

Acoustic Diversity In Coral Reefs Under Restoration In Culebra, Puerto Rico

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Background

- Coral reefs have proven to be an essential necessity around the world, hosting a wide variety of marine life and serving as a buffer for natural disasters.
- One way to determine the success of a restoration project is to assess changes in reef diversity. Bioacoustics is becoming an ideal way to evaluate restoration success in coral reef ecosystems because it is an accessible and non-invasive method.
- Soundscapes represent a functionally important measure of a reef's ecological status. On healthy reefs, a wide range of soniferous fishes and invertebrates contribute to a loud and diverse soundscape that plays an important role in ecosystem functioning; acoustic cues in the soundscape guide the recruitment and settlement behaviors of many reef organisms (Montgomery et al., 2006; Simpson et al., 2008).
- Different sound types dominated at different times of day, but the relative differences between habitat type were consistent between time periods, suggesting that differences in phonic richness are robust to within-day variation (Lamont et al., 2021).

Research Objective

The study proposes to quantify the acoustic variations of fish found among coral reefs under restoration to determine if their variation fluctuates over the course of the day and study zone.

Methods

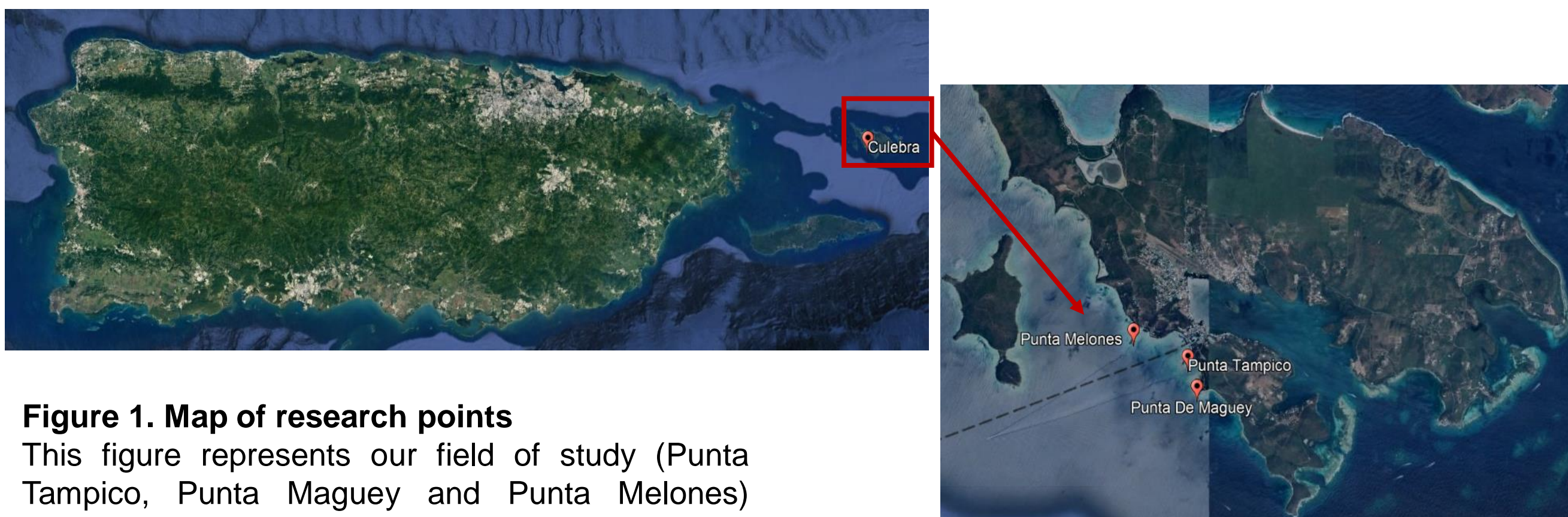


Figure 1. Map of research points
This figure represents our field of study (Punta Tampico, Punta Maguey and Punta Melones) within the island of Culebra, Puerto Rico.

