Introduction Outline

Started: 11 Feb 2019

Author: Sean Dimoff

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 been changed with the introduction of underwater acoustics. However, marine soundscapes are still one of the least understood subjects in marine biology.
  + These 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 who 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 one of the fastest growing fields 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 are working toward 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 within the field.
    - Biogenic soundscapes have been connected to temporal variations, revolving around daily, lunar and seasonal cycles (Staaterman et al. 2014; Nedelec et al. 2015).
    - Spatial variations in soundscapes have also drawn the attention of researchers, investigating differences in biogenic soundscapes and what the effects of those soundscapes for their inhabitants (Kennedy et al. 2010; McWilliam and Hawkins 2013; Staaterman et al. 2013; Radford et al. 2014)
* Several acoustic metrics and indices have been adopted from terrestrial systems to apply to the marine environment (Farina et al. 2016).
  + A variety of metrics have been studied to determine correlations with ecosystem health indicators to provide information about the reefs (Parks et al. 2014; Bertucci et al. 2016; McPherson et al. 2016; Bolgan et al. 2018).
    - Sound pressure level (SPL), used to describe a volume of a sound is often used to describe the volume of individual sounds and entire soundscapes underwater (Kaplan et al.; Radford et al. 2011b)
    - The Acoustic Complexity Index (ACI) was adapted from use in avian soundscapes to give information about acoustic complexity underwater (Pieretti et al. 2011).
      * ACI is used in a variety of ecosystems as a metric to describe complexity in the marine soundscape (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).
* One major goal of acoustic studies is to draw connections between the health of an ecosystem and its biophony (Nedelec et al. 2015; Bertucci et al. 2016; Freeman and Freeman 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).
  + Coral reef 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).
    - Within fishes, sound is actually communicated through otolith movement determined by particle motion in the immediate water surrounding an individual (Popper and Fay 2011).
    - In the damselfish, *Pomacentrus partitus*, male reproductive calls were used by females as part of the mate selection process (Myrberg et al. 1986).
    - *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).
    - 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 is unique because the dispersion of its population around the island creates a natural laboratory for studying the anthropogenic impacts of a local population on the coral reefs surrounding the island (Watson et al. 2016).
    - The population of Kiritimati is centered around the northwest corner of the island between the towns of London and Tabwakea, and a gradient of human impact extends from population centers around the island (Office of Te Beretitenti & T’Makei Services 2012).
  + Kiritimati was centrally located in the 2015-2016 El Niño climate pulse event, which warmed the surrounding waters for XX weeks creating a coral mortality event that resulted in a roughly XX% mortality rate **REF??**
  + Due to the low population and the lack of access to motorboats around the island, 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.
  + 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 were dependent on fish sounds.