Sightings of southern right whales (*Eubalaena australis*) off Chile and Peru from 1975 to 2010[1]

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Abstract

The status of southern right whales from the eastern South Pacific was assessed by reviewing 79 sightings collected between 1975 and 2010. No reports of southern right whales occurred in May and the majority of sightings were reported between winter and spring (July to November). Groups consisted mostly of one whale (44%) and pairs (45%). Cow/calf pairs represented about 34% (n=27) of the sightings and it is probable that the number of reproductive females in this population could be as low as eight. No significant increase was found in number of sightings or number of individuals but small trend to increase was found for number of calves. Although inconsistent sighting effort over the last 36 years may affect results, our analyses suggest that the population off Chile/Peru is extremely depleted and the current population size may be below 50 mature individuals. Therefore, the eastern South Pacific population clearly qualifies as "critical endangered" under The World Conservation Union (IUCN). We recommend increased cooperative effort to document all sightings and collect individual photoidentification. Furthermore, we urge the implementation of an international/regional action plan for the recovery of the eastern South Pacific population that affords maximum protection to the species in light of increasing anthropogenic activities that continue to degrade Chile-Peru coastal habitats.

Keywords: southern right whale, Chile, Peru, eastern South Pacific, population status

Introduction

Southern right whales (*Eubalaena australis*) from the eastern South Pacific were once numerous off the coast of Peru and Chile. Best (1987) estimated that over 14,600 southern right whales were killed in the 19th century in the South Pacific only by American whalers, but he did not allocate the catch to geographic regions. Along the coast of Chile, approximately 2,372 right whales were taken by French whalers in the 19th century (DuPasquier, 1986). During the 20th century 121 whales were taken from land-based operations between 1929 and 1976 (Aguayo *et al.*, 1998). No known Soviet pelagic catches of right whales were reported from Chilean waters during the 1960s when over 3,000 right whales were illegally hunted (Tormosov *et al.*, 1999).

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Little information on southern right whales in the eastern South Pacific has been reported since the end of commercial exploitation, with the exception of relatively few sightings of individuals in despite of increasing efforts to document sightings off Chilean coast since 2003. The World Conservation Union (IUCN) classified the Chile/Peru "sub-population" of *E. australis* as "critical endangered" on the 2008 Red List of Threatened Species (IUCN, 2008). In addition, the International Whaling Commission (IWC) Scientific Committee briefly considered the status of right whales off Chile and Peru during its 2007 Meeting in Anchorage (IWC, 2008) and during its 2008 Meeting in Santiago, recommended an increase in photo-identification and biopsy-sampling efforts. Furthermore, an intersessional group was created to plan an assessment of southern right whale populations (IWC, 2009) and the development of an action plan for the recovery of the species in Chilean waters is being proposed (Palazzo and Galletti, 2010).

In this paper we review the status of southern right whales off Chile and Peru by analyzing sightings recorded between 1975 and 2010 and assess its distribution, seasonality, group composition and trends.

Methods

Sightings were obtained from literature, the Museo Municipal de Ciencias Naturales y Arqueología of San Antonio, Chile, and the National Marine Mammal Sighting Network (NMMSN), established in 2003 by Centro de Conservación Cetacea (CCC) based in Santiago, Chile.

NMMSN involves the participation of a wide range of coastal communities, maritime authorities, media and tourist agencies among others. Species identification was established whenever contributors of the NMMSN provided species-identifiable photographs. All whales reported as southern right whales by NMMSN contributors without associated photographs were listed as "unconfirmed" and are not included in the analysis. Sighting information included date, location, group size, group composition and contributor. Whenever possible, individual photoidentification of southern right whales, based on callosity patterns, were obtained by CCC and provided to Instituto de Conservacion de Ballenas with southern right whale catalogues from Argentina.

Sightings from Antarctica, Magellan Strait, Beagle Channel, east side of Tierra del Fuego and Patagonia Argentina were excluded from this analysis.

