Southeast Pacific blue whale song recorded off Isla Chañaral, northern Chile

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*** Text:**

Determining the distribution and seasonal movements of baleen whales is fundamental to the development of conservation strategies and marine spatial planning, which ensure their continued protection (e.g., Pompa, Ehrlich, and Ceballos (2011), Mullen, Peterson, and Todd (2013), Redfern et al. (2013a, 2013b)). One method widely used to monitor distribution and movements of cetaceans is Passive Acoustic Monitoring (PAM) (e.g., Mellinger, Stafford, Moore, Dziak, and Matsumoto (2007), Van Parijs et al. (2009)). The loud, repetitive, low-frequency songs of baleen whales make these animals particularly good candidates for acoustically determining their occurrence and in turn their distribution (e.g., Stafford, Nieukirk, and Fox (1999a, 1999b), Cerchio, Jacobsen, and Norris (2001), Širović, Hildebrand, Wiggins, and Thiele (2009), Buchan, Hucke-Gaete, Rendell, and Stafford (2015)). Endangered (https://www.iucn.org/) blue whales (*Balaenoptera musculus*) produce distinct song types recorded in different oceanic regions with largely distinct spatial and temporal distributions (e.g., McDonald, Mesnick, and Hildebrand (2006) and references therein, Stafford, Chapp, Bohnenstiel, and Tolstoy (2011), Samaran et al. (2013), Buchan, Hucke-Gaete, Rendell, and Stafford (2014), Buchan et al. (2015), Balcazar et al. (2017)). Song in blue whales is assumed to serve some reproductive function as it is believed to be produced only by males (Oleson et al., 2007a) and is produced throughout the animals' migratory range (Stafford et al. (1999a), Stafford, Nieukirk, and Fox (2001)). Blue whale song remains relatively stable over time, although there is some intra-annual variation in song production (Oleson, Wiggins, and Hildebrand, 2007b) and a decrease in the frequency of tonal song components has been reported over decadal timescales (McDonald, Hildebrand, and Mesnick (2009), Gavrilov, McCauley, and Gedamke (2012)). Therefore, PAM offers a very useful method to monitor the distribution of blue whale acoustic groups worldwide.

The predominant song type of Southeast Pacific blue whales, known as the Southeast Pacific 2, (SEP2) (Buchan et al., 2014) has been recorded in Chilean Patagonia (Buchan et al., 2014, and 2015), off Juan Fernandez (Truong, Širović, Tripovich, and Rogers, 2016), and in the eastern Tropical Pacific (Stafford et al. (1999b), Buchan et al. (2015)). This acoustic presence supports a migratory range for this group between Chilean Patagonia and the eastern Tropical Pacific. This migratory range is also supported by genetic sampling of the individuals within this range (Torres-Florez, Hucke Gaete, and LeDuc, 2014), photo-identification (Torres-Florez et al., 2015), and studies using satellite tags (Hucke-Gaete et al., 2018). Placed within the migratory corridor of south Pacific blue whales, Isla Chañaral is part of the Humboldt Archipelago, a series of coastal islands within the productive Humboldt Current System (Thiel et al., 2007) (Figure 1). The waters surrounding Isla Chañaral, which lies 3.5 nautical miles from the mainland, are a known summer feeding ground primarily for fin whales (*Balaenoptera physalus*) (Pérez-Álvarez et al. (2006), Toro, Vilina, Capella, and Gibbons (2016), Sepúlveda, Santos, and Pavez (2017), Sepúlveda, Pérez-Álvarez, and Santos-Carvallo (2018)), but also blue whales, humpback whales (*Megaptera novaeangliae*), sei whales (*Balaenoptera borealis*), and minke whales (*Balaenoptera bonaerensis*) have also been sighted (Capella, Vilina, and Gibbons (1999), Sepúlveda pers. Comm.). This area has long since been the focus of a Marine Protected Area proposal. The acoustic identity of the blue whales that visit this area is unknown. In this study, we report the analysis of new PAM data from Northern Chile to examine whether there is evidence of southeast Pacific blue whales (SEP2 song type) in this area.

Passive acoustic data were collected within the Isla Chañaral channel, between the Isla Chañaral and the mainland, at 29°00'44" S and 71°31'26" W (Figure 1) during three periods of two weeks in January and February 2017 (see Patris, Malige, and Glotin (2017) for details). A 'BOMBYX II', which includes a Cetacean Research C57 hydrophone (sensitivity of -187 dB re 1 V μPa^{-1}, flat response down to 20 Hz, omnidirectional at frequencies less than 10 kHz), powered by a 9V source and high-pass filtered (C=47µF, frequency cut 0.15 Hz) and a commercial SONY PCM-M10 recording device (gain 6, Rin = 22 kOhm) equipped with a 256 GB memory card, set up in a specialized tube made by OSEAN SA (France) able to resist high pressure, was deployed between 15 and 20 m below the surface on a mooring where the maximum water column depth was 70 m. The 'BOMBYX II' was deployed by the University of Toulon and CNRS (DYNI team, LIS).

