

## Report on blue whales sightings (*Balaenoptera musculus* Linnaeus, 1758) in a narrow fjord during autumn- winter in southern Chile

(Mammalia, Cetacea, Balaenopteridae)

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Most blue whale sightings from southern Chile are reported from summer and early autumn (December through early April) from areas with open ocean conditions. In the narrow Comau Fjord in June 2009, three blue whales were observed during 23 days, and at least 14 blue whales were reported for more than five consecutive weeks between late April and early June 2010. In May 2012 one whale was seen in Poyo, and in July 2012 seven to nine rorqual whales (probably blue whales) have been observed close to the entrance of Comau Fjord at Lilihuapi Island. The sightings were opportunistically carried out from small vessels of the Huinay Scientific Field Station during regular, not whale related work trips between Hornopiren and the station. The whales were observed to approach shore up to 100 m on a regular base. Most whales were observed to change direction frequently while feeding on sub-superficial prey, indicated by diving sea birds, short diving times of whales (generally less than 5 minutes), and a relatively flat angle of descent. The behaviour and habitat preference of the blue whales observed in the Comau Fjord qualify the paradigm that blue whales prefer oceanic habitats and open ocean regions. From the Inner Sea of Chiloé high primary production is known from summer and autumn months, while values fall abruptly in winter. High primary production in summer is also known from Comau Fjord, however, no data are available from autumn and winter. More data are necessary concerning winter primary production in Comau Fjord to understand the presence of baleen whales.

La mayoría de avistamientos de ballenas azules en el sur de Chile es reportada entre verano y otoño (de diciembre hasta comienzos de abril) de áreas con condiciones de mar abierta. En el estrecho fiordo de Comau fueron observadas tres ballenas azules durante 23 días en junio del 2009 y al menos 14 individuos por cinco semanas consecutivas entre abril y junio del 2010. En mayo del 2012 se avistó a una ballena azul en Poyo y en julio del 2012 siete a nueve rorcales (probablemente ballenas azules) en la entrada al fiordo Comau, en la isla Lilihuapi. Estos avistamientos fueron todos hechos ocasionalmente desde pequeñas embarcaciones de la Estación Científica Huinay, en viajes regulares entre Hornopirén y Huinay no relacionados con ballenas. Se pudo observar que las ballenas se acercaban con frecuencia a la orilla hasta unos 100 m de distancia. Mientras se alimentaban debajo de la superficie, indicado por los cortos tiempos de buceo (menos de cinco minutos), los ángulos de ascenso relativamente planos y la actividad de aves marinas en el área, se podían notar varios cambios de dirección en los individuos. El comportamiento y la preferencia de hábitat vistos en el fiordo de Comau contradicen a la constatación que ballenas azules prefieren hábitats oceánicos y de mar abierta. De la región de golfos de Chiloé se conoce una alta producción primaria durante los

meses de verano y otoño, mientras esta cae abruptamente en invierno. En el fiordo de Comau la producción primaria también es elevada en verano, pero no existen datos de otoño e invierno. Es necesario establecer datos sobre la producción primaria en los meses de invierno para entender la presencia de misticetos en el fiordo.

