Specific answers or comments are given below:

Comment from referee #1:

Did you also look into associated calls (i.e. calls produced preceding and following these downsweeps)?

Response: Yes, we did. When we analysed the data, sei whales' calls appeared without associated calls. In the lines 182-183 we said: Only in two occasions humpback whale sounds above 2000 Hz were detected, in the rest of the analysed audios, only sei whale sounds were detected without associated calls.

Comment from referee #1 (page and line refer to first version):

P14, line 214-217: Did you also investigate to what extent the background noise conditions differed between the recording sessions and if this might have affected the quality of the recordings in one year and as a result may have affected the measurements? How do you explain the differences in characteristics in the recorded calls between years?

Your Response: Background noise was not part of this investigation. Future research will be conducted to characterize acoustic pollution, background/environmental and traffic sounds.

Editor: Please answer also the last question of referee #1 and add info in the text

Response: The differences in the calls are not statistically significative, so we did not separate by characteristics, only for year to give more details about these calls. It is not necessary add in the text.

Comment from referee #2 (page and line refer to first version):

Line 114: The hydrophone deployment method is a little unclear. Was the hydrophone suspended for up to 5 days over the side of the vessel? How many recording stations were conducted? What were the positions (lat/longs)? What was the sampling rate? How were the data recorded? Are these archival recorders, or were you using a computer, a recording deck, etc, and if so, what equipment was included?

Response: the methodology was change as follow: Opportunistic and planned recordings were carried out depending on the weather conditions and the vessel location. In 2017 the hydrophones were deployed for 2 to 5 days in 3 locations. In these cases, hydrophones were deployed at a depth of 5 or 10 meters on rocky bottom with no more than 40 meters depth. Hydrophones were hold on a row with an anchorage in the end and superficial buoys in the opposite side. In both years, during the day or night, hydrophones were deployed at a depth of 5 and 10 meters from the stationary vessel. In the opportunistic recordings, recordings were continuously, but in the night when the vessel was anchorage, the recordings were in intervals between 10-30 minutes each hour for guarantee the capacity of the acoustic personal to study the recording in the next day.

Editor: I think referee #2 is asking for more info than you supplied here. Please also supply the remaining info.

Response:

In the text said:" In 2016, recordings were not more than one day in each location where hydrophones were suspended over the side of the vessel. However, in 2017, also, in 3 different locations hydrophones were deployed between 2-5 days at a depth of 5 or 10 m on rocky bottom with about 40 meters bottom depth using a row with a mooring at the end and surface buoys on the opposite side" (line 129-136).

Added:" Sound was recorded during 16 days in 2016 in 23 opportunistic recordings locations and during 19 days in 24 locations in 2017" (line 158-159)

Changed: "A total of 363 hours was recorded between both expeditions, because the recordings were not continuous during every day, 136 hours (63 archives) in 2016 and 227 hours (483 archives) in 2017" (line 160-162)

Added: "Recordings were not the same duration or the same sampling rate because they were opportunistic" (line 162-163)

In the text said:" Two different hydrophones were used for the recordings: an icListenHF hydrophone (sensitivity -171 dBV re 1 µPa with pre-amp; frequency response 10–200kHz from Ocean Sonic, Canada); and a SoundTrap 202 STD hydrophone (sensitivity -205 dBV re 1 µPa; frequency response 60000Hz ±3 dB from Ocean Instruments, New Zealand). Also, we made stereo recordings on several occasions with an HTI-96-MIN hydrophone (flat frequency response from 0.02 to 30 kHz) connected to a handy recorder (H4nPro from ZOOM)." (line 121-127) and "All the recordings were stored in the internal card memory of the equipments, and at the end of the day these were download in a portable computer." (line 146-147).

Comment from referee #2 (page and line refer to first version):

Lines 119-123: This section is completely lacking in any detail on the analyses. How were the sounds reviewed? Using spectrograms? What page size, what FFT? How were signals from sei whales distinguished from other species, such as blue whales (which also produce similar low-frequency downsweeps)? How were measurements conducted? Issues with measurements such as low and high frequency that are strongly affected by spectrogram parameters and SNR have been recognized in the literature; Raven and other software packages (i.e. Ishmael) offer a set of more "ro- bust" analyses; these need to be used as well. It appears that two software packages were used (Audacity and Raven). What was each one used for?

Your Response: the methodology was change as follow: Audio data were analysed using Raven Pro 1.5 (Cornell University, Ithaca, NY). Low and high frequency (Hz), frequency range (Hz), peak frequencies (the frequency at which the maximum power occurred within a call) and duration (s) for all calls found and attributed to sei whales were analysed from spectrograms and waveform *plots created in Raven Pro 1.5 (Hann window; 50% overlap; window size 14563 samples; DFT 16384 samples). Sounds were assigned to sei whale (and not other specie) via visual identification of the specimen and related sounds recorded.*

Editor: You have improved the method section, but I think you did not answer all questions of referee #2. Please add info also to the text

Response: all the questions were answered in the last version.

Comment from referee #2 (page and line refer to first version)

Figure 1: Which whale tail corresponds to which year? Also, the area where putative sei whales were detected appear very close to recording sites where they were not detected. Is there any explanation for why this might be?

