Long term mark-recapture of blue whales in Chilean Waters

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ABSTRACT

Photographs of blue whales collected during 1997/98 IWC-SOWER surveys off Chile have been analyzed, archived and contributed to the Southern Hemisphere Blue Whale Catalogue. One hundred thirty-nine photographs were examined and 22 individuals were catalogued. One recapture within the same day was found. The IWC-SOWER Chile catalogue was compared to blue whale photographic identifications in the catalogue developed by the Centro de Conservation Cetacea, which contains 301 individuals (right side) and 290 (left side) collected between 2004-2009. The first long-term resighting of blue whales for the eastern South Pacific was found over ten years (January 1998 and March 2008) and both sightings occurred in southern Chilean waters, approximately 220 km apart.

INTRODUCTION

During the 20th century, blue whales (*Balaenoptera musculus*) became a principal target of the whaling industry worldwide (Clapham *et al.*, 1999). In Chile, catches of approximately 3,000 blue whales were reported between 1926 and 1971 (Aguayo *et al.* 1998). In spite of all catches and subsequent non-lethal efforts to increase knowledge on the species, very little is known about the migration of blue whales, population estimates, whether the currently distinct populations are defined correctly, and the level of interchange of these populations (McDonald *et al.*, 2006).

Two subspecies of blue whales currently are accepted in the southern hemisphere: the pygmy blue whale (*B.m. brevicauda)* in the Subantarctic zone; and the Antarctic or true blue whale (*B. m. intermedia*) that summers in the Antarctic Zone (Rice, 1998). Blue whales in Chilean waters have been classified as either Antarctic blue whales or pygmy blue whales (Aguayo L. 1974). However Branch *et al.* (2007) have shown, based on the length frequency of adult females, that blue whales captured off Chile fall between the two described Southern Hemisphere subspecies and therefore may represent a unique population or a different subspecies.

In 1997/1998, the second cruise conducted under the Southern Ocean Whale and Ecosystem Research (SOWER) was undertaken in Chilean waters by two vessels, *Shonan Maru* and *Shonan Maru2* (Findlay *et al.*, 1998) and more recently, a systematic effort by Centro de Conservacion Cetacea (CCC) since 2004 has provide important information to improve knowledge on Chilean blue whales (Galletti Vernazzani *et al.*, 2011).

In 2006 the Scientific Committee agreed to initiate an in-depth assessment of Southern Hemisphere blue whales (IWC, 2006) and in 2008, the Committee endorsed (IWC, 2008) a proposal to establish a central web-based catalogue of blue whale identification photographs, known as Southern Hemisphere Blue Whale Catalogue (SHBWC).

Here we present preliminary results of the SHBWC project that reports photo-identification analyses for the IWC-SOWER 1997/98 cruise and the first long-term mark-recapture of blue whales in Chilean waters through comparisons of individual photo-identification of blue whales obtained from 1997/98 SOWER survey with CCC 2004-2009 blue whale catalogue.

MATERIALS AND METHOS

Individual blue whales are identifiable from unique patterns of mottling on both sides of the body near the dorsal fin (Sears *et al*., 1990) and in some cases permanent scars can be used to identify or confirm individuals.

Blue whale identification photographs from the 1997/98 SOWER cruise have been assembled by the authors in order to archive, catalogue and analyze the photographs as a collection in the SHBWC. Findlay *et al.* (1998)

reported that 22 sightings of 22 individual blue whales were made from the *Shonan Maru*, and 17 sightings of 25 individual blue whales were made from the *Shonan Maru No* 2 from Iquique (20°S) to Talcahuano and transit to Punta Arenas (40°S). However, photo-identification experiments were conducted only on 24 sightings. "Photo-identification experiments" was used to indicate whether the vessel broke off the transect line to go and photograph blue whales. The intention was to be able to know how much time was spent doing that particular activity regardless if it was successful or not (Pitman, R., pers. comm.).

One hundred thirty-nine digitized photographs of blue whales grouped in 20 different folders were received by the authors. These folders were considered irrelevant as well as the label assigned to the whales since during selection process, we found different individual whales photographed on different sighting days in the same folders with similar labels (example: SM1#5 14 and SM1#5 30). The only labeling used was SM1 or SM2 to assign different individuals to each vessel.

Identification photos were selected for each whale to maintain separate photographic catalogues for the left and right sides of the head region, dorsal fin, flank and caudal peduncles. Photographs of poor quality or whales only partially photographed were not included in the catalogue. After the internal matching process of 1997/1998 individual blue whales off Chile was finalized, identification numbers (i.e. WhaleID) were assigned to create an IWC-SOWER Chile catalogue.

