Section S1. Sound producers in the kelp forests of the Channel Islands

Kelp forest species associated with regime shifts are well-documented sound-producers. Several kelp forest apex predators are soniferous. For example, the giant black seabass (*Stereolepis gigas*) produces low-frequency "booms” and “drum-rolls” associated with courtship (Clark & Allen 2018). Some key urchin predators also produce sound. The California spiny lobster (*Panulirus interruptus*) produces an anti-predator “rasp” made by rubbing its antennae (Patek et al. 2009), and may also produce low-frequency, high-amplitude buzzes and rattles like another species in the Palinuridae family, the European spiny lobster (*Palinurus elephas;* Jézéquel et al. 2018, Jézéquel et al. 2019). The sunflower sea star (*Pycnopodia helianthoides*) has been shown to produce low-amplitude sounds as its spines scrape along rocky substrate (Kitting 1979). Sea urchins produce sounds when they feed and move, which are amplified by their skeletons (Radford et al. 2008a). In coastal waters around New Zealand, urchins increased ambient sound energy by 2–3 orders of magnitude around dusk by making sounds between 400–4000 Hz (Radford et al. 2008b). Even fishing pressure can be tracked by monitoring acoustic patterns in boat noise (Kaplan & Mooney 2015).

In addition to the main kelp forest drivers, numerous other marine species contribute to the biological portion of the soundscape. Soniferous fish in the Channel Islands include the white seabass (*Atractoscion nobilis;* Aalbers & Drawbridge 2008), garibaldi (*Hypsypops rubicundus*; Sikkel 1990, Parmentier et al. 2016), plainfin midshipman (*Porichthys notatus*; Ibara et al. 1983), bocacchio rockfish (*Sebastes paucispinis*; Širović et al. 2009), and the aforementioned giant black seabass. Invertebrates also produce sound across the frequency spectrum. Snapping shrimp (Family: Alpheidae) produce high-amplitude, broadband snaps above 1 kHz (Bohnenstiehl et al. 2016). Due to their high density, snap rate, and snap amplitude, these snaps are the most pervasive sound in kelp forests. Snap rates can also serve as an indicator of habitat transformation. Decreased snap rates have indicated habitat degradation in coral reefs (Gordon et al. 2018), hard-bottom (Butler et al. 2016), oyster reef (Lillis et al. 2014), and kelp forest habitats (Rossi et al. 2017). Other benthic invertebrate groups that likely produce sound include Echinodermata, Mollusca, and Crustacea. Kitting (1979) recorded feeding sounds from 14 intertidal species (limpets, chitons, barnacles, crabs, urchins, sea stars, sea snails) and acoustically determined the species being recorded and its food source. Lastly, 3 pinniped and 33 cetacean species, of which around 18 are considered residents, have been reported in the Channel Islands and likely produce sound in the waters surrounding the Channel Islands (United States Coast Guard 2008).