Your Response: we incorporate a table with more detail about the sei whale recordings at the Penas Gulf and we explain this difference in the discussion: The few calls obtained in both expeditions maybe was due the duration of recorded in each site since they were opportunistic recordings, so visual observations, tagging efforts and genetic studies are needed to verify this hypothesis.

Discussion: Overall, there is no discussion of one of the main outcomes of this study – that despite the number of sites sampled, putative sei whales were only detected very rarely, and only in two locations. Why might this be? Could this have to do with the sampling scheme (ie duration of sampling at each site) or noise conditions (ie masking of signals)? How does this conform to your expectation?

Your Response: the response above explain better the idea.

Editor: I think there is more in this. Please expand

Response:

We changed the Figure 01 added a year whale tail indication and the study area. For this, we standardized the name of the area study. Specific changes:

Changed: "The Penas Gulf" by "Penas and Tres Montes Gulf" (Line 116 and 217).

Changed tittle figure 02: "The Penas Gulf" by "Penas and Tres Montes Gulf"

Changed tittle table 1.: "The Penas Gulf" by "Penas and Tres Montes Gulf"

We discussed about the differences in the text. These differences could be for the duration of recorded (as referee suggested) and we also discuss about the noise condition. We explained:

"Sound was recorded during 16 days in 2016 in 23 opportunistic recordings locations and during 19 days in 24 locations in 2017. A total of 363 hours was recorded between both expeditions, because the recordings were not continuous during every day, 136 hours (63 archives) in 2016 and

227 hours (483 archives) in 2017. Recordings were not the same duration or the same sampling rate because they were opportunistic." (Line 159-164)

The few calls obtained in both expeditions maybe was due the duration of recorded in each site since they were opportunistic recordings, so visual observations, tagging efforts and genetic studies are needed to verify this hypothesis" (Line 260-262). Also, "Other factor could be important in the discussion about the acoustic behaviour is the background noise, which masking biological important signals and impede the communications between individuals (Clark et al., 2009)"(Line 281-284).

*L43 For example, in the North Atlantic Ocean …*Replaced.

L46-47 Furthermore, the genetic divergence between North Pacific and North Atlantic stocks is well known … Replaced.

L116-118 Is there possibly a cruise report of these cruises, that could be cited? Response*:* There is not a formal cruise report, we have the data because our participating, but we did not do a formal report.

L130-131 at a depth of 5 or 10 m on rocky bottom with about 40 meters bottom depth. Replaced.

L132 I am not sure I understand this. "… with an anchorage in the end and superficial buoys in the opposite side." I suggest "…with a mooring at the end and surface buoys on the opposite side." Is that correct? Replaced

L134-135 I suggest: Opportunistic recordings were continuous … Replaced.

L135 "when the vessel was at anchor" instead of "when the vessel was anchorage"… Replaced

L136-137 I suggest to change this to: … intervals of 10-30 minutes each hour to guarantee the capacity of the acoustic personnel to study the recording during the next day. Replaced

L157 between 8 and 10 May (change format). Changed*.*

L158 delete the second "were". Deleted

L173, 174 7 May, 10 May (change format). Changed

Table 1 Hydrophone depth instead of Hydrophone Deep. Replaced

Table 1 In L130 you write that the depth of the hydrophones is 5 or 10 m. In the table this is 13 m. Please correct where needed. Response*:* Changed in the table 1*.*

L183 This must be changed to something like: only sounds were detected without associated calls *which we assign to sei whales.* Response*:* We do not think that a change is necessary.

L220-222 "low frequency is higher and 220 downsweep had been accompanied in the recorders by the Southeast Pacific type 2 221 (SEP2) (Saddler et al., 2017)," I do not understand this. Please rephrase for better understanding. Response*:* Replaced: "minimum frequency is higher than our results and downsweep had been accompanied by the Southeast Pacific type 2 (SEP2) (Saddler et al., 2017), supporting our results, that our records are really from sei whales".

L233 upper instead of superior. Replaced*.*

L260-261 "The few calls obtained in both expeditions maybe was due the 260 duration of recorded in each site" This sentence is not clear to me. Please make clear. Response: Replaced: "As recordings were opportunistic, the duration of recordings was variable, and this maybe influenced in the few calls that we recorded".

L281-283 "An other factor that could be important in the discussion about the acoustic behavior is background noise, which might be masking biologically important signals …" Replaced

L305 referees. Response: This is the reference provide by the author.

L357 (30–80°E) Replaced*.*

L359-360 Please add a translation of the title in English. Response: Added: "Blue whale Balaenoptera musculus (Linnaeus, 1758) and sei whales B. borealis Lesson, 1828 sightings in the north-occidental coastal in the Chiloé islands, Chile."

L375 update of reference: Conservation Genetics, 19, 1007-1024, 2018. Changed*.*

L392 delete [abstract only]. Deleted.

L396 22 instead of XXII. Changed.

Discovering sounds in Patagonia, characterizing sei whale (*Balaenoptera borealis*) downsweeps in the south-eastern Pacific Ocean.