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## Introduction

Whaling fleets started targeting blue whales (*Balaenoptera musculus* Linnaeus, 1758), which before had been too fast for sailing boats, with the introduction of steam vessels. At that time, populations of other hitherto hunted whales were already dramatically depleted and the newly exploited species sustained the industry. The Antarctic blue whale *Balaenoptera musculus intermedia* Burmeister, 1872 is found south of 60°S in the summer, while the pygmy blue whale *B. m. brevicauda* Ichihara, 1966 is found in more northerly latitudes, especially in the Indian Ocean. Some have suggested the Chilean population is a mixture of these two subspecies (Aguayo 1974), others that they are an entirely separate subspecies because length distributions are intermediate (Branch et al. 2007a). Thus, their taxonomic status is uncertain (Branch et al. 2007b) and in discussion. Between 1926 and 1971, approx. 3000 catches were reported in southern Chile (Aguayo-Lobo et al. 1998). Using line transect survey and surface density models, Williams et al. (2011) estimated the original population size and hypothesized that the number of Chilean blue whales was reduced to 7.2–9.5%. Efforts to monitor the recovering of the species after the moratorium concentrated on northern Los Lagos region, Chiloé Island and Corcovado Gulf (Hucke-Gaete et al. 2004, Cabrera et al. 2005, Galletti Vernazzani et al. 2012). Blue whale sightings in Chile peak in summer and early autumn (December through March) (Branch et al. 2007b), when the blue whale surveys are generally undertaken (Hucke-Gaete et al. 2004, Cabrera et al. 2005, Viddi et al. 2010, Galletti Vernazzani et al. 2012). These studies led to the conclusion that the studied oceanic areas are important feeding zones for the blue whales which merit attention and protection (Hucke-Gaete et al. 2004, Galletti Vernazzani et al. 2012).

Sporadic sightings of blue whales have been reported between April and early July from the Comau Fjord since 2002 when Huinay Scientific Field Station (HSFS) started operating (Ana Torrientes, pers. comm., local fishermen, pers. comm.). In June 2009, two blue whales were filmed from salmon farming

staff in Telele (Abramson & Gibbons 2010). Here we document further blue whale sightings from 2009, 2010, and 2012 in the Comau Fjord and adjacent Ancud Gulf, Northern Patagonian Zone.

## Methods

Since 2002, blue whale sightings have been recorded by the team of the HSFS (Tab. 1). The sightings were opportunistically carried out from small vessels of HSFS during transport trips between Hornopiren and the station, and during boat trips for not whale related field work in the Comau Fjord (Fig. 1). Since 2002 boat hours and number of trips have constantly been rising with increasing scientific activity at the station (approx. one weekly trip in winter and two to three in summer). In the same time the number of scientific staff at the station has been growing, increasing the possibility of incidental whale spotting and registers. Except two successful sighting trips made in April and May 2010, all sightings were opportunistic. The restricted water surface (the fjord is between 2 and 8.5 km broad) enabled observations from comparably short distances without the need to approach the animals actively. This reduced stress and made identifications easy. Observation and identification was also eased by usually low wave height in the protected fjord (own observations). Serial photographs allowed estimation of the relative distance between blowhole, back fin and tail fin to support species identification. Due to the low total amount of photos that allowed identifications at individual level, capture-recapture methods for group size estimations could not be applied. Thus the estimations of individual numbers were conservatively based on simultaneous or nearly simultaneous sightings.

## The study area

The Comau Fjord (42°10'–42°30'S) extends over 45 km from its mouth at Lilihuapi Island to its head at Leptepu (Fig. 1). It is between two and 8.5 km broad and up to 500 m deep, more than 200 m deeper than the adjacent Ancud Gulf. Rainfall between 4500 and 7000 mm per year (based on registers since 2002) creates a superficial low salinity layer, which varies

