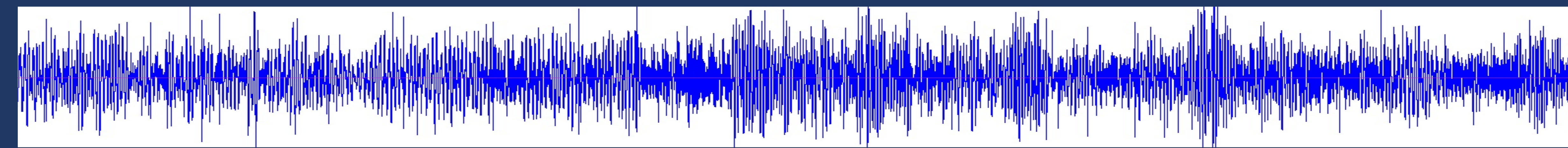
Eavesdropping on fishes reveals alterations in the soundscape across tidal creeks



By: Abigail K. Solarz, Cecilia S. Krahforst

Introduction

- Soundscape changes with species, time of day, seasonality, and the environment.
- Acoustic indices measure the soundscape throughout time but are influenced by the habitat, physical oceanographic changes, and the species present in an area.[1]
- **Goal**: To explore the soundscape in tidal creeks to obtain baseline information about ecoacoustic variability.

