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The Silence of Global Oceans: Measuring the Acoustics Impact of the Covid-19 Lockdown

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ABSTRACT

Low-frequency sounds from marine vessels are a major source of underwater ocean noise. It overlaps with frequencies marine mammals use to communicate and navigate, causing stress and increasing collision with ships. But how to measure the changes in anthropogenic noise levels in oceans? The economic slowdown and cancellation of ocean cruises because of the COVID-19 pandemic led to a decrease in ship movements in waters of over 70 percent of the countries and presented an opportunity. I analyzed hydrophones (underwater microphones) data from 8 oceanic locations, extracted low-frequency sounds (10Hz-100Hz) associated with shipping, and compared them to previous years. Global oceans quietened by an average of 4.5 dB, 2.8 times decrease in peak sound intensity during the lockdown period. Findings were validated by comparing shipping traffic using satellite-based Automated Identification System (AIS). I created MonitorMyOcean.com, a WebApp for citizens and policymakers to get updated ocean noise levels and monitor the effectiveness of their "Quiet Oceans" policies.

1. INTRODUCTION

Low-frequency sound from maritime shipping is a major source of ambient underwater noise in oceans and a threat to marine life. Annual increases in global trade, 80% of which occurs through ocean tankers and container ships, means that underwater anthropogenic noise levels are increasing [1]. As seasonal ice disappears because of climate change and new shipping routes open in the Arctic, ambient sound levels are bound to increase. Anthropogenic noise is an acoustic pollutant. In the darkness of the oceans, marine life has evolved to use acoustic cues to communicate, migrate, forage, and reproduce. Unfortunately, low-frequency sounds (20 Hz - 200 Hz) radiated by propellers and machinery of over 60,000 commercial vessels traversing the oceans overlap with frequency bands used by marine life. (Figure 1). Whales mask their call frequencies, becoming louder in the presence of shipping [2]. It can also damage their hearing leading to stranding, inability to hunt, and collision with ships.

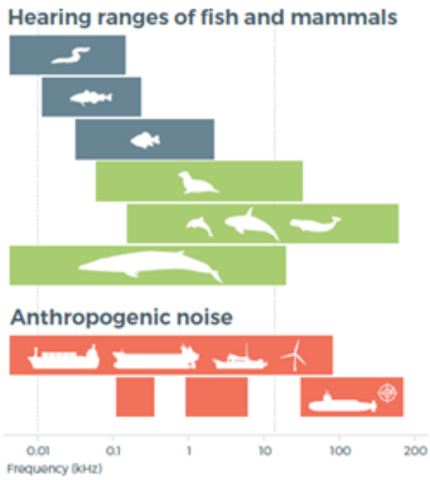

Figure 1. Overlapping of frequency bands of shipping noise with those used by marine life for communication.

2. RESEARCH RATIONALE

The onset of the COVID-19 pandemic in early 2020 brought an unexpected global "anthropause." Economic slowdown and travel restrictions meant nearly 44% of the global and 77.5% of national ocean jurisdictions showed a decrease in shipping traffic density during April 2020 (Figure 2). The ocean cruise season was canceled in 2020 by most countries. It was a rare research opportunity to create a time series quantifying the relationship between changes in anthropogenic activities and ambient noise levels in oceans.

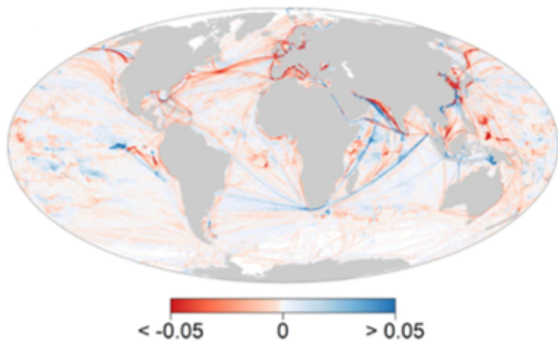

Figure 2. Global changes in vessel traffic density. https://www.nature.com/articles/s41467-021-22423-6.

2.1 Research Goals

1. Create a quantitative model to measure anthropogenic noise levels in oceans.

2. Use the model to measure the impact of COVID-19 restrictions on ambient noise levels in global oceans.

The research will mitigate the adverse impacts of economic exploitation of oceans and climate change on marine biodiversity. Research outputs will be shared with the UN agency: International Maritime Organization (IMO) responsible for international shipping routes and regulations, and submissions made to the Stellwagen Bank National Marine Sanctuary Management Plan and Environmental Assessment and to the Ocean-Noise strategy making process in Canada [3].

2.2 Research Hypothesis

The COVID-19 restrictions would have decreased underwater ambient noise levels in lower frequency bands (<1 kHz) in early 2020. The decrease would have varied across oceanic regions depending on marine activities restricted and the shipping traffic density.

