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A historical feeding ground for humpback whales in the eastern South Pacific revisited: the case of northern Patagonia, Chile

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ABSTRACT

1. Since 2000, an increasing number of humpback whale sightings have been recorded in northern Chilean Patagonia (mostly between 41.5°S and 44°S) from dedicated aerial and marine surveys and also opportunistic and land-based platforms during austral summer and autumn months.

2. Based on local knowledge from the early years of coastal whaling suggesting the historic presence of humpback whales in the area, and more recent observations confirming feeding groups, mother–calf pairs, and philopatry, it is proposed that a proportion of the eastern South Pacific humpback whales consistently use the Chiloe-Corcovado region to feed and nurse their young.

3. This mid-latitude area could be regarded as the northernmost feeding ground for humpback whales in South America, extending the previous known range some 1300 km north.

4. These findings provide further evidence for alternative life-strategies other than traditional migration and highlight the importance of northern Patagonian fjords to resolve questions that are central for large baleen whale conservation and management such as the extent and characteristics of spatio-temporal habitat use and overlap with human activities.

5. The need for future research on the migratory movements and population structure of this poorly understood population of humpback whales is emphasized, while an account is given of the threats they currently face.

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KEY WORDS: *Megaptera novaeangliae*; Corcovado gulf; Chiloense Ecoregion; philopatry; migration; photo-identification

INTRODUCTION

It is widely accepted that most baleen whales (Cetacea: Mysticeti) undertake seasonal migrations to feed in high-latitude productive waters during the summer and calve and mate in tropical waters during winter (Mackintosh, 1965; Clapham, 2000). Among these, the humpback whale (*Megaptera novaeangliae*, Borowski, 1781) is found in coastal or shelf waters throughout its cosmopolitan range, although it also travels across deep waters during migration (Dawbin, 1966; Clapham and Mead, 1999). This species was one of the first to be hunted commercially probably because of its preference for coastal waters during regular migrations and breeding, and its slower swimming speed compared with other rorqual whales (Tønnessen and Johnsen, 1982).

Eastern South Pacific humpback whales, also termed stock G by the International Whaling Commission, are known to migrate along the

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South American coast during austral autumn–winter towards breeding grounds located in coastal waters off Ecuador, Colombia, Panama and Costa Rica (Kellogg, 1929; Flórez-González, 1991; Rasmussen *et al.*, 2007). Previously, the feeding ground for this population was thought to be restricted to the Antarctic Peninsula's west coast (Kellogg, 1929). However, a second feeding area for humpback whales was recently reported further north, along the western end of the Magellan Strait (53°30′S), Chile, during the austral summer and autumn (Gibbons *et al.*, 2003; Acevedo, 2005).

This paper reports a third, and as yet unreported feeding ground located in mid-latitudes, based on a decade of observations, photographic identification, residence and philopatry information and also an examination of historical data from the modern whaling industry in Chilean waters. This paper adds to the understanding of the eastern South Pacific humpback whale population structure and life history.

METHODS

The study was carried out in waters west of Chiloe Island, the Gulf of Corcovado and the Chonos Archipelago (41–44°S), Chile, an area also recognized as the Chiloense Ecoregion (Spalding *et al.*, 2007). Data were collected between December 2000 and March 2010, through aerial surveys, land-based observations, ship-based platforms of opportunity and dedicated marine surveys. From 2004 onwards efforts have been concentrated in the Gulf of Corcovado, operating from the village of Melinka (43°53′S; 73°44′W) at Ascension Island, Chonos Archipelago.

Platforms of opportunity

Between December 2000 and November 2001, 14 cruises were carried out onboard tour and cargo ferries (Naviera Magallanes shipping company) operating from Puerto Montt (41°30'S) to Laguna San Rafael (47°S), some 600 km to the south (Viddi *et al.*, 2010). On board these platforms of opportunity, daily observations were made by two to six trained cetacean observers using 7×50 binoculars from the highest vantage point available on the ship, recording sightings, weather conditions and effort (for further details see Viddi *et al.*, 2010).