The research zone is located within the island of Culebra, Puerto Rico in the following locations: Punta Tampico, Punta Maguey and Punta Melones (Figure 1). The device pictured on the right is a hydrophone, a device deployed (one day every three months) at each site for 11 continuous hours, between the hours of 7 a.m. and 6 p.m., with the aim of gathering bio aquatic data. These recordings were taken during the months of July, August, September, and November 2022. A minute from each hour was simultaneously selected to form a subsample of 11 minutes per day consisting of low frequencies between 0 to 1.0 kHz, in the absence of anthropogenic noises. Afterwards, the subsamples were examined through the comparison of spectrograms utilizing the program Audacity to quantify the phonic richness. The sounds identified during this study are Scrape, Knock, Purr, Raspberry, Croak, Growl, Grunt, Foghorn, Whoop, Laugh, Run Run, Br Br and Others.



Results

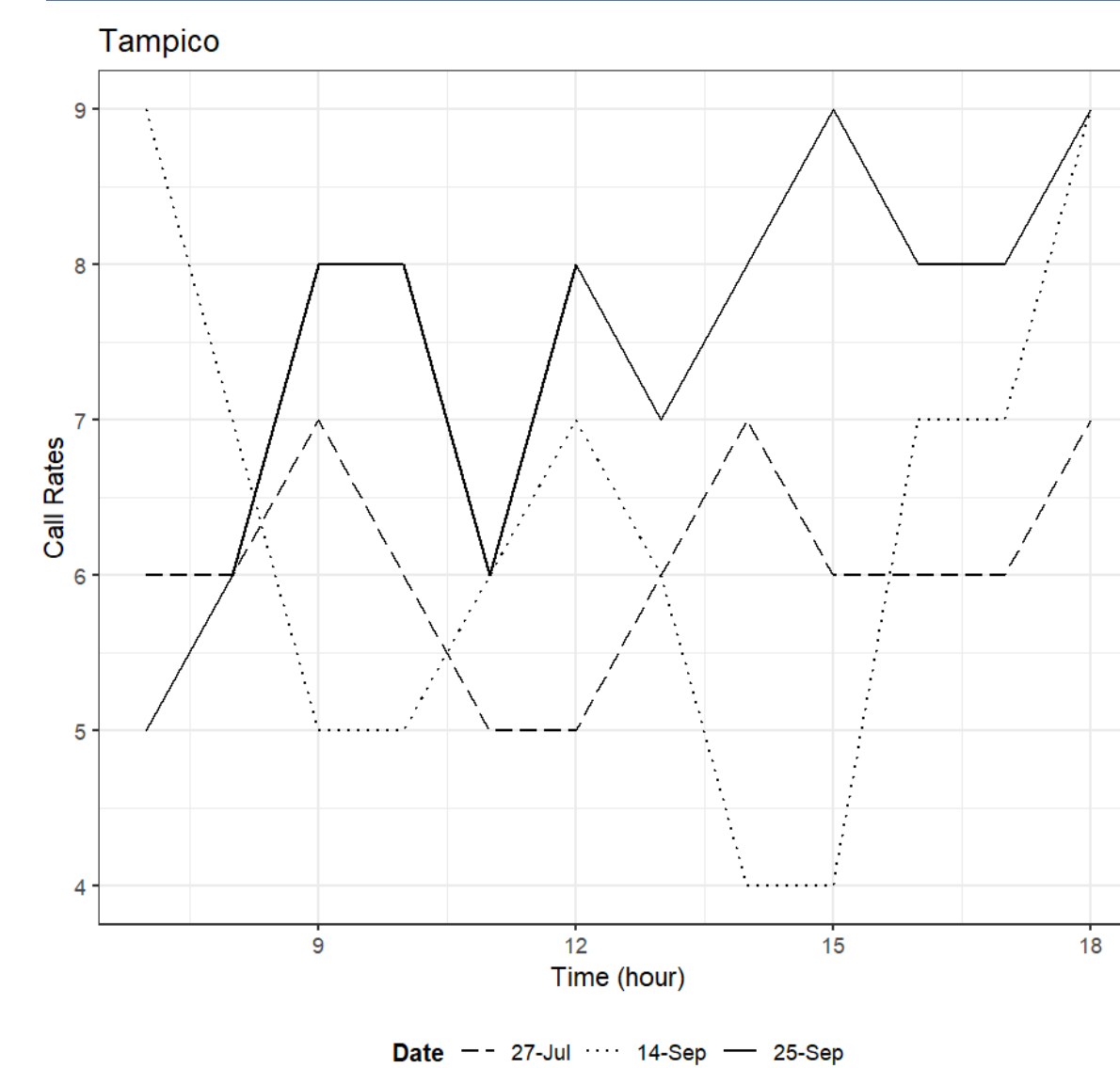


Figure 2. Fluctuations among fish calls in Tampico Culebra, Puerto Rico.

In this plot we can observe a range of four to nine call rates. An assortment of line types can also be seen to indicate the three dates on which data was collected: July 27 (long dashed line), September 14 (dotted line), and September 25 (black line). This data was collected between 7:00 am and 6:00 pm.

