Automatically Locating Whales through Analysis of Acoustic Receiver Data

Abigail Harris SAS2025, Tianyang(Nora) Han SAS2024

Dr. Joseph Kroll, SAS Dept. of Physics & Dr. John Spiesberger, SAS Dept. Earth and Environmental Science

Significance

Beaked whales are one of the least known and most difficult-to-study mammals because of their deep-sea habitat and apparent low abundance.

Navy SONAR activity is believed to cause the death of nearby beaked whales. The goal of this project is to estimate their abundance and behavior near Navy sites, and is important because of their protected status.

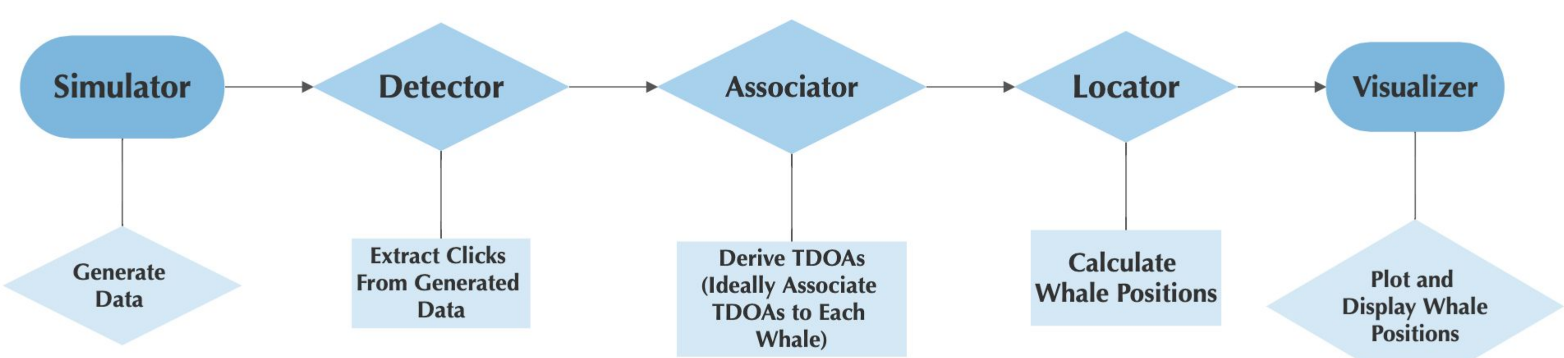
Introduction

Although they are rarely visually detected, beaked whales echolocate with loud clicks that can be heard miles away, so analyzing those clicks is the best way to locate and study them.

We are building on the methods mentioned in Susan Jarvis and her colleagues' paper on Automated Detection of marine mammals. Our method compares the time difference of arrival (TDOA) of the same signal across multiple acoustic receivers, which can be combined with the known positions of the receivers and speed of sound to solve for the positions of the whales.

This is challenging because all clicks sound identical to the receivers, and multiple whales may be calling at the same time. We solve these problems by associating the patterns of clicks, which are unique.

