Simulating Realistic Ocean Soundscapes

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Introduction

High-fidelity soundscape simulations that recreate real-world variability to benchmark detectors and trackers.

- Recreate real-world variability.
- Produce realistic test datasets for detectors and trackers.
- Validate tracking and inform sensor deployment.

Noise Sources

Biological, anthropogenic and geophysical sources dominate ocean noise.

1. Biological

Marine life, such as the cacophony of snapping shrimp or the songs of whales and dolphins.

2. Anthropogenic

Human activities, dominated by commercial shipping, but also including sonar, and construction.

3. Geophysical

Natural physical processes, including noise from wind-driven waves, rain, earthquakes, and other geological activity.

Case Study: Snapping Shrimp

Bursty
Snaps occur in non-independent clusters.

Heavy-Tailed
Extreme events are more likely than in a Gaussian model.

Impulsive
Frequent, high-amplitude clicks.

1. Snap Timing (When?)

A **Non-Homogeneous Poisson Process (NHPP)** models snap times and burstiness. The snap rate is modulated by water temperature, and rhythmic daily and tidal cycles.

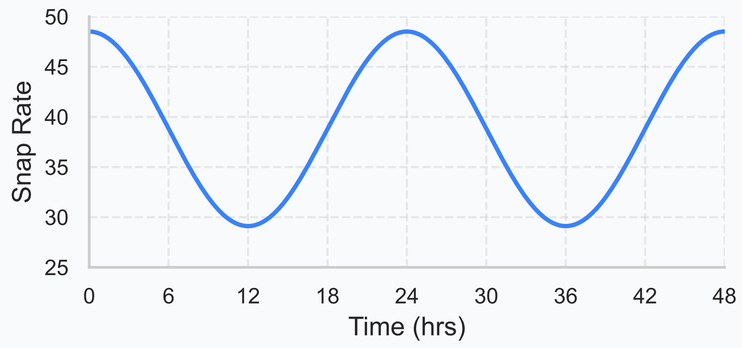

Figure 1. Snap rate variation over 48 hours.

2. Snap Waveform (What?)

Each ~2ms snap is built using a **Composite Waveform**, representing the acoustic signature of a collapsing cavitation bubble. This captures the sharp, broadband nature of the sound.

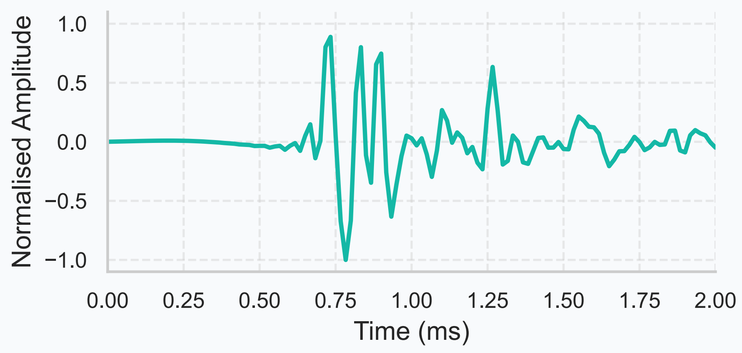

Figure 2. Modelled snap waveform (~2 ms).

3. Snap Amplitude (How Loud?)

Loudness is modelled with a heavy-tailed **Symmetric Alpha-Stable (SαS)** distribution. This correctly predicts the probability of the extremely loud snaps that characterise this type of noise.

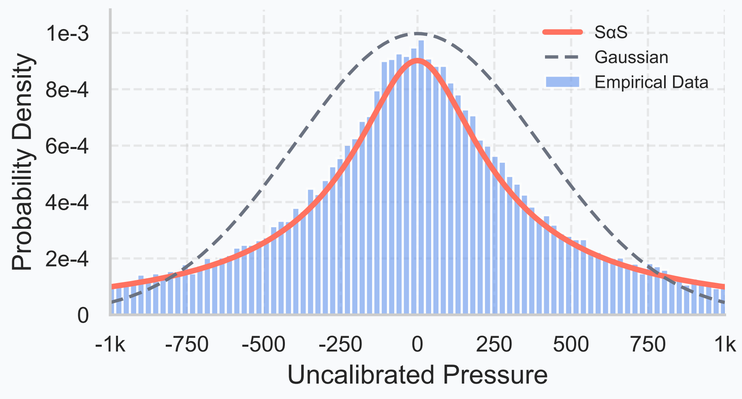

Figure 3. Amplitude distribution: SαS vs Gaussian.

Detection & Tracking

Use simulations to measure detector and tracker performance across realistic, variable noise conditions.

Detection

Measure probability of detection and false alarm rate as functions of SNR.

Tracking

Evaluate localisation error, ID switches, track fragmentation and continuity under variable noise and source density.

Operational impacts

Distant shipping reduces SNR and detection range; snapping shrimp produce clustered false positives; wind and wave noise increase background noise.

Key Points

- **Realism:** Models reproduce empirical statistics, specific to each source type.
- **Benchmarking:** Generate labelled datasets to measure detection and tracking metrics.
- **Impact:** Stress-test algorithms; guide sensor placement and processing.

More Info

Scan for audio samples, references & extra materials

https://jjwakefield.github.io/snapping-shrimp/snapping_shrimp.html

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