



Notes

MARINE MAMMAL SCIENCE, **(*): ***_*** (** 2013)

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DOI: 10.1111/mms.12030

Eastern South Pacific southern right whale photo-identification catalog reveals behavior and habitat use patterns

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Southern right whales (*Eubalaena australis*) in the eastern South Pacific were once numerous off the coast of Chile and Peru. British, French, and American whaling fleets started to hunt them in 1789 and Chilean land-based whaling started in 1860 (Pastene and Quiroz 2010) and ended in 1976 (Aguayo *et al.* 1998). However there are few details about these catches. Du Pasquier (1986) reported a catch of approximately 2,372 whales by French whalers from 1817 to 1837 in Chilean waters. Best (1987) estimated that American whalers killed over 14,600 southern right whales in the 19th century across the entire South Pacific, but he did not allocate the catch to any geographic region. Between 1951 and 1971, Soviet whaling operations in the Southern Hemisphere illegally took over 3,300 southern right whales, but none of these operations occurred in the Exclusive Economic Zone of Peru or Chile (Tormosov *et al.* 1998).

Since the end of commercial exploitation, little information on southern right whales from the eastern South Pacific has been reported. The population is likely to contain less than 50 mature individuals and therefore, the International Union for Conservation of Nature (IUCN) classified the Chile/Peru “subpopulation” of *E. australis* as “Critically Endangered” in 2008 (Reilly *et al.* 2008). Here we report on sightings of these whales since 1964, the first resighting between years of a known individual, the occurrence of additional sightings in coastal waters off northwestern Isla Grande de Chiloé (Isla de Chiloé), Chile, the southernmost sighting of a cow-calf pair, the first documented record of likely reproductive behavior in these whales, and future research needs.

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A photographic catalog of identified individuals from Chile was developed based on photographs collected by the authors, with contributions from the Chilean Navy (Directemar), Ecoceanos Center, the Natural Science and Archeological Museum of San Antonio, and members of the Chile National Marine Mammal Sighting Network (Chile NMMSN). Photographs were taken opportunistically and the oldest pictures are from 1984. Photographic documentation increased significantly after 2003 when the Chile NMMSN was established by Centro de Conservación Cetacea to archive right whale sightings. NMMSN participants include a wide range of coastal communities, maritime authorities, media, and tourist companies. Sighting data include date, location, group size, group composition, and contributor. Whenever possible, individual whales are photo-identified to record the callosity patterns found on the lower lip and rostrum (Payne *et al.* 1983) and any unusual skin pigmentation on the head or back (Patenaude 2003). Categories used to describe unusual pigmentation patterns are: white-blaze when an animal has an unpigmented area with edges that remain white through its life, gray-morph, or partially albino when animals are mostly white as calves and gray or brownish gray as adults (Schaeff *et al.* 1999).

Most of the photographs are opportunistic and do not show enough of the callosity pattern to differentiate among individuals; but can be used to confirm the species and location. Selection of photographs to be included in a photo-identification catalog is based on the quality of the photograph and the number of visible features used in identification. However, we included any photograph with sufficient quality that showed at least some of the features required for individual identification in the photo-ID catalog because of the difficulty in collecting photographs of southern right whales in the eastern South Pacific. The catalog is divided into three sections: left-side profiles; right-side profiles; and top-view profiles. When an animal was identified by its callosity patterns and, if applicable, also by its unusual skin pigmentation pattern, it was compared to the master catalog to determine whether it was a new or unknown individual. Whenever a match was found or suspected, the photographs were double checked by other southern right whale researchers to confirm the match.

