Visualising Ambient Noise in the Oceans

Yiyi Whitchelo[1], Stewart Haslinger[1], Daniel Colquitt[1] and Duncan P Williams[2]
[1]*Department of Mathematical Sciences, University of Liverpool, Liverpool, L69 7ZL, UK*
[2]*Defence Science & Technology Laboratory, Porton Down, Salisbury, SP4 0JQ, UK*

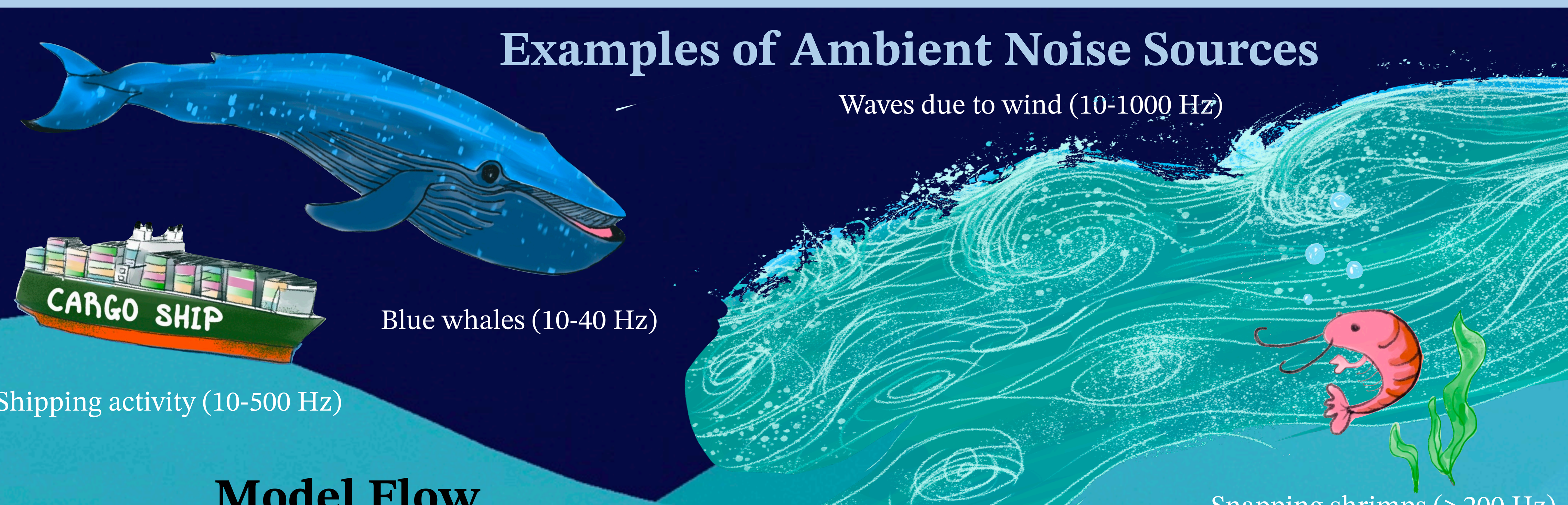
Listen for Ambient Noises in the Ocean

Ocean Ambient Noise Model: Why?

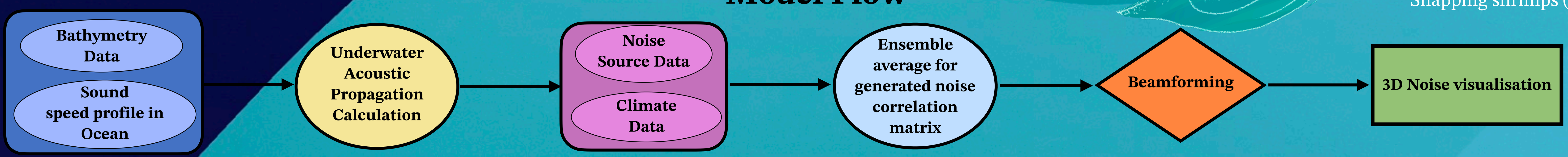
- High noise impacts marine species' behaviour, Sonar navigations and environmental pollution.
- Noise modelling helps us to understand the link between underwater ecology, biology, and technology.

