



fearuso@whoi.edu

Acoustic behavior of blue whales (*Balaenoptera musculus*) in the Gulf of Corcovado, Chile, recorded on DTAGs

Francesco Caruso^{1,3}, Alessandro Bocconcelli², Gustavo Chiang⁴, Leigh Hickmott^{5,6}, and Laela Sayigh³

(1) Institute for Coastal Marine Environment, National Research Council, Torretta Granitola, ITALY

(2) Woods Hole Oceanographic Institution, Applied Ocean Physics & Engineering, Woods Hole, USA

(3) Woods Hole Oceanographic Institution, Department of Biology, Woods Hole, USA

(4) Melimoyu Ecosystem Research Institute, MERI Foundation, Santiago, CHILE

(5) Scottish Oceans Institute, East Sands, University of St Andrews, St Andrews, UK

(6) Open Ocean Consulting, Petersfield, Hampshire, UK



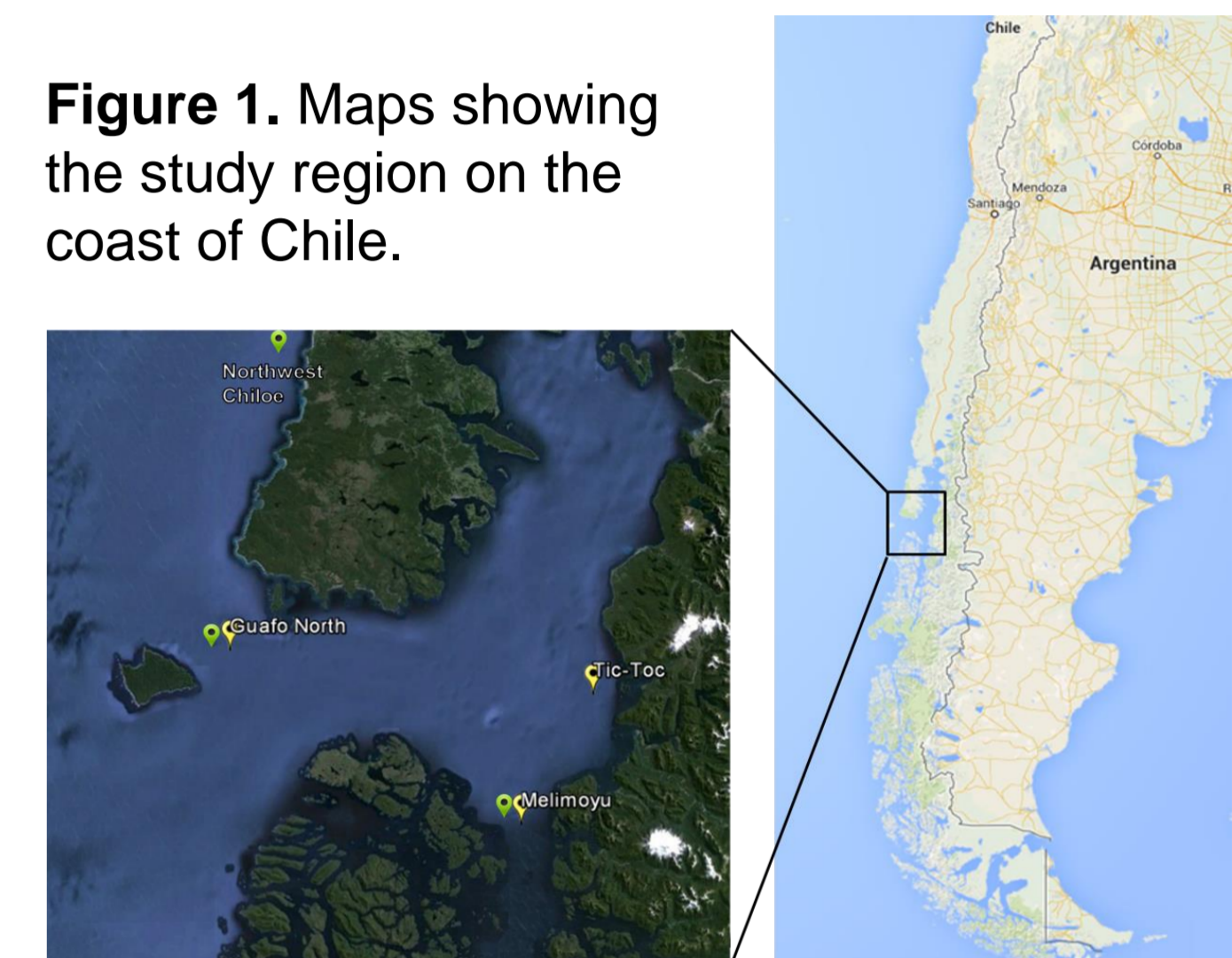
ABSTRACT

The blue whale (*Balaenoptera musculus*) is listed as 'Endangered' on the IUCN Red List of Threatened Species. In the Southern Hemisphere, the species was once abundant, but commercial whaling reduced it to near extinction during the twentieth century. A joint effort between WHOI and the Melimoyu Ecosystem Research Institute (MERI) is focusing on a population of Chilean blue whales in the Gulf of Corcovado, Chile, which is an important feeding ground for these animals. This investigation set out to obtain data on the ecology, foraging and acoustic behavior of individual blue whales, through the deployment of suction cup attached sound and orientation recording tags (DTAGs). An 18.6 m fishing vessel, the MV *Centinela*, was employed for two cruises in March of 2014 and 2015. In 2014, five tags were deployed on four individual whales, for a total of 21 hr 11 min. In 2015, six tags were deployed on six animals, for a total of 64 hr and 45 min. Acoustic data on the 2014 tags revealed numerous calls previously identified as "SEP" calls from distant blue whales, and an apparent call exchange was recorded between a tagged juvenile whale and a distant animal. The call was also detected on the juvenile whale's accelerometers, confirming caller identification. Analysis of 2015 acoustic data is ongoing, but reveals a greater variety of sound types. Tag data will prove useful for interpretation of data collected in this area from passive acoustic monitors (PAM), both for species identification and possibly also density estimation. Thus, this work has potential to contribute to efforts to protect this important population of endangered blue whales.

