

Update on 2012 blue whale field season in Chile

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INTRODUCTION

Blue whales (*Balaenoptera musculus*) were hunted in small numbers from a land-station off the southeast of Isla Grande de Chiloe (Isla San Pedro) for a few years starting in 1908. Commercial hunting started again in 1929 and about 3,000 blue whales were killed between 1929 and 1971 (Aguayo-Lobo *et al.*, 1998). In the past, blue whales taken from Chilean waters were classified as either Antarctic blue whales (*Balaenoptera musculus intermedia*) or pygmy blue whales (*B. m. breviceauda*). However, based on total lengths of adult, female blue whales taken in Chilean waters, Branch *et al.* (2007) showed that the whales off Chile are a unique population or even an unnamed subspecies. This adds strong support to the suggestion by Clarke *et al.* (1978) that the blue whales off Chile represent a subspecies that does not migrate into the Antarctic waters.

Since 1970, blue whales have been reported and often feeding in southern Chilean waters during the austral summer and fall from waters off northern Los Lagos region, south to the outer coast of Isla Grande de Chiloe, around Isla Guafo and eastward into the Golfo de Corcovado around the northern islands of the Chonos Archipelago, Chile (Gilmore, 1971; Cummings and Thompson, 1971a, b; Findlay *et al.* 1998; Hucke-Gaete *et al.* 2004; Cabrera *et al.* 2005; Galletti Vernazzani *et al.*, In Press). Only two sightings have been reported during winter (June and July 2009), both in the inlet waters east of Isla de Chiloe near the mainland (Abramson and Gibbons, 2010).

Recently, the highest overall annual return and sighting rates have been reported off northwestern Isla de Chiloe and northern Los Lagos (Galletti Vernazzani *et al.*, In Press). We have been monitoring the occurrence of blue whales off Isla Chiloe since 2004. Here we report the occurrence of a shift in blue whale distribution during 2012 in the southern Chile feeding area (Isla de Chiloe) and document an additional feeding aggregation of blue whales in northern Chile (Isla de Chanaral).

MATERIALS AND METHODS

Since 2004, the Alfaguara Project (Centro de Conservación Cetacea) has conducted systematic monitoring of blue whales during summer and fall off southern Chile using aerial, marine and land-based platforms (Galletti Vernazzani *et al.*, In Press).

In 2012, in collaboration with the Chilean Navy, we conducted two aerial surveys on 21 and 23 April, when Beaufort Sea State was less than 4. We covered approximately 33,259 km², from approximately 39°S to 44°S within 20 n.miles of the coastline (Fig. 1).

Land-based observations using 12x50 binoculars were conducted during daylight hours from a platform located 104 m above sea level (41°58' S, 74°03' W) whenever visibility was greater than 5 nm and wind speed less than 15 kt. For each whale or group of whales sighted, trained observers recorded the time, minimum number of whales, angle and estimated distance of whales from the coast as well as weather and sea conditions.

Dedicated marine surveys for photo-identification and other research activities were conducted primarily off northwestern Isla de Chiloe, between Chacao Channel (41°45'S) and south of Isla Metalqui (42° 12'S), within 12 n.

miles of the coastline, on board the 7 m *Alfaguara* research vessel. In 2012, Isla de Chanaral, located at 29°S, 73°W in northern Chile also was surveyed by small boat from 24 to 27 February (Fig 1).

Data collected during marine surveys included photo-ID, biopsy samples, group composition, behavior, weather and sea conditions, associated fauna and sea surface temperatures (SST). The position of a whale or group of whales was determined using a GPS.

Blue whale distribution off southern Chile and relative abundance using weighted kernel density estimators were assessed and compared to previous years as reported by Galletti Vernazzani *et al.* (In Press). Relationships between the number of whales per day obtained from marine and land-based platform, SST, month and year were investigated.

RESULTS

A total of 268 h. of land-based observations was collected in 39 days from 1 February to 12 April 2012. The number of groups of whales sighted daily ranged from 0 to 10, with an average of 1.07 groups per day (SD=18.7), totaling 42 groups. The number of individuals sighted daily ranged from 0 to 11, with an average of 1.3 individuals per day (SD=2.2), totaling 51 individuals.

