Sound pressure levels from hydrophone recordings at six sites in the Galapagos Islands from September 2020 through August 2022 to examine soundscapes during the Anthropause and beyond

Website: https://www.bco-dmo.org/dataset/875382
Data Type: Other Field Results
Version: 1
Version Date: 2023-09-13

Project
» RAPID: Illuminating the effects of a COVID-19 elimination of diver disturbance on reef fish behavior, distribution and ecosystem functioning in the Galapagos Marine Reserve (Galapagos diver disturbance)

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Abstract
These are passive acoustic data sampled with SoundTrap 300 hydrophones at 10-15 meters depth at 6 sites in the Galapagos Islands from September 2020 through August 2022. Data represent median Sound Pressure Levels (SPLs) in 15 minute bins measured for a minimum of 24 hours per site. These data are part of a larger project to understand the effect of the reduction of scuba diver disturbance during the COVID-19 lockdown (the "Anthropause") on the biological soundscape as well as effects on behavioral interactions among fish.

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Coverage

Spatial Extent: **N**:-0.235038 **E**:-90.14065 **S**:-1.32879 **W**:-90.38498
Temporal Extent: 2020-09 - 2022-08

Methods & Sampling

Sampling and analytical procedures:

Approximately 1900 hours of underwater sound was sampled by SoundTrap 300 hydrophones during the

study period from September 2020 through August 2022. The hydrophones were set to record at 98 hertz (hz) to record continuously over the duration of the deployment to capture acoustic signals in the soundscape including biological (fish, snapping shrimp, sea lions, etc.) and anthropogenic (divers, boat noise) sound.

A standard procedure was followed to deploy hydrophones at 3 sites of high (Champion, Gordon, Seymour) and low (Gardner, Baltra, Daphne Menor) diver disturbance during the “Anthropause” when tourism was substantially reduced in 2020 due to the COVID quarantine. Hydrophone were deployed again at the same locations in 2021 and 2022 as tourism increased. At each of the six sites, a single hydrophone was mounted on a stainless steel stand so that it was positioned vertically about 1.5 meters about the rocky bottom (~10-15 m depth). This was done by scuba diving from a small (14 m long) sport fishing type boat (MV Valeska out of Puerto Ayora). The acoustic recordings were made simultaneously at two sites for 2 to 8 days and the procedure was repeated so all 6 sites were sampled.

The 2020 data can serve as a baseline of the total amounts of biological and anthropogenic noise in the Galapagos during the Anthropause, and can be compared to 2021 and 2022 data after the COVID 19 quarantine ended and activities resumed. Biological soundscape differences between day and night can also be analyzed using the local time (Galapagos Island Time of UTC minus 6 hours).

Data Processing Description

Deployment records were cleaned in Raven Pro version 1.6 software to remove the sound of divers setting up the hydrophone stand. The resultant filtered WAV files were converted into statistical metrics with the use of Matlab-based acoustic processing package Triton (version 1.93) from Scripps Institution of Oceanography. Both the standard package and soundscape metrics "remora” were utilized to convert WAV files into full spectrogram files.

Triton, Raven, and R Studio software were used to compute and visualize sound pressure levels. Sound pressure levels for the full broadband and low frequency band were computed to isolate fish vocalization. Mean and median sound metrics were computed in both frequency bands at 15-minute and 30 second intervals. Median sound pressure levels across the broadband using 15-minute intervals offers a general coarse grain profile of the soundscape. This process created 15,800 usable sampling windows total.

Raven Pro version 1.6 software (https://ravensoundsoftware.com/software/raven-pro/)
Triton Software version 1.93 (https://www.cetus.ucsd.edu/technologies_triton.html)

BCO-DMO Processing Description

- Merged individual data tables for each site sampled in 2020 into a single data table (Baltra Anthropause Oct1-2 2020.xlsx, Champion Anthropause Sept 23 2020.xlsx, Daphne Menor Anthropause Oct17-18 2020.xlsx, Gardner Anthropause Oct20-21 2020.xlsx, Gordon Anthropause Oct 16 2020.xlsx, Seymour Anthropause Oct 10 2020.xlsx)
- Concatenated data from 2021 and 2022 to the 2020 data (WitmanAcoustic2021-01.xlsx and WitmanAcoustic2022-08.xlsx)
- Joined site location information (latitude and longitude) provided by PI to main data table
- Created a datetime column in ISO8601 format (UTC time zone)
- Removed blank spaces from column header names
- Kept separate local date and local time columns to allow analysis of day-night differences in biological soundscape, but changed date format to YYYY-MM-DD
- Sorted chronologically by site

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Related Publications

K. Lisa Yang Center for Conservation Bioacoustics at the Cornell Lab of Ornithology. (2023). Raven Pro: Interactive Sound Analysis Software (Version 1.6.4) [Computer software]. Ithaca, NY: The Cornell Lab of Ornithology. Available from https://ravensoundsoftware.com/.
Software

RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/.
Software

Wiggins, S. M., Roch, M. A., & Hildebrand, J. A. (2010). TRITON software package: Analyzing large passive acoustic monitoring data sets using MATLAB. The Journal of the Acoustical Society of America, 128(4), 2299–2299. https://doi.org/10.1121/1.3508074
Software

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Parameters

Parameter	Description	Units
ISO_DateTime_UTC	Sample Datetime in ISO8601 format	unitless
Latitude	Latitude of sampling location	decimal degrees
Longitude	Longitude of sampling location	decimal degrees
Site	Study Site	unitless
Sound_Pressure_Level	Sound Pressure Level	decibels referenced to 1 microPascal (db re 1 uPa)
Sample_Date_local	Sample date (Galapagos local timezone of UTC-6)	unitless
Sample_Time_local	Sample time (Galapagos local timezone of UTC-6)	unitless

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Instruments

Dataset-specific Instrument Name	SoundTrap 300 STD Compact recorders
Generic Instrument Name	Hydrophone
Dataset-specific Description	A single SoundTrap 300 hydrophone was mounted on a stainless steel stand vertically about 1 meter above the rocky bottom with . The hydrophone was set to record continuously at 98 hz. For instrument specs see: http://www.oceaninstruments.co.nz/product/soundtrap-300-std
Generic Instrument Description	A hydrophone is a microphone designed to be used underwater for recording or listening to underwater sound. Most hydrophones are based on a piezoelectric transducer that generates electricity when subjected to a pressure change.

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Project Information

RAPID: Illuminating the effects of a COVID-19 elimination of diver disturbance on reef fish behavior, distribution and ecosystem functioning in the Galapagos Marine Reserve (Galapagos diver disturbance)

Website: https://www.nsf.gov/awardsearch/showAward?AWD_ID=2035354&HistoricalAwards=false

Coverage: Galapagos Islands, Eastern Tropical Pacific

Large-scale changes in the magnitude of human influence on the biosphere have occurred due to travel restrictions and quarantines to contain the COVID-19 pandemic. The reduction in the number of visits to natural areas is providing an unprecedented opportunity to study the effects of people on wildlife and ecosystems. Previous studies indicate that humans can impact the entire ecosystem by frightening animals and altering their behaviors. The COVID-19 quarantine has created a "natural experiment" in the ocean at scuba-diving destinations worldwide by suspending dive tourism and temporarily eliminating the effects of diver-induced fear in reef fish communities. In the Galapagos Islands, the number of scuba divers dropped from 18,000 divers a year to zero in March 2020 when the government of Ecuador halted dive tourism. This study is measuring the changes reef fish behavior, populations and ecological interactions between species to gain an understanding of how dive activity affects the functioning of this marine ecosystem. The effects of changes in diver disturbance are being determined by comparing reef fish communities during and after the quarantine to those from a long-term pre-COVID-19 baseline study. Broader impacts include training opportunities for undergraduate students through participation in field research and senior thesis projects. Public outreach is focused on presentations to the general public and high school students in the US and in the Galapagos. A YouTube video on the ecological effects of diving activity in the Galapagos Marine Reserve is being produced and made publicly available. Insights from this project is increasing awareness of how humans impact subtidal marine ecosystems, which is aiding marine conservation efforts of marine protected areas in the Galapagos and elsewhere.

The intellectual contribution of the research lies in its ability to test hypotheses about the role of humans in influencing consumptive and non-consumptive interactions in shaping the structure, complexity and functioning of marine ecosystems. While it is known that reef fish react to humans as potential predators, less is known about how the fear of predation, a major type of non-consumptive interaction, affects subtidal marine communities, particularly on large spatial scales relevant to conservation. An integrated, observational - experimental research program is addressing this knowledge gap in the Galapagos Marine Reserve by comparing current conditions with existing pre-COVID-19 data. Four hypotheses or predictions related to pandemic spillover effects are being tested: 1) diver disturbance results in behavioral shifts in reef fishes; 2) divers decrease the abundance and diversity of reef fishes and this effect is currently reduced; 3) emergence or increased abundance of previously wary herbivorous and /or predatory fish results in greater consumption of benthic organisms during and immediately after the COVID-19 period; and 4) decreased diver disturbance associated with the pandemic changes the complexity of behavioral networks (aggressive and positive interactions) among reef fish, sharks and sea lions. The hypotheses are being tested at 14 sites over the course of three research trips using underwater observations and experiments involving fish counts, video camera deployments to record fish behaviors, feeding rates, interactions between species and underwater boat noise from dive tour boats. This project has implications for understanding how fish communities in the Galapagos Marine Reserve ecosystem will respond to future perturbations, while also providing unique insight into the ecological ramifications of a human pandemic.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2035354

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