In order to associate individuals identified in the IWC-SOWER catalogue with cruise sightings number, we reviewed both reported tables for photo-identification experiments (Findlay *et al*., 1998) and original sighting forms to obtain location and details. Although all the photographs have a visible date, we found that in ten cases the dates did not corresponded to blue whale sighting dates or cruise dates. In these cases, we allocated a date based on group size, or available sightings with photo-identifications taken but not Whale ID associated yet.

The CCC 2004-2009 blue whale photo-identification catalogue consists of 290 individuals (left side) and 301 individuals (right side). These photographs were obtained mainly off the northwestern coast of Isla de Chiloe (42°S), southern Chile, although it includes blue whales photographs in Atacama (29°S), northern Los Lagos (41°S) and Corcovado Gulf (43°S) (Galletti Vernazzani *et al*., 2011).

RESULTS

From the 1997/98 IWC-SOWER original sighting forms we found 38 blue whale sightings comprising 46 whales. This corresponds to one sighting and one individual less than that reported by Findlay *et al.* (1998) reported.

Fourteen left-side and 9 right-side individual blue whale photo-identifications from 22 different animals were selected (Table 1). Only one individual (Ch009) was photographed from both sides. 22% and 18% identification photographs were discarded from left-side and right-side respectively because of its poor quality or whales partially photographed.

One individual sighted from *Shonan Maru* on 02 January 1998 was recaptured the same day on locations separated by approximately 4km, therefore to avoid double counting, the total number of sightings should be 37 comprising 45 individuals. Original sighting forms 8 and 10 from 02 January 1998 contain notes indicating they correspond to the same individual and, on the summary of experiments of table 3a reported by Findlay *et al*. (1998), these sightings are associated but not discarded from the total count of sightings and individuals. We assumed that this within-day photo-identification recapture is related to these two sighting forms.

According to sighting forms, it was not possible to conduct photo-identification experiments during sighting number 8 made from *Shonan Maru2* on 24th January 1997, which differs from table 3b reported by Findlay *et al*. (1998)

Table 2 shows the sighting data, biopsy ID and when possible, associated whale ID numbers.

Many whales had the date and sighting data related. However, there were a few exceptions where it was inferred:

- Whale number Ch001, with photographs dated 30 January 1998, was presumed to be related to sighting #3 of 29 December 1997 because it was the only picture from *Shonan Maru* with a date not related to sightings and it showed a biopsy shot, while the individual of sighting #3 was the only sighting with a biopsy ID and photo ID experiment but without any whale ID associated.

- Whale number Ch010 and Ch007 were photo-identified on 03 January 1998. However that day *Shonan Maru* only conducted photo ID experiments on one sighting of one whale. Therefore, either more than one blue whale sighting had photo ID associated on 03 January 1998 and it was not noted on the forms, or the date on the pictures is incorrect. In the later case, it may be presumed that one of these individuals may have been photographed on 02 January 1998, where sighting number 7 is the only one of *Shonan Maru* with photo ID experiments, which has no associated whale ID photograph.

- Whale number Ch008 and Ch009 were both photo-identified on 05 January 1998 but it is not possible to identify which one corresponds to sighting number 12 with its associated biopsy ID, or to sighting number 14.

- Whale number Ch015, Ch016, Ch017 and Ch018 are photographs with date 07 February 1998, but are presumed to correspond to sighting number 1 of 01 January 1998 since this is the only day when more than two whales were photographed, in particular, a group of five individuals within which three biopsies were collected.

In two cases, sightings with photo ID experiments did not get an associated whale ID (sighting 4 from 28 December 1997 and sighting 8 from 29 December 1997 made by *Shonan Maru 2*). In addition we were not able to associate Ch011, Ch012, Ch013 and Ch014 to any sightings data from *Shonan Maru* 2. The photographs of Ch012 show at least two whales on picture frame, so it may corresponds to sightings 4 from 25 December 1997 or sighting 1 from 01 January 1998.

One recapture between years was found from comparisons made within the Southern Hemisphere Blue Whale Catalogue, between CCC 2004-2009 blue whale catalogue and IWC-SOWER 1997/98 cruise (Figure 1). This individual was first observed alone from *Shonan Maru* (Ch009) on 5 January 1998 either at 39.96^{o}S and 74.15^{o}W or at 40^{o}S and 74.14^{o}W. Ten years later, it was observed again by CCC *Alfaguara* research vessel on 13 March 2008 (L262/R736) at 41.94^{o}S and 74.29^{o}W, about 220km southwest from previous location.

Three or more characters were used to determine the match on each side. The most obvious character for the right side was the mutilated dorsal fin. I was also confirmed by the pigmentation pattern below the dorsal fin. On the left side, pigmentation patterns below the dorsal fin and towards the peduncle were used.

DISCUSSSIONS

Video experiments were taken during most of the SOWER 1997/98 blue whales encounters (Findlay *et al*., 1998). Access to these recordings will improve the IWC-SOWER Chile catalogue.