Running title: Sei whale vocalizations in Chile

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Abstract

The sei whale (*Balaenoptera borealis*) is one of the least known whale species. Information on sei whales distributions and its regional variability in the south-eastern Pacific Ocean are even more scarce than that from other areas. Vocalizations of sei whales from this region are not described yet. This research presents the first characterization of sei whale sounds recorded in Chile during austral autumn of 2016 and 2017. A total of 41 calls were identified to be sei whale downsweeps. In 2016, calls ranged from an average maximum frequency of 105.3 Hz down to an average minimum 35.6 Hz over 1.6 s with a peak frequency of 65.4 Hz. During 2017, calls ranged from an average maximum frequency of 93.3 Hz down to 42.2 Hz (over 1.6 s) with a peak frequency of 68.3 Hz. The absolute minimum frequency recorded was 30 Hz and the absolute maximum frequency was 129.4 Hz. Calls generally occurred in pairs, but triplets or singles were also registered. These low frequency sounds share characteristics with recordings of sei whales near the Hawaii Islands, but with differences in the maximum frequencies and duration. These calls distinctly differ from sounds previously described for sei whales in the Southern Ocean and are the first documented sei whale calls in the south-eastern Pacific.

1. Introduction

The sei whale (*Balaenoptera borealis*; Lesson 1828) is the third largest rorqual in the Balaenopteridae family, after the blue whale (*B. musculus*) and the fin whale (*B. physalus*). It is also one of the least known whales. The sei whale is a cosmopolitan species found in temperate oceans and subpolar areas (Mackintosh, 1942; Gambell, 1968; Rice, 1998; Horwood, 2002; Reeves *et al*., 2002; Jefferson *et al*., 2008). It prefers deep offshore waters with temperatures below 20°C and avoids semi enclosed bodies of water (Omura and Nemoto, 1955; Gambell, 1985). North Atlantic, North Pacific and Antarctic populations are almost certainly separated and probably subdivided into geographic stocks (Horwood, 1987; Baker *et al.,* 2004; Kanda *et al*., 2006; Huijser *et al*., 2018). International Whaling Commission in 1991 divided the global sei whale population in "stocks" (based on the distribution of catches, sightings and mark-recapture data) for management purposes (Donovan, 1991). However, genetic studies provide a different population distribution. For example, ~~at~~ in the North Atlantic Ocean, the sei whale population from Iceland, the Gulf of Maine and the Azores share the same genetic diversity, showing the wide latitudinal and longitudinal ranges they moved. Furthermore, ~~it is well known~~ the genetic divergence between North Pacific and North Atlantic stocks is well known, but no studies of this genetic structure between hemispheres or within the Southern Ocean have been presented (Huijser *et al*., 2018). In the Southern Hemisphere, sei whale sightings were recorded from the Subtropical Convergence to the Antarctic Convergence, but the only observation record of adult animals come from the austral summer in south of the Antarctic Convergence (Gambell, 1974; Lockyer, 1977). In general, sei whales migrate seasonally from the reproduction areas in low latitudes in winter to their feedings areas in high latitudes in summer

(Reeves *et al*., 1998). Reproduction areas are poorly known (Perry *et al*., 1999) and feeding areas show great variability between years (Jonsgård and Darling, 1977). Population boundaries and migratory patterns are also poorly understood. In the austral summer there are concentrations of sei whales between 40° and 50°S; older, larger individuals tend to travel to northern Antarctic, while smaller, younger individuals tend to stay at lower latitudes (Rice, 1998; Acevedo *et al*., 2017).

Because of their smaller size, speed and elusiveness, sei whales were comparatively less important as target species for hunting until the early 1960s. After the decline of the most profitable species such as blue whales, fin whales and humpback whales, the whaling industry increased the hunting pressure on sei whales (Gambell, 1985). Thirty years ago, between the Antarctic and the North Pacific, many whales were taken from the coasts of Peru and Chile (Tonnessen and Johnsen, 1982). Most captures were carried out by the pelagic whaling in the Antarctic, which hunted more than 110,000 sei whales between 1960 and 1970 (Horwood, 2002). The International Whaling Commission estimated the size of the sei whale populations in the South Hemisphere to be 37,000 individuals after the cessation of the commercial captures in 1984, while this number was estimated 191,000 in the 1940s (Gambell, 1985). Between 1929 and 1983 sei whales captures represented 17.3% of the total catch of whales in Chile. It was the third most hunted species with approximately 1,664 individuals captured principally on the north and central coasts (Aguayo-Lobo, 1974; Aguayo-Lobo *et al*., 1998), although these include an unknown number of Bryde whales (Valdivia *et al*., 1981; Gallardo *et al*., 1983; Aguayo-Lobo *et al*., 1998). After the whale-hunting moratorium imposed by the International Whaling Commission in 1980, several research projects focused on the populations and recovery status of the large whales such as right whales, humpback whales, blue whale and fin whales (Reeves *et al*., 2002). Since 1976, sei whales have been listed as endangered (IUCN 2018). Today, sei whales are the least studied of the large whales and there has been a lack of data since the end of the commercial hunting (Prieto *et al*., 2011).