After selecting sightings for the database, we used Patenaude's (2003) subjective method of grouping sightings to downward-bias the number of true unique sightings. Thus, we group two or more sightings when reported within ten days and in close proximity, or when photoidentification documented a resighting. Statistical analyses were conducted using SAS software solutions.

Results

Including all sightings reported for Antarctica, Magellan Strait, Beagle Channel, without grouping sightings closed in time and location, as well as possible records not confirmed by photographs, the database from 1975 to 2010 could contain a maximum of 162 sightings.

However, for this report we consider only a total of 79 confirmed, grouped sightings of 134 southern right whales, including 27 calves, collected between 1975 and 2010. "Unconfirmed"

sightings excluded from analyzes represents about 35% (CI95%=21-49%) of total possible sightings collected each year.

In addition, two sightings reported by Aguayo *et al*. (1992) were excluded from the analyses due to the possibility of misidentification of species. The first refers to seven adult whales sighted 20 mile offshore of Pisagua (19^{o} 35' S) on 1 December 1985, apparently feeding on South American pilchard *Sardinops sagax*. The second refers to a group of five adults and three calves sighted 22 miles off Constitucion (35^{o} 36' S) observed by toothfish fishermen on 10 September, 1986. These are the only two sightings that report groups greater than four individuals and the only two to report right whales offshore. The reports of *S. sagax* or toothfish interaction are inconsistent with right whale behavior/ecology, and therefore we did not accept these observations.

Distribution & seasonality
Southern right whale habitat in the eastern South Pacific, other than its coastal distribution, is primarily unknown due to the small population size and limited number of sightings (Figure 1a).

Main aggregation areas that concentrate more than 50% of the volume of a probability density distribution of southern right whales are found in northern Chile (22^{o}S to 26^{o}S) and in central and southern Chile (30^{o}S to 37^{o}S) (Figure 1b). In general, observations north of 20^{o}S are infrequent, however in recent years three sightings have been documented off the coast of Peru. This could suggest that the range of southern right whales is expanding (Van Waerebeek *et al*., 1992) or a result of increased interest and effort in Peru. The northernmost reported sighting is from 15°08' S in Bahia San Fernando, Peru (Santillan *et al*. 2004). In austral Chile, we did not include the records of southern right whales from Magellan Strait and Beagle Channel (south of 53^{o} S) because we believe they belong to the western South Atlantic population. Our southernmost record on the coast of Chile is a sighting at Golfo de Penas (47^{o}S) in 1976 (Aguayo and Torres 1986).

Females with calves have been recorded in southern Peru (15°– 17° S), northern Chile (23°-25°S), central and southern Chile (32°-40°S).

No sightings have been reported during May, with the highest number reported between July and November. Calves only have been reported from August to November (Figure2).

Groups consisted mostly of one whale (44%) and pairs (45%). Only 11% of sightings corresponded to groups of three or four whales. Cow/calf pairs represented about 34% of the sightings.

Cow-calf movements
Most cow-calf pair sightings only have been reported for one or two days.

Six records of longer residency time include: a mother-calf pair that stayed for three months in Golfo de Arauco, Chile until the calf stranded in October 1989 exhibiting both net marks (apparently from entanglement) and small-boat propeller injuries (Canto *et al.* 1991); a mother-calf pair off Atico, Arequipa, Peru (Van Waerebeek *et. al* 1998). The female likely gave birth in August, was first sighted in September 1996 and was resighted in October; a single individual first seen at San Antonio (33 ^{o} 35' S) on 1st August 2004 by the Museum (JLB) and resighted on 13 October in Las Cruces (33 ^{o} 30' S); a cow-calf pair first reported in

Los Vilos (31° 55' S) on 19 September 2004 was photo-identified (the calf) on 29 September 15nm south of Los Vilos (32° 10'S). The pair, moving south along the coats for over 94 nm, was followed by members of the NMMSN. 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). In 2008, two cow-calf pair were sighted in central Chile for longer periods. One was first seen in Las Docas (33° 06' S) in 27 July, then stayed in Quintay bay (33° 18' S) from 3 to 15 August and was last seen moving south (33° 14' S). The other pair was first seen in July and was again identified by photographs in Algarrobo (33° 20' S) in November.