Based on the line-transect surveys conducted from the IWC-SOWER 1997/98 blue whale cruise (Findlay *et al*., 1998), Branch *et al*. (2007b) estimated a population abundance of 452 individuals using standard line-transect methods and Williams *et al*., (2011) using spatial modeling methods obtained a new abundance estimate of 303 whales. The discrepancies of two sightings found between original forms and those reported, may add substantial difference when considering abundance estimates and therefore should be investigated.

The resighting over a ten year period is the first long-term resighting of blue whales in Chilean waters and the eastern South Pacific. Both sightings occurred off southern Chile, and the inshore area that has been highlighted as an important feeding ground for blue whales, being northern Los Lagos the most likely upper limit of this austral feeding ground (Galletti Vernazzani *et al.*, 2011). The first sighting made on 5 January 1998 was south of Araucania/Los Rios sub-area approximately 36km offshore. This sighting was made during transit south to Punta Arenas and it was the last day the cruise encounter blue whales. *Shonan Maru* surveyed 20nm offshore during transit to Punta Arenas while *Shonan Maru2* surveyed 10 to 15nm west of the *Shonan Maru* trackline but since 6th January

it moved to between 5 and 8 n. miles to the west of the *Shonan Maru* to search closer to the coast (Findlay *et al*., 1998). The fact that no blue whales were found south of Araucania/Los Rios sub-area, when crossing through the most important feeding aggregation known in Chile, support the hypothesis that blue whales were not in this area by that time. Also no blue whale sightings were reported between February-April, 2004 to 2010 in the South Araucania/Los Rios and in December and early January off western Isla de Chiloe (Galletti Vernazzani *et al*. 2011). The possible explanations are: (1) animals are found earlier in the area south of Araucania/Los Rios during southward transits to the main feeding ground; and/or (2) during 1997/98 El Nino event, considered one of the strongest ever recorded, blue whales were feeding earlier and changed their distribution by using areas north of the common upper limit of this feeding ground (Figure 2).

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Table 1 – Individual photo-identification of blue whales from IWC-SOWER 1997/98

WhaleID	Original file name	Left Side	Right Side	Date on pictures
Ch001	SM1 #004 20	1	0	30 January 1998
Ch002	SM1 #4 17	0	1	27 December 1997
Ch003	SM1 #5 14	0	1	29 December 1997
Ch004	SM1 #5 30 & SM1#5 32	1	0	30 December 1997
Ch005	SM1 # 6 22 & SM1 # 6 26	1	0	31 December 1997
Ch006	SM1 #7 18 & SM1 # 8 13	1	0	2 January 1998
Ch007	SM1 #10 3	1	0	3 January 1998
Ch008	SM1 #10 7	0	1	5 January 1998
Ch009	SM1 #10 19to36 & SM1# 11	1	1	5 January 1998
Ch010	SM1 #9 33	0	1	3 January 1998
Ch011	SM2 #001 15	1	0	25 January 1998
Ch012	SM2 #001 28	0	1	27 January 1998
Ch013	SM2 #002 5 & SM2 #002 6	0	1	29 January 1998
Ch014	SM2 #002 23	1	0	29 January 1998
Ch015	SM2 #002 34	1	0	7 February 1998
Ch016	SM2 #002 36	1	0	7 February 1998
Ch017	SM2 #003 5 & SM2 #003 6	1	0	7 February 1998
Ch018	SM2#003 12	1	0	7 February 1998
Ch019	SM2 # 104 36	0	1	24 December 1998
Ch020	SM2 # 105 25	0	1	25 December 1997
Ch021	SM2 #106 10	1	0	26 December 1997
Ch022	SM2 #108 24	1	0	2 January 1998

