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Short Communication

Soundscape of a management and exploitation area of benthic resources in central Chile

Alfredo Borie[1], Natalia P.A. Bezerra[2], Sebastian A.L. Klarian[3] & Paulo Travassos[1]
[1]Departamento de Pesca e Aquicultura, Universidade Federal Rural de Pernambuco
CEP 52.171-900, Recife, Brasil
[2]Departamento de Oceanografia, Universidade Federal de Pernambuco
CEP 50670-901, Recife, Brasil
[3]Centro de Investigaciones Marinas Quintay, Facultad de Ecología y Recursos Naturales
Universidad Andres Bello, Valparaíso, Chile
Corresponding author: Alfredo Borie-Mojica (a.borie@gmail.com)

ABSTRACT. Acoustic ecology is an emerging and poorly known field of research. Soundscape has been used to infer the behavior of several species in different environments and can serve as a reliable indicator of the habitat type and quality; also, it is believed that it is an important factor for larvae orientation in settlement areas. We used the passive acoustic method to evaluate the soundscape of a management and exploitation area of benthic resources, a rocky reef area in central Chile. It was possible to hear a continuous cracking sound during recording and underwater observations. We detected two distinct frequency bands with similar parameters during the night and day, a band between 90 and 300 Hz, which corresponded to the effects of sea waves (geophony), and a frequency band with a range of 1,500 to 2,700 Hz (biophony), with a fundamental frequency of 2,070 Hz. Both bands had similar energy (~88.0 dB re: 1V/µPa). These results show the relevant acoustic activity in the area, which may have important ecological implications for the recruitment of commercially important benthic resources.

Keywords: bioacoustics, acoustic ecology, coastal zone, biophony, geophony, central Chile.

Paisaje acústico de un área de manejo y explotación de recursos bentónicos en Chile Central

RESUMEN. La ecología acústica es un campo de investigación emergente y poco conocido. El paisaje acústico se ha utilizado para inferir el comportamiento de varias especies en diferentes ambientes y puede servir como un indicador confiable del tipo y calidad de hábitat, además se considera un factor importante para la orientación de larvas en zonas de asentamiento. Se utilizó el método acústico pasivo para evaluar el paisaje acústico de un área de manejo y explotación de recursos bentónicos, en una zona de arrecife rocoso en el centro de Chile. Se escuchó continuamente un crujido durante la grabación y se efectuaron observaciones submarinas. Se detectaron dos bandas de frecuencia con parámetros similares durante día y noche, una banda entre 90 y 300 Hz, que correspondía a los efectos de las olas del mar (geofónico), y una banda de frecuencia con rango de 1.500 a 2.700 Hz (biofónicos), con la frecuencia fundamental de 2.070 Hz. Ambas bandas tenían energía similar (~88,0 dB re: 1V/µPa). Estos resultados muestran la relevante actividad acústica de la zona, que puede tener importantes implicancias ecológicas para el reclutamiento de recursos bentónicos de importancia comercial.

Palabras clave: bioacústica, ecología acústica, zona costera, biofonía, geofonía, Chile central.

The set of sounds for a given environment can be considered as a soundscape and the use of such sounds for ecological studies can be termed acoustic ecology, an emerging field of ecological research (Pijanowski *et al.*, 2011a). Among the different perspectives with which it is possible to explore, describe and manage the ecological complexity of such environments, the soundscape may be an excellent *proxy* for both short- and long-term scientific investigations (Farina & Pieretti, 2012).

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The subaquatic soundscape could be a composition of several types of sound sources, including biophonics, produced by aquatic mammals, fish and invertebrates in a given environment, but also both anthrophonics (*i.e.*, vessels) and geophonics (*i.e.*, sea waves) (Pijanowski *et al.*, 2011b).

Biological sounds have been used to infer the behavior of several terrestrial and recently aquatic species. This production of sounds has been demonstrated in different aquatic environments, such as, the deep ocean (Wall *et al.*, 2014), estuaries (Lillis *et al.*, 2014), coral reefs (Staaterman *et al.*, 2013, 2014). In addition, there are significant differences in the spectral and temporal composition of ambient sound associated with different coastal habitat types (Radford *et al.*, 2010).