In Chile, there are opportunistic sightings and strandings of sei whales from Antofagasta (in the north) to the Magellan Straight (in the south), including the islands of Juan Fernandez (Gallardo *et al*., 1983; Schlatter, 1987; Aguayo-Lobo *et al*., 1998; Findlay *et al*., 1998; Pastene and Shimada, 1999; Guzmán, 2006; Acevedo *et al*., 2017). Many sightings in Central Chile and Northern Patagonia (33°-48°S) have been reported since 1966, when 286 whales were sighted in March of 1966 (between 43° and 45°S); 114 in October of the same year (between 46° and 48°S), all between 30 and 190 km off the shore (Aguayo-Lobo, 1974). In March 1968 Japanese whalers reported the sightings of several hundreds of sei whales between 46° 40′ and 48°S, with a peak concentration 30 km off the coast of the Tres Montes Peninsula at the northern limit of The Penas Gulf (Pastene and Schimada, 1999). In 2015, at Penas Gulf the largest recorded baleen whale mass mortality event was reported with 363 registered carcasses of baleen whales (Häussermann *et al*., 2017). Genetic and morphological analysis confirmed that the examined animals were sei whales (Häussermann *et al*., 2017). These historical sightings support the hypothesis of Guzman (2006) about the presence of sei whales feeding in Chilean Patagonia between Chiloe island and the Magellan Strait (Acevedo *et al*., 2017).

Since the sei whale is endangered and poorly known, population studies are crucial as a support for its conservation. Autonomous passive acoustic monitoring devices facilitate the monitoring of cetaceans by recording their vocal signals. Passive acoustic data can then be used to characterize and understand their acoustic behavior and determine their distribution patterns in time and space (Clark and Ellison, 1989; Richardson *et al*., 1995).

Acoustic signals produced by sei whales are poorly known (Prieto *et al*., 2011). To date, vocalizations have been described from six different geographic areas: New England (USA), Nova Scotia (Canada), Hawaii (USA), Azores (Portugal), Auckland Islands (New Zealand,) and Antarctic Peninsula (Thompson *et al*., 1979; McDonald *et al*., 2005; Rankin and Barlow, 2007; Baumgartner *et al*., 2008; Calderan *et al*., 2014; Romagosa *et al*., 2015). There is no record of sei whale vocalizations from the South-eastern Pacific Ocean. Comparison from intraspecific sounds from different geographic regions is interesting for possible acoustic clues to both stock and taxonomic identities. Consequently, the aim of this work is to describe sei whale vocalizations based on opportunistic recordings at the Penas Gulf, Chile and to obtain a framework baseline about the characterizes of sei whales populations in the South-eastern Pacific Ocean.

2. Methods

Two cruises to the Penas and Tres Montes Gulf ~~Tres Montes Gulf~~ (46.2-48.0° S, 74.0-75.4° W) aboard the motor sailing vessel Saoirse were carried out in May 2016 and May 2017 during which biological, oceanographic and acoustics studies were carried out (fig 01). Marine mammals were identified visually with binoculars and the naked eye for a team of experienced marine mammal observers in the vessel.

Two different hydrophones were used for the recordings: an icListenHF hydrophone (sensitivity -171 dBV re 1 µPa with pre-amp; frequency response 10–200kHz from Ocean Sonic, Canada); and a SoundTrap 202 STD hydrophone (sensitivity -205 dBV re 1 µPa;

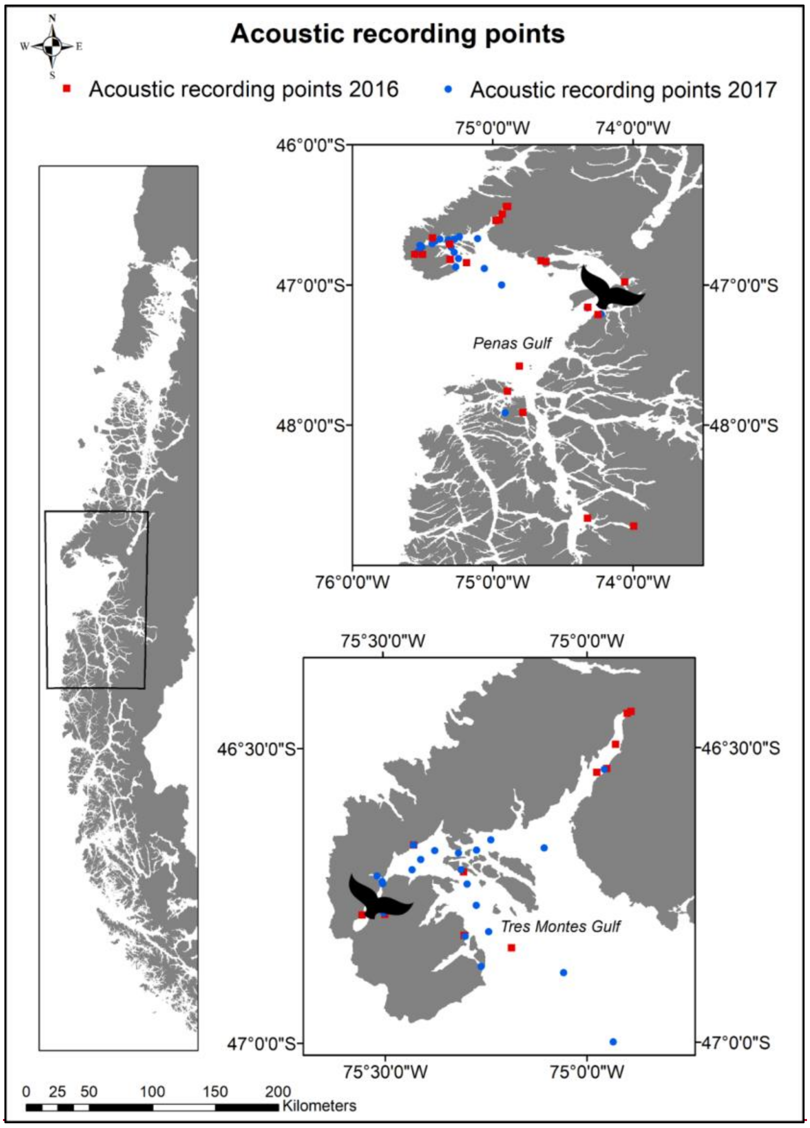
frequency response 60000Hz ±3 dB from Ocean Instruments, New Zealand). Also, we made stereo recordings on several occasions with an HTI-96-MIN hydrophone (flat frequency response from 0.02 to 30 kHz) connected to a handy recorder (H4nPro from ZOOM).