We compiled a table of all known sightings of right whales in Chilean and Peruvian waters. This compilation includes 32 sightings of 54 whales from our records or those previously reported (Clarke 1965; Aguayo-Lobo 1974; Aguayo and Torres 1986; Goodall and Galeazzi 1986; Canto *et al.* 1991; Aguayo *et al.* 1992; Van Waerebeek *et al.* 1992, 1998, 2009; Santillán *et al.* 2004), plus a subset of the records in Aguayo *et al.* (2008). Aguayo *et al.* (2008) compiled 124 sightings of 232 southern right whales from 1964 to 2008 from Chilean waters off the west coast of Chile, the Magellan Straits and Beagle Channel and the west Antarctic Peninsula (in the sector claimed by Chile). These were obtained from published reports and recent unpublished data from sightings networks. However, Aguayo *et al.* (2008) did not include two published sightings from the west coast of Chile (Aguayo *et al.* 1992, Brito 1996) and we believe their sightings from the Magellan Straits and Beagle Channel are likely individuals from the Southwest Atlantic population based on the location of the sightings (Goodall and Galeazzi 1986, Gibbons *et al.* 2006, Belgrano *et al.* 2008). Also, based on geographical considerations Aguayo *et al.* (1992) proposed that southern right whales off Chile may feed off the Antarctic Peninsula, but no direct photographic link to that area has been made yet. Therefore, 30 records are not included that were from either the Antarctic or the Magellan Straits and Beagle Channel (Aguayo *et al.* 1992, 2008).

At present, we believe that only sightings off the Pacific coasts of Chile and Peru can be considered to represent the population in the eastern South Pacific. Also, we

excluded seven more of the Aguayo *et al.* (2008) sightings: two that were attributed to our sighting network but do not exist in our records, three from a sighting network with unconfirmed species identification, and two sightings taken from Aguayo *et al.* (1992) that are probably not southern right whales. The first misidentification was seven adult whales sighted 20 miles offshore of Pisagua (19°35'S) on 1 December 1985, apparently feeding on South American pilchard, *Sardinops sagax*. The second was a group of five adults and three calves sighted 22 miles off Constitución (35°36'S) observed by toothfish (*Dissostichus eleginoides*) fishermen on 10 September 1986. These are the only two sightings that report groups larger than four individuals and also the only two reports of right whales offshore. Furthermore, as southern right whales are not known to consume fish, the reports of pilchard or toothfish interaction are inconsistent with right whale foraging ecology, and therefore we did not accept these observations.

Finally, Aguayo *et al.* (2008) included four sightings that should be considered resightings because of close proximity in space and time. Based on the criteria of Patenaude (2003) for the small population of right whales in New Zealand, we lumped sightings that were in close proximity (both location and time) into single sightings. Grouping of sightings in close proximity and location are reasonable when it is a small population. Therefore, we grouped two or more similar sightings that occurred in the same area within two weeks or when photo-identification documented a resighting. Aguayo *et al.* (2008) also included 16 records with incorrect information on dates, coordinates, or number of animals that we corrected.

After making the above corrections, the number of sightings in Aguayo *et al.* (2008) was reduced to 76 consisting of 125 whales between 1964 and 2008. To that, we have added 32 sightings with 54 whales, from either our own records or the literature, and our revised total of southern right whale sightings off Chile and Peru from 1964 to 2011 is 108 sightings comprising 179 animals, including 39 calves (Table S1, Fig. 1).

Only 18 sightings of 33 individuals included photographs that were useful for photo-identification. Not all of these individuals could be individually identified in each group. A total of 25 individuals were photographically identified. Six individuals have been photo-identified by left side, right side, and top views of the head, four by either both sides or one side plus one top view of the head, and 15 individuals only by one side or one top view of the head. Eight individuals have been photographed from the left side and these could potentially match eight individuals photographed from their right side or may represent different individuals. The oldest photographs archived are from a sighting made on 14 June 1984 in Bahía San Jorge, Antofagasta (23°38'S, 70°24'W).

To date, comparisons over time have provided information on within-season movements of at least five individuals. Most groups have been reported for a single day. Records of longest residency time include: (1) a mother-calf pair that stayed for three months, from 1 August 1989 in Golfo de Arauco, Chile, until the calf stranded and died on 23 October (sighting ID#37, Table S1), exhibiting both net marks (apparently from entanglement) and small-boat propeller injuries (Canto *et al.* 1991); (2) a mother-calf pair off Atico, Arequipa, Peru. The female likely gave birth in August, was first sighted on 7 September 1996 and remained in the area until 12 November (2 mo, sighting ID#47, Table S1). The pair was probably seen again in December close to the same area (Van Waerebeek *et al.* 1998), with a probable minimum distance travelled of 35 nmi; (3) a single individual first seen at San Antonio (33°35'S) on 1 August 2004 was resighted on 13 October in Las Cruces (33°30'S, sighting