This work advances noise modelling and creates a flexible framework for various noise sources.

Examples of Ambient Noise Sources

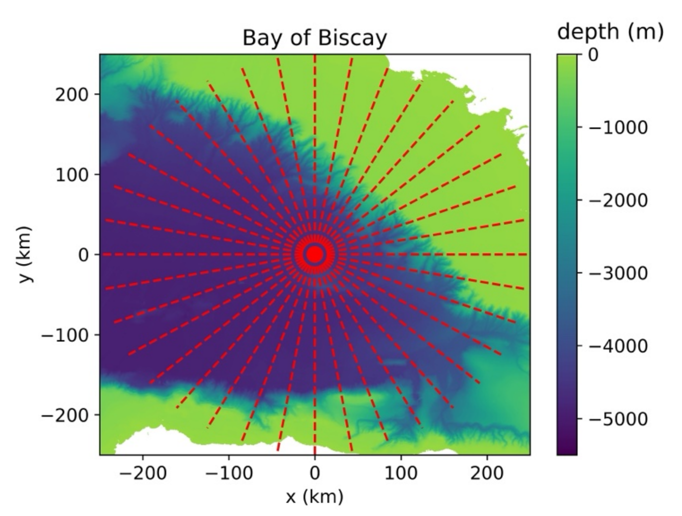


Model Flow

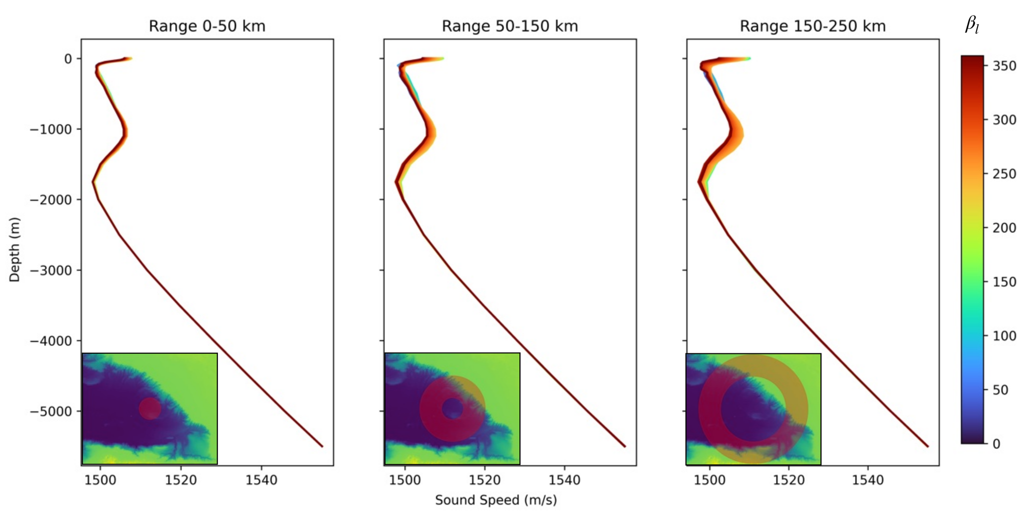


Bay of Biscay Wind and Distant Shipping

Bay of Biscay data (55Hz, relevant for wind/shipping) from GEBCO [1] (bathymetry), Copernicus [2] (wind), Acoustic.Ocean [3] (sound speed), and World Bank [4] (shipping) were mapped to a sectorial array with slices defined by bearing into modified RAMsurf [5] for sound propagation modelling, using reciprocity for efficiency of computation.