The characterization of the soundscape could serve as a reliable indicator of habitat type and potentially transmit habitat quality information to disperse organisms (Lillis *et al.*, 2014). The soundscape can be used by larvae of marine organisms to return to settlement areas, in those species where settlement occurs. Research has indicated that juvenile fish (Leis & Lockett, 2005; Radford *et al.*, 2011) and invertebrate larvae (Vermeij *et al.*, 2010; Stanley *et al.*, 2012; Eggleston *et al.*, 2013; Lillis *et al.*, 2013) use sound to locate habitats.

The monitoring of changes in the environment and its inhabitants is critical for management and a considerable technological challenge in many marine habitats. Monitoring tools, like passive acoustics, can be an effective way to assess the biological activity in places where continuous monitoring by traditional research methods is not easy or possible.

We used passive acoustics to evaluate biophonic and geophonic (sea wave effect) components of soundscape in Quintay (33º11'31"S, 71º42'05"W), one of the Management and Exploitation Areas of Benthic Resources (MEABRs) existing in Chile. Quintay MEABR is a typical rocky coastline of temperate marine environment. The most economically important benthic artisanal resources in this area are the muricid snail (*Concholepas concholepas*), the red sea urchin (*Loxechinus albus*) and keyhole limpets (*Fissurella* sp.) (Fernandez *et al.*, 2000).

For an initial approach of Quintay soundscape, we first carried out free-diving observations for 1 h 20 min (starting at 05:00 pm), that helped us to identify representative fauna and potential sound sources in February (summer).

In addition, we recorded sounds in natural and captive environments using a hydrophone (H2a Aquarian, sensibility of 180 dB re: 1V/µPa and range of 10 Hz a 100 KHz) connected to a digital recorder (Olympus Digital Voice Recorder VN-701PC). In natural habitat, recordings were made during the night (12:15 am) and day (01:15 pm) at low tide and waning crescent moon, for 8 min and 44 sec each time, in Quintay Bay.

Captive species of representative local benthic fauna were recorded in different types of captive systems (ponds, tank and aquaria) at night and day for 10 min in each system in the Quintay Center of Marine Research (CIMARQ) installations. The captive species included *L. albus*, *Tegula atra*, *Fissurella* sp. *C. concholepas*, and also *L. albus* seeds with macroalgae, the Chilean blue crab *Homalaspis plana*, and fishes such as red cusk-eel (*Genypterus chilensis*), Chilean