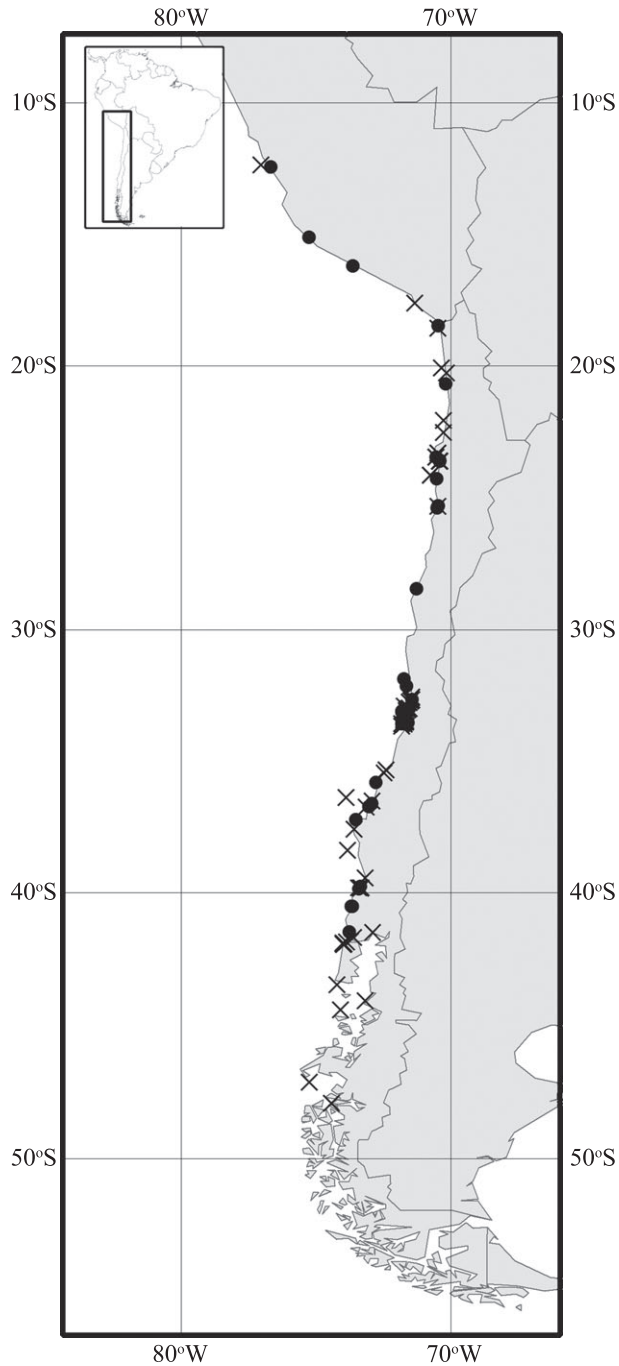


Figure 1. Sightings of eastern South Pacific southern right whales from 1964 to 2011. Cross = sightings without calf; black circle = sightings with calf.

ID#71, Table S1) (Aguayo *et al.* 2008), which corresponds to 2 mo and 13 d with a minimum distance travelled of 6 nmi; (4) a cow-calf pair first reported in Los Vilos (31°55'S) on 19 September 2004 was photo-identified (the calf) on 29 September, 15 nmi south of Los Vilos (32°10'S). The pair moved south along the coast for over 86 nmi and was followed by members of our sighting network over one month. On 19 October, CCC staff conducted a dedicated aerial survey on a Chilean Navy helicopter and photo-identified the cow-calf pair in Algarrobo (33°19'S, sighting ID#73, Table S1); and (5) a mother and newborn calf that were first seen on 27 July 2008 in Las Docas (33°06'S) stayed in Quintay (33°10'S) for over two weeks until 15 August where they were photo-identified by CCC staff, and were last observed on 23 August farther south, which total 28 d and a minimum distance traveled of 10 nmi (33°14'S, sighting ID#91, Table S1). Most individuals usually were sighted for only a couple of days and considering the five longest residency times above, the distance the whales traveled ranged from 6 to 86 nmi. Therefore, it is likely that all coastal waters are used as migratory corridors.