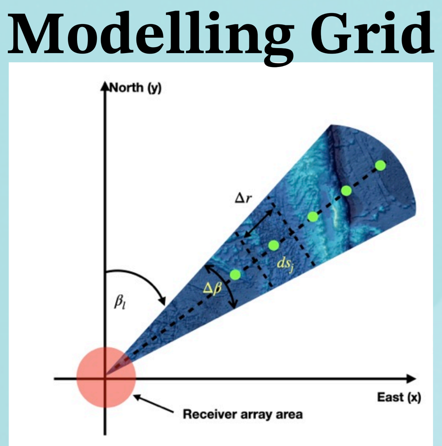


Bathymetry of Bay of Biscay with bearing slices in red.



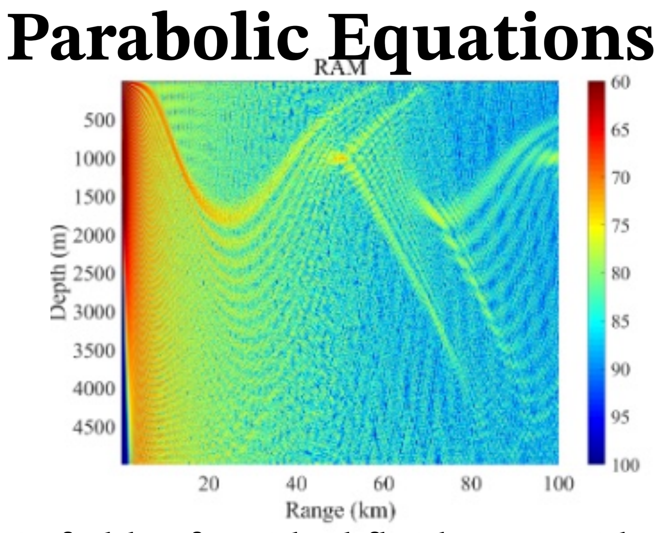
Bearing and range dependent sound speed profiles (SSPs) for Bay of Biscay. Different SSPs were used for different regions (shown in subplots).

Modelling Grid



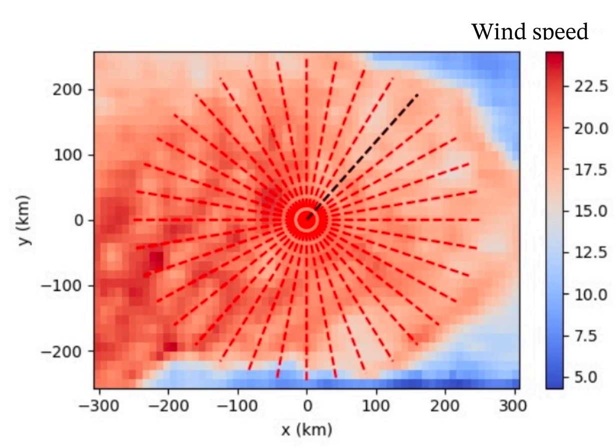
3D information is processed into 2D slices.

Sound propagation using Parabolic Equations

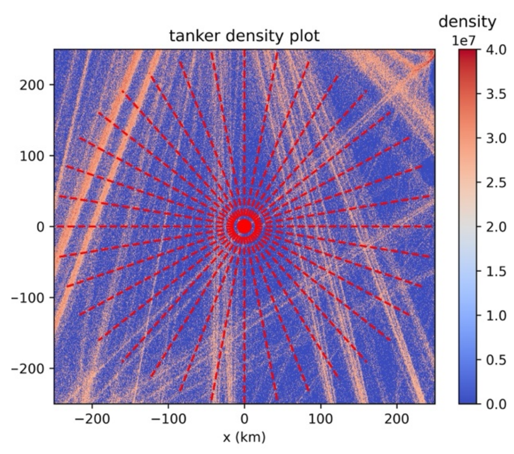


Acoustic fields of an ideal fluid waveguide with a Munk sound speed profile [6].