During nine marine surveys conducted in 2012 off northwestern Isla de Chiloe totaling 48 hr from 26 January to 3 April, 13 groups of blue whales containing a total of 19 individuals were encountered. Biopsy samples of skin and blubber were collected from three blue whales on two days. One sighting of a single humpback whale (*Megaptera novaeangliae*) and three sightings totaling eight Peale's dolphins (*Lagenorhynchus australis*) also were recorded.

Solitary southern sunfish (*Mola ramsayi*) were sighted at the surface of the water on five occasions from January to March 2012. This was the first year we recorded sunfish off northwestern Isla de Chiloe. Compared to previous years, marine bird species richness and abundance were lower, including black-browed albatross (*Thalassarche melanophrys*) which were observed only after 7 March.

The average number of whales sighted per day from land-based observations and from the boat decreased considerably in 2012 compared to previous years (Fig. 2). In past years, the average number of blue whales per marine survey generally increased through the season, with January having the lowest encounter rates and March-April the highest. By contrast, in 2012 the encounter rate decreased through the season, whales were more abundant off the west coast of Isla de Chiloe in late January and early February and then were less abundant in March and early April.

Although the average SST off northwestern Isla de Chiloe significantly increased between 2005 to 2012 ($p < 0.05$, Figure 3) and reached its maximum in 2012 (mean=20.5°C; SD=0.4°C; max=22°C), no correlation was found between whale encounter rates per year and SST.

During two aerial surveys, we recorded 29 sightings of 37 individual blue whales on 21 and 23 April 2012 (Figure 4). Most whales were located north of the entrance to the Chacao Channel (41°45'S). The northernmost blue whale recorded during aerial surveys since 2005 was on 23 April 2012 at 39.2S, 73.44W. Sightings, tracks and density distribution of blue whales in 2012 using kernel estimators are shown in Figure 4. Compared to previous years (Galletti Vernazzani *et al.*, In Press), blue whale distribution shifted to the Isla de Chiloe area, about 130 km to the North in 2012.

During four marine surveys from 24 to 27 February off Isla de Chanaral in northern Chile, totaling 26 hr, 23 blue whales in 18 groups were recorded. Feeding behaviour was recorded at both locations. Groups of humpback whales (n=2), fin whales (*Balaenoptera physalus*) (n=15) and bottlenose dolphins (*Tursiops truncatus*) (n=3) also were sighted. All measurements of SST were 16-16.5°C.

DISCUSSION

During the 2012 blue whale feeding season off southern Chile (Jan-Apr), the density of whales was lower off Isla de Chiloe than in previous years (Galletti Vernazzani *et al.*, In Press) and the encounter rate decreased through the season. These observations suggest that fewer whales entered this area; most of them did it at the beginning of the season and remained for shorter periods of time. Those changes in distribution south of Chacao Channel are consistent with a shift of blue whale distribution observed from aerial surveys and with the increased number of blue whales observed north of Chacao Channel, including sightings off South Araucania/Los Rios region where no sightings were recorded in previous years. These observations support the idea that prey availability is dynamic in our study area and presumably depends on a suite of local oceanographic conditions.

We examined the summertime remotely sensed sea surface temperature imagery (<http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdBASsta8day.graph>) for the Isla de Chiloe area, which indicated that the warm water typically found offshore during the summer months intruded into the coastal area, where water is normally cold due to upwelling processes in the Humboldt Current. We do not yet know the cause of this intrusion, but it may have occurred as a result of the relaxation of coastal winds that drive the upwelling and allows shoreward movement of warm surface waters (Narvaez *et al.*, 2006). Southern sunfish, a species from warm and tropical waters in the Southern Hemisphere (Bass *et al.*, 2005), were recorded off Isla de Chiloe between January and March 2012, when water temperatures were higher than in past years.