Opportunistic and planned recordings were carried out depending on the weather conditions and the vessel location. In 2016, recordings were not more than one day in each location where hydrophones were suspended over the side of the vessel. However in 2017, also, in 3 different locations, hydrophone were deployed between 2-5 days.~~In 2017 the hydrophones were deployed for 2 to 5 days in 3 locations.~~ In these cases, hydrophones were deployed at a depth of 5 or 10 m on rocky bottom with about 40 meters bottom depth using a ~~at a depth of 5 or 10 meters on rocky bottom with no more than 40 meters depth~~. ~~Hydrophones were hold on a~~ row with a mooring at the end and surface buoys on the opposite side~~with an anchorage in the end and superficial buoys in the opposite side~~. In both years, during the day or night, hydrophones were deployed at a depth of 5 and 10 meters from the stationary vessel. Opportunistic recordings were continuous~~In the opportunistic recordings, recordings were continuously~~, but in the night when the vessel was at anchor~~when the vessel was anchorage~~, the recordings were in intervals of 10-30 minutes each hour to guarantee the capacity of the acoustic personnel to study the recording during the next day.~~intervals between 10-30 minutes each hour for guarantee the capacity of the acoustic personal to study the recording in the next day~~.

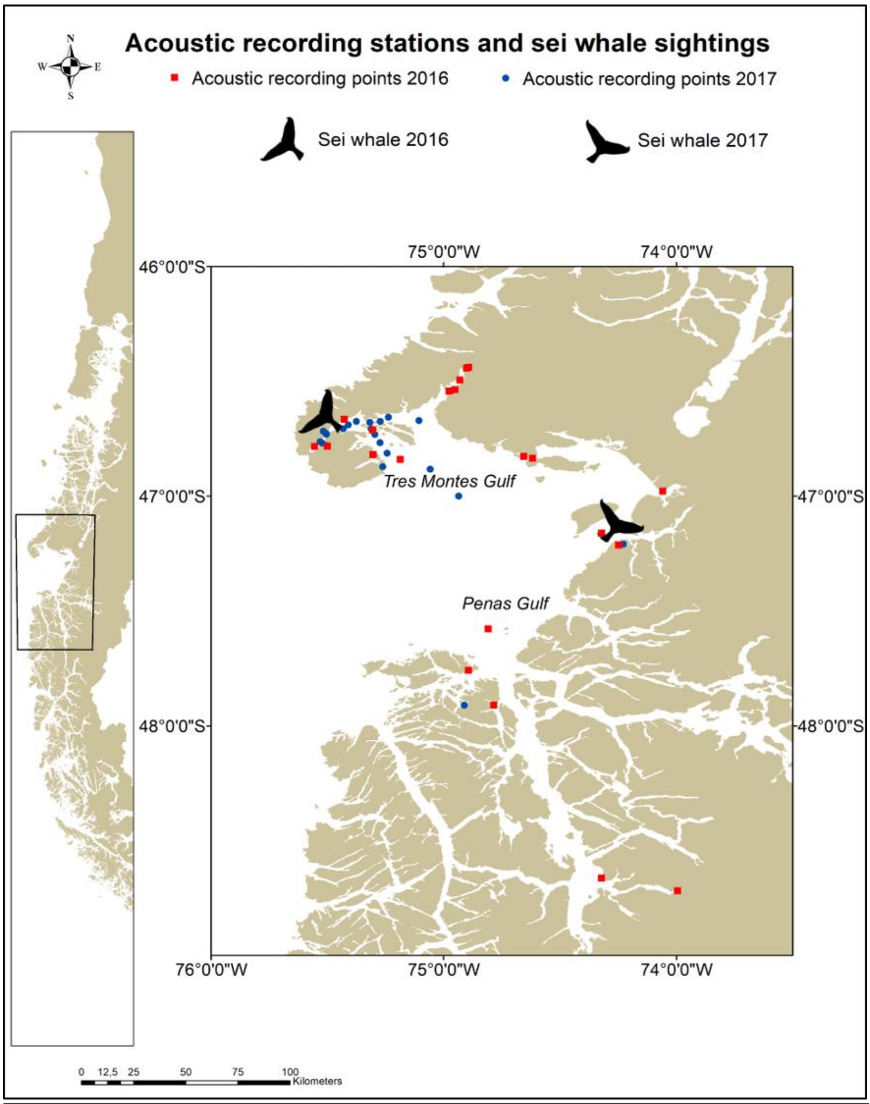
During all the recordings, the engine vessel was turn off. All the recordings were stored in the internal card memory of the equipments, and at the end of the day these were download in a portable computer.

