

Monohydrophone 3D localization of Baleen whales

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One key-parameter for whale density estimation through passive acoustics is recovery of animal position (Marques et al. 2013). Most commonly, the localization process requires an array of 4 synchronized hydrophones (Kuperman et al. 2004), which is a more technically complex and expensive option than installing one single sensor. Several attempts have been made towards recovering the position of the singer with only one hydrophone (McDonald et al. 1999, Kuperman et al. 2001, Bonnel et al. 2014), however, these methods usually permit only range (and sometimes depth) estimation.

Here, we use seismic modelling methods (SPECFEM, Tromp et al. 2008) to understand the propagation of whale vocalizations in a specific context. Thanks to this precise time-domain modelling, we explore all the information inside the signal, including modifications produced by environmental complexity (bathymetry, speed variation, etc.). Subsequently we applied a low-cost inversion method based on Green's functions reciprocity principle to reconstruct the whale's position.

First tests on simulated data confirm that the technique is well suited to biological signals of very low frequency, such as the Southeast Pacific two Blue whale song type (described in Buchan et al. 2014). We also show the possibilities of this method for determining the range of an animal in shallow coastal waters. The results of two simulations in a 3D 10 km-wide box lead to the recovery of the range (with a precision greater than 100 m) in 98 % of cases, of the depth in 100 % of cases and of full position (that is range, depth and azimuth, thanks to our 3D modelling, with a resolution greater than 500 m) in 43% of cases.

Although these first tests ignore much of the real-world problems (fine modelling and source signal estimation) that we are currently addressing in a study in northern Chile, we think that they are encouraging and open the way for time-domain spectral-element methods in bioacoustics and shallow-water propagation modelling.

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