Exploring Ocean Soundscapes: Leveraging Matlab in Noise Removal Techniques

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Introduction

- The Earth's oceans are a vast frontier and scientists are eager to explore the depths of uncharted territory and the millions of marine species that inhabit them.
- Difficulties in studying underwater habitats, considering visibility and inaccessibility due to the extreme pressure, along with the benefit of sound traveling faster and further in water than light, and that animals use acoustics as a primary medium for communicating and catching prey, ocean acoustics are particularly useful.
- Acoustic techniques are effective in mapping, assessing, and monitoring habitats, in addition to habitat connectivity in determining the degree to which distinct patches of habitat are connected (Howe et al., 2019).

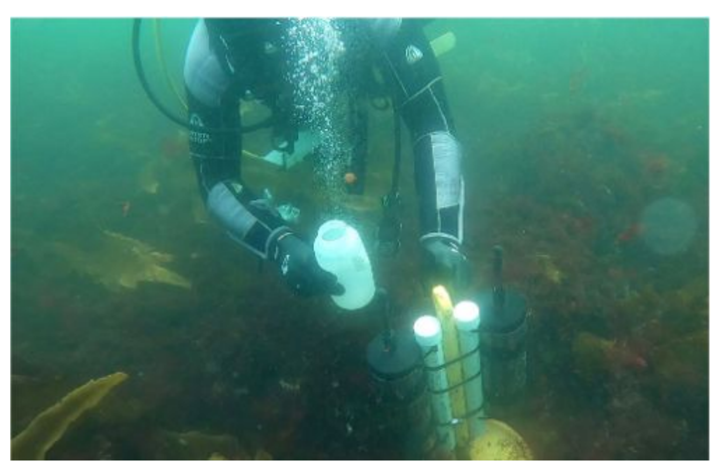

Figure 1. Diver placing hydrophone in eelgrass habitat

- Acoustics techniques are beneficial in recognizing types of marine animals present in a region, changes in ocean circulation patterns, and monitoring certain species for conservation purposes.
- The navy utilizes ocean acoustics to enhance underwater communication, detect and track submarines, and analyze marine environments for strategic and defense purposes.

Background

- Passive Acoustic Monitoring (PAM) is an ocean acoustics method that records naturally occurring sounds in the ocean, including sounds of marine animals, human activity, and geological activity.
- Prior to PAM, ocean habitats were primarily studied through visual surveys using cameras, submarines, and human divers
- PAM involves the use of hydrophones - underwater microphones deployed at various depths and locations to collect sounds and store them for researchers to later listen and gather information to analyze the underwater soundscape over extended periods of time.
- Underwater soundscapes are defined as “characterization of the ambient sound in terms of its spatial, temporal and frequency attributes, and the types of sources contributing to the sound field” (ISO 18405:2017).

01	Kurtosis	quantifies the degree of peakedness or flatness of a probability distribution's shape
02	Sound Pressure Level (SPL)	express the intensity of a sound relative to a reference level in decibels (db)
03	Root Mean Square (RMS)	square root of the average of the squared values in a data set to determine the amplitude of a waveform
04	Dissimilarity	measures the degree of difference between sound data over two frames of time

Figure 2. Key definitions

- The primary noise removal method divides the sample data into 0.1 second bins. Three metrics **– kurtosis, RMS, and sound pressure level** – were measured. A bin of data was removed if it exceeds a threshold along one of these metrics.
- The **Fourier Transform supplements** above methods by dividing the data into different frequency bands. The noise was primarily in the lower frequency band. A **Band Pass Filter** analyzed a precise frequency range (600-900 Hz).
- **Support Vector Machine** is a machine learning model used to predict and separate noisy data across the data set.
- MATLAB and the Signal Processing Toolkit was used for writing the code.
- RAVEN was used for data analysis.

Methods

Kurtosis. The Kurtosis Noise Removal Method segments data into 0.1-second bins, calculates kurtosis per bin, and removes 0.9 seconds of highly impulsive data when kurtosis exceeds a set threshold.