Recording was done at a sample rate of 48 kHz so as to record a vast diversity of cetaceans, ranging from large whales to dolphins, and at 16-bits, allowing for high sensitivity without saturating the memory [i]. No low-pass filter (such as an anti-aliasing filter) was used for this recording, since it was not considered necessary for our purpose. Acoustic data were recorded between the 16 January and the 27 February 2017. No data were recorded during the 30 and 31 January and during the night between the 13 and 14 February because of instrument redeployment.

The SEP2 song is made up of a four-unit phrase (A, B, C, D, see Figure 2) lasting 60 s that is repeated every two minutes, in long series lasting for hours. All units are long and stable pulsed sounds; thus their power spectra show a set of discrete frequencies

(Patris, Malige, Glotin, Asch, and Buchan, 2019). The energy of the spectra is generally concentrated around the 24 Hz peak. Unit A has an average duration of 22 s, unit B of 13 s, unit C of 5 s, and unit D an average duration of 13 s. Usually, not all units are visible due to low signal to noise ratio (SNR) and units C and D contain most of the signal's energy. In this study SEP2 song phrases were annotated whenever at least the 24 Hz-frequency peak of units C and D were visible. The SEP2 songs of Southeast Pacific blue whales were annotated manually, i.e., a box was drawn around the C and D units of the SEP2 song phrase, on the spectrogram visible in Raven Pro 1.5 (Bioacoustics Research Program, 2012). The following parameters were used: 8,192 sample FFT, 50% overlap, Hann window, with a Raven scale set to view 60 Hz over 200 s. Herein, we refer to all phrases with at least C and D units as SEP2 song phrases.

A nonsystematic double check of the data by another analyst showed that few phrases (with only unit B visible) were not counted by the first analyst (missed detections). Units C and D were not visible due to noise or propagation effects that mask low frequencies. Furthermore, unit A and the pair C-D are sometimes confoundable (having similar characteristics in duration and peak frequency). Thus, in some cases, unit A and the pair C-D of the same phrase were counted as two distinct occurrences of a phrase (false positive). As the second analysis was not systematic on all data but only on a portion of it (one third), it served to evaluate the importance of errors during the counting of the first analysis. Based on this double check, we estimate the error in counting SEP2 occurrences to be less than 3%.

A total of 913 h of acoustic recordings were analyzed, over which 1,981 SEP2 song phrases were identified, annotated and counted by the first analyst (Figure 3). As presented in these studies, we also noted the presence of two short high frequency precursors before units A (around 430 Hz) and D (around 350 Hz) (see Figure 2). Two faint downsweeps are identified in phrases with high signal-to-noise ratio: in unit A (duration of 5 s from 150 Hz to 120 Hz) (n = 10) and in unit B (duration of 12 s from 450 Hz to 300 Hz) (n = 10), see Figure 2. This sound may be a byproduct of the pulsed low frequency sound, a resonance artefact or sound made independently. In the latter, no mechanism of sound production has been proposed to explain this superposition of two sounds, called two-voiced sounds (Brown, 2008) and this has not been described for other blue whale's song types (McDonald et al., 2006).

There was no noticeable trend in the total number of SEP2 song phrases counted over the study period although, overall, more phrases were counted in January (64 phrases/day in average) compared to February (36 phrases/day) (See Figure 3). No significative difference was found between day and night in the number of phrases. Although this is a short period study, these results show low but consistent acoustic presence of Chilean blue whales throughout the months of January and February off Isla Chañaral.

From the Raven Pro selection tables, we calculated the time between SEP2 phrases, i.e., the inter-phrase interval (IPI), (Fig. 4). The peaks at 2 and 4 min are characteristic of SEP2 individual song (Buchan, Rendell, and Hucke-Gaete, 2010) and suggest that phrases could be produced by single singers rather than multiple overlapping singers. There is only one instance of song phrase overlap on January 28, 2017, reflected by shorter IPIs of 50-70s, which might suggest the presence of two singers. This is consistent with limited opportunistic sighting observations: A single blue whale performing circular dives and fluking, consistent with foraging behavior (Buchan and Quiñones, 2016), was observed by S. Buchan on February 15-17 and 23, 2017 within the Chañaral Channel and to the South of Isla Chañaral; and sightings of two blue whales together on January 16, 2017 (observed by J. Patris, S. Buchan, and F. Malige).