Trends in abundance

A total of 79 sightings of 134 whales were reported off Chile and Peru during the last 36 years (mean= 2 sightings per year; SD = 1.9), with no reported sightings in five years (figure 3).

Between 1975 and 2010, no statistically significant increase was found in the overall number of sightings (linear regression; R sq (adj) = 0.078, p-value=0.053), or the number of whales (linear regression; R sq (adj) = 0.02, p-value=0.16). A linear regression of the time series of the number of calves was significant (linear regression; R sq (adj) = 0.12, p-value=0.02) and an apparent increase rate in number of calf of 3.5% (CI_{95}=2.1%-4.9%) may be inferred. However, Rsq continue to be relatively low and therefore little variance is explained under this model (figure 4).

The maximum number of cow-calf pairs sighted off Chile and Peru is only 27. Considering a three to four-year calving interval, and assuming cows are sighted once they calve, the number of reproductive females in this population could be as low as eight (table 1).

Human-induced threats

Human related mortality in right whales due to entanglements in fishing gear and collisions with ships are known throughout the Southern Hemisphere (IWC, 2001). In Chile, at least two right whale mortalities from human activities are known. One was a calf harpooned by fishermen (Aguayo *et al*., 1992) and the other a stranded calf that bore both net marks (apparently from entanglement) and small-boat propeller (Canto *et al*., 1991). Human mortality from entanglement and vessel strikes is a very serious issue for western North Atlantic right whales. Any anthropogenic mortality in the population off Chile and Peru, especially females, could seriously impact the population.

Finally, it is important to note that no recent sightings have been documented in San Jorge Bay, near Antofagasta, an area were several sightings occurred during 1980's. Today, the bay is being used for aquaculture of scallops, and the lack of sightings possibly could be attributed to increased vessel activity and habitat degradation or loss.

Discussion

Little data have been reported for southern right whales off Chile and Peru although data collection increased with research effort and sighting networks from the 1980's and 2000 onwards. Thus, results may be affected by inconsistent efforts in reporting sightings through the years and a limited database. It is critical that efforts are directed to document all unconfirmed sightings and therefore increase our dataset.

Distribution and movements
The IWC (2001) has identified several calving grounds for southern right whales in the Southern Hemisphere. In particular, along the east coast of South America, important calving grounds have been identified off Brazil (8-32°S) and Argentina (42-43°S). It is not known if the Uruguayan coast was an historical reproductive ground that is now being repopulated (Piedra *et al*. 2006).

Compared to other populations, it is probable that there are more than one major calving area within the range of the Chile/Peru population. Probably those areas are located in northern Chile (22°S to 26°S) and in central and southern Chile (30°S to 37°S), the areas which registered the highest density distribution probabilities.

Considering that individuals primarily are sighted for only one day and that one cow-calf pair has been photo-documented traveling south over 94 nm in a month, it is likely that all coastal waters are important areas and appear to be used as migratory corridors.

As suggested by Gibbons *et al*. (2006), we consider the right whales reported from the Magellan Strait and Beagle Channel (Goodall and Galeazzi, 1986; Gibbons *et al.*, 2006) corresponds to individuals from the western South Atlantic population.

Population status
In recent years, various papers have been published on the increase in right whale populations in three major regions in the Southern Hemisphere: South Africa, Argentina and Australia. However, the populations off mainland New Zealand and Chile/Peru are the only populations to date recognized as showing little to no signs of increase. Preliminary results on the status of southern right whales off mainland New Zealand suggest the population may be increasing at some unknown rate (Patenaude, 2003).