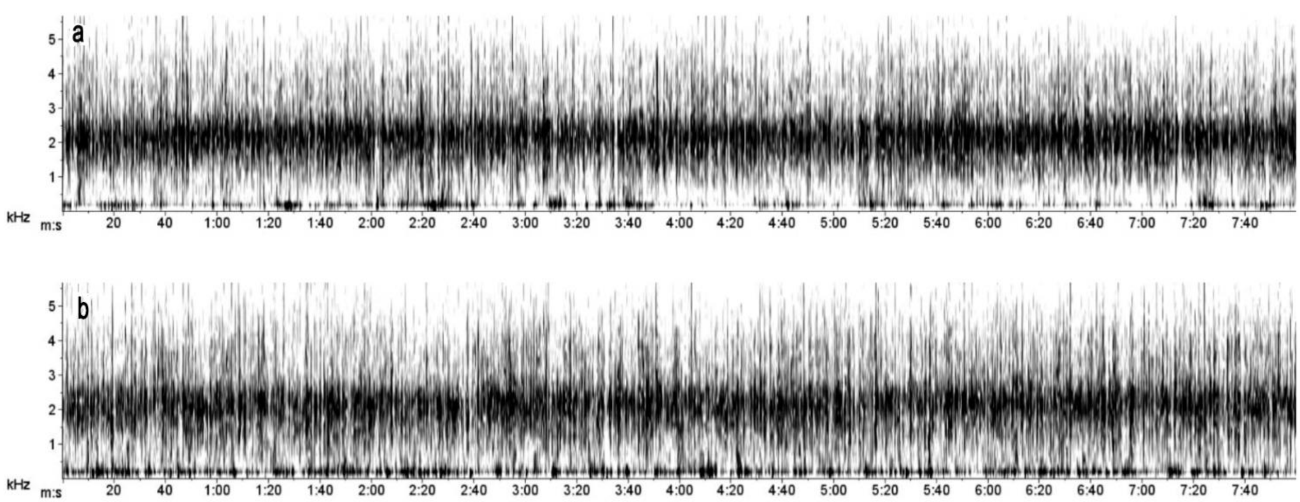

Figure 1. Spectrogram of soundscape of a management and exploitation area of benthic resources in central Chile. a) 12:15 am, and b) 01:15 pm. Hanning 256 points with 50% overlap, 70% brightness and 90% contrast.

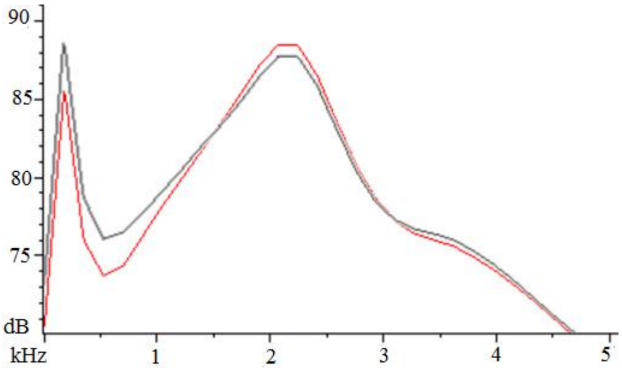

Figure 2. Soundscape power spectrum of a benthic resource management and exploitation area in central Chile. Red line: 12:15 am, and black line: 01:15 pm. Hanning 256 points with 50% overlap, brightness 70% and contrast 90%.

flounder (*Paralichthys adspersus*) and *Paralabrax humeralis*.

Sounds were analyzed in the software Raven pro v1.4, using acoustic parameters like energy (dB), fundamental, minimum and maximum frequencies (Hz), the analysis of the frequency bins of the acoustic spectrogram can provide proxies for understanding and interpreting acoustic patterns and processes in action across a landscape (Farina & Pieretti, 2012).

Continuously audible biological cracking sounds were heard during subaquatic observations. We observed a characteristic benthic diversity in the zone, including patches of macroalgae (*Lessonia* sp.), echinoderms (*L. albus*, *Tetrapygus niger*, *Meyenaster gelatinosus*, *Heliaster helianthus*), gastropods (*Tegula atra*, *Fissurella* sp., *C. concholepas*), and crustaceans (*Rhynchocinetes typus*, *Taliepus dentatus*) as expected and observed by Fernandez *et al.* (2000).

The spectrogram and power spectrum analyses of natural environment sounds showed two easily distinct bands and peaks respectively, at low tide and waning crescent moon during summer. A continuous band of biophony of cracking sounds and periodic geophony of waves (Fig. 1) were detected during recordings.

The cracking bands had similar acoustic parameters to the natural environment during recordings at night (12:15 am) and day (01:15 pm), low and high frequency band between 1,500 and 2,700 Hz respectively, with a fundamental frequency of 2,070 Hz and an energy around 88.0 dB re: 1V/µPa (Figs. 1-2). Radford *et al.* (2010) found two bands dominated by sea urchins with a peak around 1,000 to 1,200 Hz, and snapping shrimp with a broad peak at 5,000 Hz in New Zealand. A distinct peak (2-4 kHz) was observed in habitat patches, attributable to a snapping shrimp focused in these frequency bands of inshore marine soundscapes (McWilliam & Hawkins, 2013).