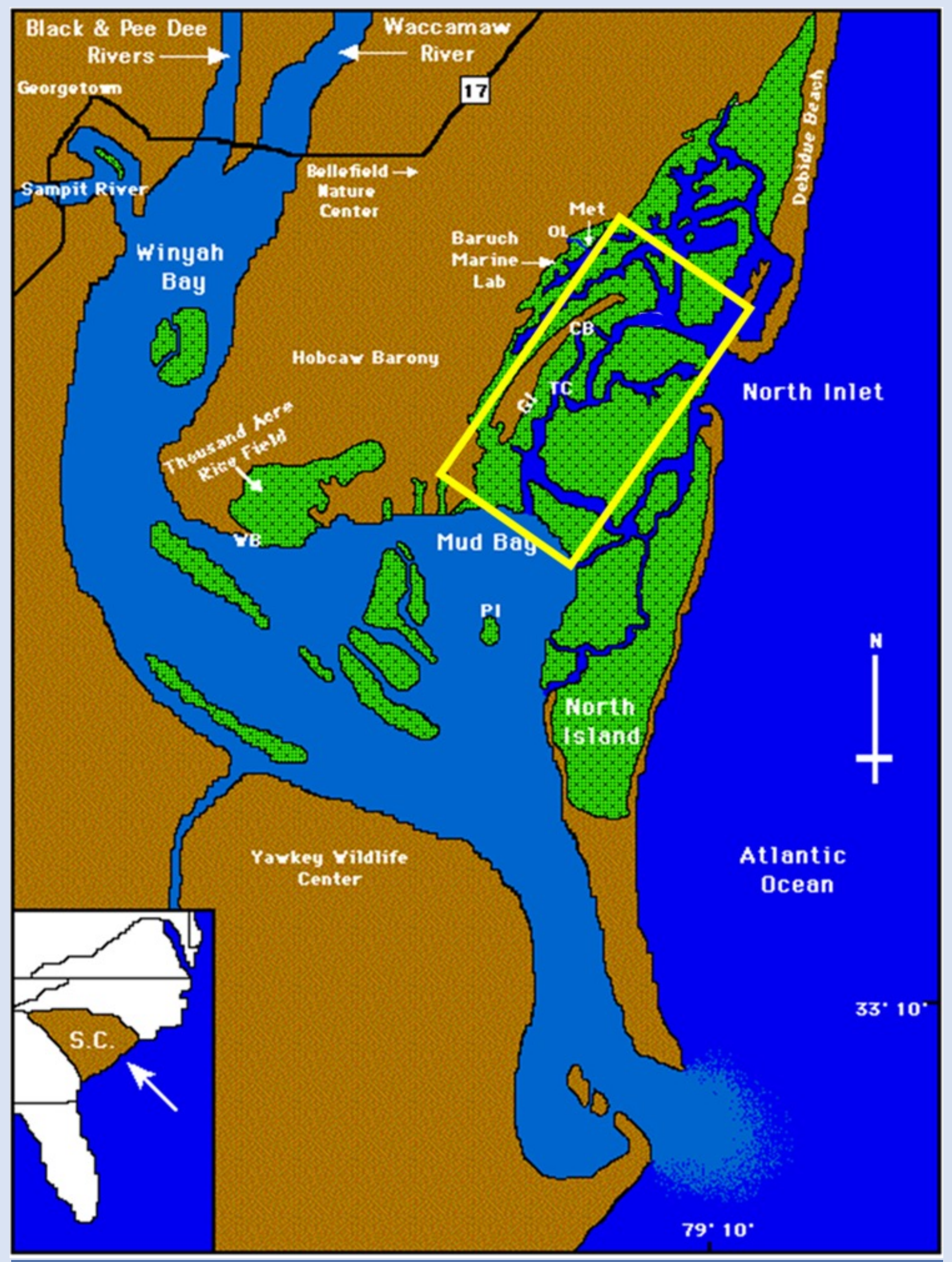


Figure 1. General location of study sites (yellow box) in the North Inlet estuary.[2]

Methods

- Soundscape was recorded at 7 sites (Fig. 1) using a hydrophone and water quality was obtained using a YSI.
- Soundscape was processed for acoustic indices: (a) entropy [H] – soundscape energy, (b) acoustic diversity [H'] – soundscape players, and (c) acoustic complexity index (ACI) – how the soundscape changes throughout time.[3] Soundscape players - number of species throughout the recording – were also assessed in each recording.
- Within site difference across months was explored using a one-way ANOVA with a significance level of $p<0.05$.
- Regression relationships were explored between variables across sites with a significance level of $p<0.05$.

Results

Clam Bank Changes Across Months

- The soundscape varied throughout time, with the lowest acoustic indices on 5/02/2019 and the highest acoustic indices on 5/20/2019. The spectrogram clearly demonstrates soundscape difference across these dates (Fig. 2).

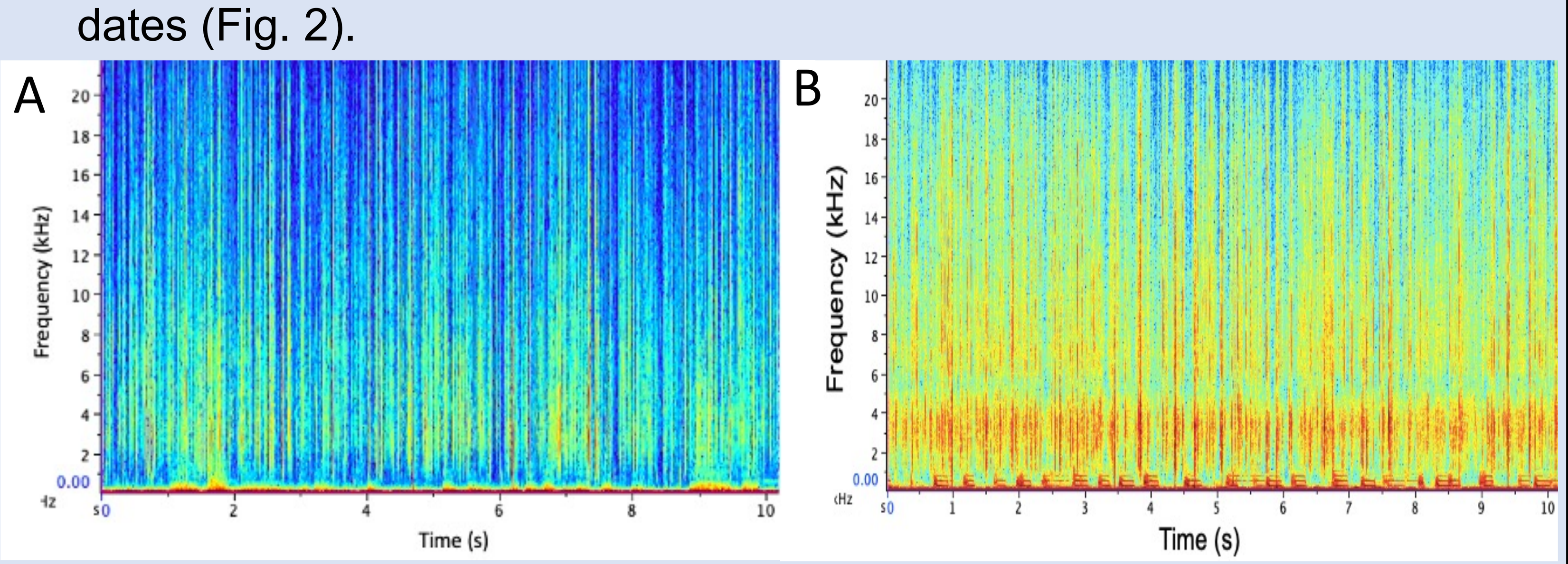


Figure 2. Spectrograms of (A) quiet recording on 5/02/19, and (B) noisy recording on 5/20/19 at Clam Bank. Hotter colors indicate higher amplitude and cooler colors are lower amplitude sounds.