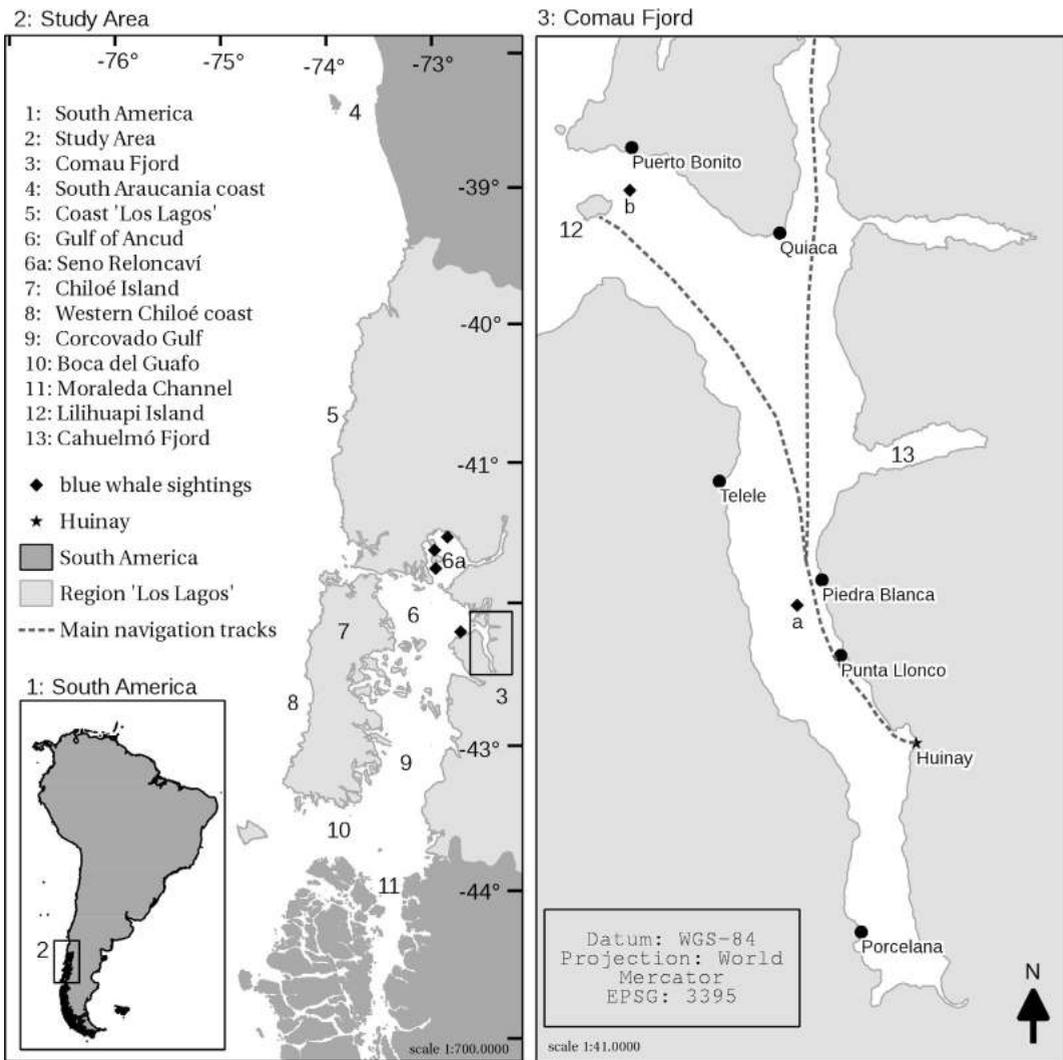


Fig. 1. The Comau Fjord area.

in thickness between 0.5 m and 8 m. Density differences to the underlying higher saline water body are very pronounced and strongly reduce vertical mixing. Tidal amplitudes vary between 0.35 m and 7.42 m. Water temperatures below the pycnocline vary seasonally between 8 °C and 12 °C, surface temperatures between 6 °C and 23 °C.

First studies reveal a highly complex oceanography of the Northern Patagonian fjord region (Djurfeldt, pers. comm.; Sobarzo 2009). Relatively high primary production rates are naturally given in the spring and summer months in the Corcovado Gulf and the northern Patagonian fjords, also called Inner Sea of Chiloé (Hucke-Gaete et al. 2004, Delgado &

Marin 2006, Iriarte et al. 2007, González et al. 2010, Aracena et al. 2011). In the fjords planktonic algae biomass is strongly and rapidly fluctuating (several short and intense algae blooms, sometimes producing intensely green superficial waters have been observed by the authors to be followed by “clear water” conditions in Comau and neighbouring Reloncaví Fjord during summer). A high primary production of 1–3 g C m<sup>-2</sup> d<sup>-1</sup> was assessed for the Inner Sea of Chiloé and even up to 4.7 g C m<sup>-2</sup> d<sup>-1</sup> in spring and 9.4 g C m<sup>-2</sup> d<sup>-1</sup> in summer for the Reloncaví fjord (Aracena et al. 2011). As a comparison, the values from Guafo mouth in spring (oceanic conditions) were 3.7 g C m<sup>-2</sup> d<sup>-1</sup>, values from high latitude fjords

lie  $< 1 \text{ g C m}^{-2} \text{ d}^{-1}$ . Iriarte et al. (2007) found a second maximum of chlorophyll *a* in autumn (March, April) in the Corcovado Gulf but then (May through July) values fall abruptly in the open Inner Sea of Chiloé (Iriarte et al. 2007).