The between year resighting reported here is one of two adult individuals (body length estimated at greater than 12 m, compared to vessel length), that was first observed on 25 October 2010 close to shore off northwestern Isla de Chiloé (41°58'S, 74°03'W). One of these whales was photographed again on 17 October 2011 with another whale not in our catalog at 41°55'S, 74°02'W. The reidentification of this individual (Fig. 2) was based on the callosities on the left side of the head as well as the gray-morph skin pigmentation pattern on both dorsal sides of the body. The short distance (3 nmi) between these two locations where this individual was sighted in 2010 and 2011 shows that this whale used the same area in two successive years (Fig. 3).

On 20 September 2011, three southern right whales were recorded off the northwestern coast of Isla de Chiloé (41°55'S, 74°01'W). The videotape showed likely reproductive behavior based on the extended penises of two males, each with a unique ventral pigmentation pattern, entering the genital slit of a female. This is the first time potential reproductive behavior has been documented for the eastern South Pacific southern right whale population and highlights the importance of these coastal waters for the species. In North Atlantic right whales (*Eubalaena glacialis*), group



Figure 2. First resighting between years of a southern right whale individual. (a) 25 October 2010, (b) 17 October 2011

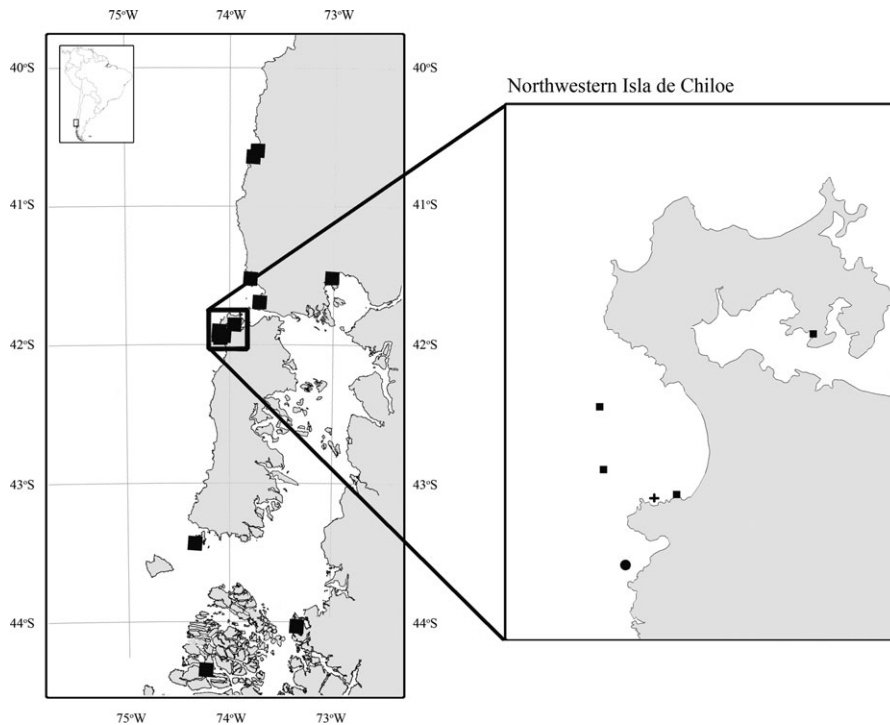


Figure 3. Sightings of southern right whales in southern Chile and northwestern Isla de Chiloé (insert). Black square = sightings locations; black circle = sighting of adult on 25 October 2010; black cross = same individual on 17 October 2011.

composition and timing of occurrence of surface active groups (SAGs) do not support the hypothesis that all SAGs serve a purely conceptive function (Parks *et al.* 2007). However, data on specific behaviors, such as observed copulations, were not systematically reported in the database and therefore were not included in the analysis (Parks *et al.* 2007). Off northwestern Isla de Chiloé, the composition of the group (two males, one female, and no calf), the observation of extended penises and intromission, and the timing of the observation during the breeding season support the hypothesis that this group was exhibiting reproductive behavior, although not necessarily for conception purposes. One of us (BGV) observed probable reproductive behavior between two whales in a SAG off central Chile (33°05'S, 71°39'W) on 24 September 2008 for about 50 min but no extended penis was observed.