Aerial surveys

During the austral summer and early autumn 2003, nine dedicated aerial surveys were completed between Puerto Montt (41°30'S), Corcovado Gulf (43.5°S) and Adventure Bay (45°S). Platforms included single-engine Cessna, twin-engine Piper, a Chilean Air Force twin-otter and helicopters. All plane surveys were conducted at flight speeds of 90–130 knots, maintaining a fixed altitude of 500 m above sea-level (masl) and following non-random saw-tooth and linear transects. Flights were made within *c.*40 km of the coastline, only under Beaufort seastate ≤ 2. Data recorded included geographical position of animals (using a hand-held GPS), time of the sighting and group size.

Land-based observations

Land-based observations were made between 2006 and 2010 from a vantage point located about 80 masl on Ascension Island (43º53'S; 73º44'W, Chonos Archipelago), which has an open view-angle of *c.*150° facing the Corcovado Gulf and part of the Moraleda Channel. Two or three observers made daily observations divided into two periods of 4 h each. Each observer made continuous scans of the area, using 7×50, 10×50 binoculars or telescope. Whenever a sighting was made, focus was given to determining the species and confirming group size, which was conditional on the distance of animals from shore and weather conditions. After a sighting was achieved, observers guided a boat-based team to the whales through VHF radio for species and group size confirmation.

Boat-based surveys

In total, 167 days of dedicated marine surveys were undertaken in the area of the Corcovado Gulf and adjacent waters between 2003 and 2010, from late January through to mid-April. These surveys were undertaken mostly on board the 7.6 m semi-rigid hull inflatable research vessel *Musculus*. During all marine surveys, observers recorded the animals' geographic position using a hand-held GPS, time of sighting, group size and conspicuous behaviour (such as feeding, breaching or defecation). When possible, samples of potential prey aggregated on the surface were obtained using a hand-held sieve and preserved in 70% alcohol for species identification in the laboratory. Searching effort

was terminated when visibility and/or weather conditions were poor (i.e. strong winds, rain, fog or high sea-state).

Photo-identification

Photographs for individual identification were obtained from boat-based platforms whenever possible using the coloration pattern of the fluke's ventral area (Katona and Whitehead, 1981). Nikon D70, D100 and D300 digital cameras equipped with 70–300 mm and 80–200 mm lenses were used. Each picture was classified according to quality and scored from 1 to 3, taking into account focus, contrast, sharpness, angle and proportion of the fluke that was photographed (following Mizroch and Harkness, 2003). Only pictures with quality equal to 1 and 2 were used for further analysis.

Photographic data from identified animals were used to estimate a return rate to the Corcovado Gulf in accordance with Acevedo *et al.* (2006). The return rate was calculated as the proportion of identified animals re-sighted every following year, as follows:

$$Return\ rate = (Nrec/Ntot) \times 100$$

Where

Nrec = total number of identified whales during a year and re-sighted in the following years, and

Ntot = total number of whales identified during all years.

Historical whaling information

A detailed review was made from available literature and databases to obtain a general view of the situation during the onset of industrial whaling in Chile and establish the historical importance of the study area for whales. The International Whaling Commission's (IWC) Catch Database (version 5.0) (Allison, 2010) contains data from both member and non-member nations and was searched for humpback whales caught within the 20th century from Chilean waters. The database lists all catches of large whales reported to the IWC since 1900, except incidental catches. A sub-set of these data contains detailed information regarding individual catches such as, date, position, length, sex, stomach content, etc.

RESULTS

Historical presence of humpback whales off Chile

More than 6000 humpback whales were caught in Chilean waters (including Chilean operations in the South Shetlands, Antarctica) from 1907 to 1969 (Harmer, 1931 cited by Aguayo-Lobo *et al.*, 1998; Allison, 2010), however, there is quite a high level of uncertainty regarding associated data, including geographic positions of where the whales were caught. In view of this limitation, meta-analysis was restricted to coastal operations, which tended to provide more detailed information.