## Results

Blue whales were sporadically observed in the Comau Fjord since 2002 (local fishermen and Ana Torrientes, pers. comm.). Between June 5 and 24, 2009, in five opportunities between two and three blue whales were documented close to the mouth of the fjord between Lilihuapi and Piedra Blanca. Fishermen reported the presence of blue whales in the fjord until June 27, 2009. Between April 19 and June 1, 2010, during nine own sightings and one reliable report from fishermen, up to at least 14 (fishermen estimates up to 20) specimens were seen in the same area (Fig. 2). At least two individuals entered the fjord deeper and were observed from HSFS. The individuals observed were mainly adults (twice a calf was present); most of medium size and at least two very large specimens. On May 8, 2012 one whale was seen in Poyo, and on July 2, 2012 seven to nine rorqual whales (probably blue whales) have been observed close to the entrance of Comau Fjord at Lilihuapi Island. The whales approached the shore up to 100 m (Fig. 2) and were generally seen in areas with high concentrations of diving birds such as boobies, penguins and cormorants. Most whales regularly changed direction and were followed by swarms of sea gulls. Diving times of whales were relatively short (generally less than five minutes), and the angle of descend relatively flat, the caudal fluke generally did not leave the water.

Blue whales are individually identifiable from the unique pattern of mottling on both sides of the body near the dorsal fin (Sears et al. 1990). Photos that were usable for an individual identification catalogue were taken during two sighting events in April and May 2010, respectively. Separate photographic catalogues for the left and right sides were compiled. Photographs of low quality or whales only partially photographed were not included in the catalogue. This way a total of five individuals have been indentified, three from the left side, one from the right side and one from both sides (Fig. 3). All individual whales were then compared to the catalogue of Centro de Conservacion Cetacea (CCC) that conduct the Alfaguara (blue whale) project off northwestern Isla de Chiloe (approx.  $42^{\circ}\text{S } 74^{\circ}\text{W}$ ) (Galletti Vernazzani et al. 2012). From 2004 to 2009 they photographed the dorsal portions of blue whales for individual identification. The catalogue allows the

identification of a total of 288 individual blue whales from the left side and 301 from the right side. Two out of five photo-identifiable animals from Comau Fjord were individuals known from the CCC catalogue. One was first seen on 27 April 2007 at  $41.8^{\circ}\text{S } 74.2^{\circ}\text{W}$  and was then seen on 24 April 2010 between the entrance of Cahuelmo fjord, Telele and Quiaca (Huinay002; see Fig. 1). The second individual was first seen on 19 April 2009 at  $42.1^{\circ}\text{S } 74.4^{\circ}\text{W}$  and was later seen on 25 May 2010 at Telele (Huinay003; see Fig. 1)

In the neighbouring, more exposed Reñihué Fjord which is open towards the Ancud Gulf, staff of the Pumalin Park reported five blue whales in 2010, and sightings in the mouth or just outside the fjord “practically every year”. No blue whales were sighted in the Reñihué Fjord in 2011 and 2012 (park admin., pers. comm.). Between April 1, and May 8, 2012 one and two blue whales, respectively were observed during four sightings in the Ancud Gulf by staff of the Pumalin Foundation (Tab. 1, Fig. 1).