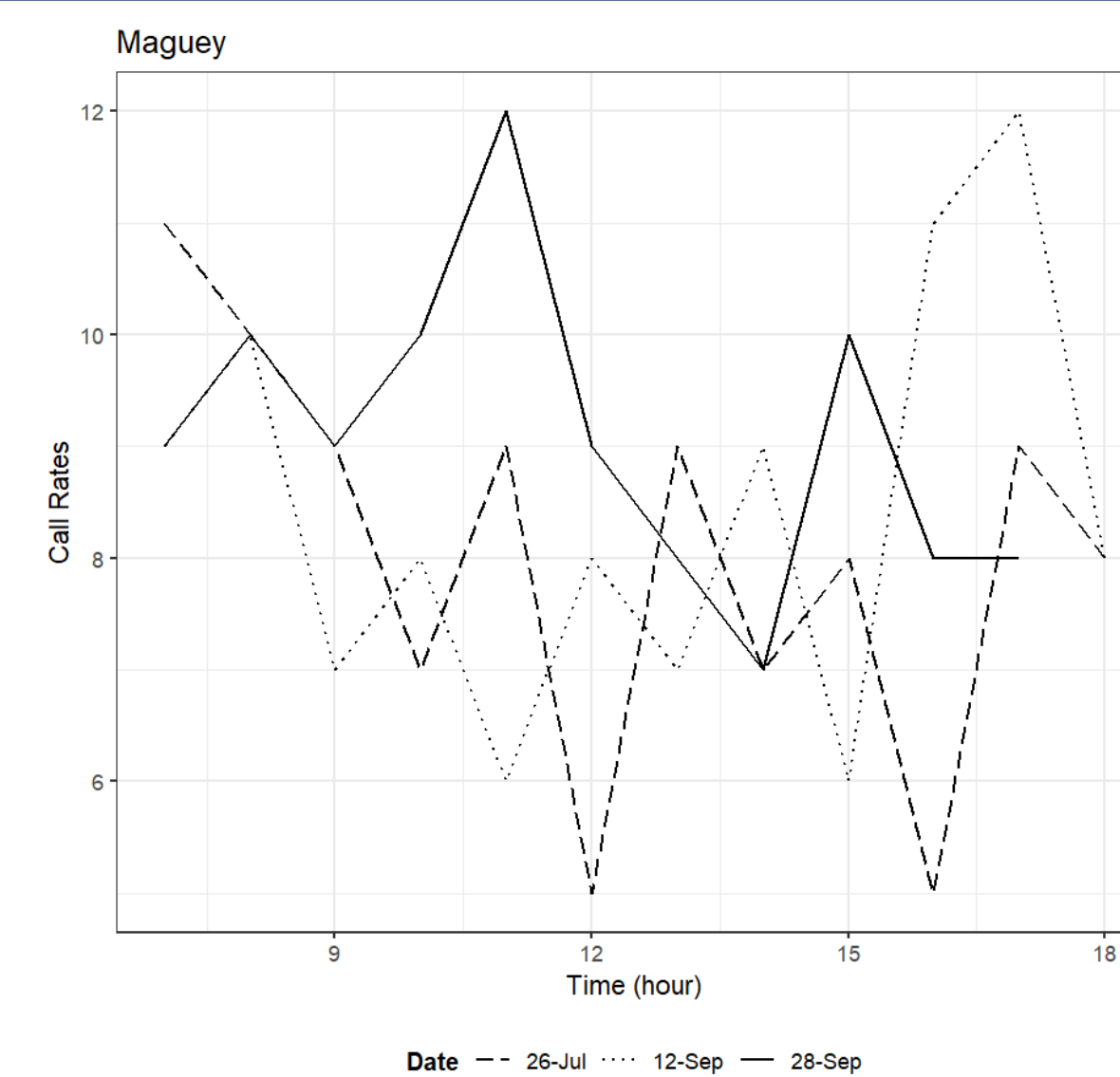


Figure 3. Fluctuations among fish calls in Maguey Culebra, Puerto Rico.

In this plot a range of between zero and twelve call rates was seen. The three dates on which data was collected are represented with a variety of different types of lines: 26 July (long dashed line), 12 September (dotted line), and 28 September (black line). In the case of September 28, phonic richness was analyzed from 7 am to 5 pm, while September 12 and July 26 from 7am to 6pm.