The number of phrases per day reported remains low compared to acoustic studies from Chilean Patagonia, where over one thousand SEP2 phrases were automatically detected per day between the months of March and May 2012-2013, which is thought to be the time of maximum abundance of animals in this region (Hucke-Gaete, Osman, Moreno, Findlay, and Ljungblad (2003), Buchan et al. (2015), Galletti-Vernazzani, Jackson, Cabrera, Carlson, and Brownell Jr (2017)). Since there is not yet year-round data off Isla Chañaral, it is impossible to compare seasonal trends in acoustic presence of Chilean blue whales at both sites. However, sighting data off Isla Chañaral (Sepulveda et al., 2017) and in Chilean Patagonia (Hucke-Gaete et al. (2013), Galletti-Vernazzani et al. (2017)) still suggest much higher abundance in Chilean Patagonia, which is considered the primary feeding ground for Chilean blue whales.

During visual inspection of the data set, no Antarctic blue whale song type (Ljungblad, Clark, and Shimada (1998), Matsuoka, Murase, Nishiwaki, Fukuchi, and Shimada (2000)) has been detected, although it has been recorded in the Chilean Patagonia (Buchan, Hucke-Gaete, Stafford, and Clark, 2018) and also in low-latitude East Pacific Ocean (Stafford et al., 2004). No SEP1 blue whale's song type (Cummings and Thompson, 1971) has been detected in this data set. SEP1 has been recorded in Chilean Patagonia, off Juan Fernandez Archipelago and in the East Tropical Pacific (Cummings and Thompson (1971), Truong et al. (2016), Stafford et al. (1999b)) but is the least common of the two Southeast Pacific song types (Buchan et al. (2015), Saddler et al. (2017)).

This is the first report of Southeast Pacific blue whale song (or any baleen whale call) in the coastal waters off Northern Chile and in the Humboldt Current System. Given the high levels of productivity of this system, and considering that Southeast Pacific blue whales are known to migrate between wintering grounds near Galapagos and summer feeding grounds in Chilean Patagonia (Hucke-Gaete et al. (2003 and 2018), Buchan et al. (2015), Torres-Florez et al. (2015), Buchan and Quinones (2016)), it would make sense that some animals would take advantage of the available prey in the Humboldt Current System. In particular, the dense patches of Humboldt Current krill (*Euphausia mucronata*) known to be exploited by fin whales off Isla Chañaral (Toro et al., 2016) would also offer foraging opportunities for blue whales that are on their way to or from their primary feeding ground in Chilean Patagonia. The presence of southeast Pacific blue whales off Isla Chañaral is further evidence of the importance of this area for the conservation of endangered baleen whale populations.

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REFERENCES

Balcazar, N. E., Klinck, H., Nieukirk, S. L., Mellinger, D. K., Klinck, K., Dziak R. P. and Rogers, T. L. (2017) Using calls as an indicator for Antarctic blue whale occurrence and distribution across the southwest Pacific and Southeast Indian Oceans. *Marine Mammal Science*,33,172–186.

Bioacoustic Research Program. (2012) Raven Pro: Interactive Sound Analysis Software (version 1.5) [Computer Software]. Ithaca, NY: *The Cornell Lab of Ornithology*. Available from: http://www.birds.cornell.edu/raven.

Brown, J. C. (2008). Mathematics of pulsed vocalizations with application to killer whale biphonation, *Journal of the Acoustical Society of America* 123(5), 28752883.

Buchan, S.J., Rendell L.E. and Hucke-Gaete R., Preliminary recordings of blue whale (Balaenoptera musculus) vocalizations in the Gulf of Corcovado, northern Patagonia, Chile (2010), *Marine Mammal Science*, 26(2), 451–459

Buchan, S. J., Hucke-Gaete, R., Rendell, L. E. and Stafford, K. M. (2014). A new song recorded from blue whales in the Corcovado Gulf, Southern Chile, and an acoustic link to the Eastern Tropical Pacific. *Endangered Species Research* 23,241–252.

Buchan, S. J., Hucke-Gaete, R., Rendell, L. E. and Stafford, K. M. (2015). Seasonal occurrence of Southeast Pacific blue whale songs in southern Chile and the eastern tropical Pacific. *Marine Mammal Science* 31,440–458. NOTES 227

Buchan, S. J., and Quiñones, R. A. (2016). First insights into the oceanographic characteristics of a blue whale feeding ground in northern Patagonia, Chile. *Marine Ecology Progress Series* 554,183–199.

Buchan, S.J., Stafford, K., Hucke-Gaete, R., Clark, C.W., Balcazar-Cabrera, N., Gutierrez, L., Patris, J., Malige, F., Neira, S., Sepulveda, M., Santos-Carvallo, M., and Olavarría, C. (2017). A review of blue and fin whale acoustically-inferred seasonal movements in the eastern South Pacific, *Poster in the Society for Marine Mammalogy's 22nd Biennial Conference on the Biology of Marine Mammals.*

Buchan, S.J., Hucke-Gaete, R., Stafford, K.M., and Clark, C.W. (2018). Occasional acoustic presence of Antarctic blue whales on a feeding ground in southern Chile. *Marine Mammal Science* 34(1),220–228.