## Discussion

In addition to reports on blue whales from the Corcovado Gulf, western coast of Chiloé island and northern Los Lagos Region (Hucke-Gaete et al. 2004, Cabrera et al. 2005, Galletti Vernazzani et al. 2012), the sightings in the Comau Fjord represent new important information on blue whale distribution in the Northern Patagonian Fjords. The waters off northwestern Chiloé Island and northern Los Lagos Region (Fig. 1) seem to be the most important aggregation areas currently known for this species in Chile (Galletti Vernazzani et al. 2012). In Comau Fjord, whales were only recorded for late autumn-early winter 2009 (throughout June), autumn 2010 (April to early June), and autumn to winter 2012 (May to early July). The probability that a larger number of individuals was present in recent years at other times for a longer time period but stayed unnoticed is low, since sightings in such a restricted area are comparably easy and information about sightings generally spread. This is less given for other areas such as the Corcovado Gulf and the northwestern coast of Chiloé Island since coincident sightings are less probable and more difficult in open, wave impacted areas. Thus the absence of registers from May through October for these areas may also be explained by less or no sampling effort.

Telemetric studies with satellite tracked transmitters indicated a comparably high local fidelity of five blue whales in the Corcovado Gulf during summer and autumn (Hucke-Gaete 2004, Hucke-Gaete & Mate 2005), photographic surveys showed

the same for the blue whales at the northwestern coast of Chiloé Island (Galletti Vernazzani et al. 2012). In autumn two of the five tagged whales were observed to migrate north to areas which have been hypothesized to represent the population's reproductive areas where they can also continue to feed (Hucke-Gaete 2004, Hucke-Gaete & Mate 2005). Two of the whales sighted in Comau Fjord in 2010 have been sighted at the northwestern coast of Chiloé Island in April 2007 and April 2009, respectively. This indicates that either there is a significant exchange between subpopulations or the observations at both sites refer to the same population. In both cases this suggests a dynamic feeding area. It is possible that sampling bias across study areas affect the pattern of sightings concerning the priority areas of this species and the seasonality of their residence. More studies with systematic approaches reducing geographic

and temporal bias are necessary to resolve some remaining doubts. In particular passive acoustic recording devices might efficiently help to detect blue whale presence over larger areas and over longer time periods. At the same time a shared data bank of ID photos and coordinated and/or synchronized sampling efforts would help to combine the different sampling efforts and reveal migration patterns.

The behaviour and habitat preference of the blue whales observed in the Comau Fjord relativize the paradigm that blue whales prefer oceanic habitats and open ocean regions (Viddi et al. 2010). Although there is evidence that large whales transit through narrow and deep fjords and channels (Hucke-Gaete et al. 2004), to our knowledge they have never been reported to stay for longer periods in narrow fjords. Our observations suggest that the whales were feeding on sub-superficial prey which supports the

**Table 1.** Blue whale sightings along the Comau Fjord and in Ancud Gulf.

Date	Number	Site	Activity	Time
February 13, 2009 <sup>1</sup>		Huequi Peninsula		morning
June 5 <sup>2</sup> , 2009	2	between Puerto Bonito and Telele		
June 15, 2009	3	42°19'23"S 72°28'54"W, Piedra Blanca (a)		11–12 a.m.
June 15, 2009	3	42°09'05"S 72°34'30"W, Lilihuapi (b)		1–2 p.m.
June 18, 2009	3	Lilihuapi to Puerto Bonito	feeding	
June 25, 2009	3 or 4	W of Lilihuapi	feeding	9–11 a.m.
April 19, 2010	14 (–20)	Telele		
April 22, 2010	3 to 4	Telele		
April 23, 2010	5	W side of Comau Fjord (Telele to Punta Llonco)		late afternoon
April 24, 2010	2	Calmaco		morning
April 24, 2010	9 to 10, probably 14 (3 groups: 4, 4, 1 to 2)	Comau Fjord (Quiaca, opposite Cahuelmo, N of Pta. Llonco)		morning
May 7, 2010	approx. 5, one calf	Lilihuapi		
May 12, 2010	6	Lilihuapi		morning
May 14, 2010	2	Lilihuapi		afternoon
May 25, 2010	at least 7 (four groups: 2, 2, 2, 1)	Telele	feeding	afternoon
June 1, 2010 <sup>3</sup>				
April 1, 2012 <sup>2</sup>	2 (mother with calf)	S of Guar island, Seno Reloncaví (41°45'23.64"S 72°57'34.33" W)		
April 8, 2012 <sup>2</sup>	1	between Maillen and Guar Island, Seno Reloncaví (41°37'35.57" S 72°58'15.73" W)		
May 5, 2012 <sup>2</sup>	1	S of Chamiza, Seno Reloncaví (41°32'1.39" S 72°50'54.11" W)		
May 8, 2012 <sup>2</sup>	2 (mother with calf)	S of Guar Island, Seno Reloncaví		
May 8, 2012 <sup>2</sup>	1	Poyo (42°12'17.24" S 72°43'22.69" W)		
July 2, 2012	7–9 <sup>4</sup>			afternoon
Total sightings	83–98			