INTRODUCTION

Blue whales are known principally by two contrasting accolades, firstly, as being the largest animal to have ever lived on Earth, and secondly, as having been hunted to near extinction during twentieth century whaling. During the whaling era over four thousand animals were caught in Chilean waters alone (Williams et al. 2011). The species has been slow to recover from almost total decimation and hence a valuable discovery was made in 1993, when a small blue whale population of 232 individuals was found in the Gulf of Corcovado in the Chiloense Ecoregion of Southern Chile (Hucke-Gaete et al. 2004). Genetic, acoustic and morphometric studies indicate that these blue whales are part of a wider Southeast Pacific population that is distinct from both the Antarctic (*B. musculus intermedia*) and "pygmy" (*B. musculus brevicauda*) blue whale subspecies (Branch et al. 2007, Buchan et al. 2014, Torres-Florez et al. 2014). This investigation set out to obtain data on the acoustic behavior of individual blue whales in and around the Gulf of Corcovado, Chile (Fig 1), through the deployment of suction cup attached digital acoustic tags (DTAGs).

Figure 1. Maps showing the study region on the coast of Chile.



MATERIALS AND METHODS

DTAGs are miniature sound and orientation recording tags (Fig. 2) developed at WHOI (Johnson and Tyack 2003). These tags contain a VHF transmitter used to track the tagged whale during deployment and to retrieve the tag after release. DTAGs record sound at the whale, as well as depth, and 3-dimensional acceleration and magnetometer information, and thus provide data on vocal, movement and dive behavior.



The tag is attached with four suction cups using a hand-held 8 m carbon fiber pole (Fig 2), and can be programmed to release after durations of up to 24 hours. The aim was to achieve DTAG carries of several hours combined with visual tracking, radio tracking and photo-identification.

An 18.6 m fishing vessel, the MV *Centinela*, was employed as the principle survey vessel (Fig 3). The month of March was chosen to conduct the field efforts, based on historical blue whale sightings, acoustic detections and weather data.