Capella, J., Vilina, Y., and Gibbons, J. (1999). Observación de cetáceos en laisla Chañaral y nuevo registros para el área de la reserva nacional Pinguino de Humboldt, norte de Chile, observación of cetaceans at Isla Chañaral and new records at the Humboldt Penguin national reserve, northern Chile. *Estudios Oceanologicos* 18, 57-64.

Cerchio, S., Jacobsen, J.K., and Norris, T.F. (2001). Temporal and geographical variation in songs of humpback whales, Megaptera novaeangliae : synchronous change in Hawaiian and Mexican breeding assemblages. *Animal behaviour*, 62, 313–329

Cummings, W.C., and Thompson, P.O. (1971). Underwater sounds from the blue whale, Balaenoptera musculus. *Journal of the Acoustical Society of America* 50,1193–1198.

Eaton, J.W., Bateman, D., and Hauberg, S. (2009). GNU Octave version 3.0.1 manual: a high-level interactive language for numerical computations (CreateSpace Independent Publishing Platform, 2009). Available from http://www.gnu.org/software/octave/doc/interpreter, 11ISBN 1441413006.

Galletti-Vernazzani, B., Carlson, C.A., Cabrera, E. and Brownell Jr, R.L. (2012). Chilean blue whales off Isla Grande de Chiloe, 2004-2010: distribution, site-fidelity and behavior. *Journal of Cetacean Research and Management* 12, 353–360.

Galletti-Vernazzani, B., Jackson, J.A., Cabrera, E., Carlson, C.A. and Brownell Jr, R.L. (2017). Estimates of abundance and trend of Chilean blue whales off Isla de Chiloé, Chile. *PLOS ONE* 12(1), e0168646.

Gavrilov, A. N., McCauley, R.D. and Gedamke, J. (2012). Steady inter and intra-annual decrease in the vocalization frequency of Antarctic blue whales. *Journal of the Acoustical Society of America* 131, 4476–4480.

Hucke-Gaete, R., Osman, L.P, Moreno, C.A., Findlay K.P. and Ljungblad, D.K. (2003). Discovery of a blue whale feeding and nursing ground in southern Chile. *Proceedings of the Royal Society London B (Supplement)* 271, S170–S174.

Hucke-Gaete, R. (2004). Distribución, preferencia de hábitat y dinámica espacial de la ballena azul en Chile: 1997-2004 [Distribution, habitat preference and spatial dynamics of the blue whale in Chile: 1997–2004]. Ph.D. thesis, Universidad Austral de Chile, Valdivia, Chile.

Hucke-Gaete, R., Haro, D., Torres-Florez, J., Montecinos, Y., Viddi, F., Bedriñana-Romano, L., Nery, M. and Ruiz, J. (2013). A historical feeding ground for humpback whales in the eastern South Pacific revisited: The case of Northern Patagonia, Chile. *Aquatic Conservation Marine and Freshwater Ecosystems.* 23. 10.1002/aqc.2343.

Hucke-Gaete, R., Bedriñana-Romano, L., Viddi, F.A., Ruiz, J.E., Torres-Florez, J.P. and Zerbini, A.N. (2018). From Chilean Patagonia to Galapagos, Ecuador : novel insights on blue whale migratory pathways along the Eastern South Pacific. *PeerJ* 6, e4695,

Ljungblad, D. K., Clark, C.W. and Shimada, H. (1998). A comparison of sounds attributed to pygmy blue whales (Balaenoptera musculus brevicauda) recorded south of the Madagascar Plateau and those attributed to 'true' blue whales (Balaenoptera musculus) recorded off Antarctica. *Report of the International Whaling Commission* 48, 439–442.

Matsuoka, K., Murase, H., Nishiwaki, S., Fukuchi, T. and Shimada, H. 2000. Development of a retrievable sonobuoy system for whale sounds recording in polar region. *Paper SC/52/O7 presented to the IWC Scientific Committee,* (2000), in Adelaide, Australia (unpublished).

McDonald, M. A., Mesnick, S.L. and Hildebrand, J.A. (2006). Biogeographic characterisation of blue whale song worldwide: Using song to identify populations. *Journal of Cetacean Research Management* 8, 55–56.

McDonald, M. A., Hildebrand, J.A. and Mesnick, S. (2009). Worldwide decline in tonal frequencies of blue whale songs. *Endangered Species Research* 9, 13–21.