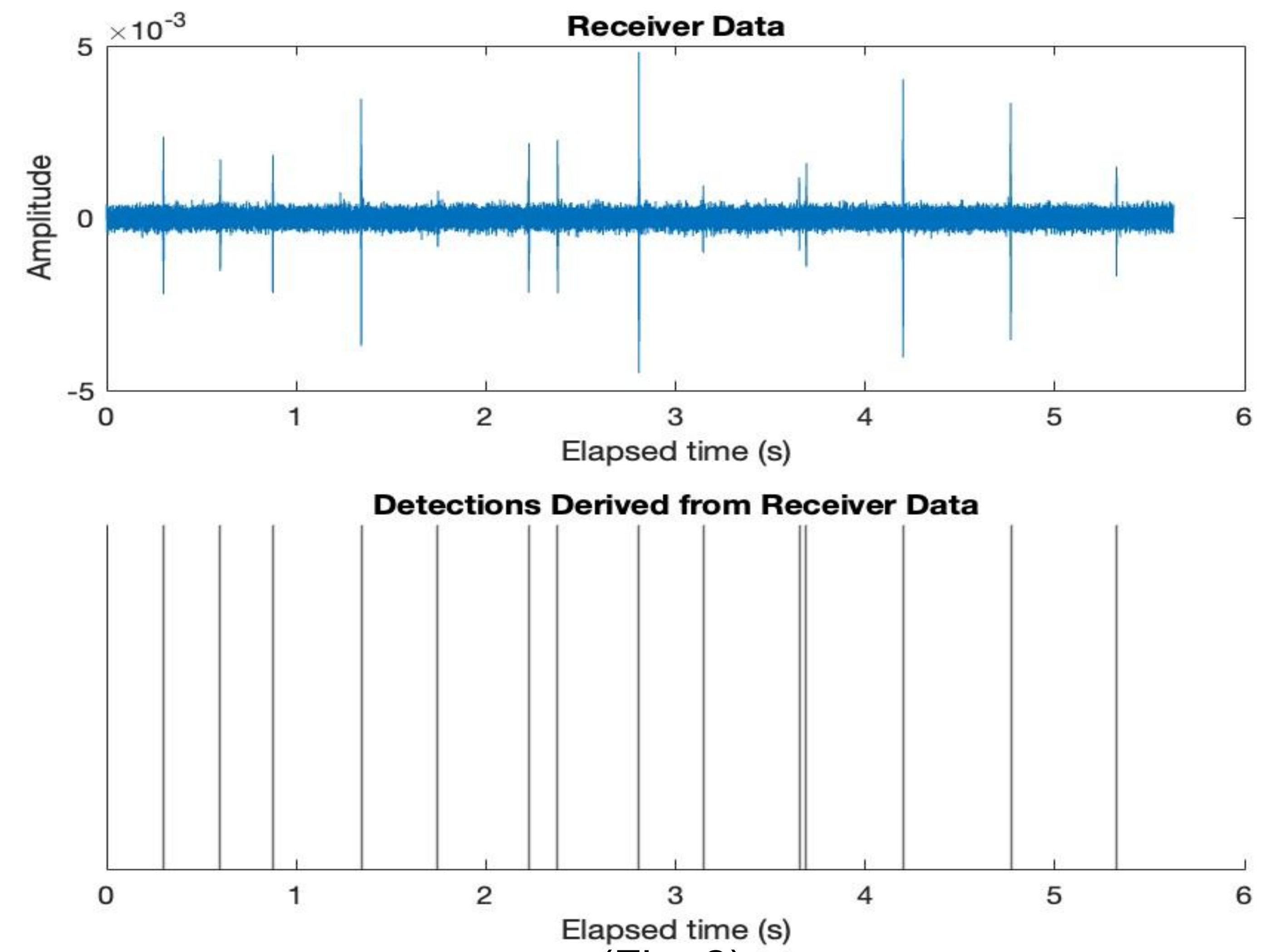
Method



(Fig 1). The program is broken into multiple sections. All sections after the simulator are independent from it and do not use anything from it except the data it is fed