Figure 3. The MV *Centinela*.

RESULTS

In 2014, five tags were deployed on four individual whales, for a total of 21 hr 11 min. Acoustic data on the 2014 tags revealed numerous calls previously identified as "SEP" calls from distant blue whales (Cummings and Thompson 1971, Buchan et al. 2010, 2014). Dives were generally shallow, predominantly between 10 and 50 meters in depth. Occasional deeper dives were recorded, with a maximum depth of 139 m. An apparent call exchange was recorded between a tagged juvenile whale and a distant animal. Although this whale's mother was tagged at the same time, we can confirm that the call was not produced by her, because it was quieter on her tag than on the juvenile's tag (Fig 4). Further confirmation that the call came from the juvenile whale came from a signal on the tag's accelerometers, which were sampled at a high enough frequency (50 Hz) to detect calls at or below 25 Hz. This method of caller identification for baleen whales that produce low frequency calls, such as blue and fin whales, was recently described by Goldbogen et al. (2014).

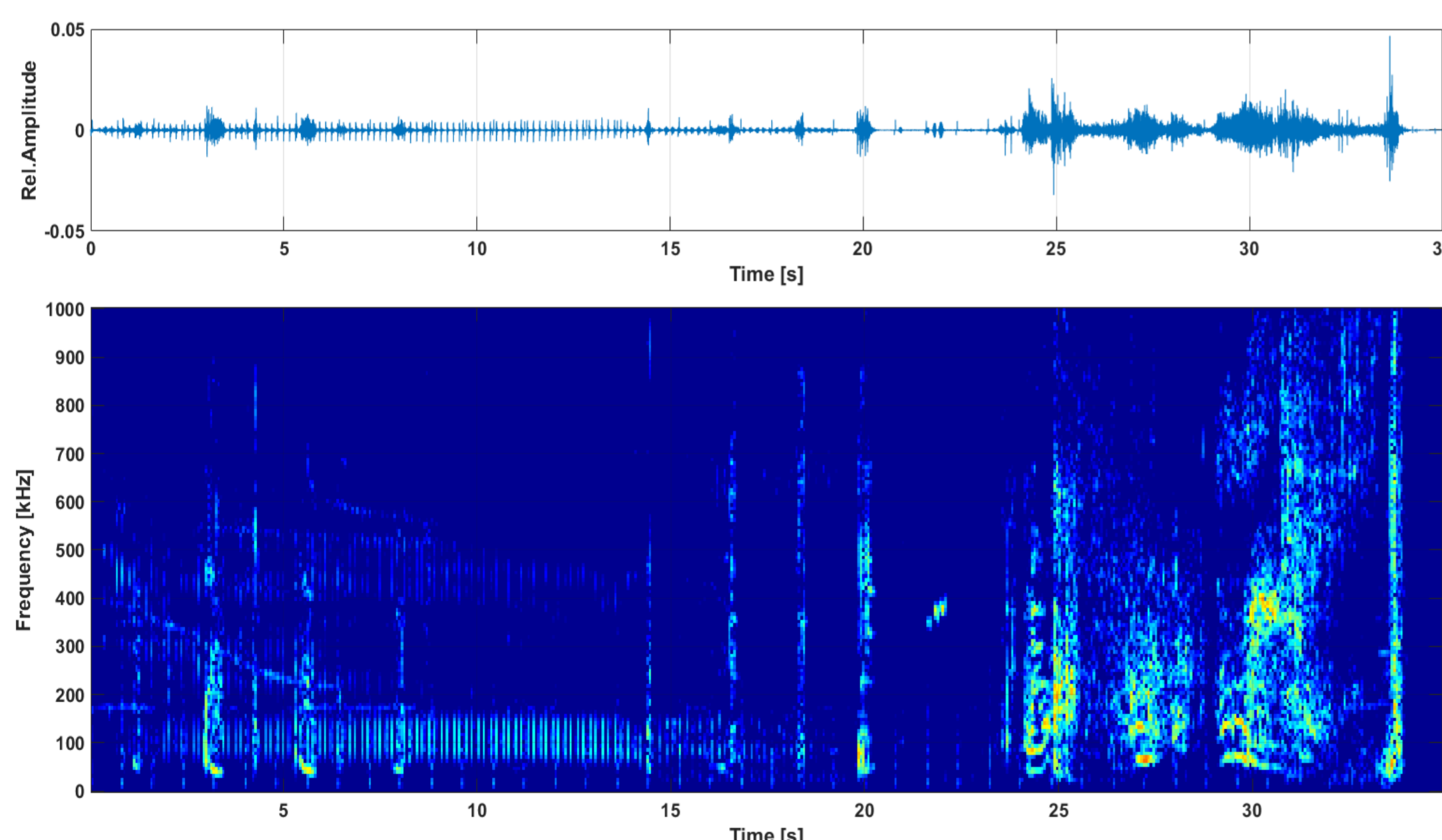


Figure 6. Waveform (amplitude vs. time - top) and spectrogram (bottom) of a 35-sec section with different sounds recorded on a DTAG.

In 2015, six tags were deployed on six animals, for a total of 64 hr 45 min. Analysis of the acoustic data is ongoing, but reveals a greater variety of sound types (Figs 5 & 6). Dives were generally shallow, predominantly between 5 and 30 meters in depth. Occasional deeper dives were recorded, with a maximum depth of 155 m.

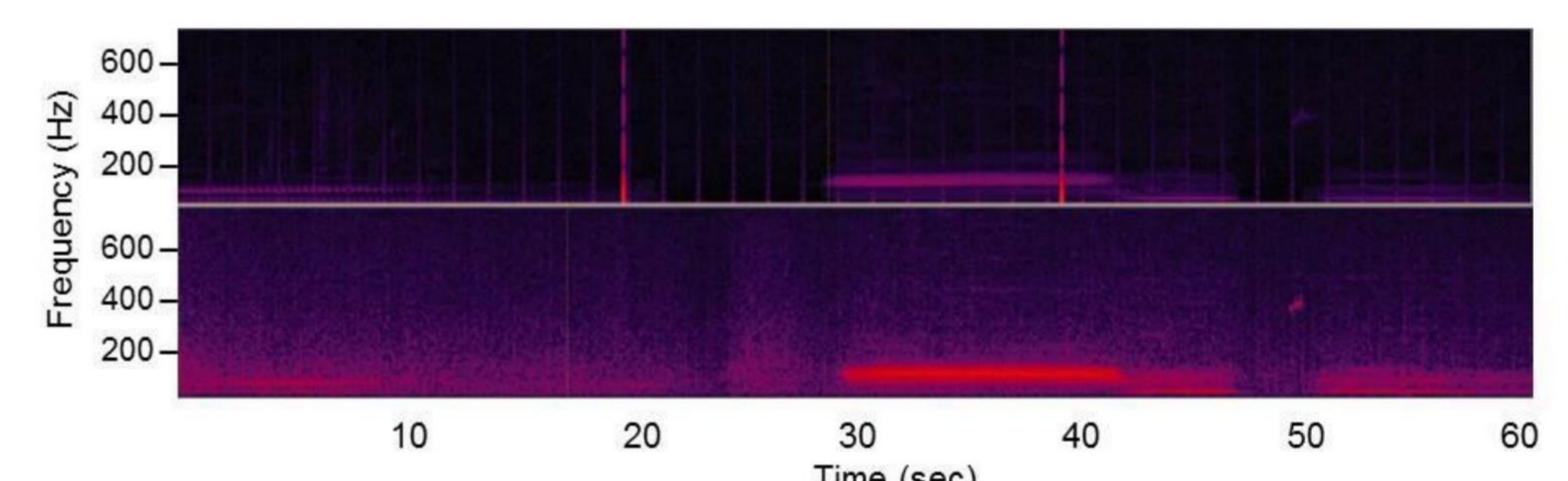


Figure 4. Spectrograms (plots of frequency vs. time) of sounds recorded on the DTAGs of the presumed mother (top) and juvenile (bottom).