Mellinger, D.K., Stafford K.M., Moore S.E., Dziak R.P. and Matsumoto H. (2007) An overview of fixed passive acoustic observation methods for cetaceans. *Oceanography.* 20(4), 36–45.

Mullen, K.A., Peterson,M.L., and Todd, S.K. (2013) Has Designating and Protecting Critical Habitat Had an Impact on Endangered North Atlantic Right Whale Ship Strike Mortality? *Marine Policy* 42, 293–304.

Oleson, E. M., Calambokidis, J., Burgess, W.C., McDonald, M.A., LeDuc, C.A. and Hildebrand, J.A. (2007a). Behavioural context of call production by eastern North Pacific blue whales. *Marine Ecology Progress Series* 330, 269–284.

Oleson, E. M., Wiggins, S.M. and Hildebrand, J.A. (2007b). Temporal separation of blue whale call types on a southern California feeding ground. *Animal Behaviour* 74, 881–894.

Piñones, A. and Fedorov, A.V. (2016). Projected changes of Antarctic krill habitat by the end of the 21st century. *Geophysical Research Letters* 43, 8580–8589.228

Patris, J., Malige, F., and Glotin, H. (2017). Construction et mise en place d'un système fixe d'enregistrement à large bande pour les cétacés "bombyx 2" isla de chañaral, été austral 2017. *Technical Report 2017-03, LSIS CNRS.*

Patris, J. (2019). Contribution en méthodes pour le suivi de mysticètes par acoustique passive, *PhD thesis, Université de Toulon, France. Avaiblable from* http://www.theses.fr/2019TOUL0016

Patris, J., Malige, F., Glotin, H., Asch, M. and Buchan, S. (2019). A standardized method of classifying pulsed sounds and its application to pulse rate measurement of blue whale southeast Pacific song units. *The Journal of the Acoustical Society of America.* 146, 2145-2154.

Perez-Alvarez, M., Thomas, F., Uribe, F., Sepúlveda, M., Flores, M. and Moraga, R. (2006). Fin Whales (Balaenoptera physalus) Feeding on Euphausia mucronata in Nearshore Waters off North-Central Chile. *Aquatic Mammals*. 32, 109-113.

Pompa, S., Ehrlich, P.R., and Ceballos G. (2011). Global Distribution and Conservation of Marine Mammals. *Proceedings of the National Academy of Sciences of the United States of America* 108 (33), 13, 600–605.

Redfern, J.V., McKenna, M.F., Moore, T.J., Calambokidis, J., Deangelis, M.L., Becker, E.A., Barlow, J., Forney, K.A., Fiedler, P.C., and Chivers, S.J. (2013a) Assessing the Risk of Ships Striking Large Whales in Marine Spatial Planning. *Conservation Biology* 27 (2), 292–302.

Redfern, J.V., Hatch, L.T., Caldow, C., DeAngelis, M.L., Gedamke, J., Hastings, S., Henderson, L., McKenna, M.F., Moore, T.J., and Porter, M.B. (2013b). Assessing the risk of chronic shipping noise to baleen whales off Southern California, USA. *Endangered Species Research.* 32, 53–167.

Saddler, M.R., Bocconcelli, A., Hickmott, L.S., Chiang, G., Landea-Briones, R., Bahamonde, P.A., Howes, G., Segre, P.S. and Sayigh, L.S. (2017) Characterizing Chilean blue whale vocalizations with DTAGs: a test of using tag accelerometers for caller identification, *Journal of Experimental Biology* (220), 4119-4129

Samaran, F., Stafford, K.M., Branch, T.A., Gedamke, J., Royer, J.R., Dziak, R.P. and Guinet, C. (2013). Seasonal and geographic variation of the southern blue whale subspecies in the Indian Ocean. *PlOS ONE* 8(8), 1–10.

Sepúlveda, M., Santos, M. and Pavez, G. (2017). Whale-watching en la Reserva Marina Isla Chañaral: Manejo y planificación para una actividad sustentable. *Primera Edición* 2017, ISBN: 978-956-368-225-0

Sepúlveda, M., Pérez-Álvarez, M.J., and Santos-Carvallo, M. (2018) From whaling to whale watching: Identifying fin whale critical foraging habitats off the Chilean coast. *Aquatic Conservation Marine and Freshwater Ecosystems* 018, 1–9.

Širović, A., Hildebrand, J. A., Wiggins, S.M. and Thiele, D. (2009). Blue and fin whale acoustic presence around Antarctica during 2003 and 2004. *Marine Mammal Science* 25, 125–136.

Stafford, K. M., Nieukirk, S.L. and Fox, C.G. (1999a). An acoustic link between blue whales in the eastern tropical Pacific and the northeast Pacific. *Marine Mammal Science* 15, 1258–1268.