Data obtained from Allison (2010) and those reported by Pastene and Quiroz (2010) showed that during the first-half of the 20th century (particularly between 1903 and 1949) coastal whaling operations in Chile were mostly undertaken throughout a vast area ranging from South-Central Chile (37°S) to the Antarctic Peninsula, a period referred to by Pastene and Quiroz (2010) as the start of 'modern whaling' in Chile. During this period, catcher boats sailed from at least three coastal whaling stations (Guafo Island, San Pedro Island and Corral) belonging to at least five companies and returned to port for processing the catch. These companies operated within, but were not restricted to, the Chiloense Ecoregion. From these operations, detailed information regarding total catch (e.g. geographic position, length, sex, pregnant females, etc.) is available only from a subset of 54 humpback whales (Allison, 2010) caught from 1931 to 1935. From these, 50 humpback whales (95.2%) were captured between 42°S and 44°S (i.e. within the Chiloense Ecoregion) between September and April (austral spring, summer and early autumn) (Table 1).

A second phase, termed by Pastene and Quiroz (2010) as 'modern whaling and industrial development' was mostly developed from 1932 to 1983 north of the Chiloense Ecoregion, from Chome (37°S), Quintay (32°S) and Los Molles (20°S) land stations (Allison, 2010). More detailed information was recorded between 1947 and 1966 from 82 humpback whales. However, *c*.98% of these catches came from waters between 32°S and

Table 1. Humpback whales caught between 42° and 44°S from 1931 to 1935

Year	Number caught	Length (m)	Sex	Pregnant females
1931	1	14	F	-
1932	20	13–15	16 M - 4 F	2
1933	9	13–14	1 M - 8 F	-
1934	6	10–14	3 M - 3 F	-
1935	14	10–14	7 M - 7 F	-

38°S, so in the case of humpback whales and for comparative purposes, this second area, termed South-Central Chile, can be delineated by these latitudes.

Thus, a comparison between these two areas showed that humpback whale catches over a monthly basis peaked during different months and no catches were made during the austral winter (Figure 1). While most catches in the Chiloense Ecoregion (42–44°S) were consistently made from December to April (austral summer to early autumn), in South-Central Chile (32–38°S) two peaks are noted, one in May–June (late austral autumn) and another during October–November (austral spring). The latter seasonal pattern coincides with the traditional migratory timings of northward and southward whale movements, respectively.

Sightings during this study

From 2000 to 2010, 107 humpback whale groups (including 222 individuals), which included 19 calves, were sighted from marine and aerial platforms during 1123 h of effort (Figures 2 and 3(a)). Of these, only eight groups (24 individuals) were sighted from platforms of opportunity and have been reported previously (Viddi *et al.*, 2010). Land-based observations performed during 885 hours of effort between 2006 and 2010 provided an additional 96 sightings of 144 animals (Figure 3 (b)), which could occasionally include duplicates obtained from other platforms operating simultaneously in the Corcovado Gulf (Figure 2). Group size ranged from one to seven individuals