1 tourist vessel Arrecife.

2 staff of Pumalin Park from small plane. Since late 2011, the Pumalin Park has a register of sightings.

3 reliable fishermen.

4 orqwal whales, most probably blue whales.



idea that this species opportunistically follows high concentrations of pelagic preys (see also Viddi et al. 2010).

Although blue whales are thought to mainly feed on krill, fish species such as anchovies and other swarm fish can be part of their diet (Leatherwood & Reeves 1983, Larkman & Veit 1998). There are no winter data on zooplankton in Comau Fjord. However in July, low concentrations of zooplankton were measured in the neighbouring Reloncaví Fjord and Inner Sea of Chiloé (González et al. 2010). At least in summer, during night-time in the Comau Fjord high concentrations of krill *Euphausia vallentini* emerge close to the pycnocline during their daily vertical migration and hide around 150 m during daytime (Stebbing 1900; own observations). The year-round presence of large schools of small fish like anchovies (*Engraulis ringens* Jenyns, 1842) in the Comau Fjord could provide additional food for the whales close to the surface during day-time since the anchovies generally feed close to the pycnocline around 10 m depth. This is supported by the observed feeding activity during daytime close to the surface.

Areas which can support a larger group of blue whales for a longer period generally need a major surface and/or relatively high primary production. This is true for the Inner Sea of Chiloé in summer and autumn but winter values (May to July) fall abruptly (Hucke-Gaete et al. 2004, Delgado & Marin 2006, Iriarte et al. 2007, González et al. 2010, Aracena et al. 2011). Fertilising effluents from fish farms (there are 13 mid-sized salmonid farms in the Comau Fjord and Comau channel) and urban sewage could also contribute to elevated primary production in areas with restricted water exchange (Honkanen & Helminen 2000, Goldberg et al. 2001). The absence of data on primary production and zooplankton abundances for the fjord in late autumn and early winter does not allow conclusions on the stability of food availability for blue whales during this time of the year. However, in areas where whales do not need to dive deep the requirements in quantity and concentration of prey drop (Acevedo-Gutiérrez et al. 2002).

◁ **Fig. 2.** Blue whales sighted in the Comau Fjord. **A.** The head of the blue whale is flat, U-shaped and has a prominent ridge running from the blowhole to the top of the upper lip. The typical straight blow can reach more than 10 m height. **B.** Aerial view of blue whales in Comau Fjord (Foto: Carlos Zambrano). **C.** The small dorsal fin which is located around three-quarters of the way along the length of the body is visible only briefly during the dive sequence. **D.** The whales approach the shores of the Comau Fjord as close as 100 m. **E.** The tail fluke is only raised during deeper dives.



**Fig. 3.** Individual blue whales photographed in Comau Fjord. Blue whales are distinguished by the unique pattern of mottling on both sides of the body near the dorsal fin.

