Deep-Sea Research I 115 (2016) 103–111

Contents lists available at ScienceDirect

Deep-Sea Research I

journal homepage: www.elsevier.com/locate/dsri

Acoustic habitat of an oceanic archipelago in the Southwestern Atlantic

Lis Bittencourt [a,b,*], Mariana Barbosa [a], Eduardo Secchi [c], José Lailson-Brito Jr. [a], Alexandre Azevedo [a]

[a] Laboratório de Mamíferos Aquáticos e Bioindicadores – MAQUA, Faculdade de Oceanografia, Universidade do Estado do Rio de Janeiro, Rua São Francisco Xavier 524, Maracanã, Rio de Janeiro 20550-013, Rio de Janeiro, Brazil
[b] Programa de Pós-Graduação em Oceanografia, Faculdade de Oceanografia, Universidade do Estado do Rio de Janeiro, Rua São Francisco Xavier 524, Maracanã, Rio de Janeiro 20550-013, Rio de Janeiro, Brazil
[c] Labortório de Ecologia e Conservação da Megafauna Marinha – EcoMega, Instituto de Oceanografia, Universidade Federal do Rio Grande, Av. Itália KM 8, Centro, Rio Grande 96201-900, Rio Grande do Sul, Brazil

ARTICLE INFO

Article history:
Received 12 January 2016
Received in revised form
17 May 2016
Accepted 13 June 2016
Available online 15 June 2016

Keywords:
Soundscape
Underwater acoustics
Trindade Island
Humpback whales

ABSTRACT

Underwater soundscapes can be highly variable, and in natural conditions are often dominated by biological signals and physical features of the environment. Few studies, however, focused on oceanic islands soundscapes. Islands in the middle of ocean basins can provide a good example of how untouched marine soundscapes are. Autonomous acoustic recordings were carried out in two different seasons in Trindade-Martin Vaz Archipelago, Southwestern Atlantic, providing nearly continuous data for both periods. Sound levels varied daily and between seasons. During summer, higher frequencies were noisier than lower frequencies, with snapping shrimp being the dominating sound source. During winter, lower frequencies were noisier than higher frequencies due to humpback whale constant singing. Biological signal detection had a marked temporal pattern, playing an important role in the soundscape. Over 1000 humpback whale sounds were detected hourly during winter. Fish vocalizations were detected mostly during night time during both summer and winter. The results show an acoustic habitat dominated by biological sound sources and highlight the importance of the island to humpback whales in winter.

1. Introduction

Acoustic habitats, also referred to as soundscapes, are the aggregation of all sounds in the environment, including noise caused by natural features such as wind and wave action, and signals of biological origin (Dumyahn and Pijanowski, 2011; Pijanowski et al., 2011). These soundscapes can be highly variable, reflecting the physical and biological characteristics of their environments, including seasonal variations and diel patterns (Radford et al., 2008; Staaterman et al., 2014). In natural non-impacted environments, it is possible to find fauna that have evolved acoustic communication signals to fill unoccupied frequency bands within their soundscapes. This has been observed in different animal groups, such as birds (Schuster et al., 2012), whales (Clark et al., 2004; Edds-Walton, 1997; Payne and Webb, 1971) and fishes (Fay, 2009; Myrberg, 1997; Speares et al., 2010), amongst others.

Acoustic characterization and monitoring of environments is becoming a major concern for scientists and governments, due to the importance of sound to several species (Dumyahn and Pijanowski, 2011; Pijanowski et al., 2011). Several marine species are dependent on the acoustic cues of their habitats or on the efficient propagation of their signals to transmit important information (Bradbury and Vehrencamp, 1998; Fay, 2009; Myrberg, 1997). Baleen whales use sound to communicate across great distances; fishes use sound for reproduction, agonistic behavior, and predator detection (Codarin et al., 2009; Ladich, 2013; Slabbekoorn et al., 2010); and it is possible that larvae can detect soundscapes and use them as orientation for settlement (Simpson et al., 2004). Human-generated sounds such as shipping noise, oil exploration and associated activities, and sonar have become part of many marine soundscapes in coastal areas and some mid-oceanic regions, increasing noise levels and modifying the acoustic environment in which marine fauna have adapted and evolved (Clark et al., 2009; Hildebrand, 2009; Klinck et al., 2012; Miksis-Olds and Nichols, 2016; Miksis-Olds et al., 2013; Tyack, 2008).

Offshore environments are of special interest since they have not been heavily impacted by underwater noise pollution as most coastal areas throughout the world, thus providing us with

* Corresponding author at: Laboratório de Mamíferos Aquáticos e Bioindicadores – MAQUA, Faculdade de Oceanografia, Universidade do Estado do Rio de Janeiro, Rua São Francisco Xavier 524, Maracanã, Rio de Janeiro 20550-013, Rio de Janeiro, Brazil.
E-mail address: lis.bitt@gmail.com (L. Bittencourt).

http://dx.doi.org/10.1016/j.dsr.2016.06.001
0967-0637/

relatively preserved soundscape scenarios. Although shipping and seismic exploration are major sources of noise in non-coastal areas (Miksis-Olds and Nichols, 2016; Parks et al., 2014) and sound propagation in oceanic area can carry these signals through great distances (Richardson et al., 1995), thus making it difficult to find truly pristine environments, there are still parts some of the ocean that are not in the path of main shipping routes and other exploration activities. Identifying and characterizing areas that still retain mostly natural conditions is critical. Isolated, non-tourist, oceanic islands are relatively free of human activities, contrasting with continental shore areas. Understanding how biological signals influence natural soundscapes can help us understand the most critical frequency bands that, if masked, can interfere with marine fauna communication.