Add Noise Source Data

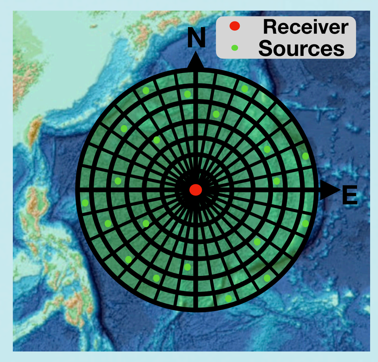


Wind speed plot of Bay of Biscay with bearing slices in red.



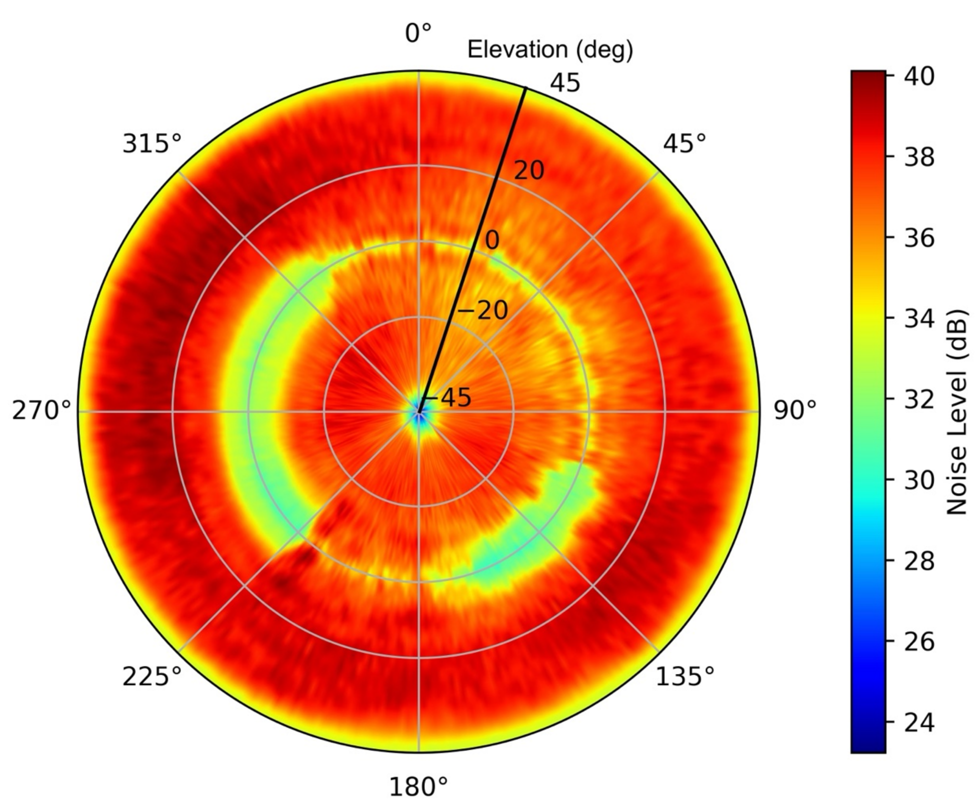
Shipping density of Bay of Biscay with bearing slices in red.