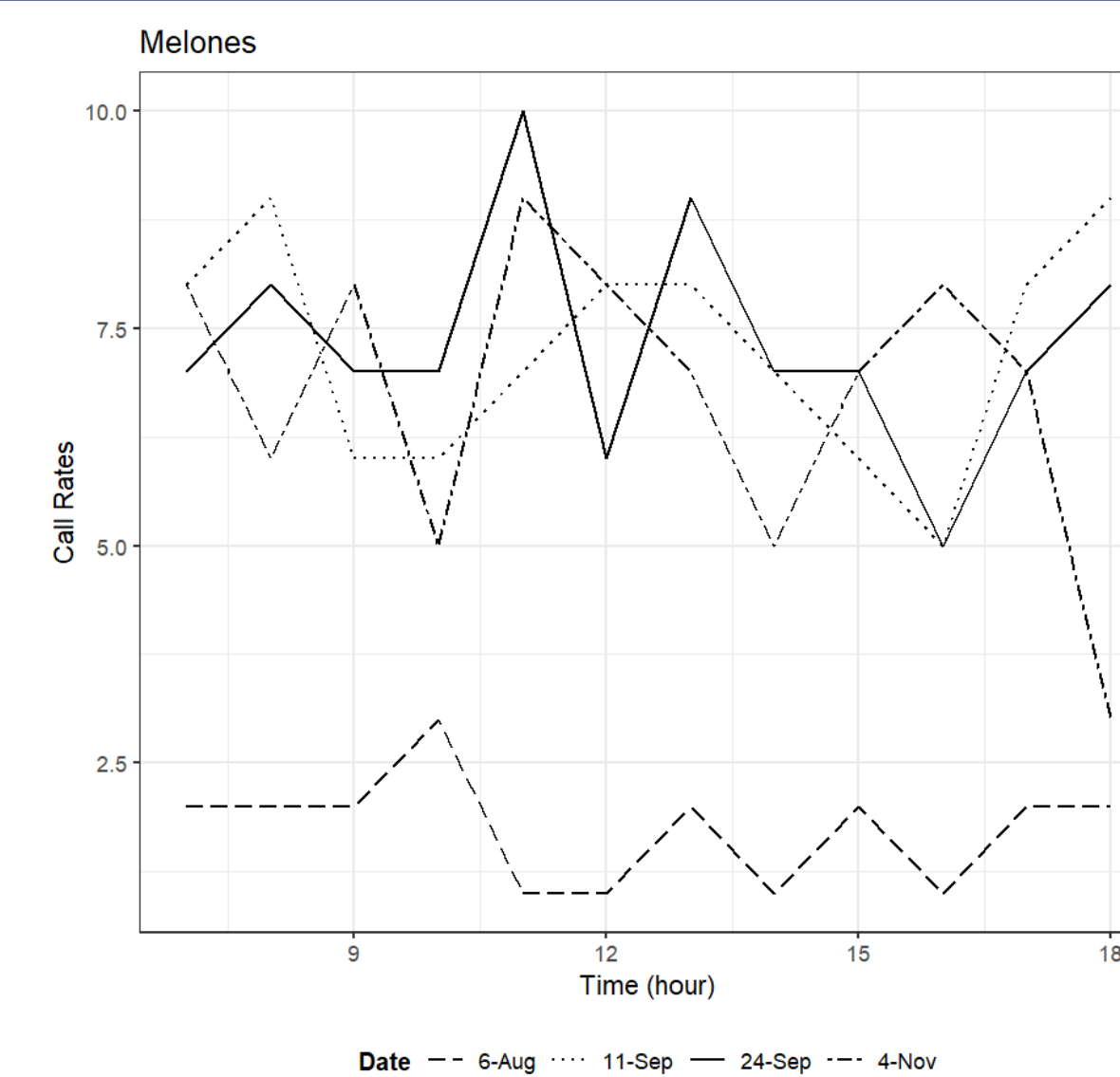


Figure 4. Fluctuations among fish calls in Melones Culebra, Puerto Rico.

In this plot a range from one to ten call rates is shown. A variety of line types are also seen to represent the three dates on which data was collected: August 6 (long dashed line), September 11 (dotted line), September 24 (black line), and November 4 (two-dash line). This data was collected between 7:00 am and 6:00 pm.