In addition to the potential mating behavior described above, there is evidence that calving may be occurring north off Isla de Chiloé. A mother with a young calf was recorded nearshore on 22 October 2010 at 41°27'S, 73°51'W, about 18 nmi north of Isla de Chiloé. The video was reviewed by southern right whale experts,^{2,3} who reported that the smaller whale had the typical head shape of a calf, and that its body

²Personal communication from Vicky Rowntree, Department of Biology, University of Utah, 257 South 1400 East Salt Lake City, UT 84112, July 2012.

³Personal communication from Mariano Sironi, Instituto de Conservación de Ballenas, CC 39-1623, Ingeniero Maschwitz, Provincia de Buenos Aires, Argentina, July 2012.

length appeared to be less than half of its mother's body length. Other features that indicated that the smaller whale was a young calf were the shape of its blow holes, its wide back and its typical following behavior shown by young calves. Based on these observations, they agreed this animal was a calf born in 2010, and was probably <3 mo old. This is the southernmost record of mother-calf pair for this population. A possible birth occurred in central Chile (33°34'S, 71°48'W) in 1991, based on the sudden appearance of a small calf with a female that was previously seen alone.⁴ Clarke (1965) also observed a female and calf pair off Cartagena (33°32'S, 71°37'W) in August 1964.

Although the data are limited, one small area in southern Chile appears to be more utilized by right whales than previously thought. Sixteen sightings have been reported off Chile south of 40°S, with six of them in a small area off northwestern Isla de Chiloé and five of them south of Isla de Chiloé (Table 1). Isla de Chiloé is the northern limit of the Chilean fjord system and was a former whaling ground for southern right whales. Between 1830 and 1832, 91 British whaling vessels operated around Isla de Chiloé (Gay 1847). Today, fewer than 1,000 people live in the coastal area of northwestern Isla de Chiloé and only about 10% of them are involved in marine activities such as fishing, making it significant that 6 (6%) of the 108 sightings off Chile and Peru since 1964 were in this small area. In addition, the fact that at least six different individuals were recorded between 20 September and 21 October 2011 (Fig. 3), potential reproductive behavior has been observed, and the southernmost record of a female-calf pair was just 18 nmi north of Isla de Chiloé, strongly suggest that northwestern Isla de Chiloé is an important area, although with as yet undetermined boundaries.

Coastal and marine large-scale development projects may negatively impact these southern right whales, through habitat loss, marine degradation, or even direct mortality. Laist *et al.* (2001) suggested that right whales may be more vulnerable to ship strikes than other species because of their behavior, such as skim feeding, nursing, and mating, which occur at the surface. Mothers and calves may be the most vulnerable because they spend more time at or near the surface than other classes of right whales. Further, North Atlantic right whales did not respond to the playback of ship sounds (Nowacek *et al.* 2004), suggesting that southern right whales are unlikely to respond to the sounds of oncoming vessels. The construction of mega wind farm projects in the coastal area of this region and the increased traffic in their associated ports is of serious concern. In June 2011, the Scientific Committee of the International Whaling Commission strongly recommended the urgent development of an environmental impact assessment (EIA) for Isla de Chiloé (IWC 2012). Minimum requirements for an effective EIA include the collection, collation, and analysis of appropriate baseline cetacean data, the development of mitigation measures, and the design of a monitoring program aimed to assess impacts against predetermined conservation objectives and to measure the efficacy of any mitigation measures that are implemented. Research should include collection of baseline information on temporal and spatial aspects of cetacean habitat use, population structure, and behavior, and evaluation of all lethal and nonlethal impacts of human activities in an integrated manner, taking into account the cumulative impacts from all threats and project developments around the area (IWC, in press). Successful mitigation of vessel strikes

⁴Personal communication from Jose Luis Brito, Museo Municipal de Ciencias Naturales y Arqueología de San Antonio, Sanfuentes 2365, Barrancas, San Antonio, Chile, November 2011.