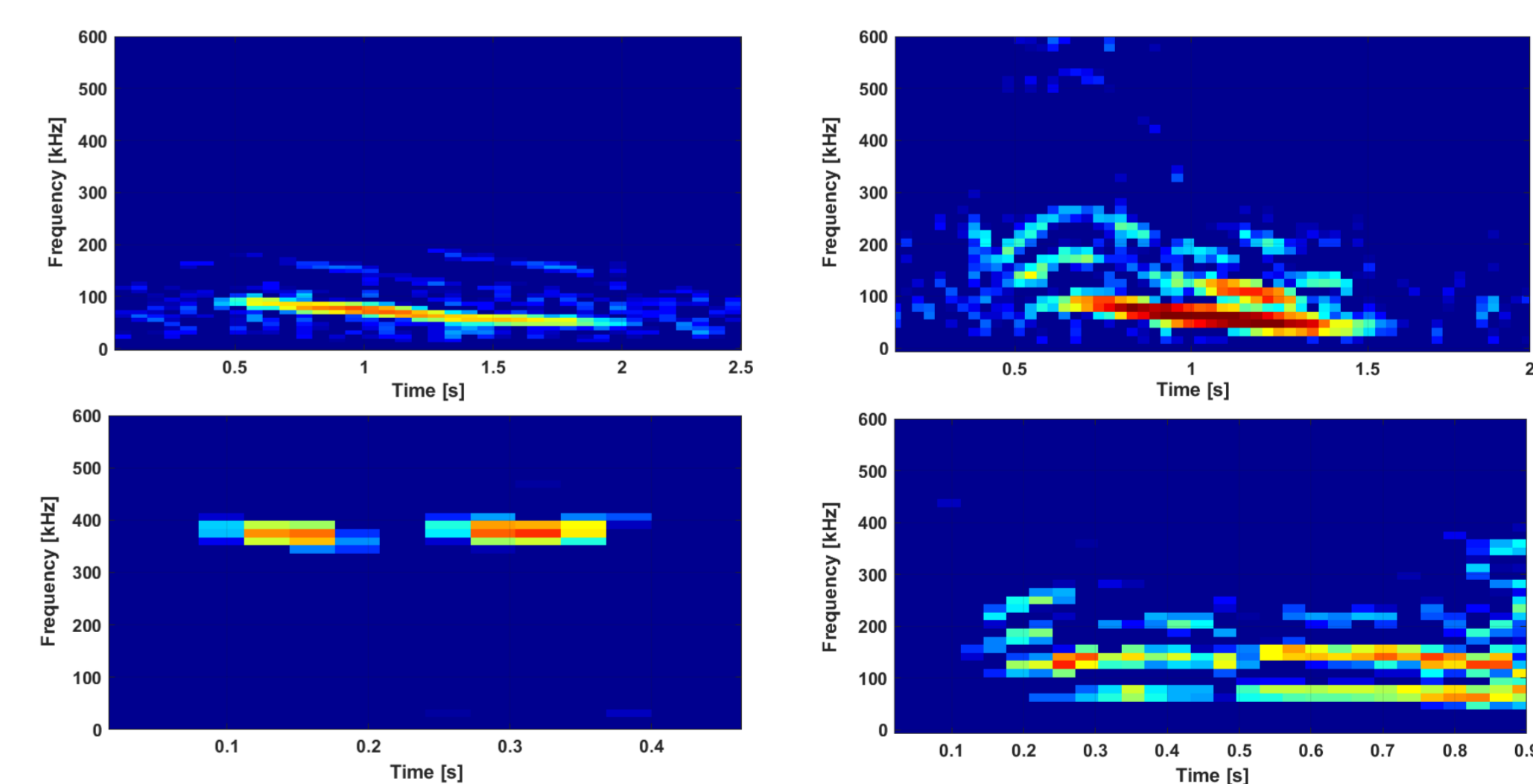


Figure 5. Spectrograms of different short calls recorded on the DTAGs.

CONCLUSIONS

Preliminary results on the sounds of Chilean blue whales recorded using DTAGs in the Gulf of Corcovado are presented. Analyses are ongoing to characterize the acoustic behavior of this population.

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