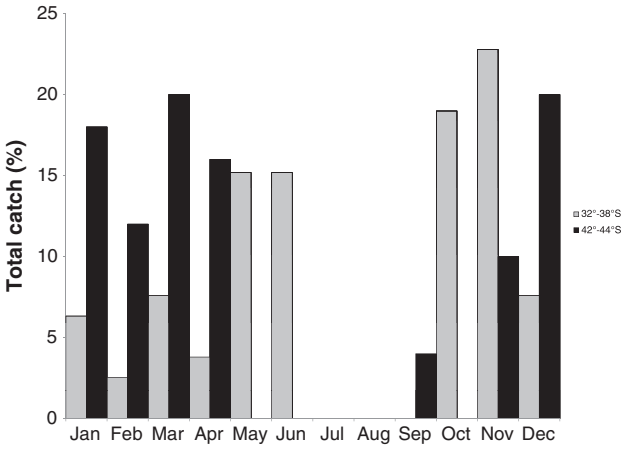

Figure 1. Monthly humpback whale catches made by the whaling industry operating from land stations along south-central Chile and northern Patagonia. Black bars indicate catches made in the Chiloense Ecoregion (42–44°S) from 1931 and 1935, and grey bars show catches made throughout central Chile (32–38°S) between 1933 and 1966 (data taken from Allison (2010)).

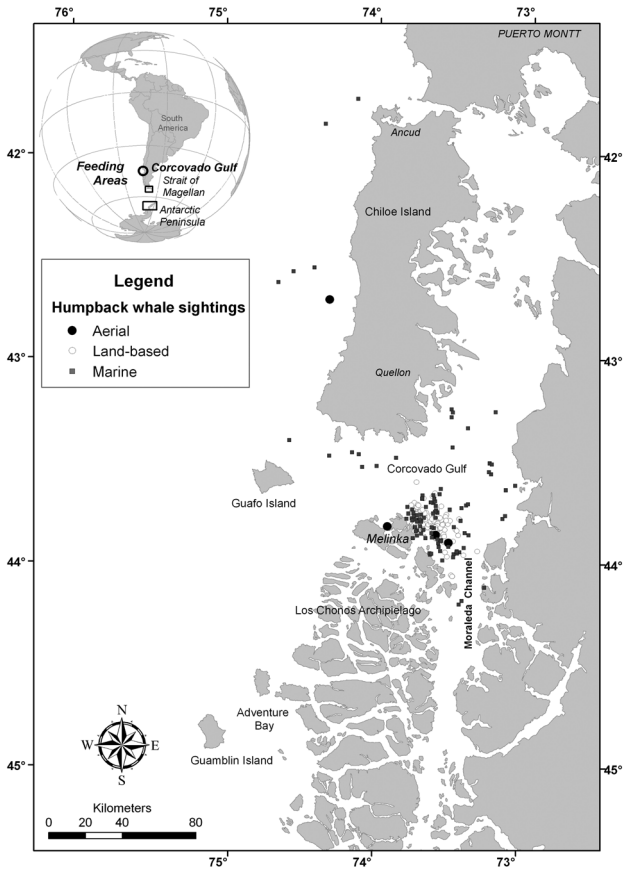

Figure 2. Humpback whale sightings recorded in the Chiloe–Corcovado region, southern Chile, between 2000 and 2010.

with a median of two. A great majority of sightings were made during summer and early autumn months (the period when most effort was concentrated) (Figure 3(a) and 3(b)).

Direct feeding events were first observed during 2004 at a distance, but from 2006 onwards group feeding (vertical and coordinated side lunges; *sensu* Jurasz and Jurasz (1979)) was confirmed on several occasions over swarms of *Euphausia valentinii* and *Munida* spp. (*M. subrugosa/gregaria*).

In total, 947 digital photographs of humpback whale flukes and dorsal fins were obtained from boat-based surveys between 2003 and 2010 of which 241 were of acceptable quality for further analysis. From the total number of individuals recognized by their fluke coloration patterns (n = 32), 10 were re-sighted with a maximum of 5 years since first identified (Table 2), resulting in a 31% return-rate to the Corcovado Gulf. Average residence time, based on re-sighted individuals during the same year was 14.8 days (95% CI = 8.23–21.46), however, some individuals remained in the study area for over a month.