No increase was detected when performing the analyses with data until 2007 (Galletti Vernazzani *et al*., 2008). The apparent increase in the number of calves recorded between 1976 and 2010 for the eastern South Pacific population of southern right whales may be an indicator of an increasing population at some unknown rate; and the recent sightings off Peru could suggest an expanding range. However, both of these observations could be the result of increased interest and effort to observe right whales in this region. In addition, lengths of calving intervals are likely related to oceanographic conditions (Leaper *et al.*, 2006).

The maximum 1-day count of only four whales (Aguayo *et al*. 1992) is extremely low compared to maximum daily counts of 15, 40, 155 and 256 (over 2 days) off SE Australia, SW Australia, Argentina and South Africa respectively (IWC 2001, Table 3). In addition, there are little data for the Chile/Peru population (n=79) compared to the other small population around mainland New Zealand (110 sightings from 1976 to 2003). The Chile-Peru population does not show any trend of increase in sightings and individuals, and the current population is likely to contain eight reproductive females.

Our results suggest that the population off Chile and Peru is extremely depleted and that the current population size is below 50 mature individuals. This finding strongly support the recent IUCN listing of this "subpopulation" as "critical endangered" (IUCN, 2008).

Recommendations
Additional cooperative efforts are needed to document all sightings of right whales in the waters of Peru and Chile and collect individual photo-identification to improve our understanding of this critically endangered population.

Considering that the NMMSN has proven to be a cost-effective tool to collect significant information about the presence of cetacean species along the Chilean coast (Cabrera *et al*., 2007), it is strongly recommended that the network be strengthened and research effort increased whenever a sighting is reported. In addition, increased effort is needed to search for right whales at times they are known to occur in specific areas along the coast of both Chile and Peru.

Research activities should be oriented to identify habitats essential to the survival and recovery of the population, as well as monitor population size and trends in abundance. The results of this research then should be used by management authorities to protect the population, its habitat and feeding sources.

The fact that this population is in serious danger highlights the need to implement appropriate management actions and evaluate their performance as soon as possible. Therefore, it is critical to develop an international/regional action plan for the recovery of the Chile/Peru population of southern right whales and review it periodically.

Management actions should at least include the goal of reducing the human-induced mortality to zero; releasing whales entangled in fishing gear; identify and afford maximum protection to critical habitat by reducing habitat loss and degradation; and coordinate and combine efforts at a national, regional and international level to best benefit the Chile/Peru southern right whale population. In addition, Cabrera and Galletti (2006) suggestion to limit commercial and recreational whale watching activity with the species to land-based platforms should be applied to all individuals of this population.