- The maximum difference in entropy (H) was 0.19 (Fig. 3). There was a significant difference in H across sampling periods (ANOVA, $p=0.01$).
- Acoustic complexity (ACI) on 5/02/2019 and 5/20/2019 was 387±28 and 501±1, respectively. There was a significant difference in ACI across sampling periods (ANOVA, $p=0.039$).
- Diversity (H') on 5/02/2019 and 5/20/2019 was 0.91±0.01 and 0.96±0.01, respectively. There was a marginal significant difference in H' across sampling periods (ANOVA, $p=0.047$).

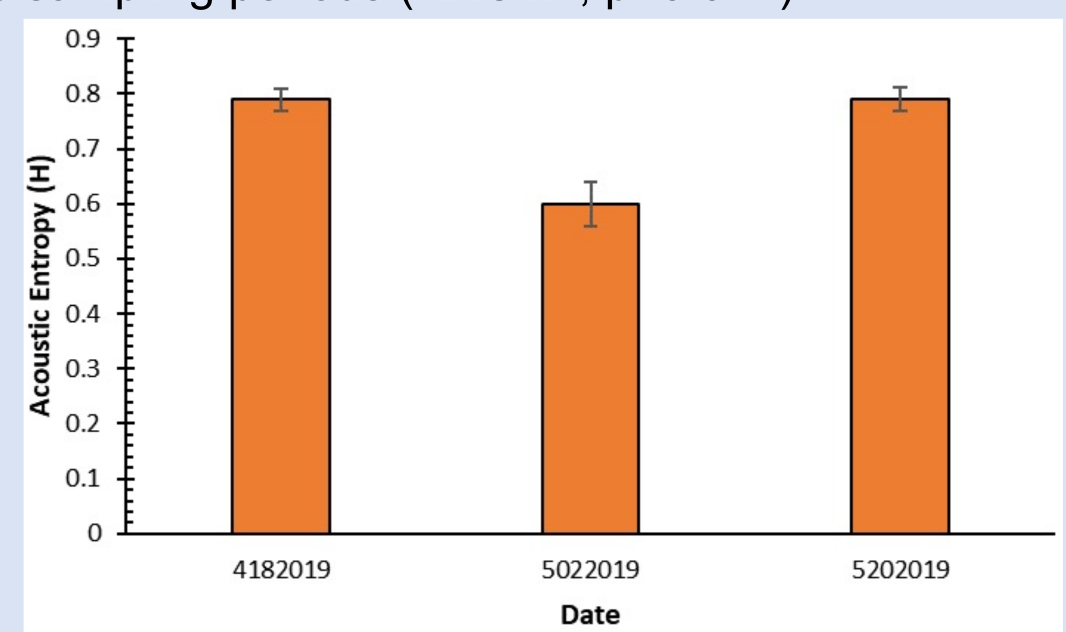


Figure 3. Acoustic entropy (H, ±1SD) taken on several dates at Clam Bank at Baruch Marine Lab in April and May 2019.