Taking into account their food consumption (Roman & McCarthy 2010), the activity of large whales has to have a significant impact on trophic processes, at least during certain times, in areas with regular presence of whales (Hucke-Gaete 2011) and needs to be taken into account in the trophic models and calculations of carrying capacities. However, the sporadic presence of the whales sighted in the Comau Fjord (mainly *Orcinus orca* (Linnaeus, 1758), see Häussermann et al. 2012, and *Balenopterus musculus*) and the particularity of their behaviour (feeding close to the surface) rather suggests a horizontal export of biomass and nutrients than a vertical recycling pump, as proposed by Roman and McCarthy (2010).

All these details indicate the necessity of geographically coordinated and all-season studies to get more data on the distribution and population size of

blue whales in the northern Patagonian Zone. Data that reveal the seasonality and fluctuation of primary production in the fjords are necessary to differentiate existing conclusions on the role of large cetaceans in the trophic systems in areas with limited water exchange.

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### References

- Abramson, J. Z. & Gibbons, J. 2010. New records of blue whales *Balaenoptera musculus* (Linnaeus, 1758) in winter season in the inlet waters of Chiloe Continental-Chile. *Anales Instituto Patagonia (Chile)* 38: 107-109.
- Acevedo-Gutiérrez, A., Croll, D. A. & Tershy, B. R. 2002. High feeding costs limit dive time in the largest whales. *The Journal of Experimental Biology* 205: 1747-1753.
- Aguayo-Lobo, A., Torres, D. & Acevedo, J. 1998. Los mamíferos marinos de Chile: I. Cetacea. *Serie Científica INACH* 48: 19-159.
- Aguayo, L. A. 1974. Baleen whales off continental Chile. Pp. 209-217 in: Schevill, W. E. (ed.). *The whale problem: a status report*. Cambridge, Massachusetts (Harvard University Press).
- Aracena, C., Lange, C. B., Iriarte, J. L., Rebolledo, L. & Pantoja, S. 2011. Latitudinal patterns of export production recorded in surface sediments of the Chilean Patagonian fjords (41-55°S) as a response to water column productivity. *Continental Shelf Research* 31: 340-355.
- Branch, T. A., Abubaker, E. M. N., Mkango, S. & Butterworth, D. S. 2007a. Separating southern blue whale subspecies based on length frequencies of sexually mature females. *Marine Mammal Science* 23: 803-833.
- , Stanford, K. M., Palacios, D. M., Allison, C., Banister, J. L., Burton, C. L. K., Cabrera, E., Carlson, C. A., Galletti, B., Gill, P. C., Hucce Gaete, R., Jenner, K. S., Jenner, M. N., Matsuoka, K., Mikhalev, Y. A., Miyashita, T., Morrice, M. G., Nishiwaki, S., Sturrock, V. J., Tormosov, D., Anderson, R. C., Baker, A. N., Best, P. B., Borsa, P., Brownell Jr., R. L., Childerhouse, S., Findlay, K. P., Gerrodette, T., Ilangakoon, A. D., Joergensen, M., Kahn, B., Ljungblad, D. K., Maughan, B., McCauley, R. D., McKay, S., Norris, T. F., Oman Whale and Dolphin Research Group, Rankin, S., Samaran, F., Thiele, D., Van Waerebeek, K. & Warneke, R. M. 2007b. Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and northern Indian Ocean. *Mammal Review* 37: 116-175.
- Cabrera, E., Carlson, C. A. & Galletti Vernazzani, B. 2005. Presence of blue whale (*Balaenoptera musculus*) in the northwestern coast of Chiloe Island, southern Chile. *LAJAM* 4: 73-74.
- Delgado, L. E. & Marin, V. H. 2006. Determinación de zonas de alta concentración de clorofila en la región norte de los fiordos y canales australes (Crucero Cimar 9 Fiordos) por medio de sensoramiento remoto. *Ciencia y Tecnología Marina* 29: 87-94.
- Galletti Vernazzani, B., Carlson, C. A., Cabrera, E. & Brownell Jr., R. L. 2012. Chilean blue whales off Isla Grande de Chiloe, 2004-2010: distribution, site-fidelity and behaviour. *Journal of Cetacean Research and Management* 12: 353-360.
- Goldburg, R. J., Elliott, M. S. & Naylor, R. L. 2001. *Marine Aquaculture in the United States: Environmental impacts and policy options*. 34 pp., Arlington, VA (Pew Oceans Commission).
- González, H. E., Calderón, M. J., Castro, L., Clement, A., Cuevas, L. A., Daneri, G., Iriarte, J. L., Lizárraga, L., Martínez, R., Menschel, E., Silva, N., Carrasco, C., Valenzuela, C., Vargas, C. A. & Molinet, C. 2010. Primary production and plankton dynamics in the Reloncaví Fjord and the Interior Sea of Chiloé, Northern Patagonia, Chile. *Marine Ecology Progress Series* 402: 13-30.
- Häussermann, V., Försterra, G. & Plotnek, E. 2012. Sightings of marine mammals and birds in the Comau Fjord, Northern Patagonia, between 2003 and mid 2012. *Spixiana* 35(2): 247-262.
- Honkanen, T. & Helminen, H. 2000. Impacts of fish farming on eutrophication: comparisons among different characteristics of ecosystem. *International Review of Hydrobiology* 85(5-6): 673-686.
- Hucce-Gaete, R. 2004. *Distribución, preferencia de hábitat y dinámica espacial de la ballena azul en Chile: 1997-2004*. Doctoral thesis, Universidad Austral de Chile, Valdivia.
- 2011. Whales might also be an important component in Patagonian fjord ecosystems: Comment to Iriarte et al. *AMBIO* (2011): A Journal of the Human Environment 40: 104-105.
- & Mate, B. 2005. Feeding season movements and fall migration to wintering areas for Chilean blue whales: 16th Biennial Conference on the Biology of Marine Mammals, San Diego, CA, USA.
- , Osman, L. P., Moreno, C. A., Findlay, K. P. & Ljungblad, D. K. 2004. Discovery of a blue whale feeding and nursing ground in southern Chile. *Proceedings of the Royal Society of London Series B* 271: 170-173.