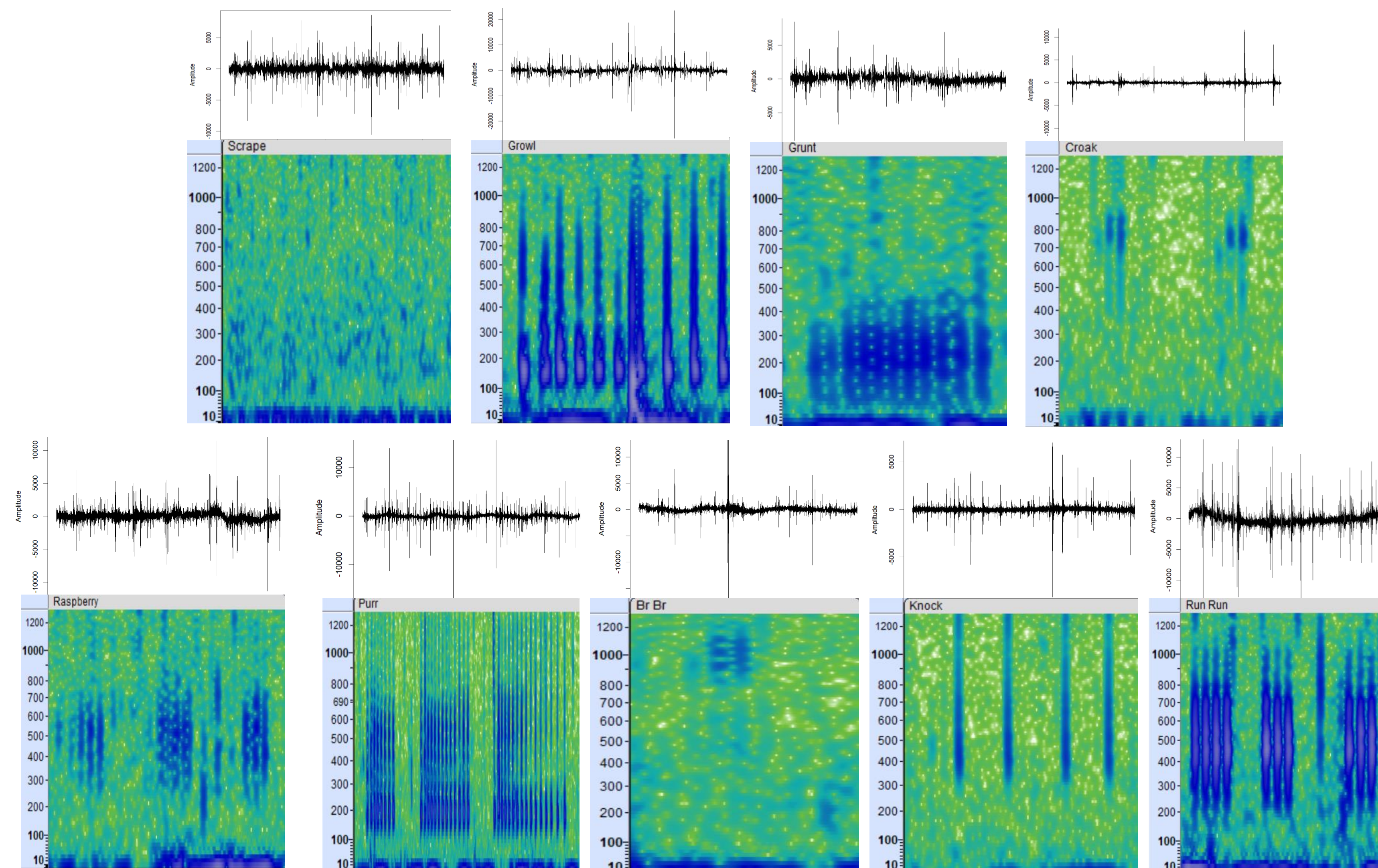


Figure 5. Spectrograms/Waveforms

All spectrograms were produced using the Audacity program to evaluate the frequency bands(kHz) of the various biophonic sounds. The blue shading indicates the intensity of the sound; the darker, the louder the noise. Furthermore, we have specified frequency ranges in the spectrograms for the top row: Scrape(broadband frequency), Growl(100kHz to 1000kHz), Grunt(100kHz to 450 kHz), Croak(650kHz to 900kHz); for the bottom row, Raspberry(250kHz to 800kHz), Purr(100kHz to 800kHz), Br Br(800kHz to over 1000kHz), Knock(300kHz to over 1000kHz), and finally Run Run(200kHz to 1000kHz).

Discussion

- During the data recollection, a total of nine distinctive vocalizations were identified: Scrape, Knock, Purr, Raspberry, Croak, Growl, Grunt, Run Run and Br Br (Figure 5). Of those, Run Run and Br Br, had not been identified among other non-invasive monitoring studies. Validating and confirming the complexity and uniqueness of marine habitats.
- Maguey displayed a higher quantity reaching twelve call rates in September 28 and September 12 (Figure 3). Therefore, it is speculated that this site may present a more diversified marine environment.
- Across all sites, a wide range of biotic calls (Call Rates) were evident between the various hours of the day. This variation was especially observed through the high peak values generally found in the morning and afternoon in locations Tampico and Melones (Figure 2 & 4).
- Following the natural disaster Hurricane "Fiona" that took place between September 17 and September 19, all the study sites showed an increased acoustic response at the following dates: September 25 (Tampico), September 28 (Maguey), and September 24 (Melones). Such behavior may be caused as a result of fish reverting to their habits upon evacuating into deeper water.
- Based on the results presented in this study, it becomes apparent there is variation of sounds among the area of study related to space and time. Potential explanations for this variation may include differences in terrain morphologies, refuge variety, changes of temperature, seasons, salinity values, spawning period, anthropogenic effects, and other natural phenomenon.

Conclusion

These observations indicate a variation of bioacoustics diversity relative to the time of day and study sites. Ultimately, this data demonstrates that despite there being some similarity in the abundance of sound across regions, each coral reef presents a distinctive acoustic pattern. Thus, we believe such data will provide a greater understanding as to how coral restoration can contribute to the recovery of soundscapes.

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