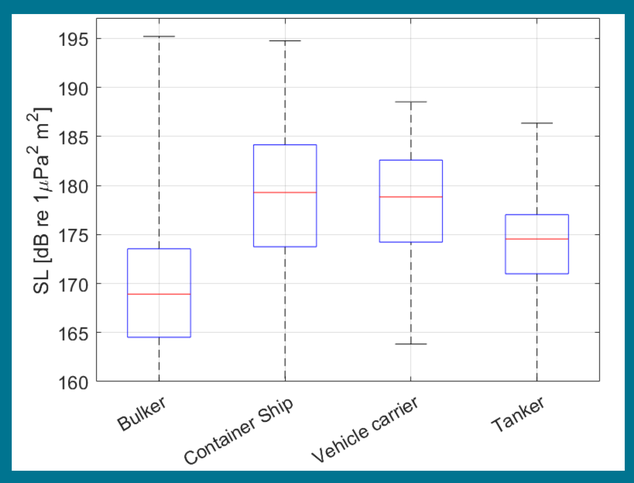

Fig. 3: Source level statistics. Median (red line), 25th and 75t percentile (blue box) and Maximum and minimum (errorbars) of source level.

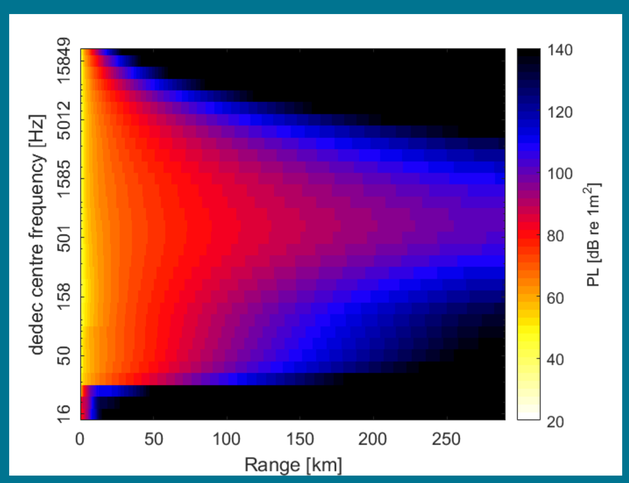

Fig. 4: Depth averaged propagation loss.

Scenarios for URN mitigation

In addition to the reference scenario (no mitigation measure applied), slow steaming and radiated noise level (RNL) limits were investigated. Slow steaming was Implemented by setting (1) a limit at 75% of the design speed (Fig. 6) or setting (2) a speed limit at 11.5 kn for bulkers and tankers and at 14.5 kn for container ships and vehicle carriers. The DNV Environmental 'transit' and 'quiet cruise' limits were applied to the RNL at the ship design speed. Fig. 7 shows how the different scenarios affect the underwater noise outside the shipping lane:

- Slow steaming scenarios achieve a similar reduction of the permanent shipping noise (2 dB median reduction).
- The 11.5 and 14.5 kn speed limits have a larger effect on the SPL reduction during ship passages than a 75% of design speed limit (2 dB vs 4 dB in the mean and 10% exceedance of the noise reduction).
- Applying the RNL limits (DNV transit and quiet) to all ships is more effective than slow steaming for reducing both temporary loud vessel passings (7 dB and 12 dB in the 10% exceedance level) and permanent vessel noise (4 dB and 8 dB in the median).
- The highest SPL reduction (11 dB in the median and 16 dB in the 10% exceedance level) is achieved when all ships adopt a combination of the DNV(E) quiet limit and slow steaming.

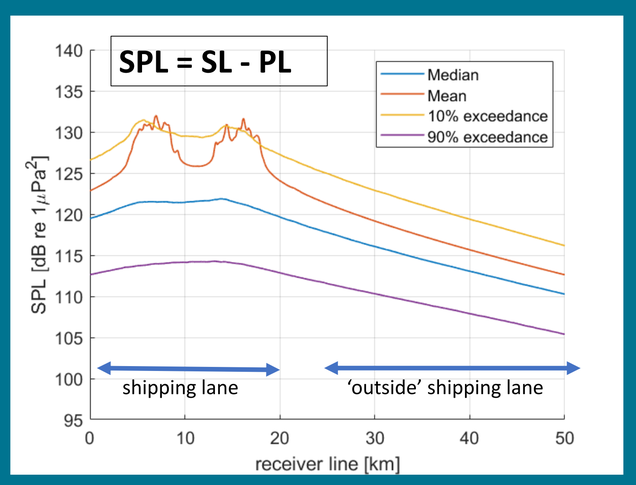

Fig. 5: Monthly SPL statistics modelled on the receiver line (dashed + solid yellow line shown in Fig. 1). Reference scenario, without mitigation.