- Iriarte, J. L., Gonzalez, H. E., Liu, K. K., Rivas, C. & Valenzuela, C. 2007. Spatial and temporal variability of chlorophyll and primary productivity in surface waters of Southern Chile (41.5–43°S). *Estuarine, Coastal and Shelf Science* 74: 471–480.
- Larkman, V. E. & Veit, R. R. 1998. Seasonality and abundance of blue whales off southern California. *CalCOFI Report nr 39*: 236–239.
- Leatherwood, S. & Reeves, R. R. 1983. *The Sierra Club handbook of whales and dolphins*. 302 pp., San Francisco.
- Roman, J. & McCarthy, J. 2010. The whale pump: marine mammals enhance primary productivity in a coastal basin. *PLoS ONE* 5: e13255. doi:10.1371/journal.pone.0013255
- Sears, R., Williamson, J. M., Wenzel, F. W., Bérubé, M., Gendron, D. & Jones, P. 1990. Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada. Pp. 335–342 in: *Reports of the International Whaling Commission (special issue)*.
- Sobarzo, M. 2009. The southern Chilean fjord region: oceanographic aspects. Pp. 53–60 in: Häussermann, V. & Försterra, G. (eds). *Marine benthic fauna of Chilean Patagonia*. 1000 pp., Puerto Montt, Chile (Nature in Focus).
- Stebbing, T. R. R. 1900. On some crustaceans from the Falkland Islands collected by Mr Rupert Vallentin. *Proceedings of the Zoological Society of London* 1900: 517–568.
- Viddi, F. A., Hucke-Gaete, R., Torres-Florez, J. P. & Ribeiro, S. 2010. Spatial and seasonal variability in cetacean distribution in the fjords of northern Patagonia, Chile. *ICES Journal of Marine Science* 67: 959–970.
- Williams, R., Hedley, S. L., Branch, T. A., Bravington, M. B., Zerbini, A. N. & Findlay, K. P. 2011. Chilean blue whales as a case study to illustrate methods to estimate abundance and evaluate conservation status of rare species. *Conservation Biology* 25: 526–535.