We found an absence of audible sound in all captive species. This was unexpected; the acoustic signals may be a significant component in the social behavior in crustaceans (Boon *et al.*, 2009; Buscaino *et al.*, 2011). The sea urchin *Evechinus chloroticus* in captivity can produce sound with frequencies in the range of 800 to 2,800 Hz during feeding, and it was consistent with the dominant component of the ambient chorus recorded near a reef (in the range of 700 to 2,000 Hz) (Radford

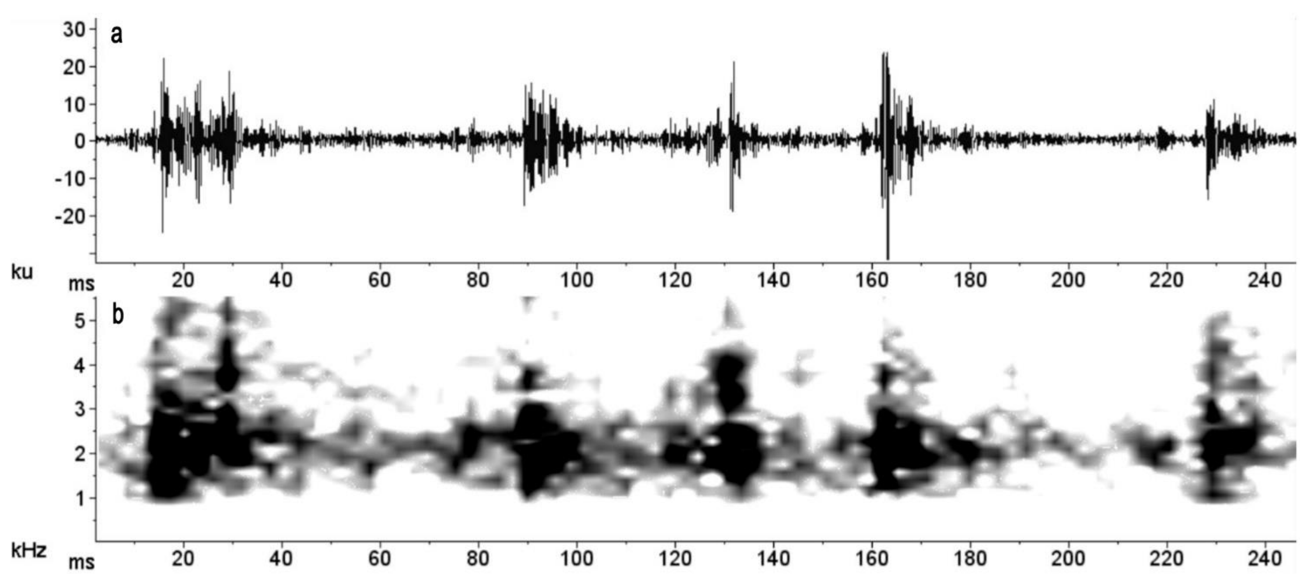

Figure 3. a) Ocillogram and b) spectrogram of cracking train of a filtered section (1.0 and 5.5 kHz) recorded during the day (01:15 pm). Hanning 256 points with 50% overlap, 70% brightness and 90% contrast.

et al., 2008). We found similar fundamental frequency in an isolated cracking composed of a train of pulses, with duration around 10 milliseconds and a variable interval (Fig. 3). For this reason, we believe that biological sounds in our study area were probably produced by the rocky shrimp *Rhynchocinetes typus* and sea urchin *L. albus*, even when we did not hear them in captivity.

The sea wave effect did not have an influence due to the very low frequency, in our case with a range between 90 and 300 Hz (note the continuously wave sound during the day, Fig. 1b) and the energy (dB) similar to the cracking sounds (Fig. 2). Ambient levels in frequencies affected by surf-generated noise (f <100 Hz) characterize the site as a high-energy end member within the spectrum of shallow water coastal areas influenced by breaking waves (Haxel *et al*., 2013). In general, the rocky reef soundscape includes bands of small waves, some fish and low frequency noise from distant shipping and offshore storms in a 100 to 800 Hz range (Radford *et al*., 2010).

Quintay soundscape could indicate that sounds can be used for larval orientation of important economic benthonic resources like *C. concholepas* and *L. albus*. However, we still need to evaluate the possibility of soundscape seasonality (including biophonic and anthrophonic sounds) during future long-term monitoring and find out the potential biological sound sources and larval orientation by sound in protected and exploited marine areas.

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