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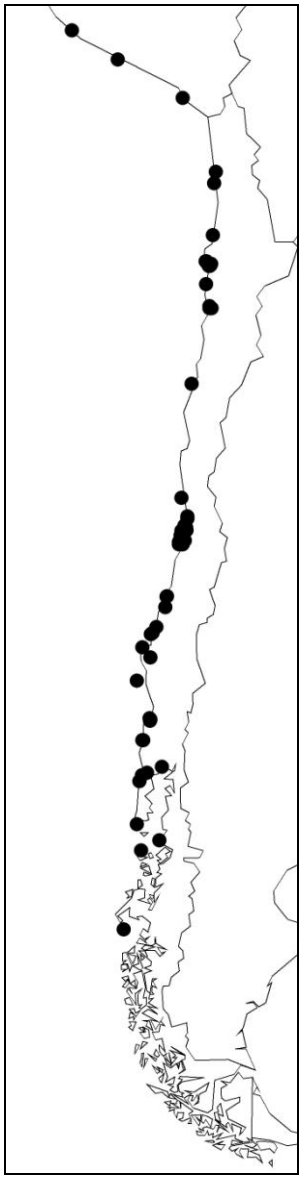
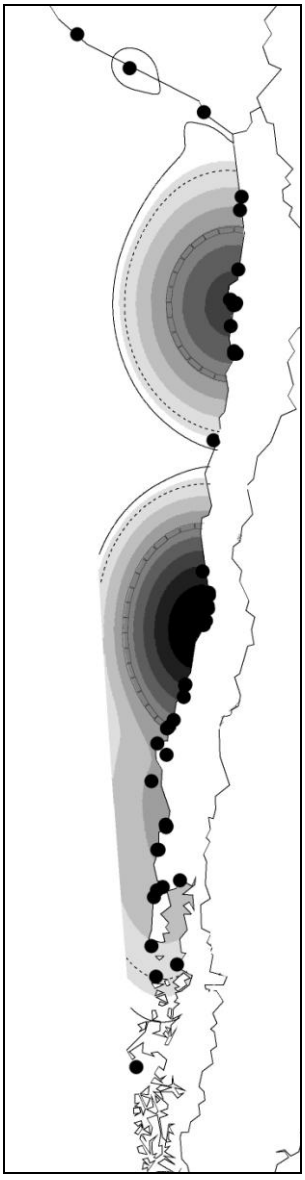
Figure 1 – a) Confirmed sightings of southern right whales off Chile and Peru between 1975 to 2010 and b) Density kernel distribution and probability contours



a) Black dot = confirmed sightings



b) Shaded area represents kernel density. Thick lines represent 95%, dashed lines 90%, and double-lines 50% of the volume of a probability density distribution of southern right whales

