Introduction Outline

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Purpose: We looked to find what aspects of the soundscape were creating changes seen in the acoustics of different reef habitats around Kiritimati.

Aspects of the Soundscape: Broadband (All frequencies), Snapping shrimp (high frequencies) and Fish (low frequencies).

Hypothesis: We investigated the mechanisms of these patterns, quantifying snaps and fish calls to determine their effect on metrics commonly used to describe biogenic sound underwater,

* The notion of the “silent world” was forever altered by the study of underwater acoustics. However, marine acoustics are still one of the youngest subjects in marine biology.
  + Marine soundscapes are made up of a combination of different sounds from marine organisms (biophonies), their environment (geophonies), and anthropogenic sources (technophonies) (Farina and James 2016).
  + Growth in ocean transport, shipping, and resource extraction have added to the technophony of the underwater world, putting stress onto individuals and ecosystems which now have to compete with entirely new sources of sound (Slabbekoorn et al. 2010).
  + The discovery of this sonic intrusion in the marine environment has resulted in the growth of the underwater acoustics field and spawned new methods in studying underwater soundscapes.
* Underwater acoustics is a growing field in marine biology with a large part of that movement centered around the interpretation of large acoustic data files collected by passive acoustic monitoring (PAM) systems (Lammers et al. 2008; Luczkovich et al. 2008; Wall et al. 2013; Merchant et al. 2015; Phillips et al. 2018).
  + Several studies have worked towards learning programs that can pull information from this big data without user input (Sattar et al. 2016; Lin et al. 2017, 2018).
  + Due to the largely passive nature of recordings, large time scales and varying spatial scales have been extensively studied (REF).
* Acoustics can provide vital information about ecosystem health and can reveal the influence of specific contributors in the biophony (Parks et al. 2014; Bertucci et al. 2016; McPherson et al. 2016; Bolgan et al. 2018).
  + Sound pressure level (SPL) describes the total volume of individual sounds or entire soundscapes underwater (Kaplan et al.; Radford et al. 2011b)
  + The Acoustic Complexity Index (ACI), which calculates differences in sound level between time steps to determine a sum complexity for a soundscape, was adapted from use in avian soundscapes to give information about acoustic complexity underwater (Pieretti et al. 2011).
    - * ACI has been used in a variety of ecosystems in the marine soundscape, to determine its usefulness in determining differences between different habitats (Kaplan et al.; McWilliam and Hawkins 2013; Butler et al. 2016).
  + Particle motion, an underwater metric in its origin, provides information about the kinetic energy released with sound production (Popper and Hawkins 2018).
    - * However, while particle motion is a determinate factor in the study of underwater acoustics, because it requires such close proximity to the sound producer, it is difficult to assess on a community level and therefore was excluded from this study (Nedelec et al. 2016).
* Biophonies of coral reefs are made up by the complex acoustic interactions of their inhabitants.
  + High frequency sounds of the reef are often made of the “snaps” created by snapping shrimp (Butler et al. 2017).
  + Mid-frequency sounds are the result of a variety of organisms, but are often contributed to different invertebrate sounds and herbivory on the reef **NEED REF** (Radford et al. 2008).
  + While low frequency sounds are typically reserved for fish communications, consisting of a variety of different types of calls, knocks, and grunts (Lobel et al.; McCauley and Cato 2000; Tricas and Boyle 2014).
* These biophonies are affected by the communities that create them, their habitats, and their interactions with non-biogenic sounds.
  + Reef soundscapes are independent of one another spatially, compositionally, and temporally (Staaterman et al. 2013; Radford et al. 2014).
  + These soundscapes have been connected to larval settlement patterns in both fish and invertebrate larvae (Simpson et al. 2008; Radford et al. 2011b, 2011a; Stanley et al. 2012).
    - In addition to larval settlement, fish use sound production as a method of communication involved in a variety of behaviors (Lobel et al.; Tricas and Boyle 2014).
    - In the damselfish, *Pomacentrus partitus*, male reproductive calls were used by females as part of the mate selection process (Myrberg et al. 1986).
    - Another damselfish, *Chromis viridis,* larvae were more attracted by the sounds of conspecifics than those of different species when determining where to settle (Lecchini et al. 2005).
    - Finally, juvenile reef fishes migrated toward man-made patch reefs that broadcasted reef sounds significantly more than man-made patch reefs broadcasting no sounds (Radford et al. 2011a).
* Kiritimati Island (Pronounced “Christmas”), is a part of the Line Islands in the country of Kiribati in the equatorial Pacific Ocean.
  + Kiritimati provides a natural laboratory for studying local anthropogenic impacts due to dispersion of its population around the island.
    - Kiritimati’s population is centered in the northwest corner of the island between the towns of London and Tabwakea, creating a gradient of human impact that extends across the island (Office of Te Beretitenti & T’Makei Services 2012; Watson et al. 2016).
  + Due to the small local population and the lack of access to motorboats, the reefs around Kiritimati provide a unique soundscape with minimal human input.
* ~~Our study investigated the connections of Kirimati’s reef soundscape to temporal and spatial gradients around the island.~~
* We sought to uncover the biogenic mechanisms of coral reef soundscapes.
  + Using acoustic data collected in the summers of 2017 and 2018 at 5 different sites around the island, we hypothesized that human impact and reef health would significantly change sound levels and ACI between our different reefs.
  + Within each site, we also hypothesized that temporal changes in ACI at low frequencies would reflect the quantity of identifiable fish sounds.