The soundscape of the South Atlantic is still largely unknown regarding sound levels and biological signals, although studies indicate that it is different from other ocean basins (Miksis-Olds et al., 2012; Parks et al., 2014). It has been observed that seismic air gun signals are a major source of human-generated sounds in the South Atlantic (Miksis-Olds et al., 2012; Miksis-Olds and Nichols, 2016), showing that the acoustic environment in this ocean basin is not completely pristine. However, there is still a large data gap to be filled. The goal of our study was to characterize the soundscape of an oceanic archipelago in the Southwestern Atlantic Ocean (SWAO), quantifying sound levels and identifying dominating sound sources as well as their seasonal variation. Throughout our work we have focused specially in the biological aspects of soundscapes, since we had no means of measuring physical features such as tide movement, flow speed and wave action.

2. Material and methods

2.1. Study site

Trindade-Martin Vaz is a volcanic offshore, subtropical archipelago located at 1150 km off the coast of South America (Fig. 1). The archipelago is part of the Vitória-Trindade seamount chain, which originated from mantle plume activity (Alves, 2006). The seafloor around the island is mostly rocky, and covered by a thin sandy layer. Shallow waters are restricted to a very narrow band around the islands. The shelf length varies between 100–200 m, with a steep slope and some flat areas.

The archipelago is the easternmost point in Brazil. It is only inhabited by militaries and researchers, being visited by military supply ships only once a month and occasional fishing vessels. Other human activities that produce underwater noise occur far from the archipelago. The main international shipping routes in this part of the South Atlantic consist of ships that cross from Brazil to South Africa, mainly Cabo Verde, and are located over 200 km from the study area. Seismic air gun activity and oil exploration occur over 800 km from the archipelago, close to Brazilian coast. Therefore, the soundscape remains undisturbed by human activities during most of the year.

Marine fauna on and around the archipelago consists mainly of fish, seabirds and crustaceans. Approximately 100 fish species have been identified in the area, some of which are endemic to the archipelago (Gasparini and Floeter, 2001; Pinheiro et al., 2009). There are a few records of cetaceans (Carvalho and Rossi-Santos, 2011; Siciliano et al., 2012; Wedekin et al., 2014) but no seasonal data is presently available. Several crustaceans species have been identified, including the snapping shrimp *Alpheus amblyonyx* (Soledade and Almeida, 2013). The archipelago is also an important nesting site for green turtles (*Chelonia mydas*) in the South Atlantic (Almeida et al., 2011; Proietti et al., 2012).

2.2. Data collection

An SM2M+ underwater autonomous recorder (Wildlife Acoustics Inc.) was moored at a depth of 20 m, approximately 550 m from Trindade Island (Fig. 1). Although bottom depths decline rapidly in the study area, the equipment was deployed in a flat section of the seafloor. The recorder was programmed at a 66% duty cycle (recording for 1 h, then pausing for 30 min), with a 48 kHz sampling rate. These recording configurations were chosen

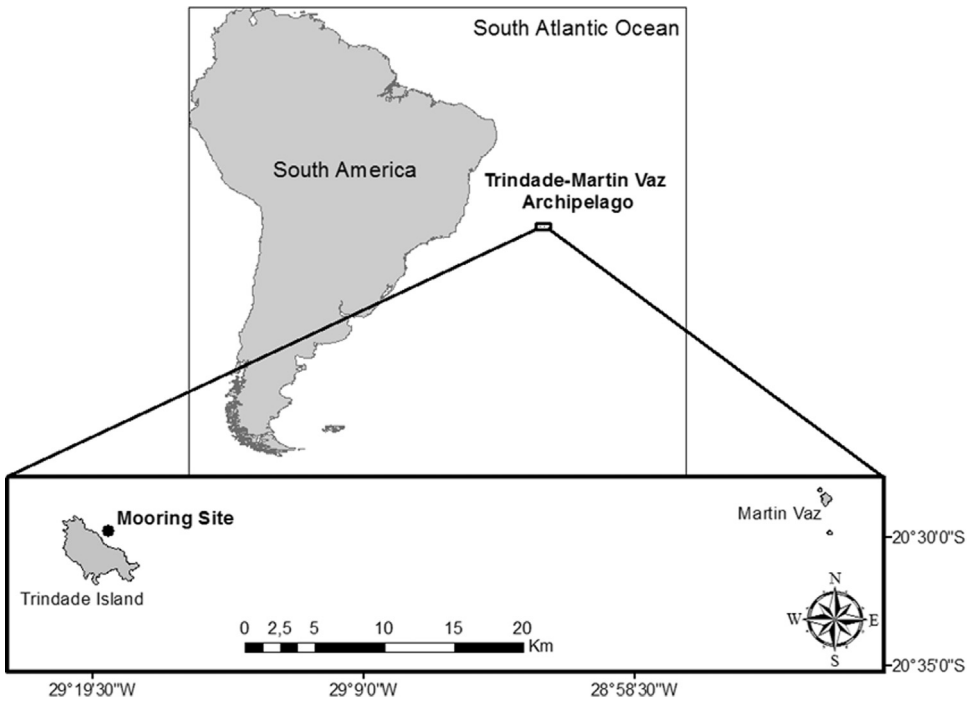

Fig. 1. Trindade Island, SWAO, located 1150 km from the continent. The mooring site of the autonomous recorder is indicated.