Audio data were analyzed using Raven Pro 1.5 (Cornell University, Ithaca, NY). Low and high frequency (Hz), frequency range (Hz), peak frequencies (the frequency at which the maximum power occurred within a call) and duration (s) for all calls found and attributed to sei whales were analysed from spectrograms and waveform plots created in Raven Pro 1.5 (Hann window; 50% overlap; window size 14563 samples; DFT 16384 samples).

Figure 01. Study area including sighting and recording locations. The whale tail indicates the area where sei whale were sighted and vocalizations were identified.



Acoustic recording points
N
S
W
E
Acoustic recording points 2016
Acoustic recording points 2017
75°0'0"W
74°0'0"W
46°0'0"S
47°0'0"S
48°0'0"S
Penas Gulf
76°0'0"W
75°30'0"W
46°30'0"S
Tres Montes Gulf
0 25 50 100 150 200
Kilometers


Acoustic recording stations and sei whale sightings
N
W
E
S
Acoustic recording points 2016
Acoustic recording points 2017
Sei whale 2016
Sei whale 2017
75°0'0"W
74°0'0"W
46°0'0"S
47°0'0"S
47°0'0"S
48°0'0"S
48°0'0"S
Tres Montes Gulf
Penas Gulf
76°0'0"W
75°0'0"W
74°0'0"W
0 12,5 25 50 75 100
Kilometers

3. Results

Sei whales were sighted in both expeditions (2016 and 2017). In addition, during one day in 2017, humpback whales were sighted. Sound was recorded during 16 days in 2016 in 23 opportunistic recordings locations and during 19 days in 24 locations in 2017 ~~and during 19 days in 2017~~. A total of 363 hours was recorded between both expeditions, because the recordings were not continuous during every day, 136 hours (63 archives) in 2016 and 227 hours (483 archives) in 2017. Recordings were not the same duration or the same sampling rate because they were opportunistic. Sei whale calls were found in 8 archives for 3 days, on 7 May 2016 and 10-11 May 2017, at 2 different locations (one in 2016 and other in 2017) (Table 1). In acoustic data from 2016, sei whale calls were detected when sei whales were sighted closer the vessel (fig 02). In 2017, between 8 and 10 May~~between May 8th and 10th~~, sei whales were sighted in the area ~~were~~ after sei whale calls had been recorded (fig 02). Sei whale calls from 2016 were only recorded around midday, while in 2017 they were recorded in the late afternoon or at night (Table 1).

Figure 02. Photographed sei whale at Penas and Tres Montes Gulf the Penas Gulf a) 7 MayMay 7th, 2016. Photo by: Katie McConnell; b) 10 MayMay 10th, 2017. Photo by: Keri-Lee Pashuk.

Table 1. Sei whale recordings at Penas and Tres Montes Gulf~~the Penas Gulf~~.

Year	Date	Local Hour	Latitude	Longitude	Sampling rate	Hydrophone depth ~~Hydrophone Deep~~ (meters)	Recording duration (minutes)	Hydrophone	Sightings
2016	07-may	14:07	S47°09.625'	W074°19.266'	44100	5	34	HTI-96-MIN hydrophone + Handy recorded	2 individuals of sei whale closer to the vessel. Figure 02 (a).
2017	10-may	19:43 22:43 23:43	S46°46.100'	W75°31.400'	48000	10~~3~~	30 minutes each hour	SoundTrap 202 STD	3 individuals of sei whale in the area between 8-10 May. Figure 02 (b).
2017	11-may	00:43 02:43 05:43 07:43	S46°46.100'	W75°31.400'	48000	10~~3~~	31 minutes each hour	SoundTrap 202 STD	3 individuals of sei whale in the area between 8-10 May. Figure 02(b).

Only in two occasions humpback whale sounds above 2000 Hz were detected, in the rest of the analyzed audios, only sei whale sounds were detected without associated calls. Only calls with high-visual quality were measured. All vocalizations reported in this study were identified as downsweep calls (fig 03). We identified a total of 41 calls; 5 calls in

2016 and 36 in 2017. In 2016, calls ranged from an average maximum frequency of 105.3 Hz (SD=18.3 Hz) down to an average minimum frequency of 35.6 Hz (SD=4.6 Hz) over 1.6 s (SD=0.1 s) with a peak frequency of 65.4 Hz (SD=14.1 Hz) (Table 2). In 2017, calls ranged from an average maximum frequency of 93.3 Hz (SD=10.9 Hz) down to 42.2 Hz (SD=5.6 Hz) over 1.6 s (SD=0.3 s) with a peak frequency of 68.3 Hz (SD=14.2 Hz). The minimum frequency was 30 Hz and the maximum frequency was 129.4 Hz. Calls occurred in pairs (n=12), singles (n=5) or triplets (n=4) (Table 2).