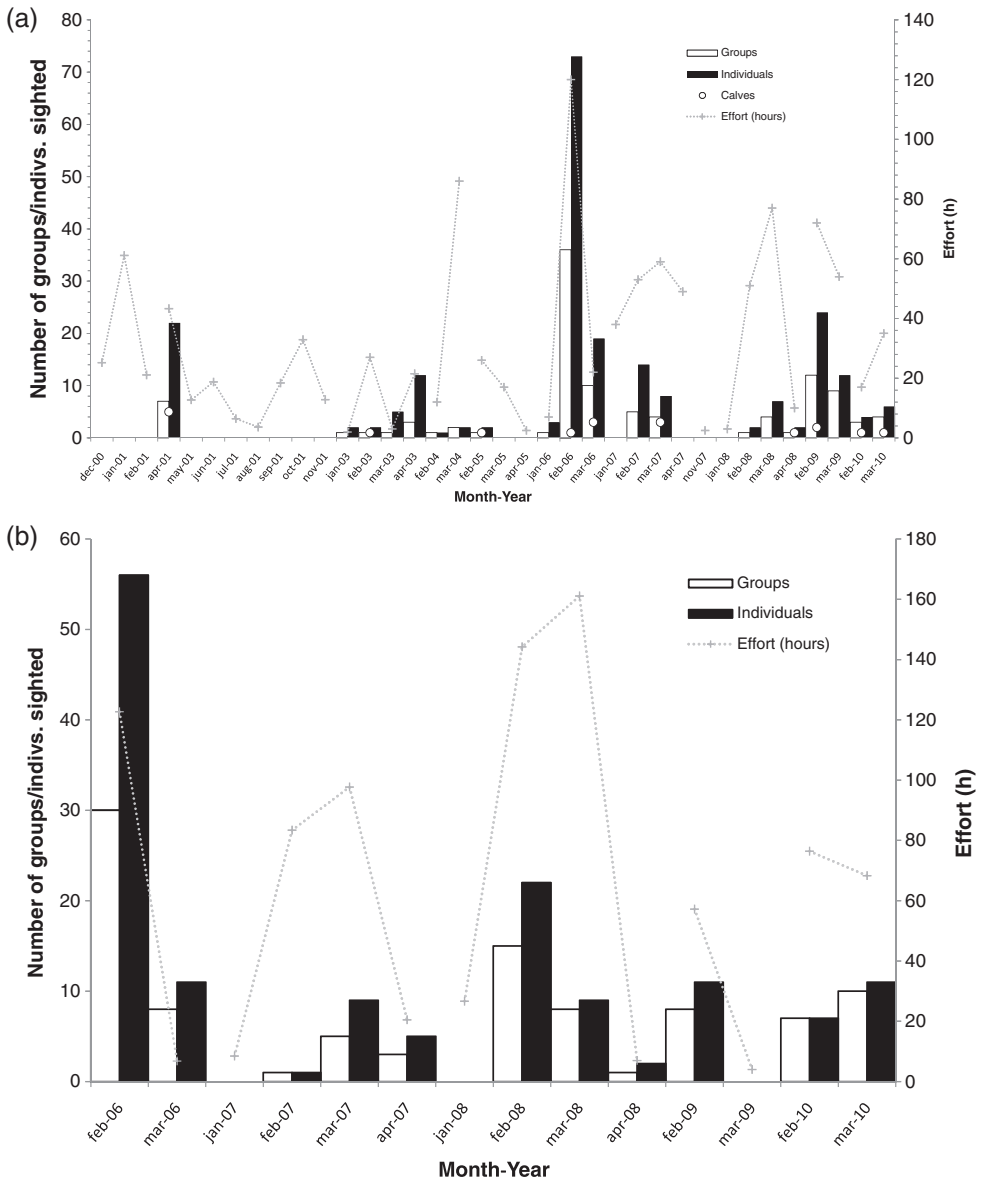

Figure 3. Humpback whale sightings and effort from (a) marine and aerial platforms and (b) land-based platforms between 2000 and 2010.