Section S2. Spectrograms of recordings containing boat noise

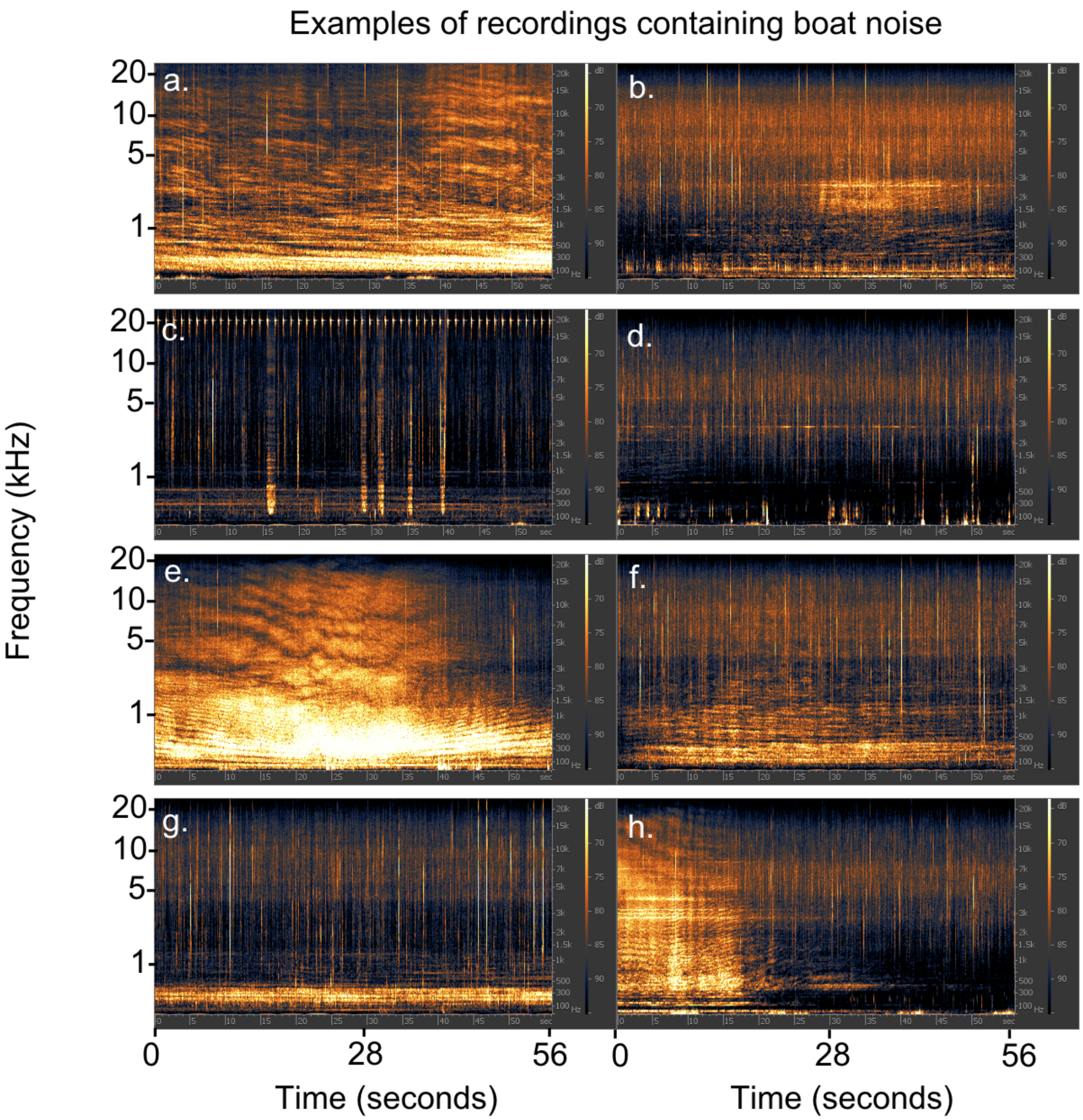

Figure S1: Spectrograms of eight recordings that contained boat noise, including a) Cathedral Cove (May 12, 2018, 14:45), b) Cathedral Cove (May 12, 2018, 14:45), c) Cavern Point (June 16, 2018, 12:00), d) Cathedral Cove (May 12, 2018, 09:45), e) East Fish Camp (June 20, 2018, 09:30), f) Black Seabass Reef (June 18, 2018, 15:00), g) Cavern Point (June 14, 2018, 10:45), h) Cavern Point (June 15, 2018, 12:45), i) Cathedral Cove (May 12, 2018, 14:45).

Section S3. Acoustic data and computer codes

Acoustic recordings containing different notable biological and anthropogenic sounds as well as the computer codes and dataframes associated with this data analysis are available at https://github.rcac.purdue.edu/PijanowskiGroup/Gottesman_et_al_2020_KelpForestSoundscapes. Please contact the lead author if you are interested in acquiring the complete acoustic dataset or other materials pertaining to the study.

Section S4. Selection of sound pressure level measurements

We measured sound pressure levels across three frequency bands in order to obtain indices of the diversity and abundance of animals that produced sound within these frequency ranges and also as a proxy of habitat condition. To obtain one sound pressure level value per recording for each frequency band, it was necessary to average the 328 SPL values that were output from the Discrete Fourier Transform. There are several common methods for averaging a series of sound level measurements. To determine which method was suitable in this system, we tested the root-mean-square, median, 75th percentile, and 95th percentile and investigated how these values reflected biological patterns by inspecting comparing SPL values with spectrograms.

We selected the 75th percentile value for several reasons. First, it effectively indicated chorusing events as well as more discrete biological sound pulses. In contrast, the median mainly measured the ambient soundscape levels, while the root-mean-square and 95th percentile values mainly reflected the discrete, high-amplitude sounds that may have been short-duration and not indicative of overall soundscape patterns. RMS in particular was highly biased by short-duration, high amplitude sound events, and as a result was a poor measurement of other aspects of the soundscape. While we are confident that the 75th percentile method was appropriate for measuring biological sound patterns within these frequency bands, it has a narrower range of values than the RMS or median values, and could underrepresent the diel and between-site variation. The following visualization (Figure S2) illustrates the different qualities of these four measurements.