Soundscape Players

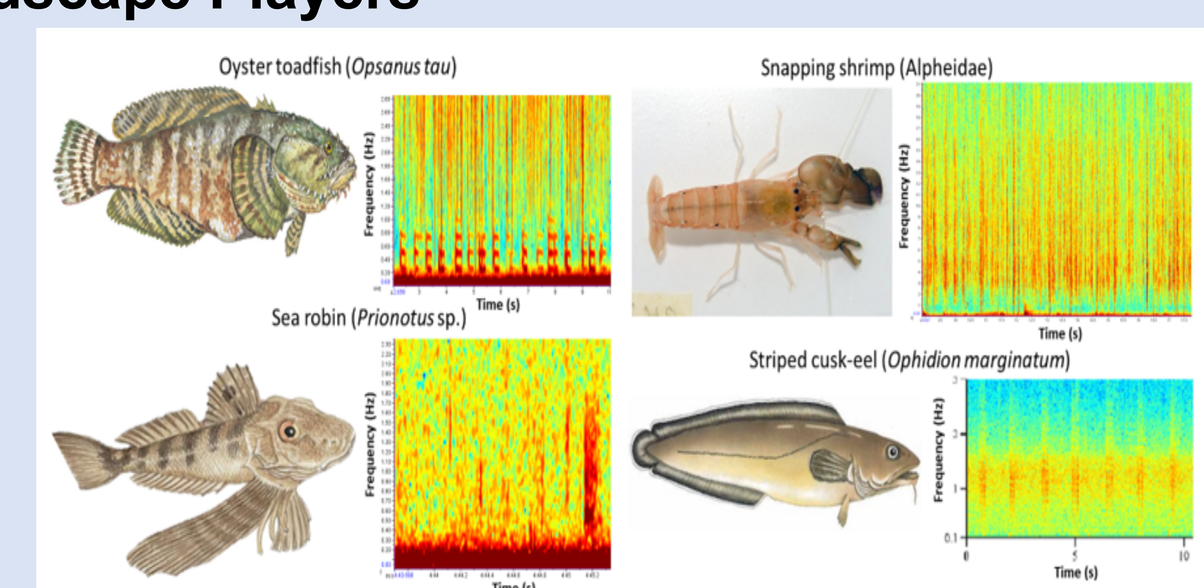


Figure 4. The four most dominate soundscape species across the tidal creeks and a spectrogram their sounds.

- The most dominate species across sites were oyster toadfish and snapping shrimp (Fig. 4). Oyster toadfish were detected at 62.5% and snapping shrimp were detected at 75% of the sites.
- Number of species varies across site with Towns Creek East & Clam Bank having the highest number (4 & 3.5 species, respectively) of soniferous species recorded (Fig. 5) and Bread and Butter and Mud Bay having some of the lowest number (1 & 2 species, respectively) soniferous species recorded.
- There was a weak linear relationship ($R^2=0.09$) between the number of species in a tidal creek and the acoustic diversity (H') at a site and this relationship was not statistically significant ($p=0.75$).

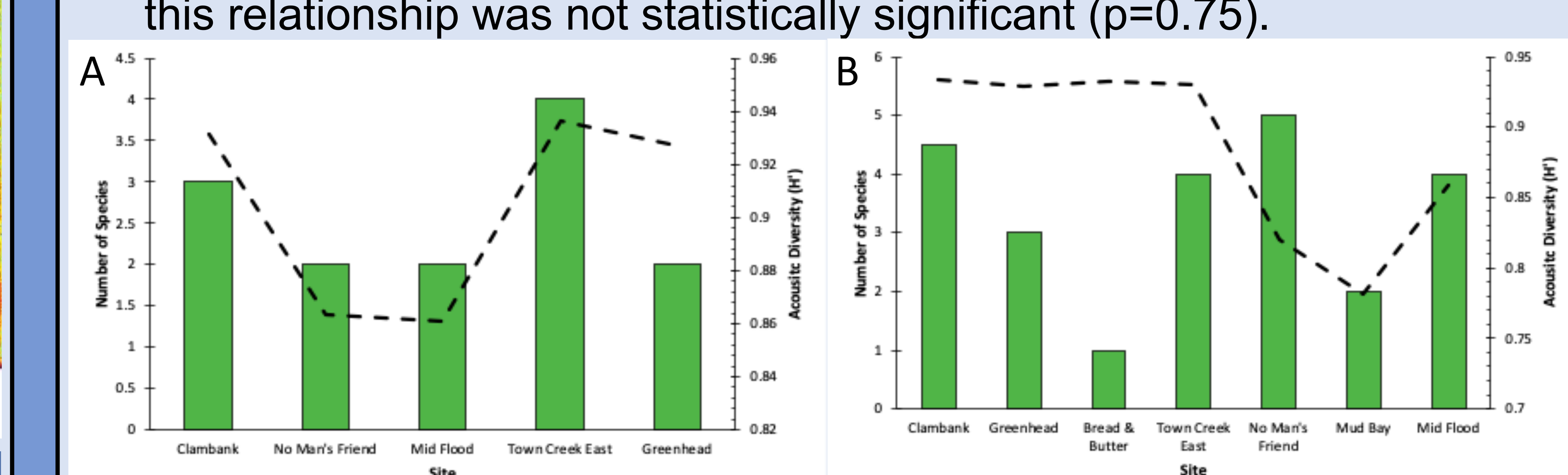


Figure 5. Number of species (green bars) and acoustic diversity (H', dashed line) on (A) 4/18/2019 and (B) 5/20/2019 across sites.

Salinity Variability

- Salinity varied across sites. No Man's Friend, Mud Bay, and Mid-Flood had the lowest salinity levels across sites (Fig. 6).
- Sites with the lowest salinities (<20 ppt) had an average acoustic entropy (H) of 0.51±0.10 but sites with the highest salinities (≥30 ppt) had an average acoustic entropy of 0.79±0.02 (Fig. 6).
- There was a strong linear relationship ($R^2=0.85$) between site salinity and acoustic entropy. This relationship was statistically significant (Regression, $p<0.001$).