Table 2. Humpback whale photo-id recaptures between 2004 and 2010 in the Corcovado Gulf, northern Patagonia, Chile

#	Photo-id code	First capture date (dd/mm/yy)	Re-capture dates (dd/mm/yy)			Interval from first capture
1	CBA 003	08-03-2004	16-02-07	06-02-09		5 years
2	CBA 004	17-02-2005	10-03-06	25-02-09		4 years
3	CBA 006	30-01-2006	03-03-07			1 year
4	CBA 009	02-02-2006	03-03-09			3 years
5	CBA 013	06-02-2006	16-02-07	01-03-08	25-02-10	4 years
6	CBA 015	03-03-2006	16-02-07	01-03-08		2 years
7	CBA 016	10-03-2006	17-02-07	25-02-09		3 years
8	CBA 023	07-03-2007	02-02-09	28-02-10		3 years
9	CBA 026	02-02-2009	01-03-10			1 year
10	CBA 029	03-03-2009	01-03-10			1 year

DISCUSSION

Based upon several humpback whale feeding-event observations, mother–calf pair sightings, philopatry, analysis of historical catches and local knowledge from coastal whaling years (Townsend, 1935; pers. comm. Rene Saldivia (a local ex-whaler)), it is reasonable to suggest that Chilean northern Patagonia has been used consistently by humpback whales as a feeding ground since at least the early 1900s, when first reports from whaling in the area became available (Tønnessen and Johnsen, 1982). This occurrence is similar to that reported earlier for blue whales in the same region (Hucke-Gaete *et al.*, 2004).

Analysis of historical data from coastal whaling operations in Chile suggest that the study area was recognized as important by whalers (Martinic, 1973, 1977; Allison, 2010; Pastene and Quiroz, 2010). It is worthwhile noting that only two of the 23 female humpback whales caught in the Ecoregion between 1931 and 1935 were pregnant. This could be indicative that in the past the area was also used by mother–calf pairs as suggested by the number of calves sighted. Monthly takes from the Chiloense Ecoregion occurred mainly during austral summer, while catches from South Central Chile peaked at two different times, late autumn and spring, suggesting that the former area was (and possibly still is) used as a feeding ground and the latter as a migratory corridor towards the breeding grounds in the tropics. The aggregation of humpback whales reported here might therefore represent a segregated group of feeding whales, as occurs among other populations like the North-western Atlantic humpback whale which are known to use four to six different feeding areas linked to a single breeding ground (Katona and Beard, 1990; Stevick *et al.*, 2006). Best *et al.* (1995) and Barendse *et al.* (2010) also show that some humpback whales in South African waters use mid-latitudes for feeding and thus do not fully complete their traditional migrations to the southernmost feeding grounds, but remain in the productive waters of the Benguela upwelling system.

Humpback whales in northern Patagonia were recorded between February and April coinciding with the sightings peak reported for the Magellan Strait (Acevedo, 2005) and Western Antarctic Peninsula (Mackintosh, 1965; Thiele *et al.*, 2004). Thus, it is unlikely that whales present in the Corcovado Gulf during summer months are migrating further south to feeding grounds within the Magellan Strait (or the west coast of the Antarctic Peninsula) so late in the feeding season. Whales would be arriving at those feeding grounds during autumn, leading to an extremely short residence time there, thus making such a migration energetically inefficient. Unpublished 2009 data from Haro supports this hypothesis when comparing photographically identified whales from the Chiloense Ecoregion (n = 32) with those identified in the Magellan Strait (n = 107), finding no matches.

Reported return rates to feeding grounds are usually as high as 70% for Alaska (Gabriele, 1997), 71–88% for California (Calambokidis *et al.*, 1996) and 78.9% for the Magellan Strait (Acevedo *et al.*, 2006). The reported 31% in the present study could be explained by the few large-scale surveys undertaken to date and the fluctuating effort dedicated to humpback whales over the years while blue whales have remained the research priority. Because of the study area's size, circulation patterns and prey patchiness, the commutation of some individuals to adjacent and dynamic feeding areas could have precluded re-sighting of some whales during the study period and thus further studies should consider revising the scale at which research is undertaken.