Noise Intensity Calculations

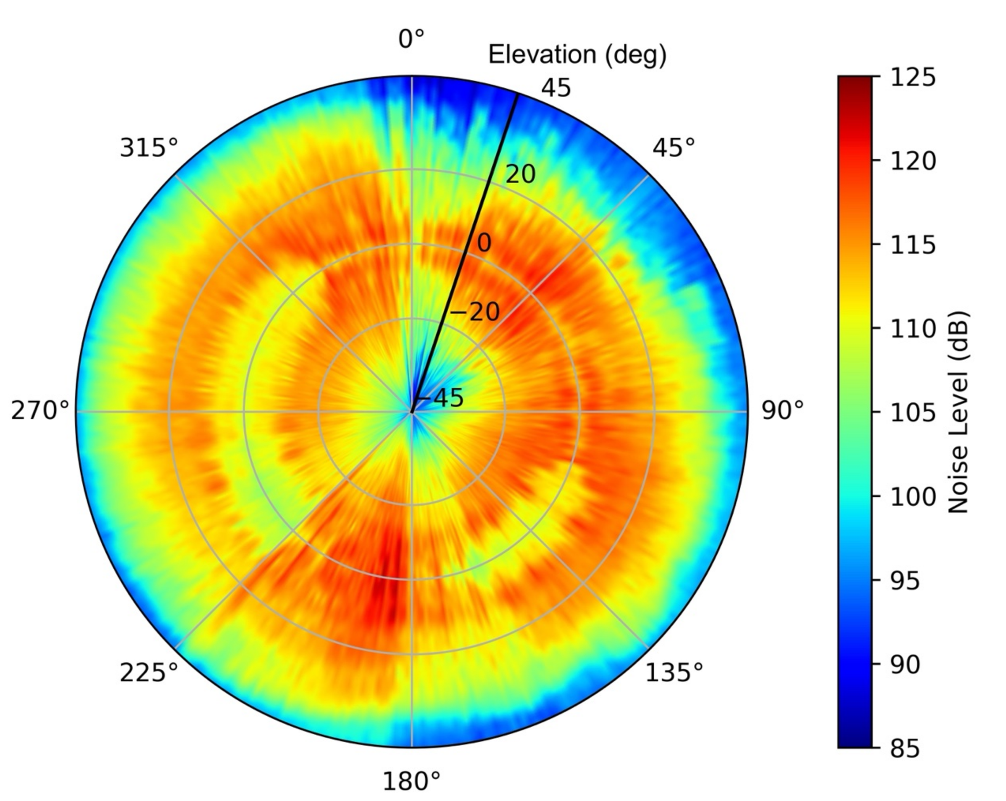


- **Randomising Noise**: We make sure our noise data is truly random. By taking an average over many samples from a random distribution, we eliminate bias and get a clearer understanding of the underwater noise.
- **Finding Noise Sources Direction:** We shuffle our results and pinpoint where the loudest underwater sounds are coming from. This technique is called **beamforming**.

Noise Visualisation



Directional Ambient Noise Intensity in elevation and bearing at 55Hz for **wind**.



Directional Ambient Noise Intensity in elevation and bearing for **distant shipping** at 55Hz.

Conclusions

- **SHIPS ARE LOUDER:** Distant shipping noise overpowers wind noise at 55 Hz.
- **SEABED MATTERS**: The ocean floor's shape (bathymetry) changes underwater sound.
- **HIDDEN NOISE**: Ship sounds hide quiet areas ("Noise Notches") created by the seabed.
- **ADAPTIVE MODEL**: Our model works anywhere and includes rain, earthquakes, and animal sounds.
- **MACHINE LEARNING**: This data is essential for training AI to understand underwater noise where real datas are limited.

[1] GEBCO, "GEBCO 2024." [Online]. Available: https://www.gebco.net/data_and_products/gridded_bathymetry_data/
[2] Copernicus, "Copernicus 2024."[Online]. Available: https://marine.copernicus.eu/
[3] Dushaw, 2023. Acoustic.Ocean: A graphical user interface (Matlab) for selecting geodesic paths across the global oceans, extracting oceanographic properties (sound speed, temperature), and computing expected acoustic propagation properties
[4] D. A. Cerdeiro et al. World seaborne trade in real time: A proof of concept for building AIS-based now casts from scratch, no. 20–57. International Monetary Fund, 2020
[5] S. G. David C. Calvo, "Quiet oceans : Ramsurf." GitHub, 2012.
[6] Tu et al. (2022). J. Theoretical and Computational Acoustics, 30(2), 2150013.

Bathymetry SCAN ME | Wind SCAN ME | Shipping SCAN ME

University of Liverpool · UKRI Engineering and Physical Sciences Research Council · dstl Delivering Mission Success