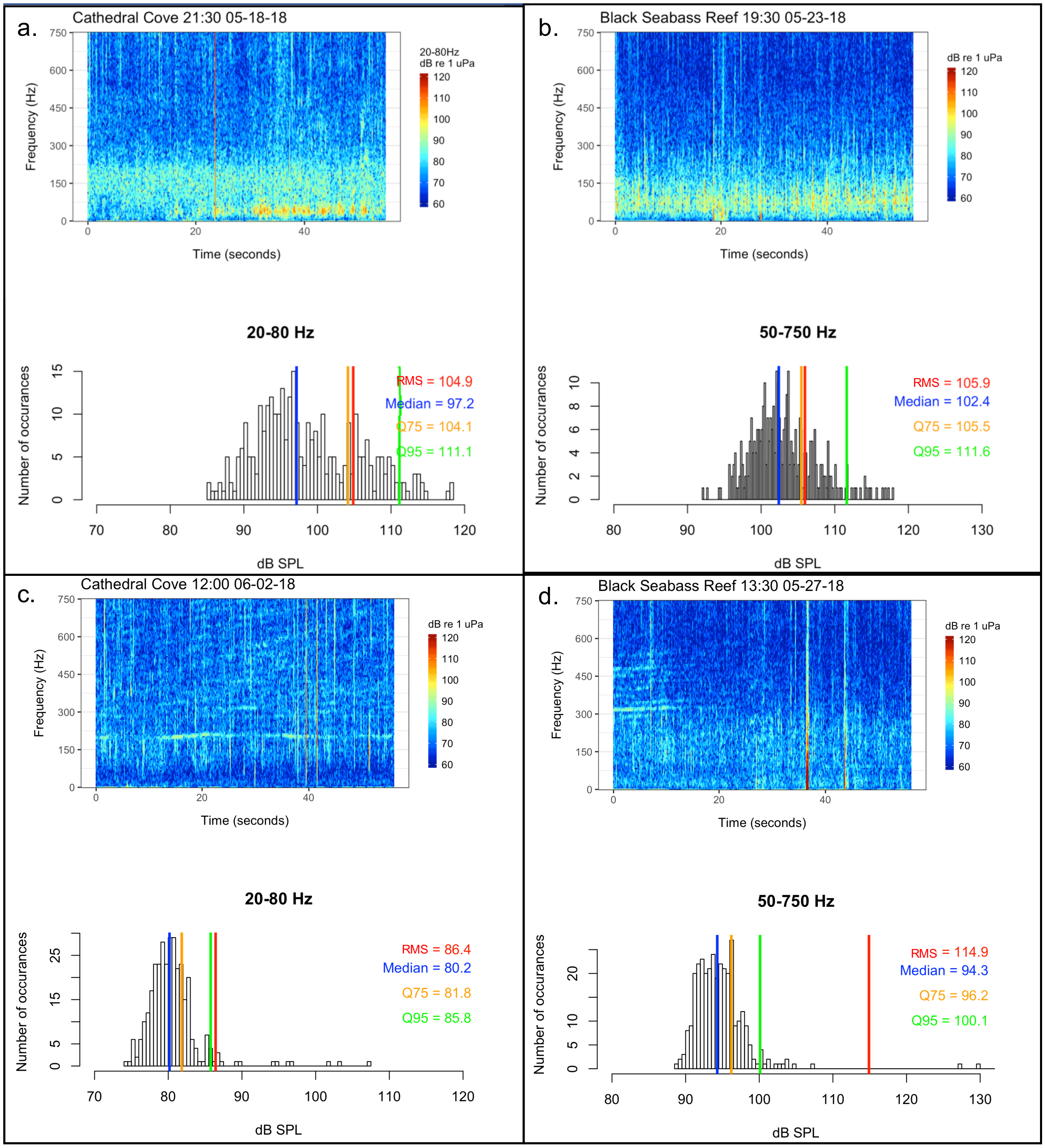

Figure S2: Spectrograms and corresponding histograms of the 328 sound pressure level values generated for each sound file. In the histograms, we demarcated the root-mean-square amplitude (RMS), median amplitude (Median), 75th percentile (Q75) and 95th percentile (Q95). These four visualizations (a-d) demonstrate why we selected the 75th percentile: a) More sporadic fish sounds start midway through the recording and influence Q75, Q95, and mean, but not median; b) continuous fish chorus influences all four measurement types; c) though biological sounds in this recording are relatively low-intensity and sparse, a single high-amplitude pulse results in higher RMS and Q95 values but not median and Q75 values; d) a single high-amplitude sound results in the very high RMS value, while the other three metrics better reflect the overall soundscape.

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