Table 1. Southern right whale sightings between 40°S and 44.5°S in southern Chile.

Location name	Latitude, longitude	Date	Number of individuals	Number of calves
North of Isla de Chiloé and south of 40°S				
Pucatrihue, Osorno	40°30'S, 73°44'W	1 September 2005	2	1
Maicolpué, Osorno	40°35'S, 73°45'W	14 August 2005	3	1
Norte Puerto Godoy, Maullín	41°28'S, 73°50'W	22 October 2010	2	1
Canal Tenglo, Puerto Montt	41°29'S, 72°57'W	15 January 1981	2	0
Puerto Godoy, Maullín	41°33'S, 73°46'W	17 October 2004	2	0
Northwestern Isla de Chiloé				
Golfo Quetalmahue, Ancud	41°51'S, 73°56'W	26 October 2006	1	0
Cocotue Bay, Ancud	41°53'S, 74°04'W	17 October 2011	1	0
Mar Brava, Ancud	41°55'S, 74°01'W	20 September 2011	3	0
Puñihuil, Ancud	41°55'S, 74°02'W	17 October 2011	2	0
Cocotue Bay, Ancud	41°55'S, 74°04'W	25 October 2011	1	0
Pumillahue, Ancud	41°57'S, 74°03'W	25 October 2010	2	0
South of Isla de Chiloé				
Boca el Guafo, Quellón	43°28'S, 74°17'W	17 April 2009	1	0
Seno Melimoyu, Cisnes	44°5'S, 73°14'W	2 February 1986	2	0
Isla Level, Cisnes	44°25'S, 74°10'W	25 September 2007	1	0

requires quantitative estimates of strike number, how strike rates change seasonally, where strikes are most likely to occur, and options for minimizing strikes (Vanderlaan *et al.* 2009). Blue whales (*Balaenoptera musculus*) should also be included in the EIA because the waters off the northwestern Isla de Chiloé are important feeding habitat for them from late January to early May (Galletti Vernazzani *et al.* 2012).

Our observations highlight the importance of these coastal waters for southern right whales and the need to increase long-term studies, both dedicated and opportunistic, to monitor this critically endangered population. The first interannual resighting of an eastern South Pacific southern right whale and the small number of photo-identified individuals provide additional evidence that this is a small population that deserves its IUCN listing as the “Critically Endangered” Chile-Peru subpopulation (Reilly *et al.* 2008). The fact that this “subpopulation” is extremely small and several coastal industrial developments may impact it reinforces the need to implement appropriate management actions and evaluate their performance as soon as possible.

ACKNOWLEDGMENTS

We wish to acknowledge Jaime Conde and Katja Siemund for their valuable contribution with photographs of the recaptured whale; as well as the General Directorate of Maritime Territory and Marine Merchant of the Chilean Navy, Jose Luis Brito from the Natural Science and Archeological Museum of San Antonio and members of the National Marine Mammal Sighting Network for their important collaboration. We would also like to thank Francisco and Miguel Altamirano for their support with the marine survey, Magdalena Altamirano for contributing the videotape showing the reproductive behavior and Roberto Brahm for contributing the video showing the southernmost record of a mother-calf pair. Our special gratitude to Juan Carlos Cardenas and Jose Truda Palazzo Jr. for their continuing support of the Southern Right Whale Project/Chile and the Global Greengrants Fund for funding the project. We would also like to thank Carole Carlson, Katherine Ralls, Vicky Rowntree, Mariano Sironi, and two anonymous reviewers for their improvements to the note.

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Received: 12 April 2012

Accepted: 5 February 2013

Note added in proof: After the paper was accepted we learned of another sighting in central Chile. On 9 September 2011, a mother with calf was sighted and photographed off Viña del Mar (33°01'S ; 71°35'W; Pers. Comm. Sarah Allen, Ocean and Coastal Resources Program, Pacific West Region, National Park Service, 495 Jefferson Street, San Francisco, CA 94123, March 2013).

SUPPORTING INFORMATION

The following supporting information is available for this article online at <http://onlinelibrary.wiley.com/doi/10.1111/mms.12030/supinfo>.

Table S1. Southern right whale sightings off Chile and Peru from 1964 to 2011.