Stafford, K. M., Nieukirk, S.L. and Fox, C.G. (1999b). Low-frequency whale sounds recorded on hydrophones moored in the eastern tropical Pacific. *Journal of the Acoustical Society of America* 106, 3687–3698.

Stafford, K. M., Nieukirk, S.L. and Fox, C.G. (2001). Geographical and seasonal variation of blue whale calls of the North Pacific. J*ournal of Cetacean Research Management* 3, 65–76.

Stafford, K. M., Bohnenstiehl, D. , Tolstoy, M., Chapp, E.,Mellinger, D. and Moore, S. (2004). Antarctic-type blue whale calls recorded at low latitudes in the Indian and eastern Pacific Oceans. *Deep Sea Research Part I: Oceanographic Research Papers*. 51. 1337-1346. 10.1016/j.dsr.2004.05.007.

Stafford, K. M., Chapp, E., Bohnenstiel, D.R and Tolstoy M.. (2011). Seasonal detection of three types of “pygmy” blue whale calls in the Indian Ocean. *Marine Mammal Science* 27, 828–840.

Thiel, M., Macaya, E., Acuna, E., Arntz, W., Bastias, H., Brokordt, K., Camus, P., Carlos Castilla, J., Castro, L., Cortes, M., Dumont, C., Escribano, R., Fernandez, M., Gajardo, J.A., Gaymer, C., Gomez, I., Gonzalez, A.E., González, H.E, Haye, P. and Vega, A. (2007). The Humboldt Current System of Northern and Central Chile. *Oceanography and marine biology*. 45, 195-345

Toro, F., Vilina, Y.A., Capella, J. and Gibbons, J. (2016) Novel Coastal Feeding Area for Eastern South Pacific Fin Whales (Balaenoptera physalus) in Mid-Latitude Humboldt Current Waters off Chile, *Aquatic Mammals* 42(1), 47-55.

Torres-Florez, J.P., Hucke Gaete, R., and LeDuc, R. (2014). Blue whale population structure along the eastern South Pacific Ocean: Evidence of more than one population. *Molecular Ecology* 23(24), 5998–6010.

Torres-Florez, J.P., Olson, P.A., Bedriñana-Romano, L., Rosenbaum, H.C.R., Ruiz, J., LeDuc, R. and Hucke Gaete, R. (2015) First documented migratory destination for eastern South Pacific blue whale. *Marine Mammal Science*, 31(4), 1580–1586

Truong, G., Širović, A., Tripovich, J., and Rogers, T. (2016). Seasonal patterns in Chilean blue whale call detections between 2003 and 2015. SC/66b/SH/25, *International Whaling Commission.*

Van Parijs, S.M., Clark, C.W., Sousa-Lima, R.S., Parks, S.E., Rankin, S., Risch, D.,and Van Opzeeland, I.C. (2009). Management and research applications of real-time and archival passive acoustic sensorsover varying temporal and spatial scales. *Marine Ecology Progress Series* 395, 21–36.

Figure captions and captions

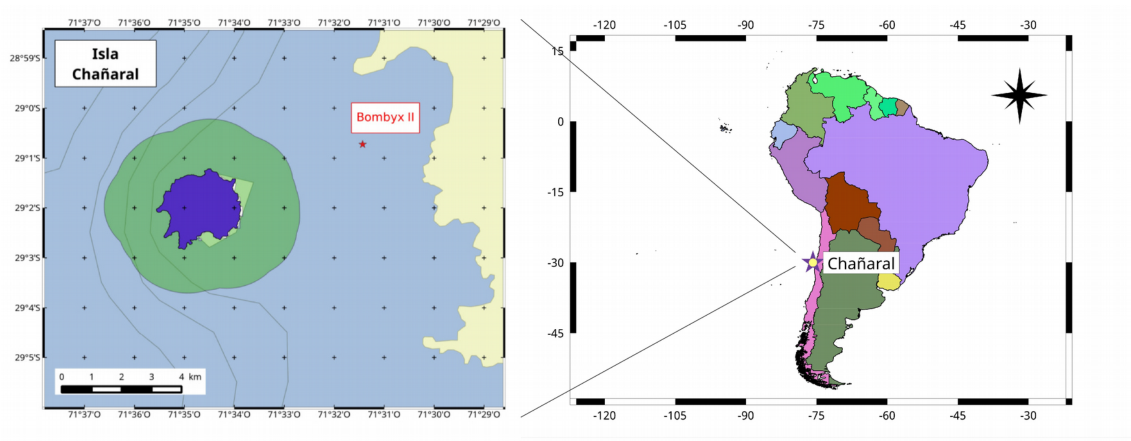

Figure 1. Map of the deployment zone of the BOMBYX II device (left). The green zone around the Island is a marine protected area (Reserva Marina Isla Chañaral). General location in South America (right).