Simulator and Detector

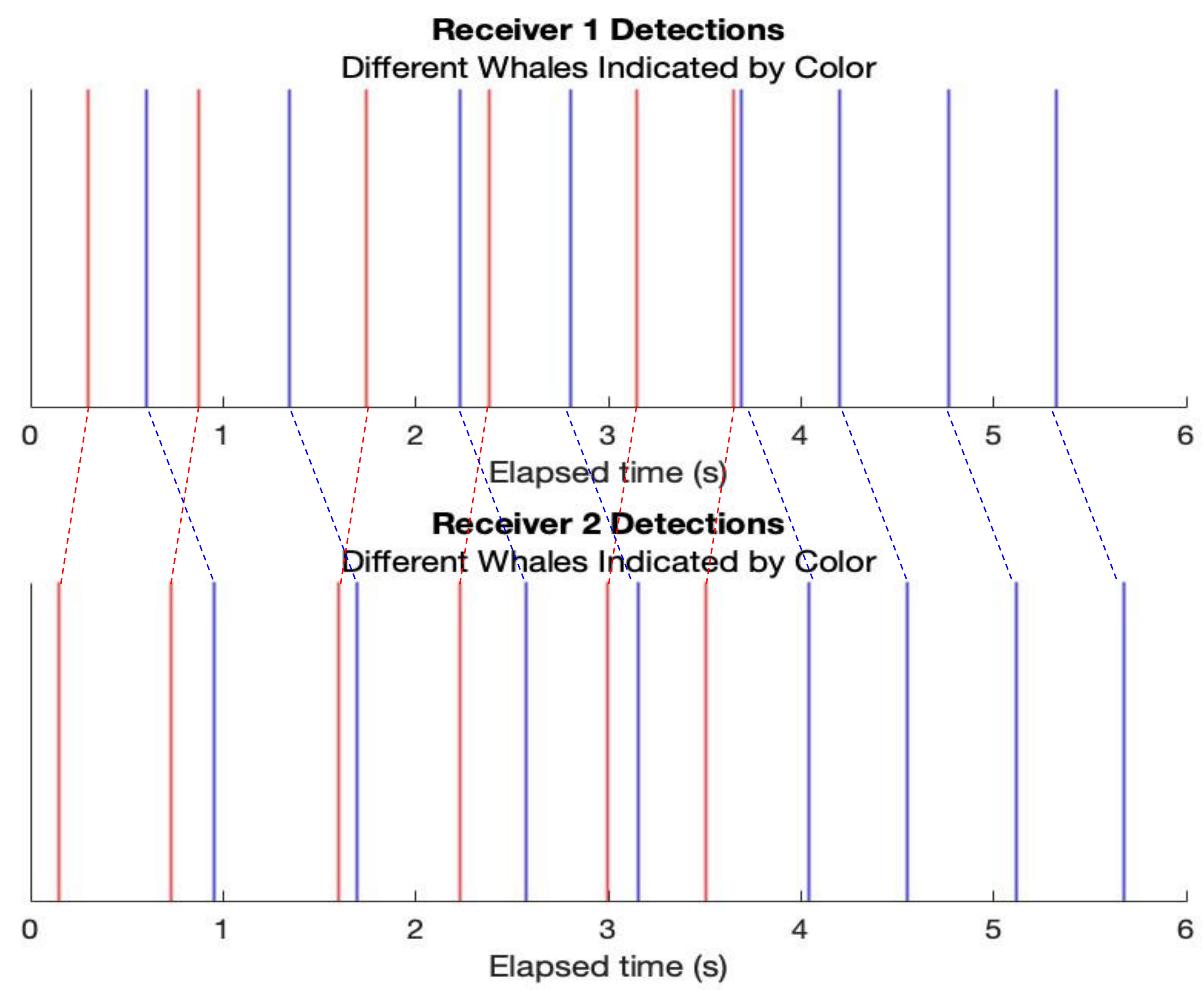
The simulator produces realistic microphone data to be fed into the detector, which record sounds above a certain threshold as clicks



(Fig. 2)