3. DATA AND METHODOLOGY

3.1 Data Source

Hydrophones measure noise levels in the oceans. These underwater devices generate an electric signal when subjected to pressure change – allowing them to measure ocean sounds with great precision. I selected eight hydrophones in the Arctic, Atlantic, Pacific Ocean, and the Mediterranean Sea (Figure 3). Each of these oceanic regions was affected by human activities from commercial shipping to tourism, passenger ferries, or offshore exploration. I collected wind speed data at hydrophone locations from buoys operated by the National Buoy Data Centre (USA) [4]. Over 20 terabytes of data were downloaded and analyzed for this research study.

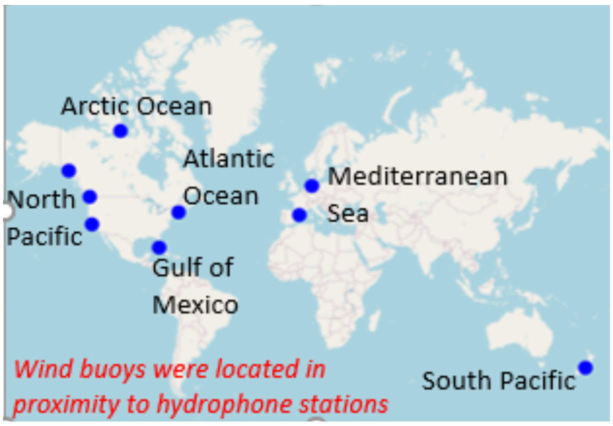

Figure 3. Selection of hydrophones in global oceans.

3.2 Methodology

The classification of primary ambient noise sources in oceans was done using Wenz curves. (Figure 4). It shows that the ambient noise produced by distant ship traffic is dominant between 10 and 100 Hz, while contributions from ocean winds occur at frequencies between 100 Hz and 25 kHz [4]. A five-step methodology was followed to isolate anthropogenic noise in oceans and observe changes brought by the COVID-19 restrictions.

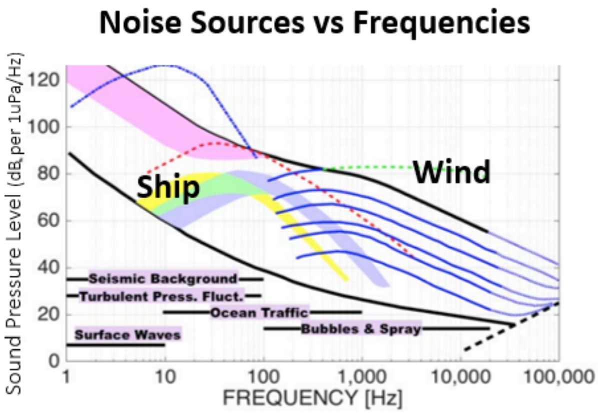

Figure 4. Wenz curves classify sources of ambient noises with frequency as a parameter.

1. **Preprocessing of Data:** Indexing the raw hydrophone WAV files to check for temporal continuity.
2. **Resampling Data:** Different hydrophones record sounds at different sampling rates. To maintain consistency, I resampled data at 2 kHz. It allowed me to analyze frequencies up to 1000 Hz (Nyquist theorem), which is the range of interest.
3. **Calculating Power Spectral Densities:** I split raw data into 1-minute segments and applied Fast Fourier Transformations (FFT) with a Hann window. This process resulted in 1-minute Power Spectral Densities that described the power of the acoustic signal as a function of frequency.
4. **One-Third Octave Bands Analysis:** The frequency bands were divided into 1/3 octave bands. Daily and monthly geometric means, medians, and quantiles of sound pressure levels in 1/3 octave bands centered around 63 Hz were calculated and compared to a previous year.
5. **Eliminating Wind and Weather Contributions:** Daily ocean [5] conditions at each hydrophone site were categorized using the Beaufort Scale: an empirical measure that relates wind speed to observed conditions at sea. Only measurements with equivalent natural noise impact were compared so that the resulting differences were due to the variability in the anthropogenic noise.

4. RESULTS

I compared underwater noise data for the lockdown period in 2020 with previous or the following year data depending on the availability of datasets [6] in order to assess changes in noise levels. The following results are organized by stages of the hypothesis and by findings / data sets.

4.1 Mean Ocean Noise Levels Decreased

Analysis from all hydrophone stations revealed a decrease in the geometric mean of noise levels during the COVID-10 lockdown period (Figure 5).

