M1 - BIM project - Analysis of active acoustic datasets

Lloyd Izard (lloyd.izard@locean.ipsl.fr), Nadège Fonvieille (nadege.fonvieille@univ-amu.fr)

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1 Context

The Indian sector of the Southern Ocean is home to numerous colonies of marine mammals and seabirds that feed on organisms belonging to intermediate trophic levels (e.g. fish, squid, zooplankton). Southern elephant seals (SES) are deep-diving predators and among the most significant consumers of resources in this region. The Kerguelen Archipelago hosts one of the largest colonies of this species. During the post-breeding period (late October to January), females from this colony feed on small fish (myctophids) in the pelagic waters of the circumpolar current (Figure 1). During this foraging trip, females appear to target an area east of the Kerguelen Plateau, where the vertical distribution of prey shifts, making them more accessible and thus more favourable for hunting. To better understand the environmental mechanisms (both biotic and abiotic) responsible for structuring intermediate trophic levels (particularly pelagic fish), analysing active acoustic data in the Indian sector of the Southern Ocean emerges as a promising approach.

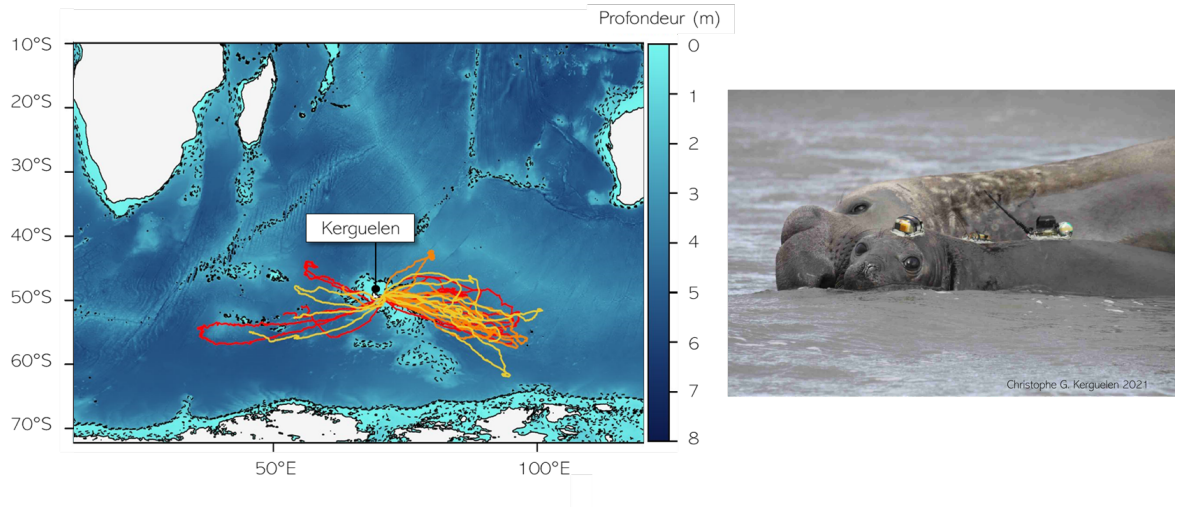

Figure 1: (Letf) Post-Breeding female southern elephant seal trajectories from 2018 to 2020. (Right) Female southern elephant seal equiped with three biologgers.

Active acoustic is an observation method that relies on the propagation of sound waves through the water column to measure the density and depth of animals that can be detected by echosounders. It enables high-resolution monitoring of pelagic fauna dynamics in four dimensions (depth, longitude, latitude, and time). Active acoustic data is typically represented as echograms, where signal intensity is shown as a function of depth and time or spatial dimensions (Figure 2). The data for this project comes from Australia's Integrated Marine Observing System (IMOS, Figure 3), supported by the National Collaborative Research Infrastructure Strategy (NCRIS) (https://portal.aodn.org.au/).

