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COMMUNICATING IN NOISY WATERS: HOW SHIPPING NOISE AND ENVIRONMENTAL CONDITIONS AFFECT BLUE AND FIN WHALE CALLING ACTIVITY

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ABSTRACT

Large whales are often found in areas of high traffic and their interaction with this anthropogenic activity is a concern. In this study, we investigated the impact of shipping activity and environmental conditions on the blue (*Balaenoptera musculus*) and fin whale (*B. physalus*) calling activity in the Santa Barbara Channel. Passive acoustic data were collected from November to March over two consecutive years (2019/20 and 2020/21), partly overlapping with the Covid-19 pandemic. Occurrence of five different whale call types and ship passages were identified and counted. Environmental data, including sea surface height (SSH), sea surface temperature (SST) and chlorophyll a (Chla) were extracted from remote sensing data streams and used, along with shipping, to model whale calling activity.

All blue whale and fin whale 20 Hz-calls were less frequent in 2019/20 than 2020/21, while fin whale 40 Hz-calls had higher presence in 2019/20. No significant difference in shipping activity was observed between the years. Blue whale calls were significantly related to Chla and lagged SST in 2020/21, whereas fin whale calls were related to shipping, Chla, and lagged SST independent of the years.

These findings highlight the combined impact of environmental factors and shipping on whale calling behavior.

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1. INTRODUCTION

Marine organisms rely on sound for a variety of purposes, including mate selection, habitat localization, and foraging [1–3]. Blue whales (*Balaenoptera musculus*) are among the most prolific sound producers in the ocean, emitting calls that are characterized by a high intensity (maximum recorded at 188 dB re 1 μPa) and low-frequency (16-100 Hz) [4–6]. Fin whales (*B. physalus*) across the eastern North Pacific typically produce two high-intensity (up to 189 dB re 1 μPa) frequency-modulated call types, referred to as the 20 Hz and the 40 Hz call [7, 8]. Shipping vessels (mostly commercial) produce noise in the lower frequency bands, which therefore considerably overlap with hearing and communication ranges of baleen whales [9]. Noise pollution from shipping traffic is already the biggest contributor to anthropogenic noise in the lower frequencies (below 200 Hz) in the ocean and predicted to further increase [10–15]. Low-frequency noise pollution from shipping traffic has been shown to affect both the acoustic behavior and overall activity patterns of blue and fin whales [16–19].

The Southern California Bight (SCB) serves as an important feeding habitat for blue and fin whales [20–22]. Within the SCB, the Santa Barbara Channel (SBC) is a well-studied area because of its local upwelling [23]. Fin whales have been observed in the region year-round [7, 22, 24], while blue whales use the area as a seasonal foraging habitat, primarily from June to October [25], with peak acoustic activity occurring in the fall and early winter [24, 26].

However, the SBC also functions as a main shipping route connecting Asian markets to the United States [27]. Noise pollution from shipping traffic in this area is affected by the local bathymetry that traps noise, therefore making the natural acoustic environment susceptible to the high intensity of local shipping [28]. As the SBC functions as main habitat for blue and fin whales, as well as an important shipping route, it is crucial to investigate the impacts of shipping activity on the acoustic behavior of these whales in this area.

The Covid-19 pandemic substantially decreased shipping traffic worldwide, particularly between March to June 2020, because of the drastic effects of global lockdowns on global economic activity [29]. The presumed reduced noise levels allow for a natural experiment to investigate the impact of shipping activity on the acoustic behavior of blue and fin whales in the Santa Barbara Channel.

2. MATERIALS AND METHODS

A buoy was deployed in the SBC at 180m depth recording passive acoustic data. The buoy was deployed at a location near the shipping lanes from and to the ports of Los Angeles (LA) and Long Beach (LB) and it recorded from November 23rd 2019 until March 30th 2021. The data were recorded using a Digital acoustic MONitoring (DMON) instrument with a sensitivity of -203.0 dB re V/µPa rms with a total gain of 33.2 dB, zero-to-peak voltage of 1.5 V, and 16-bits A/D converter [30]. Furthermore, data were recorded at a sampling rate of 2 kHz, on a duty cycle that recorded for 30 minutes every hour to optimize data storage.

Acoustic data from four months of two consecutive years were analyzed (November 25th 2019/20 – March 25th 2020/21) to investigate the potential effect of shipping activity on blue and fin whale calling activity without having to account for seasonal differences. The first year represents the time period just before the onset, and early start of the pandemic, and the second year the time period represents assumed ‘normal’ shipping conditions.

Long-term spectral averages (LTSAs) with 5 second temporal and 1 Hz frequency resolution were created using Triton via MATLAB (Version 2019b). Spectrograms were set to display 60 seconds of data at a 0-200 Hz frequency band to detect blue and fin whale calls. FFT size was set to 1000 samples with a 90% overlap using Hanning window. Individual ship passages within 30 minutes of data were logged within the LTSA set to display a 0-2 kHz frequency band. We then summed the count data of whale calls per call type and ship passages per day.

We accessed environmental satellite data using the European Union Copernicus Marine Service Information (CMEMS; managed by the Copernicus Programme of the European Union) from https://www.data.marine.copernicus.eu/en. Data for sea surface height (SSH), sea surface temperature (SST), and chlorophyll a (Chl a) were extracted.

We investigated the relationships between the predictor environmental variables and calling activity over time using generalized additive modeling (GAM) framework. GAMs were implemented using the ‘mgcv’ package in software program R (Version 2022.12.0+353). . We selected the best-fitted model for each call type from models with all possible permutations of predictor variables using the Akaike Information Criterion (AIC).

3. PRELIMINARY RESULTS AND DISCUSSION

Preliminary analyses indicate no substantial change in shipping traffic between the two studied periods (2019/20 and 2020/21). This finding contrasts with several global studies showing clear declines in maritime activity as a result of the Covid-19 pandemic. These initial findings might therefore suggest regional variability in shipping patterns and fine-scale trends of the effects of the pandemic on shipping activity worldwide.

Nevertheless, notable differences were observed in the calling activity of both whale species between the years. These differences might be influenced by variability in environmental conditions rather than shipping activity. Preliminary analyses of the environmental data suggest strong differences in environmental conditions between the two years, which could affect prey availability and consequently whale presence and calling activity. While these patterns are still being investigated, they underscore the potential importance of environmental conditions affecting whale acoustic activity, possibly unaffected by persistent presence of shipping activity in the SBC.

4. ACKNOWLEDGMENTS

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