Due to the low numbers of blue whales off Isla de Chiloe in February, we conducted four marine surveys in northern Chile around Isla de Chanaral (29°01'S - 71°37' W) in late February. We recorded 23 blue whales during 26 hr and some of them were observed feeding. We also observed fin whales, humpback whales and bottlenose dolphins in the area. The SST was about 3-4° C lower than off Isla de Chiloe. Between 1988 and 1995, Capella *et al.* (1996) recorded 35 sightings of seven cetacean species off Isla de Chanaral: fin whales, minke whales (*B. acutorostrata*), humpback whales, killer whales (*Orcinus orca*), bottlenose dolphins, long-finned pilot whales (*Globicephala melas*), and dusky dolphins (*Lagenorhynchus obscurus*). Fin whales were the most frequently observed cetacean (Capella *et al.*, 1996), and blue whales were not reported at the time. Between 2003 and 2005, fin whales were sighted off Isla de Chanaral feeding on krill, *E. mucronata* but no blue whales were reported. This area represents a highly dynamic coastal environment, characterized by the upwelling off Coquimbo, Chile (30° S) in the HCELME. High productivity and prey availability for fin whales are thought to be related to local upwelling events (Perez *et al.*, 2006).

Blue whales were sighted around Isla de Chanaral during summer 1998 (pers. obs. EC), but no blue whales were observed in this region in the following summer (1998/1999) (per. comm. M. A. McDonald to RLB). According to local whale watch operators, blue whales visit the area but not as frequently as other species. A blue whale photographed in this area on 21 December 2006 was later resighted off northwestern Isla de Chiloe on 22 February and 26 April 2007 (Galletti Vernazzani *et al.* In Press). This resighting documents the same animal in both the southern (Isla de Chiloe) and northern (Isla de Chanaral) feeding areas. It seems that in 2012, an unusually high number of blue whale sightings occurred around Isla de Chanaral.

Our marine study area is in the southern section of the Humboldt Current Large Marine Ecosystem (HCLME) considered to be the most productive marine ecosystem in the world, with the largest upwelling system and high rates of primary and secondary productivity which support the world's largest fisheries. These productivity and fish populations, mainly sardines, anchovies and jack mackerel support large populations of marine mammals (blue whales, Brydes whales, humpback whales, long-beaked common dolphins, dusky dolphins, Burmeister's porpoises and Peruvian fur seals) and birds (Peruvian pelicans, Guanay cormorants, and Peruvian boobies). The upwelling of the HCLME has various hot spots along the coasts of southern Chile to northern Peru. The upwelling of the HCLME is disrupted by the El Nino-Southern Oscillation (ENSO). ENSO events, which have become stronger and more frequent in recent years, strongly influence the distribution of marine mammals and birds in the HCLME (Heileman *et al.*, 2008).

CONCLUSIONS

There appears to be more than one feeding area for blue whales in Chile. The relatively small number of blue whales sighted per day off Isla de Chanaral compared to the southern Chile feeding area (off Isla de Chiloe) suggests that Chanaral may be a secondary feeding area for the population or part of another larger feeding area north of Isla de Chiloe. Therefore, it is critical to continue to monitor the presence of blue whales in this northern blue whale feeding habitat and to increase photo-identification efforts.

Climate change can impact the pattern of marine biodiversity through changes in species' distributions. Cheung *et al.* (2009) applied a bioclimate envelope model to more than 1,000 exploited marine fish and invertebrate species distributions worldwide and predicted that biodiversity in the Pacific Ocean would experience an increasing high invasion intensity and local extinction of species from 30°S to 60°S by 2050. Similar models applied to fisheries catch potential in the global ocean predicted that inshore species would shift offshore and that those changes would be most apparent in the Pacific Ocean. Chile's EEZ region is one of the areas with the greatest predicated loss in maximum fisheries catch potential from 2005 to 2055 (Cheung *et al.*, 2010).

It appears that the 1997-98 and 2012 (this report) shifts in blue whale distribution and the occurrence of southern sunfish off Isla Chiloe are a consequence of oceanographic events like ENSO or other anomalous intrusions of warmer water into the Humboldt Current. It is not known if predictions of decreasing biodiversity in the Pacific Ocean coastal waters due to climate change will impact marine mammals, although it is known that prey availability affects blue whale distribution.