Table 2 – Sighting and photo-identification data from IWC-SOWER 97/98 cruise

ID	Platform	Date (dd/mm/yy)	Latitude (S)	Longitude (W)	Sighting ID	Photo ID experiment	Photo ID quality	Individuals	Biopsy ID	WHALE ID[6]
1	SM	15/12/97	28.92167	73.47333	3	Y	Poor	1		
2	SM	21/12/97	35.59833	75.26667	6			1		
3	SM	22/12/97	34.955	76.85167	4	Y	Poor	1		
4	SM	23/12/97	34.785	76.58667	1			1		
5	SM	24/12/97	34.29333	74.615	3	Y	Poor	1		
6	SM	27/12/97	32.455	74.24	1	Y	Medium	1	9856002	Ch002
7	SM	28/12/97	30.84667	72.54	4			1		
8	SM	29/12/97	30.56333	72.35	1	Y	Good	1	9856004	Ch003
9	SM	29/12/97	30.60667	72.28	2			1		
10	SM	29/12/97	30.66667	72.315	3	Y[1]	Medium	1	9856003	Ch001[1]
11	SM	30/12/97	30.81667	72.72667	10	Y	Medium	1	9856005	Ch004
12	SM	31/12/97	30.725	72.06167	2	Y	Medium	1		Ch005
13	SM	1/1/1998	29.99833	72.39	4			1		
14	SM	2/1/1998	29.89167	72.08167	7	Y[2]	Medium	1		Ch010 or Ch007? [2]
15	SM	2/1/1998	29.81667	71.94167	8	Y	Medium	1	9856008	Ch006
	SM	2/1/1998	29.815	71.89833	10	Y	Medium	0	9856006	Ch006
16	SM	3/1/1998	32.56333	72.2	4	Y[2]	Medium	1		Ch010 or Ch007? [2]
17	SM	3/1/1998	32.57167	72.215	5			1		
18	SM	3/1/1998	32.61833	72.22667	6			1		
19	SM	5/1/1998	39.96833	74.14667	12	Y[3]	Medium & Good	1	9856007	Ch008 or Ch009? [3]
20	SM	5/1/1998	40	74.13667	14	Y[3]	Medium & Good	1		Ch008 or Ch009? [3]
21	SM2	17/12/97	20.63833	71.42833	25			1	9856107	
22	SM2	19/12/97	21.97333	70.52333	17	Y	Poor	1	9856113	
23	SM2	24/12/97	26.67	71.97	2	Y	Poor	1		
24	SM2	24/12/97	26.84	71.56833	3	Y	Medium	1	9856119	Ch019
25	SM2	24/12/97	27.22167	71.74667	8			1		

26	SM2	25/12/97	27.53	73.46667	4	Y	Medium	2	9856122 & 9856123	Ch020
27	SM2	26/12/97	27.71	72.55833	9	Y	Medium	1	9856124	Ch021
28	SM2	28/12/97	27.73667	72.91333	4	Y[4]		1	9856128	
29	SM2	29/12/97	27.685	73.97	8	Y[4]		1	9856129	
30	SM2	30/12/97	28.035	71.78	11			1		
31	SM2	1/1/1998	28.65	71.76667	1	Y[5]	Medium & Good	5	9856132 & 9856133 & 9856134	Ch015, Ch016, Ch017 y Ch018 [5]
32	SM2	1/1/1998	28.74333	71.69833	2			3		
33	SM2	1/2/1998	29.335	71.79833	2	Y	Medium	1		Ch022
34	SM2	1/2/1998	29.78	71.87	4			2		
35	SM2	1/3/1998	32.15333	72.31833	4			1	9856135	
36	SM2	31/12/97	28.62333	71.77833	10			1		
37	SM2	31/12/97	28.64167	71.76	11			1		

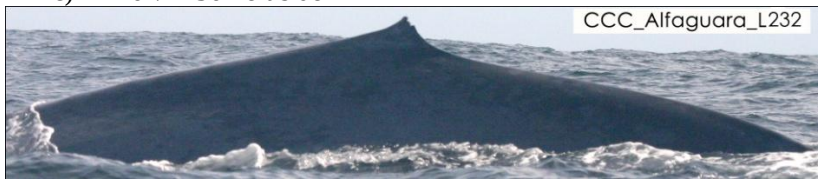
[1] Ch001 are photographs with date 30 January 1998, presumed to be related to sighting #3 of 29 December 1997.
[2] Ch010 and Ch007 are photoIDs with date 03 January 1998, but it was only one whale photoID that day by *Shonan Maru.*
[3] Ch008 and Ch009 were both photoID on 05 January 1998 but it is not possible to identify which one corresponds to the sighting number 12 with its associated biopsy ID or to sighting number 14.
[4] Sightings with photoID experiments but no whaleID were able to be related or inferred.
[5] Ch015, Ch016, Ch017 and Ch018 are photographs with 7 February 1998 date, but are presumed to correspond to sighting number 1 of 1 January 1998 since this is the only day and sighting when more than two whales were photographs.
[6] Whales Ch011, Ch012, Ch013 and Ch014 were not able to be associated to sightings.

Figure 1 – Long-term resighting of blue whales off Chile: a) left side and b) right side of whale Ch009 photographed by IWC-SOWER in 1998 and c) left side and d) right side of whale L262/R736 photographed by CCC in 2008.

a) Ch009 Left side

b) Ch009 Right side

c) L262/R736 Left side



d) L262/R736 Right side

Figure 2 – Southern Chile blue whale feeding ground and sightings: black dots = sightings made from 2005-2010; thick line represents represent 50% and dashed lines represent 90% of the volume of a probability density distribution of blue whales obtained from kernel analysis (Galletti Vernazzani *et al.*, 2011); grey area represents southern Araucanía/Los Rios sub-area; and black square = location of possible sightings associated with 1998 blue whale Ch009.