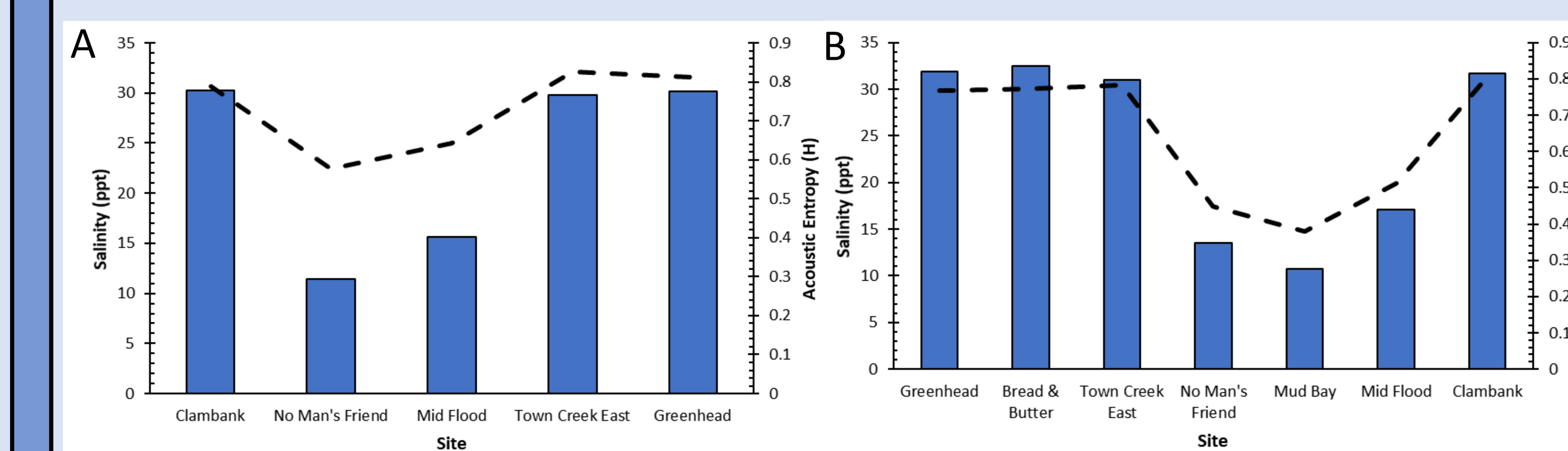


Figure 6. Salinity (blue bars) and acoustic entropy (dashed line) on (A) 4/18/2019 and (B) 5/20/2019 across sites.

Discussion

- Soundscape is highly variable across months and with salinity. The data from Clam Bank indicates variability across months but not across players throughout time. Thus, water quality parameters seem to be influencing the acoustic indices at this site. Simultaneously, soniferous species seemed to be similar across sites. While some sites had more species, this did not consistently influence the ecoacoustic indices. Of the measured variables presented here, salinity seems to be influencing the most ecouacoustic indices across sites.
  - Future work will explore water depth across sites to assess if tidal flux and/or other water quality parameters that may be drivers of this change. All samples across sites were taken on the ebbing tide but at different ebbing stages. Future work will include water depth as a confounding factor in these data.
- The ecoacoustic indices found in this study were similar to those found on oyster reefs[3] but lower than those on coral reefs.[4] This indicates similarities of ecoacoustic indices in oyster reef habitat and tidal creeks, regardless of depth difference. The tidal creeks within this study do contain oyster reef habitat, so this similarity was expected.
- Biological life, through the soundscape, reacts to environmental changes. These changes can be monitored throughout space and time.[5] To understand these changes we must first explore inter- and intra-annual variability in the soundscape.
  - Ecoacoustic measurements could provide insight on how these tidal creeks are changing over time both with short-term and long-term effects of climatic variability.[6]

Acknowledgements & References

- Thanks to Julianna Harding & Baruch Marine Lab for help with data collection and to Owen Brown for help with data processing.

- [1]Farina 2019. Mathematics, [2]Boumans et al. 2002. CICEET Final Report, [3]Harris et al. 2015. Methods Ecol Evol, [4]Kaplan et al. 2015. Mar Ecol Prog Ser, [5]Farina and Reid. 2020. Biodiversity, [6]Krause and Farina. 2016. Biol Conserv.