SST alone was not a good predictor for blue whale encounter rates in southern Chile so more sophisticated models including chlorophyll-a and other environmental variables should be investigated to better understand blue whale distribution and its shift under different oceanographic and climate scenarios.

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Figure 1 – Blue whale study areas in northern and southern Chile. Circle: waters around Isla de Chanaral, northern Chile; Rectangle: southern Chile feeding area in the region of Isla de Chiloe; Cross: southern Chile land-based station

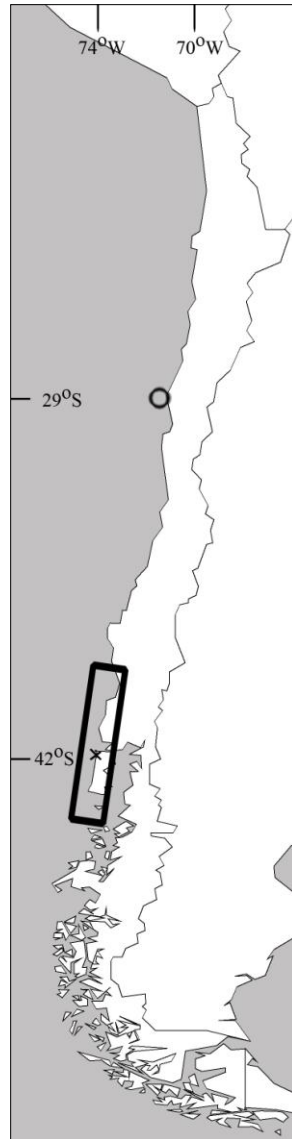


Figure 2 – Average number of whale groups sighted per day off northwestern Isla de Chiloe for the period 2005-2012

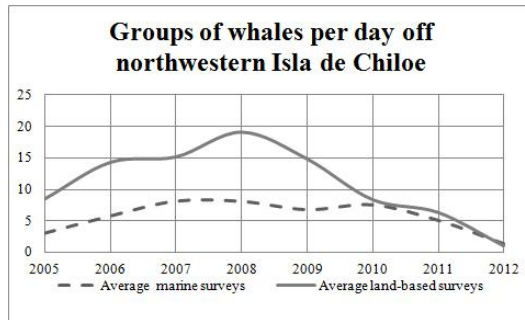


Figure 3 – Average annual In-situ Sea Surface Temperature off northwestern Isla de Chiloe for the period 2005-2012

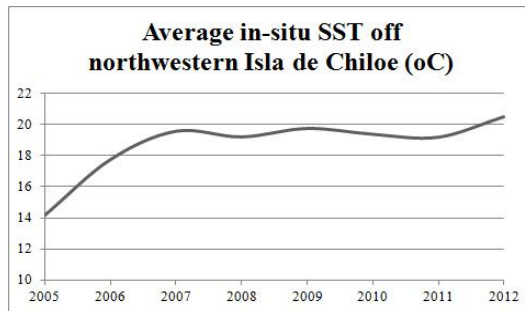
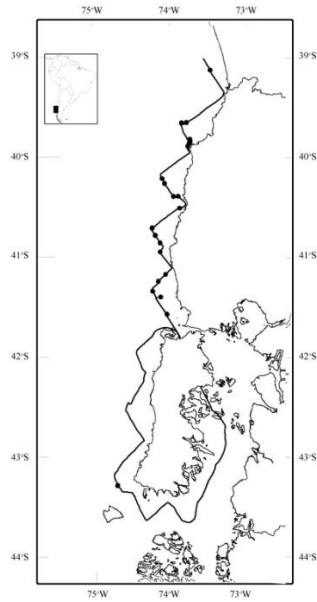


Figure 4 – a) Blue whale sightings and track from aerial surveys in 2012. Solid line: track, Dot: sighting b) Blue whale distribution probability using kernel density effort-weighted analyses. Solid line: 99% of probability, Dash-line: 55% of the volume probability.

a)



b)