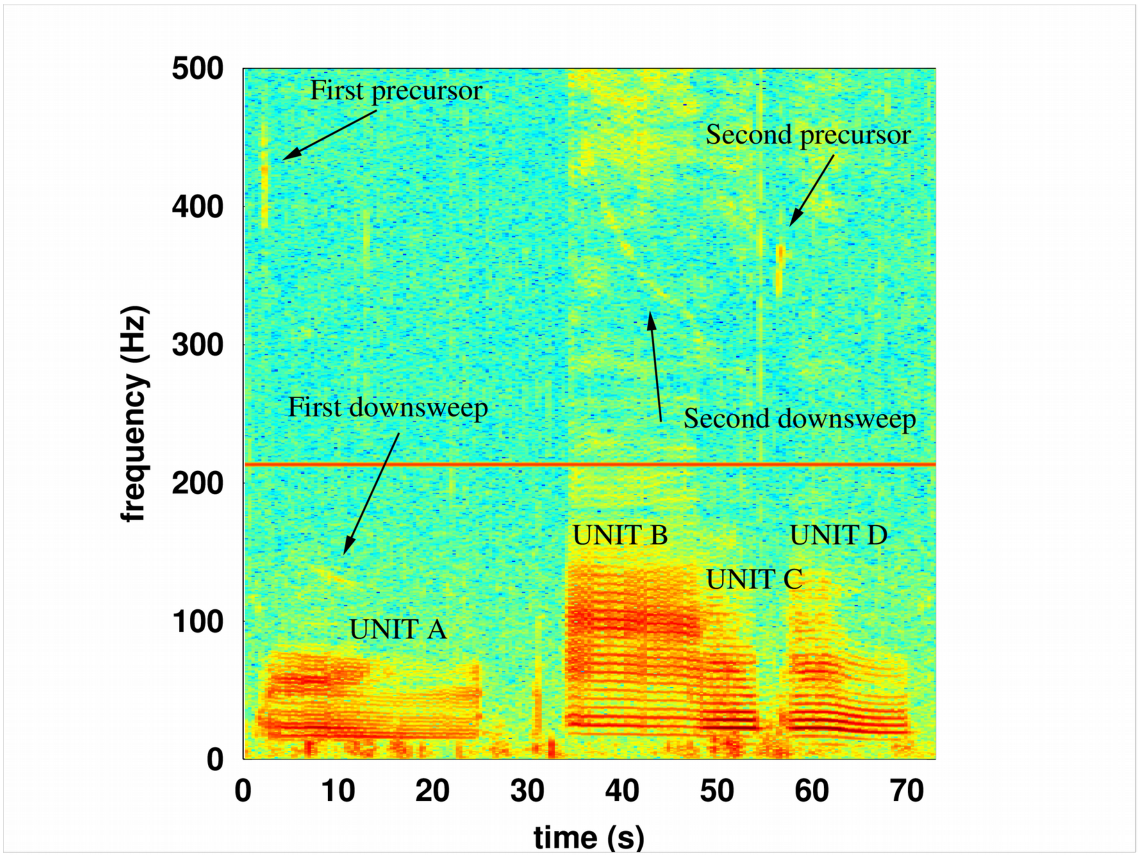

Figure 2. Time frequency representation of a SEP2 song recorded off Isla Chañaral, on February 2, 2017 (Fast Fourier transform, Blackman window of 65,536 points, overlapping 75%) using Octave software (Eaton, Bateman, and Hauberg, 2009). The line at 213 Hz is a constant electronic noise coming from the coupling between the hydrophone and the recording device. Units A, B, C, D are clearly visible as well as precursors and downsweeps belonging to the song.