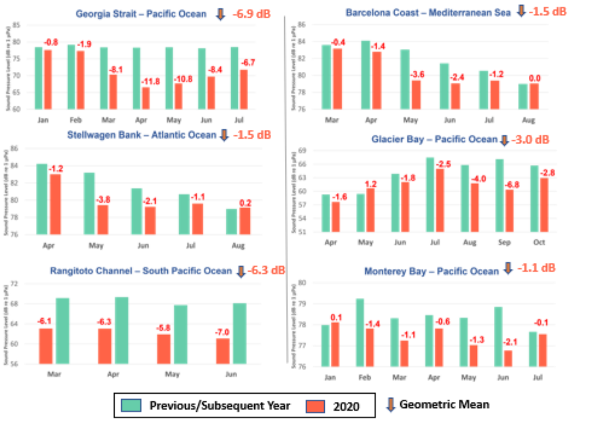

Figure 5. Decrease in mean anthropogenic noise levels in global oceans.

4.2 Noise Generated from Shipping Decreased

L_{25} exceedance Analysis shows that higher intensity noise (the value above which 25% of sound levels were found) decreased by an average of 5.5 dB (Figure 6). The decrease happened when the decrease in marine traffic was observed using satellite-based Automated Identification System (AIS) data that tracks the position of ships.

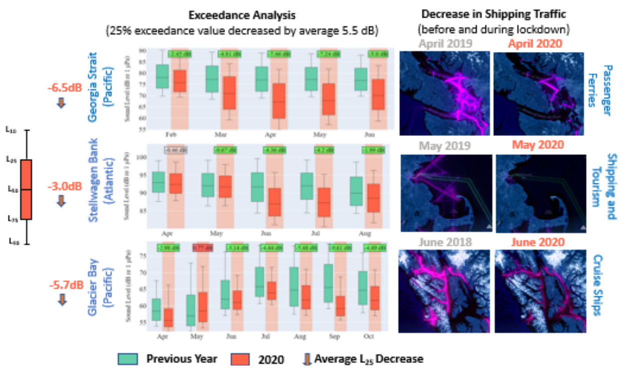

Figure 6. 25% Exceedance Value Analysis.

5. CONCLUSIONS

Commercial shipping dropped by 17% during the peak lockdown period. This led to a reduction in underwater ambient noise levels caused by human activities. Global oceans quietened during the lockdown period by an average of 4.5 dB, or 2.8 times decrease in peak sound intensity levels compared to previous years (Figure 7).

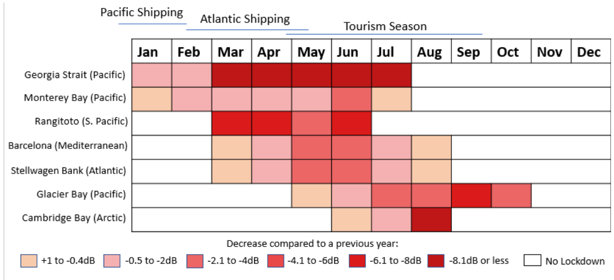

Figure 7. The Silence of Global Oceans During COVID-19 Lockdown.

Once the pandemic restrictions were put in place, noise levels fell immediately. This drop shows that strategically induced "anthropauses" are effective at reducing ocean noise. These could include moratoria on deep-sea mining, delaying of tourist seasons, and shifting shipping routes during breeding seasons. These strategies will minimize the effect of noise pollution on marine mammals and help reverse the decline in marine population.

6. DISCUSSIONS

6.1 Limitations of the Study

As hydrophones operate at varying depths in open oceans, they sometimes malfunction, leading to gaps in continuous data in time-series analysis. A large volume of data recorded by hydrophones means many observatories cannot store and provide access to raw data archives. In some cases, hydrophone data is retrieved by ocean-going vessels and delays data by several months.

6.2 Outreach and Future

It is the goal of my research to help create an evidence-based foundation for global policy that aims to preserve marine life. To do so, we need to create strong citizen science communities and enrich our datasets. I have released the source code on GitHub and created an interactive WebApp www.MonitorMyOcean.com to monitor and compare anthropogenic noise levels in global oceans. The United Nations has proclaimed 2021-2030 as the UN Decade of Ocean Science for Sustainable Development [6]. The MonitorMyOcean.com App has been endorsed as a UN Ocean Decade Activity. I hope to expand it further for monitoring other anthropogenic activities, including impact of deep-sea mining, and bringing it to other oceanic regions through initiatives such as the International Quiet Oceans Experiment.

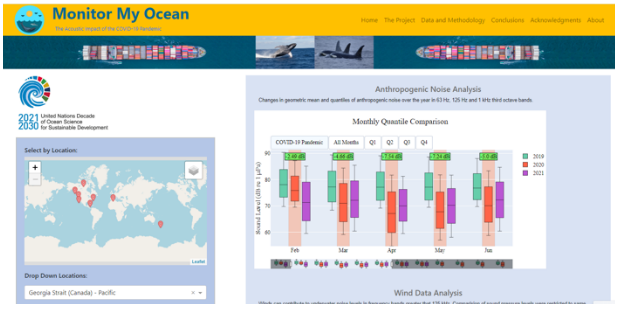

Figure 8. Screenshot of MonitorMyOcean.com WebApp.

7. REFERENCES

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