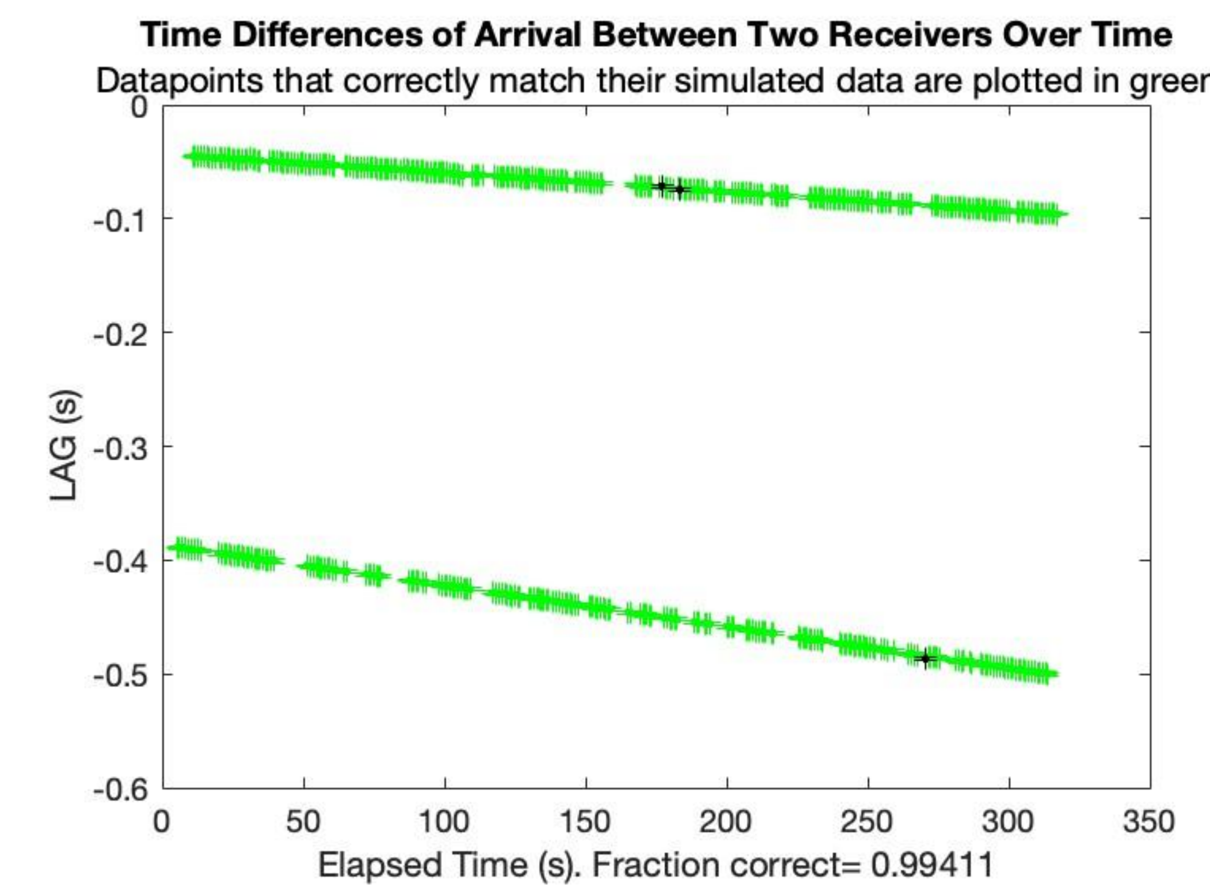
Associator

The associator goes click-by-click on one receiver and tries to find a time difference of arrival with signals on each other receiver by comparing the click patterns. It looks forward for about 10 seconds and compares the patterns of the two receivers at different time lags.



(Fig 3)