Figure 03. Spectrogram of sei whale vocalization recorded with the hydrophone (32768 FFT, Hamming window). A. five seconds spectrogram zoomed in on a pair of calls. B. five seconds spectrogram of a pair of call. C. A pair and a single call of sei whale call within 15 seconds.

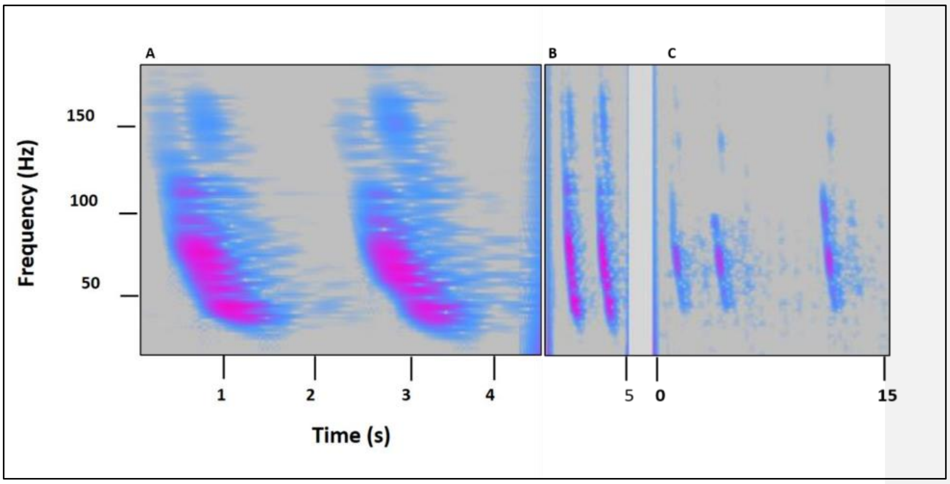


Table 2. Comparison of the frequency and timing of recorded calls in the present study with studies in other areas. Values are mean value ± standard deviation. ND = no data (the study did not include that information)

Source	Location	Year/nº vocalizations	High Frequency (Hz)	Low frequency (Hz)	Peak frequency (Hz)	Duration (s)
Present study	Chile, South-eastern Pacific	2016/5	105.3±18.3	35.6±4.6	65.4±14.1	1.6±0.1
		2017/36	93.3±10.9	42.2±5.6	68.3±14.2	1.6±0.3
Romagosa *et al.* (2015)	Azores, Northern Atlantic Ocean	2012/53	99.8±13.6	37.4±8.4	52.0±11.4	1.21±0.33
Calderan *et al.* (2014)	Auckland Islands, Southern Atlantic Ocean	2013/4	78.0±2.0	69.0±08	73.8±0.5	1.1±0.0
		2013/4	83.3±4.1	53.8±4.9	78.3±3.1	1.2±0.0
		2013/30	66.3±10.7	36.6±2.1	45.8±11.0	1.2±0.3
Gedamke and Robinson (2010)	East Antarctica, Southern Ocean	2006/ND	570	170	ND	ND
Baumgartner *et al.* (2008)	New England, North western Atlantic Ocean	2006-2007/108	82.3 ±15.2	34.0±6.2	ND	1.38±0.37
Rankin and Barlow (2007)	Hawaii, Pacific Ocean	2002/2	100.3±11.1	44.6±2.9	ND	1.2±0.007
		2002/105	39.4±3.4	21±2.4		1.2±0.11
McDonald (2005)	West Antarctica, Southern Ocean	2003/50	433	192	ND	0.45±0.3
Knowlton *et al.* (1991)	Canada, Northern Atlantic Ocean	1986-1989/ND	3500	1500	ND	0.5-0.8
Thompson (1979)	Canada, Northern Atlantic Ocean	ND	3000	ND	ND	0.7

4. Discussion

Given that recordings from this project were opportunistic and without digital acoustic recording tags (DTAG) deployed in sei whales we cannot prove the origin of the calls. However, we can confirm with reasonable certainty that vocalizations recorded off Penas and Tres Montes Gulf~~The Penas Gulf~~ were produced by sei whales, due to the sightings of this species during the recordings and the expeditions. Blue whales (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*) or minke whales (*Balaenoptera acutorostrata*) produce downsweep as well (Thompson *et al*., 1996; Schevill and Watkins, 1972; Watkins, 1981). Bryde whales (*Balaenoptera brydei*) has also several call types, included downsweep, but inhabit tropical and subtropical waters and we do not have any record in this area yet (Omura, 1959; Wade and Gerrodette, 1993; Oleson, *et al*., 2003). Generally, fin whales downsweep have initial frequencies below 35 Hz and final frequencies around 20-18 Hz (Watkins, 1981), similar than minke whales but with shorter durations (0.2-0.3 sec) and higher frequencies (130-60 Hz) (Schevill and Watkins, 1972). Minke whales in the North Atlantic produce long pulse trains (Mellinger *et al*., 2000), these were not recorded in this area, fin and minke whales downsweep are definitively different than our recordings. Only downsweeps from blue whales described in Chile, through the DTAG data, has a lower peak frequency and duration; ~~low~~ minimum frequency is higher than our results and downsweep had been accompanied ~~in the recorders~~ by the Southeast Pacific type 2 (SEP2) (Saddler *et al*., 2017), supporting our results, that ~~these~~ our records are really from sei whales. In addition, sei whale vocalizations described here show very similar characteristics to those described off Azores Islands by Romagosa *et al.* (2015), off New England by Baumgartner *et al*. (2008) and off Hawaii by Rankin and Barlow (2007). In these areas, sei whale vocalizations are characterized by low frequency downsweeps. However, sei whales sweeps recorded off Nova Scotia by Thompson (1979) and Knowlton et al. (1991) or in Antarctic waters by McDonald (2005), Gedamke and Robinson (2010) are different from our recording and are characterize by higher frequencies.