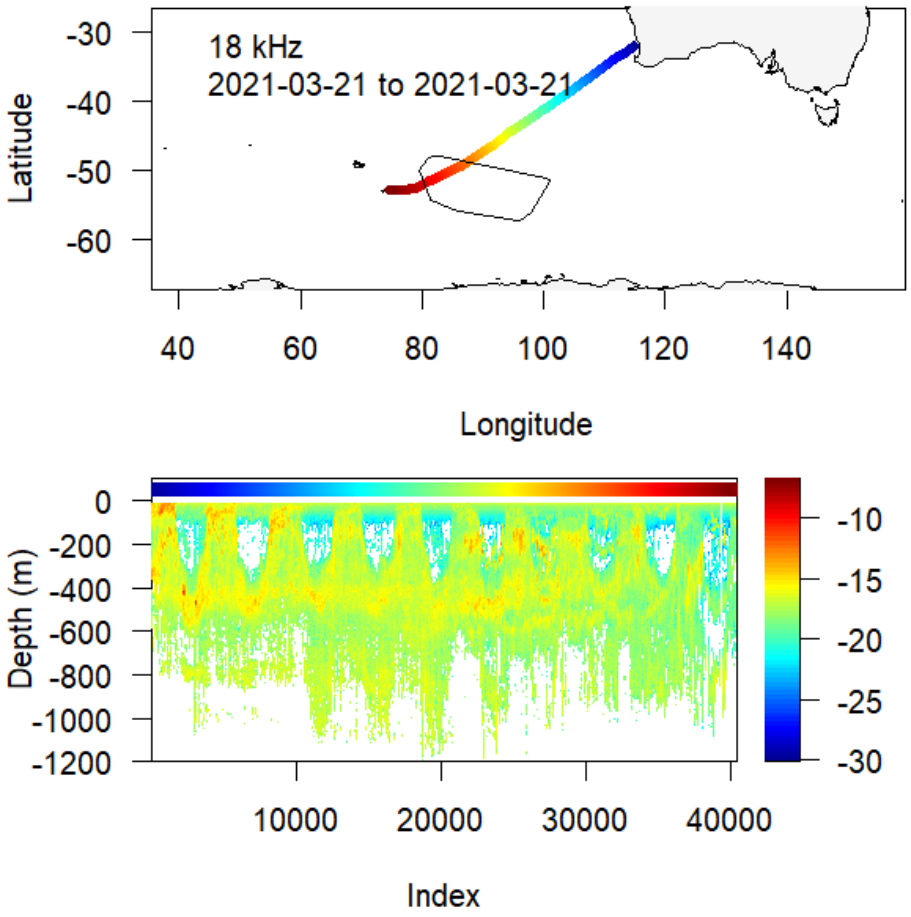

Figure 2: (Top) Transect of the Antarctic-Aurora ship, in March 2021. (Bottom) Echogram displaying the active acoustic data (Sv) recorded along the ship transect.

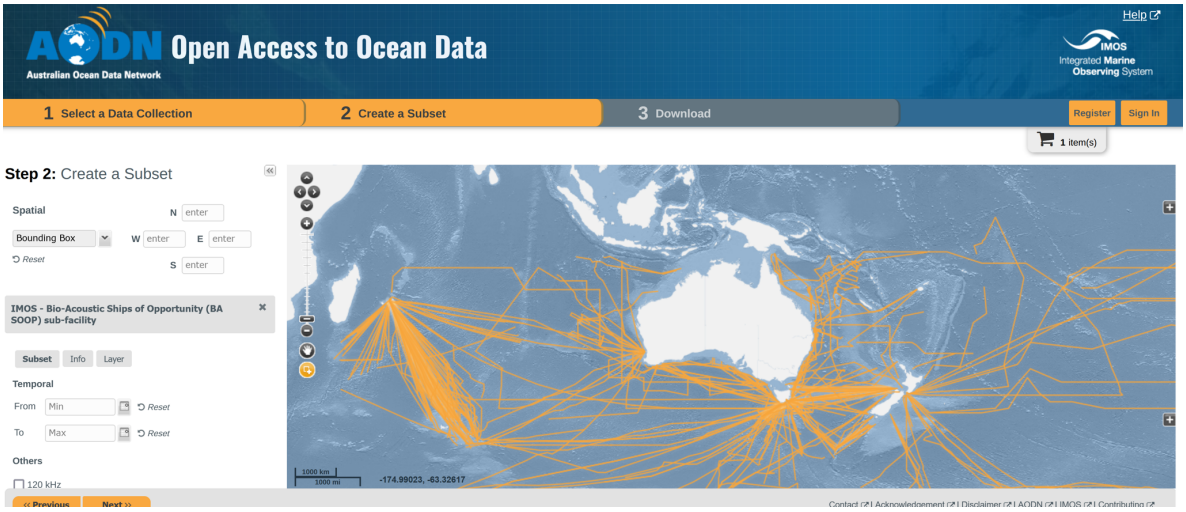

Figure 3: Open access platform from the Australia's Integrated Marine Observing System (IMOS).

2 Objectives

The objective of this project is twofold:

- To determine whether the acoustic signals observed in the area east of the Kerguelen Plateau,

particularly between 100 and 200 m, differ from those outside this area and whether they could explain the diving patterns of Southern Elephant Seals.

- To develop a model to understand the environmental variables that may explain the distribution of organisms at the regional scale.

3 Key activities

1. Set up an effective working environment (Refer to Reproducible Research https://rdatatoolbox.github.io/chapters/course-opensci.html or Research Compendium https://rdatatoolbox.github.io/chapters/course-compendium.html).
2. Retrieve active acoustic data from Australia's Integrated Marine Observing System (https://portal.aodn.org.au/). Select transects that include 18 kHz, 38 kHz, or both.
3. List the available datasets by season/month and frequency, and indicate the maximum sampling depth (which varies between transects).
4. Visualise and explore the data.
5. Map the NASC (Nautical Area Scattering Coefficient) at 18 and 38 kHz at a selected maximum depth, distinguishing between day and night. Perform the same analysis for the 100–200 m depth range (SES target zone).
6. Create a model to understand and predict acoustic distribution at 18 and 38 kHz using environmental variables.

4 Expected Outcomes

The results of this acoustic project will enable the coupling of two large ecological datasets (MEOP and IMOS) to better understand the pelagic seascape in the remote and relatively pristine environment of the Southern Indian Ocean. By identifying matching patterns between prey distribution and the diving behaviour of these predators, we can improve our ability to anticipate the effects of marine heatwaves and global change on their feeding grounds.

For the student, this project provides an opportunity to investigate complex 4D multivariate datasets, offering a unique experience in ecological research. Additionally, they will apply the skills and tools learned in their coursework to manage a large database, explore the data, and develop a model. The subject and objectives of this internship may evolve and/or become more specific based on the student's progress, their interests, and the requirements of the course module in which their project is situated.