Figure 2 – Sightings and number of calves by month from 1975 to 2010

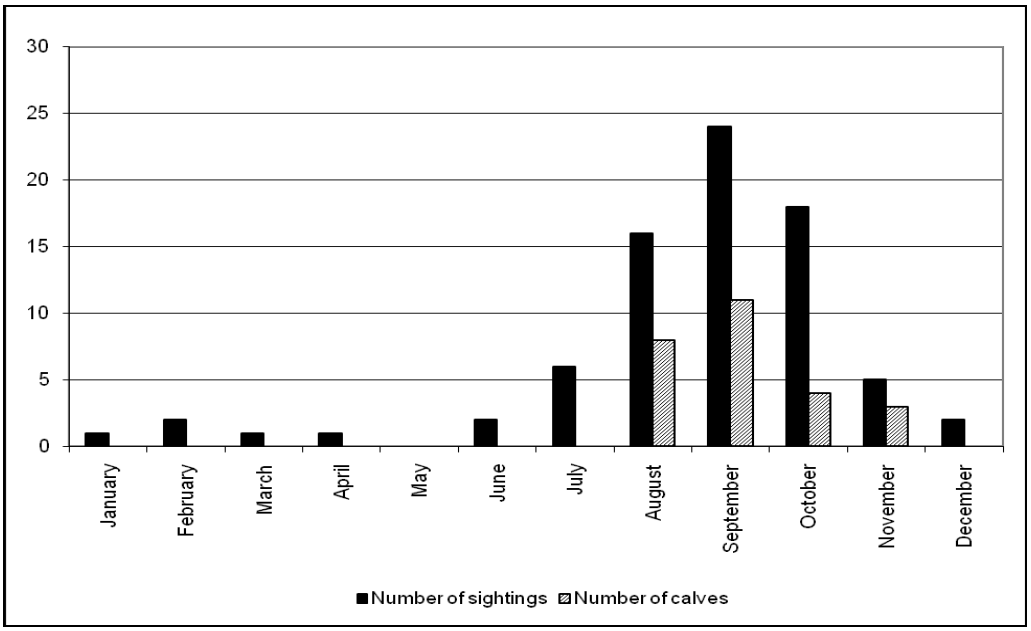


Figure 3 – Number of sightings and number of whales from 1975 to 2010

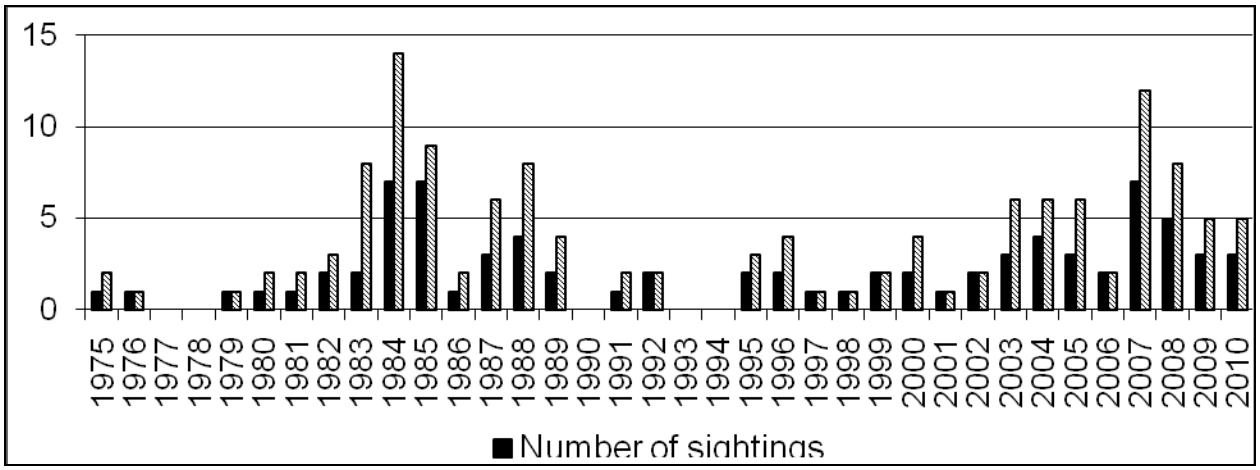
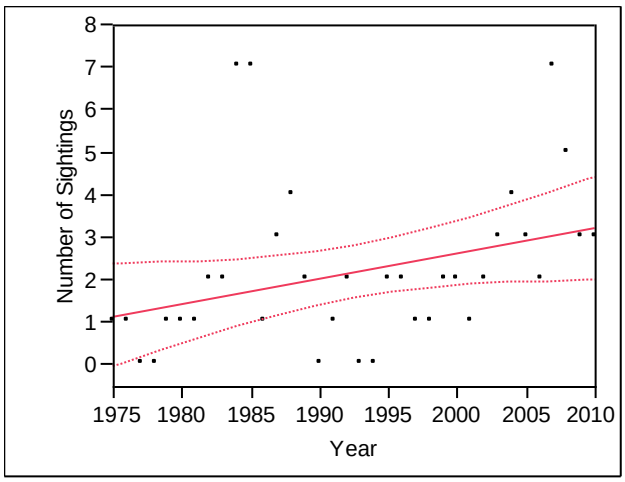
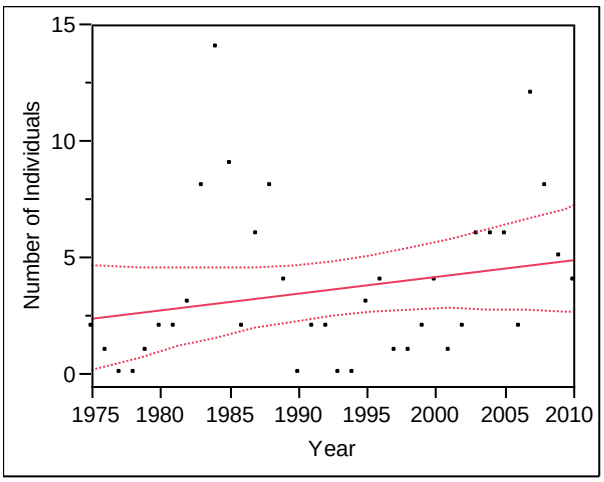