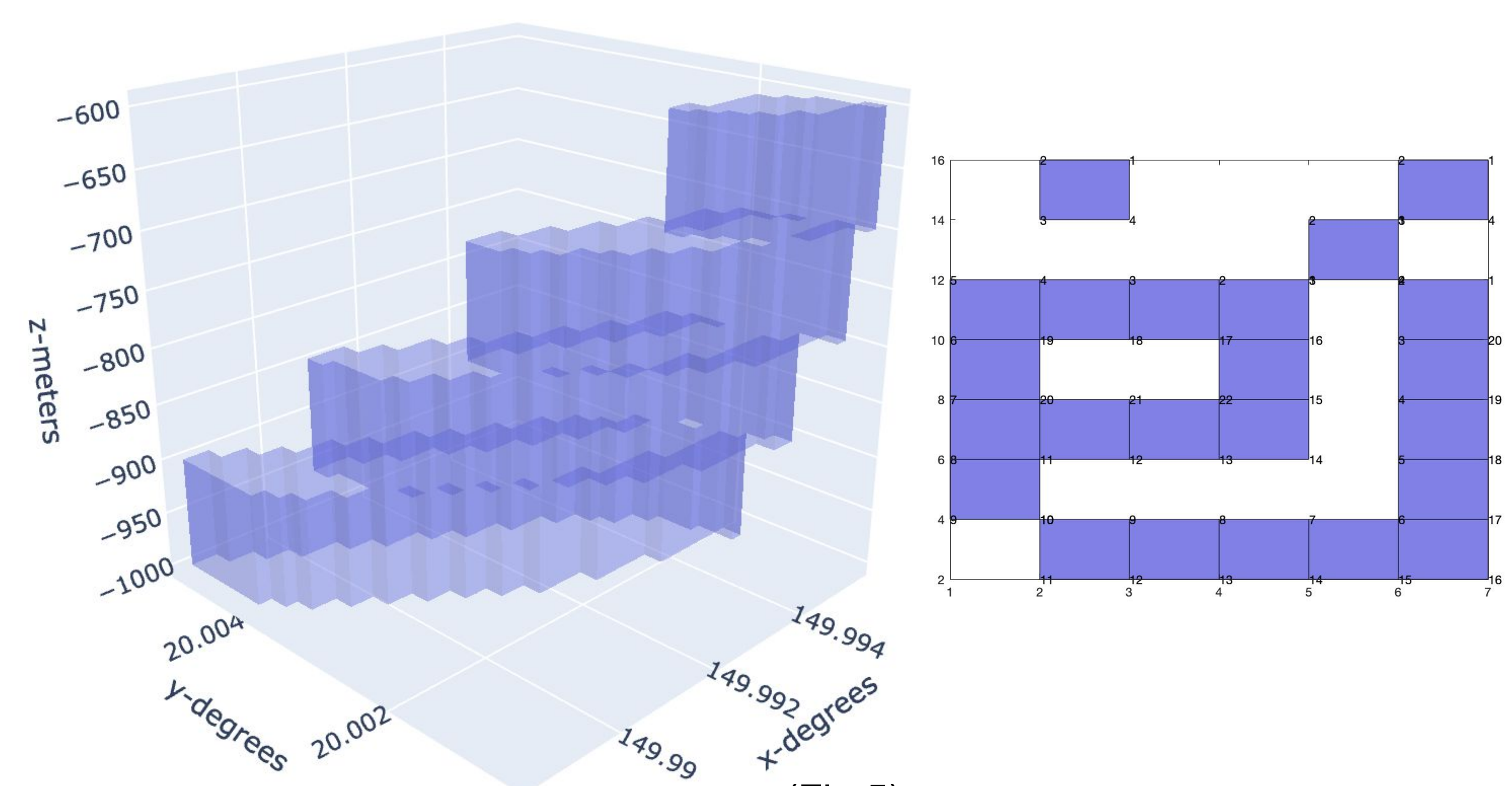
TDOAs of Each Click Over Time



(Fig 4)

The TDOAs calculated by the associator are green if, within their error bounds, they contain the correct answer known by the simulator. There are two "tracks" because there are two whales calling from different locations

Locator and Visualizer



(Fig 5)

The Visualizer takes in the output of the Locator(written prior to this project) and plots out the whale's location in 3D.

It takes the 2D rectangles of the estimated whale position(colored if a whale was calculated to be there, otherwise blank) and uses Julia Plotly package to plot the calculated whale positions in 3D within a few seconds.

It consists of a program that finds the 2D perimeter of the whale's estimated position(see Fig 5 right), and a program that plots the shape in 3D(see Fig 5 left).

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