Rankin and Barlow (2007) describe two ranges for the low frequency downsweeps, 100-44 Hz and 39-21 Hz with durations of 1.0 s and 1.3 s, respectively. In the present study, the minimum frequency was 30 Hz, being the average calls in the ~~superior~~ upper range defined by those authors. The range of frequencies described here are similar to what Baumgartner *et al*. (2008), Newhall *et al*. (2012) and Romagosa *et al*. (2015) reported, although the maximum frequency reported in the present study is higher. The higher frequency calls recorded in the North Pacific (Hawaii) and in the present study are similar, but our results showed higher frequencies in the top range (maximum off 111.4 Hz versus 129.4 Hz, respectively) and a longer duration (maximum 1.27 s versus 2.27 s, respectively). The similarities could be expected due to the possibility of there being a stereotypical call used in feeding grounds, as suggested by Romagosa *et al*. (2015). However, sei whales recorded in this study have shown a different call with higher frequencies and longer durations than those detected from North Atlantic or North Pacific waters.

In the sub-Antarctic Auckland Islands, a series of four calls is predominant (Calderan *et al.*, 2014), but the calls recorded at Penas Gulf occurred principally in pairs, although single calls and triplets were also detected. During this study, no four-call series were recorded as have been recorded in North Atlantic or Pacific waters (Baumgartner *et al*., 2008, Newhall *et al*., 2012, Romagosa *et al*., 2015).

Sei whale calls from Antarctic waters are characterized by broadband, tonal, frequency modulated vocalizations between 100 and 600 Hz with durations between 1 and 3 s (McDonald 2005, Gedamke and Robinson, 2010). These calls do not present similarities with the calls recorded here. This may be due a geographic separation of the populations, suggesting that different sei whale populations produce different stereotypic calls. The structure of the calls of sei whales is more variable between whales than within an individual whale (Baumgartner *et al.*, 2008). This suggests that sei whales present in Antarctic waters do not transit through southern Chile, or at least near shore Patagonia, in their migration to the breeding grounds in lower latitudes. Thus, the sei whales found in Chile, near shore in Penas and Tres Montes Gulf, might represent a different population. As recordings were opportunistic, the duration of recordings was variable, and this maybe influenced in the few calls that we recorded.~~The few calls obtained in both expeditions maybe was due the duration of recorded in each site since they were opportunistic recordings~~, so visual observations, tagging efforts and genetic studies are needed to verify this hypothesis.

In the present study, most acoustic activity was recorded during the night, while Baumgartner and Fratantoni (2008), Newhall *et al.* (2012) and Romagosa *et al*. (2015) recorded calls mostly during the day. These darkness patterns coincide with results from humpback whales songs reported from Chile (Español-Jiménez and van der Schaar, 2018). However, low frequency sei whale downsweeps may have a different function from the stereotyped humpback vocalizations considered as songs (Edds-Walton 1997). Though the behavior of sei whales is poorly studied, most studies on this species state that sei whales prefer offshore waters, but these new records and sightings along the coast of Penas and Tres Montes Gulf (Aguayo-Lobo 1974; Pastene and Schimada, 1999;

Häussermann *et al*., 2017), demonstrated a wide habitat range, with the whales probably following productive feeding areas. If this is true, it is reasonable to assume that the calls of sei whale's calls are influenced by the feeding conditions (as proposed by Baumgartner and Fratantoni (2008)) and have communicative functions, e.g. cooperatively searching for prey as suggested Newhall *et al*. (2012). Baumgartner and Fratantoni (2008) hypothesize that calling rates are reduced at night while the whales are feeding but increase with social activity during the day when copepods are either more difficult or less efficient to capture at depth. Our data could not support this hypothesis since calls were recorded at night and it was not possible to observe what activities the whales were engaged in. Another factor that could be important in the discussion about the acoustic behavior is background noise, which might be masking biologically important signals ~~Other factor could be important in the discussion about the acoustic behavior is the background noise, which masking biological important signals~~ and impede the communications between individuals (Clark *et al.,* 2009).

This new description of sei whale calls adds knowledge to the vocalizations and distribution of an endangered species (IUCN, 2018) red-listed under criteria A-1. It is also listed in Appendix I ("Endangered migratory species") and II ("Migratory species with unfavorable conservation status which require international agreements for their conservation and management") in the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention 1979). Satellite tracking of the Chilean sei whale population, individual photo identification, distribution and characteristics of the prey species, behavioral, genetic and oceanographic studies are necessary to test some hypotheses and improve our understanding of this species.

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