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An adaptive grid to improve the efficiency and accuracy of modelling underwater noise from shipping

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Underwater noise from shipping is becoming a significant concern and has been listed as a pollutant under Descriptor 11 of the Marine Strategy Framework Directive. Underwater noise models are an essential tool to assess and predict noise levels for regulatory procedures such as environmental impact assessments and ship noise monitoring. There are generally two approaches to noise modelling. The first is based on simplified energy flux models, assuming either spherical or cylindrical propagation of sound energy. These models are very quick but they ignore important water column and seabed properties, and produce significant errors in the areas subject to temperature stratification (Shapiro et al., 2014). The second type of model (e.g. ray-tracing and parabolic equation) is based on an advanced physical representation of sound propagation. However, these acoustic propagation models are computationally expensive to execute.

Shipping noise modelling requires spatial discretization in order to group noise sources together using a grid. A uniform grid size is often selected to achieve either the greatest efficiency (i.e. speed of computations) or the greatest accuracy. In contrast, this work aims to produce efficient and accurate noise level predictions by presenting an adaptive grid where cell size varies with distance from the receiver. The spatial range over which a certain cell size is suitable was determined by calculating the distance from the receiver at which propagation loss becomes uniform across a grid cell. The computational efficiency and accuracy of the resulting adaptive grid was tested by comparing it to uniform 1 km and 5 km grids. These represent an accurate and computationally efficient grid respectively.

For a case study of the Celtic Sea, an application of the adaptive grid over an area of 160×160 km reduced the number of model executions required from 25600 for a 1 km grid to 5356 in December and to between 5056 and 13132 in August, which represents a 2 to 5-fold increase in efficiency. The 5 km grid reduces the number of model executions further to 1024. However, over the first 25 km the 5 km grid produces errors of up to 13.8 dB when compared to the highly accurate but inefficient 1 km grid. The newly developed adaptive grid generates much smaller errors of less than 0.5 dB while demonstrating high computational efficiency.

Our results show that the adaptive grid provides the ability to retain the accuracy of noise level predictions and improve the efficiency of the modelling process. This can help safeguard sensitive marine ecosystems from noise pollution by improving the underwater noise predictions that inform management activities.

References

Shapiro, G., Chen, F., Thain, R., 2014. The Effect of Ocean Fronts on Acoustic Wave Propagation in a Shallow Sea, Journal of Marine System, 139: 217 – 226. http://dx.doi.org/10.1016/j.jmarsys.2014.06.007.