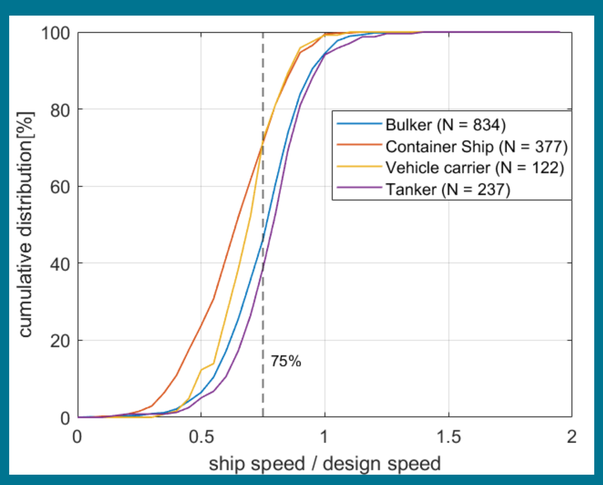

Fig. 6:Cumulative distribution of the ratio between ship speed and design speed (reference scenario). The dashed line indicates the percentage of ships being affected in the slow steaming scenario.

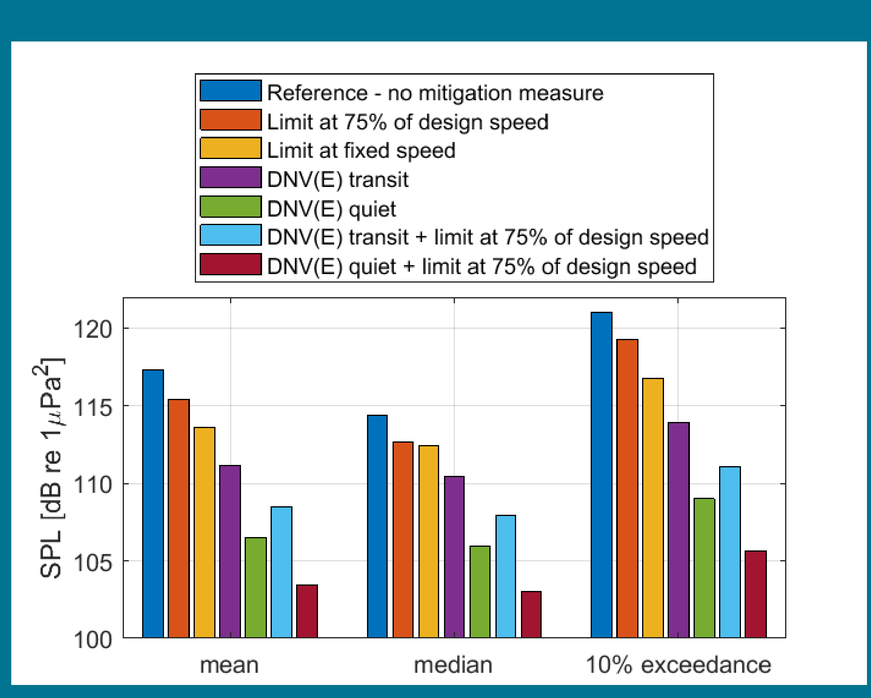

Figure 7: Modelled SPL statistics outside the shipping lane (averaged over 25 to 50 km range on the receiver line) for the reference scenario and six different noise mitigation scenarios and.

References

- https://www.interregnorthsea.eu/demask
- MacGilivray & de Jong (2021). A reference spectrum Model for estimating source levels of marine shipping based on automated identification system data. Journal of Marine Science and Engineering 9 (4).
- Collins (1993). A split-step Pade solution for the parabolic equation method. J. Acoust. Soc. Am. 93, 1736-1742.