Use of broadband split-beam echosounder signals for target size discrimination

Context and objectives

The science of active acoustical oceanography consists in emitting sound pulses into the water and analyze their echoes to obtain information about the targets present in the water (identification, abundance and size), as well as physical properties of the water itself (Medwin and Clay, 1998). Acoustical oceanography experimented a revolution in the 1980s with the development of the split-beam echosounder, which allowed for the first time to obtain precise abundance estimates acoustically and has since become a standard for estimating the underwater biomass of fish. However, one of the main limitations of the classic split-beam echosounder is its poor target identification capability (Simmonds and Maclennan, 2005). The combination of echosounders of different frequencies offers some improvement by providing a low resolution (one point per echosounder) frequency response which helps to identify some targets (Fernandes *et al.*, 2006; Korneliussen *et al.*, 2008). Nevertheless, the development in 2015 of the new generation of broadband split-beam transceivers has increased dramatically the acoustic information obtained in each ping, by changing from the discrete, single point response of the "narrowband" signal (Korneliussen *et al.*, 2016) to the continuous acoustical signature of the "broadband" (Forland *et al.*, 2014; Stanton *et al.*, 2010). This new technology, opens new perspectives in providing identification information about the targets, both concerning species and size. But, it also provides new challenges given the amount of data to be processed and opportunities to test novel approaches from machine learning and Big data. The old technology used to produce up to 5 GB of data per day, whereas the new sensors generate 1 TB of data per day. For advancing the state-of-the-art a multidisciplinary approach combining physics, oceanography, biology and computer science is needed.

The purpose of this project is to develop routines to process the information generated from the new echosounders in near real-time. This process will aim to extract several characteristics that will allow to determine the size and species of the fish.

The work will involve combining three tasks, each involving different types of analyses:

(i) Pre-processing of acoustic data

(ii) Extract the size information

(iii) Statistical checking

Task 1. Pre-processing of acoustic data

Standard acoustic processing tools (Echoview or LSSS) will be used to filter, correct, scale and isolate appropriate single targets detected by broadband acoustics (Korneliussen and Ona, 2002). The acoustic database will include data collected either in controlled situations as sea cages or in oceanographic surveys, both with concurrent biological information. The frequency response bands of these standardized single targets will be exported to data files to be further analyzed. The student will learn about oceanographic physics and signal processing as well as other principles needed for the following tasks.

Task 2. Extract the size information

The main objective of the work will consist in developing new routines to extract the size information in real-time from the single targets data files exported in Task 1. Here, already existing scripts will be modified and developed using R software to characterize and smooth the continuous frequency response curves. The nulls of the response curves will be located and their distance in the frequency domain measured. The use of software parallelization methods to speed up and real-time processing will be of special interest. The frequency distances will be used to predict the size of the targets based on the theoretical acoustical interference of the Rayleigh waves around the external surface of the target.

Task 3. Statistical checking of predicted vs observed sizes

The predicted target sizes will be tested statistically against observed sizes and species, based on the biological information available. This information will be based on biological sampling and/or concurrent underwater digital imaging.

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Required skills: Programming in R, basics of statistics

Required language: Spanish or English

Research line: Signal processing, Big data

Duration and Dates: 6 months (negotiable)

Covered expenses: To be negotiated

References

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