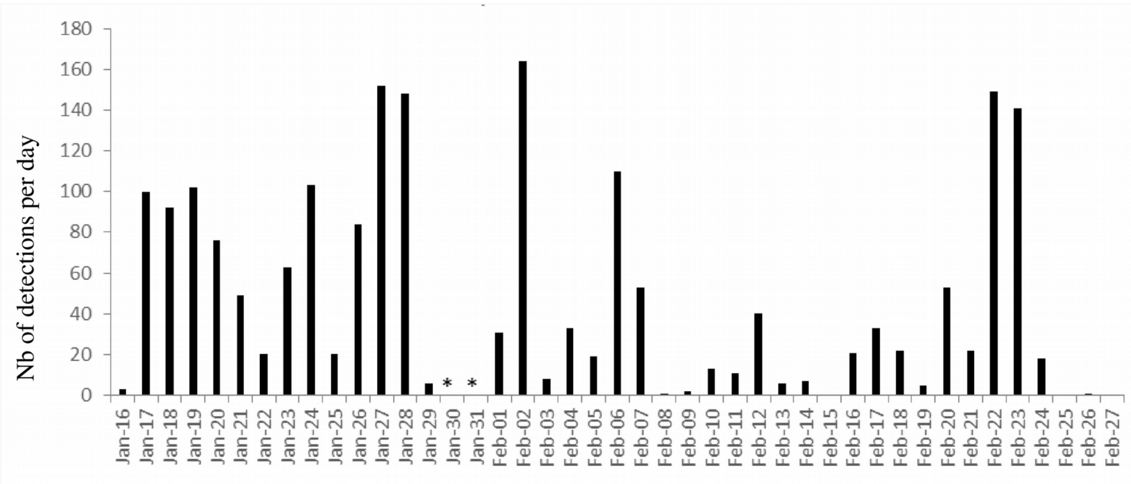

Figure 3. Number of SEP2 phrases counted in the first season of recording off Isla Chañaral. The device was off duty during January 30 and 31 (asterisks) and the February 13 and 14.

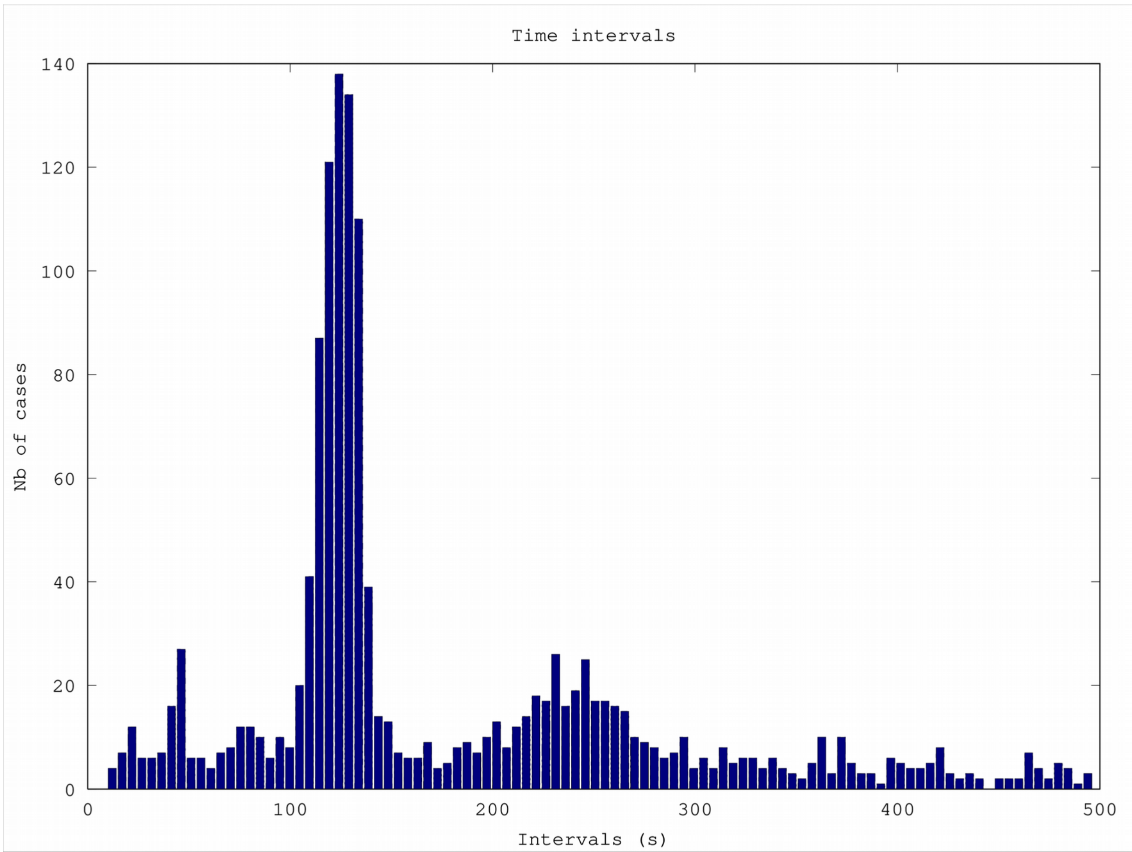

Figure 4. Histogram of the inter-phrase intervals (IPIs) between two occurrences of SEP2 phrases, from the Raven Pro selection table.

i During the analysis, other vocalizations were found: blue whale “D-calls”, fin whale (*Balaenoptera physalus*) vocalizations, bottlenose dolphins' (*Tursiops truncatus*) echolocation clicks, whistles and low-frequency vocalizations, and dusky dolphin (*Lagenorhynchus obscurus*) burst of pulses (see Patris, 2019). This dataset can be obtained asking the authors.