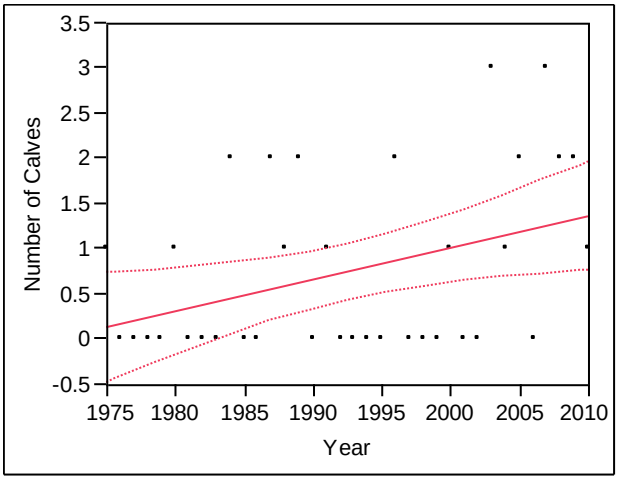
Figure 4 – Linear regression through years for a) number of sightings, b) number of individuals and c) number of calves.



a) Thick line = fitted linear regression for number of sightings. Dashed lines = confidence interval of fitted model. No statistically significant.



b) Thick line = fitted linear regression for number of animals. Dashed lines = confidence interval of fitted model. No statistically significant.



c) Thick line = fitted linear regression for number of calves. Dashed lines = confidence interval of fitted model. $p<0.05$

Table 1 – List of cow/calf pairs and number of calving females off Chile and Peru based on 3-years and 4-years calving interval

Year	Location first seen	3-year calving interval	4-year calving interval
1975	San Antonio (33º 34'S)	Cow 1	Cow 1
1980	Reñaca (32º 59'S)	Cow 2	Cow 2
1984	Bahia San Jorge (23º 38'S)	Cow 1	Cow 2
1984	Bahia San Jorge (23º 38'S)	Cow 3	Cow 3
1987	Bahia San Jorge (23º 38'S)	Cow 1	Cow 1
1987	Bahia San Pedro (39º 44'S)	Cow 3	Cow 4
1988	Pelluhue (35º 48'S)	Cow 4	Cow 2
1989	Punta Lavapie (37º 12'S)	Cow 2	Cow 5
1989	San Antonio, El Tabo (33º 27'S)	Cow 5	Cow 6
1991	Cartagena (33º 34'S)	Cow 4	Cow 1
1996	Atico, Arequipa (16º 13'S)	Cow 1	Cow 2
1996	Algarrobo (33º 30'S)	Cow 3	Cow 3
2000	Cachinales (25º 05'S)	Cow 4	Cow 2
2003	Bahia San Fernando (15º 08'S)	Cow 4	Cow 1
2003	Caleta Blanco (24º 18'S)	Cow 6	Cow 4
2003	El Quisco (33º 26'S)	Cow 7	Cow 7
2004	Los Vilos (31º 55'S)	Cow 2	Cow 2
2005	Maicolpue (40º 30'S)	Cow 1	Cow 5
2005	Pucatrihue (40º 30'S)	Cow 3	Cow 6
2007	Tal Tal (25º 10'S)	Cow 2	Cow 1
2007	Punta de Tralca (33º 25'S)	Cow 5	Cow 4
2007	Talcahuano (36º 42'S)	Cow 8	Cow 7
2008	Quintay (33º 10'S)	Cow 1	Cow 2
2008	Algarrobo (33º 20'S)	Cow 3	Cow 3
2009	Antofagasta (23º 35'S)	Cow 4	Cow 5
2009	Iquique (20º 42'S)	Cow 6	Cow 6
2010	Laguna Verde (33º 05'S)	Cow 2	Cow 8