Root Mean Squares (RMS)
Like Kurtosis, the Root Mean Squares Removal Method calculates bin RMS, removing data when RMS surpasses a threshold, functioning similarly in sound data analysis.

Sound Pressure Level
The Sound Pressure Level Method, like Kurtosis and RMS, analyzes bins for noisy sound. It calculates pressure differences, removes data when they exceed a set threshold.

Fourier Transform
The Fourier Transform supplements the three methods by focusing on lower frequencies, filtering out higher frequencies for analysis.

Band Pass Filter
The Band Pass Filter complements noise removal by analyzing an even narrower frequency range (typically 600-900 Hz) using Fourier Transform.

Support Vector Machines
Support Vector Machines classify clean and noisy data in a test set to predict and separate them across the entire dataset.

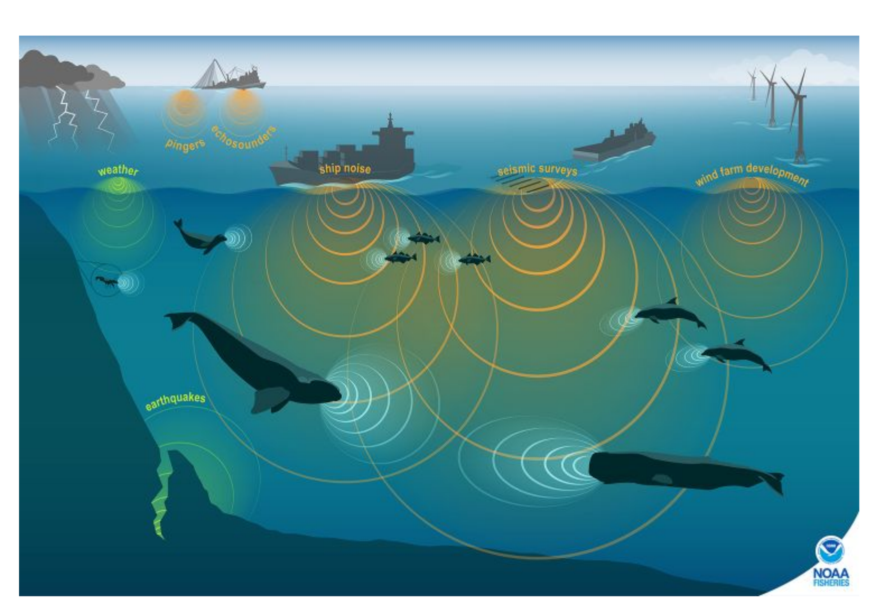

Figure 3. visual representation of of ocean soundscape

Results

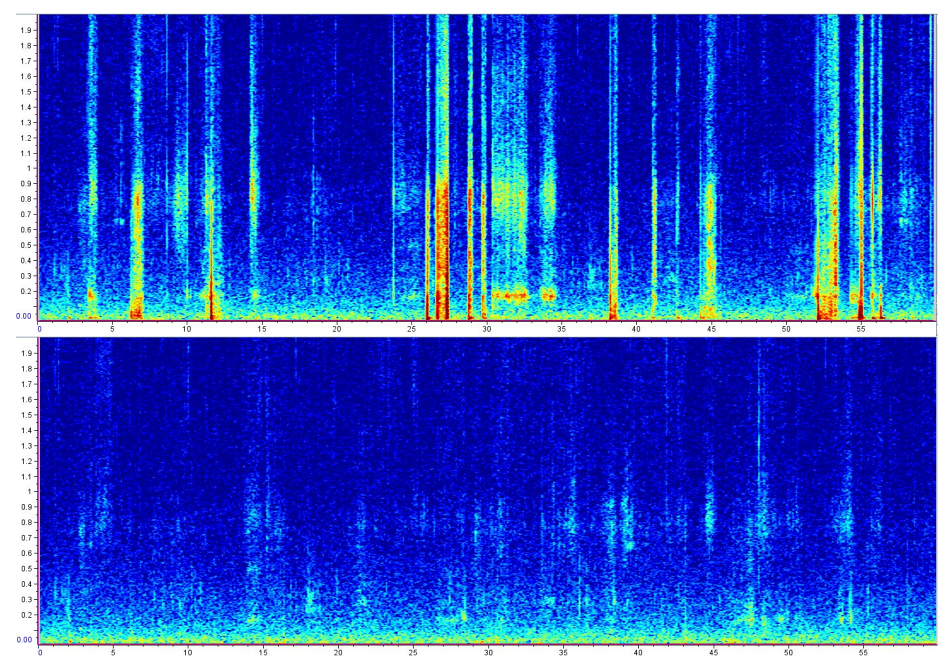

Figure 4. Spectogram view of original, noisy data, compared to new, cleaned data

- The most effective technique for removing physical contact noise was using the Sound Pressure Method along with the band pass filter and fourier transform.
- Using a threshold of 500000 micropascals for the difference in sound pressure over the 0.1 second interval, we were able to remove a significant amount of the noise while retaining much of the clean data. Utilizing the band pass filter, a lot of the lower frequency noise between 600 and 900 hz was removed/

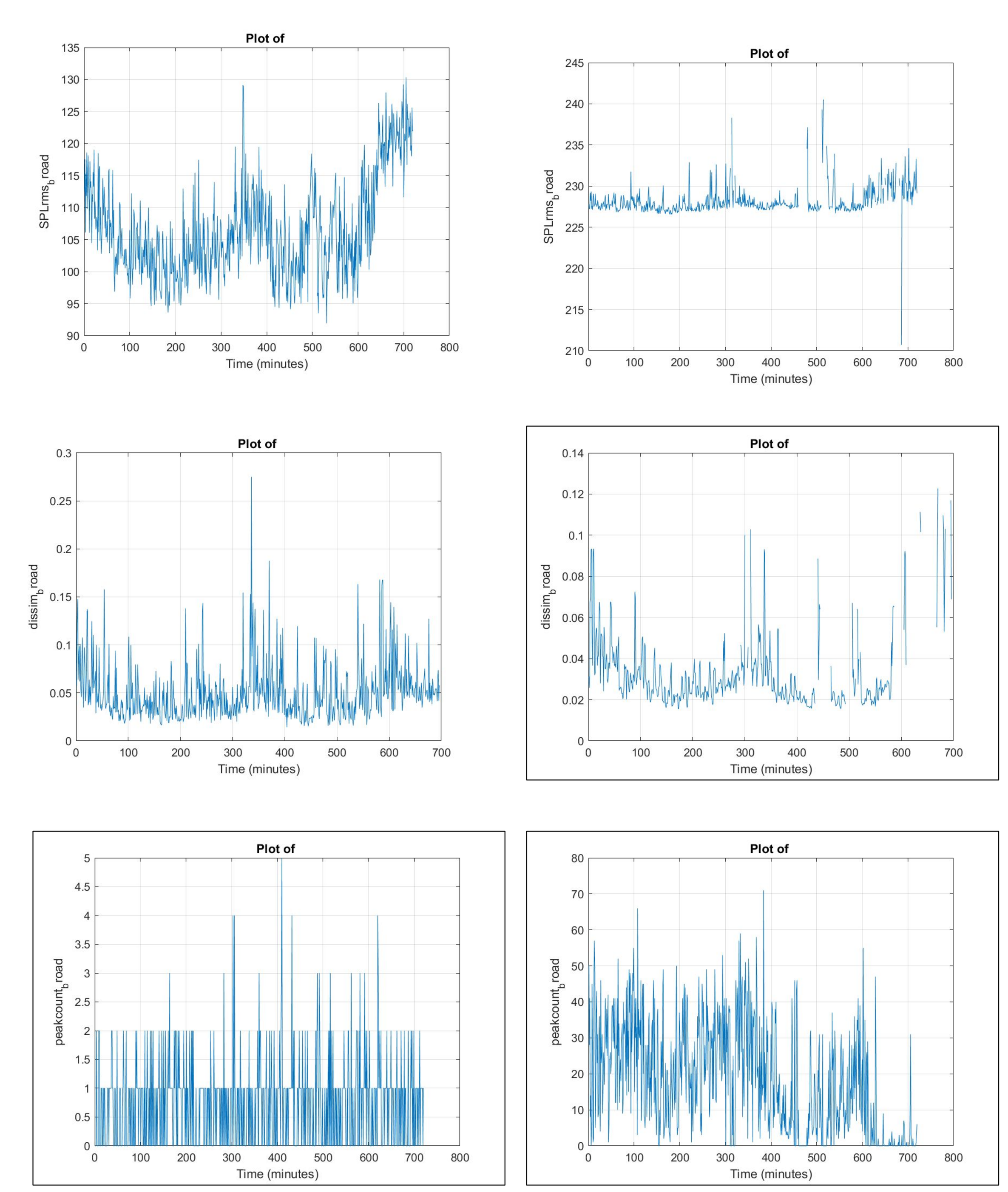

Figure 5. Difference in key metrics for noisy and cleaned data

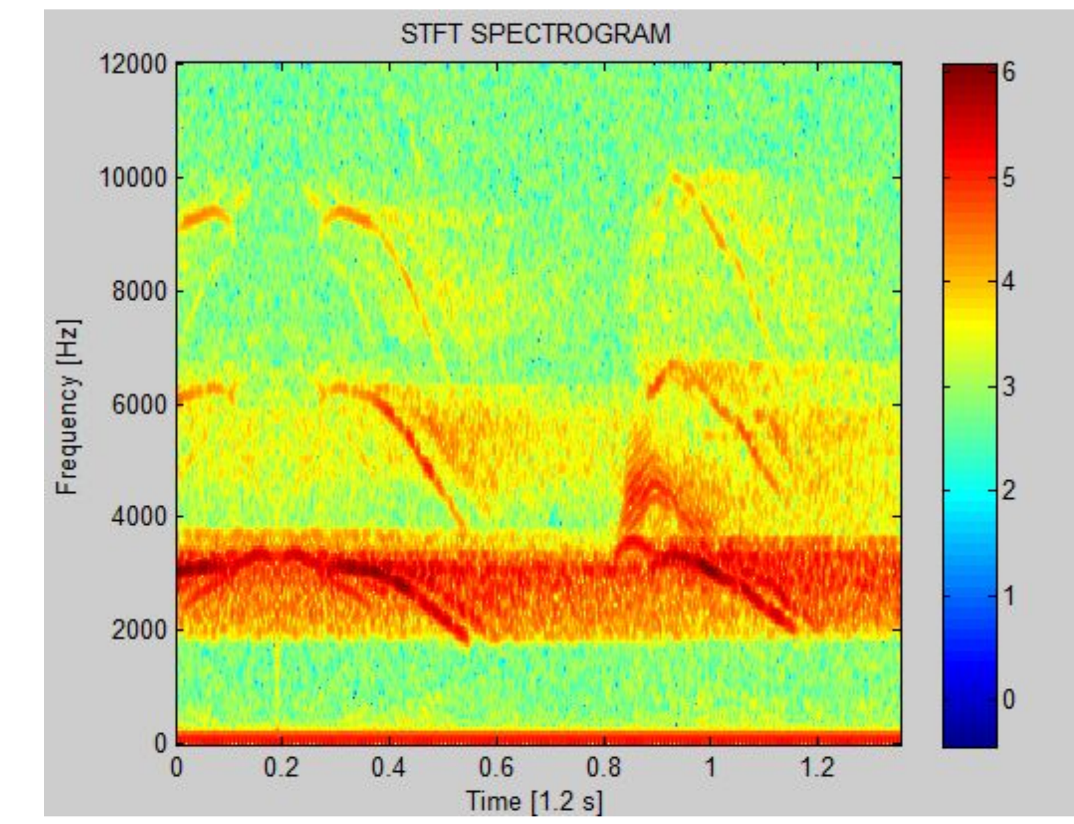

Figure 6. Spectrogram view of a dolphin whistle sound

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ISO 18405:2017 (2017) Underwater acoustics — Terminology (how to cite this?)

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