The occurrence of this mid-latitude feeding ground does not agree with the paradigm of large whale migration between the poles and tropics, adding to the mounting evidence from other areas (Best *et al.*, 1995; Papastavrou and Van Waerebeek, 1997; Hucke-Gaete, 2004; Barendse *et al.*, 2010). We propose that a fraction of the eastern South Pacific humpback whale population is using an alternative life strategy, such as the selection, preference and use of predictable productive areas along mid-latitudes. This strategy would allow some whales to obviate traditional migratory movements between the high latitudes and the tropics, by simultaneously (or sequentially) exploiting different productive centres along the eastern South Pacific. The Corcovado Gulf could be regarded as the northernmost feeding ground for humpback whales in South America, extending previous records (Carlos III Island, Magellan Strait) some 1300 km north.

These findings provide further evidence that highlight the importance of northern Patagonian fjords for large baleen whale conservation and the need for continued research. Seasonal high productivity in the Chiloense Ecoregion has been highlighted previously (Silva *et al.*, 1997; Avaria *et al.*, 2004; Hucke-Gaete, 2004; Viddi *et al.*, 2010), as well as its potential (and

vulnerability) as a major 'CO_2 sink' (Iriarte *et al.*, 2010). This area also comprises the habitat of several fish and invertebrate species of economic importance and has been depicted as one of the most important blue whale (*Balaenoptera musculus*) feeding and nursing grounds in the entire Southern Hemisphere (Hucke-Gaete *et al.*, 2004; Branch *et al.*, 2007). The ecological role of large whales might be an important and largely overlooked missing piece in the puzzle of why some areas of the Patagonian fjords such as the Chiloense Ecoregion are highly productive, even more so than more northerly coastal upwelling areas (Hucke-Gaete, 2004). In this sense, whales make an appealing biological model for exploring their overall influence on primary productivity dynamics, ecological community structuring and ecosystem functioning (Hucke-Gaete, 2011).

The coastal habitats exploited by whales in this Ecoregion and their prevalent concentration in well-defined areas for feeding make them vulnerable to human activities such as fishing, vessel traffic, aquaculture, point and non-point source pollution, as well as unregulated tourism, among others. In particular, salmon farming which operates using: (i) open-cage net pens; (ii) moorings and anchoring; (iii) external supplementary feeding (rich in phosphorus and nitrogen); and (iv) a significant quantity of chemical products (antimicrobials and pesticides) can have significant impacts on the environment (Buschmann *et al.*, 1996; Naylor *et al.*, 2000).

For example, a humpback whale calf became entangled in a salmon farm's 'anti sea lion' nets during the austral summer of 2007 (Figure 4). Additional (albeit less visible) impacts coming from eutrophication (Folke *et al.*, 1994) and the use of antibiotics (Cabello, 2006; Fortt *et al.*, 2007) and pesticides (Buschmann *et al.*, 2009) are a matter of concern since they can affect the food web at several scales (Buschmann *et al.*, 2009).

The Chiloe inner sea, the Corcovado Gulf and channels further south are also a main navigational route between ports of the region and the Pacific Ocean (mainly serving Puerto Montt, Quellon, Chaiten, Melinka, Raul Marin Balmaceda and Puerto Aysen). The level of ship traffic has increased considerably during the last decade as a result of more cargo and supply shipping for the salmon farming industry, as well as public transportation, tour boats and fishing. The main threats originating from shipping traffic are collisions with animals such as cetaceans, noise pollution, and accidents (especially oil spills). There are records of boat collisions with blue whales in the Corcovado Gulf (Hucke-Gaete *et al.*, 2005) whereas Ribeiro *et al.* (2005) have shown that Chilean dolphins in southern Chiloe Island react negatively to boat presence, with behavioural responses such as changes in swimming reorientation rate and speed.

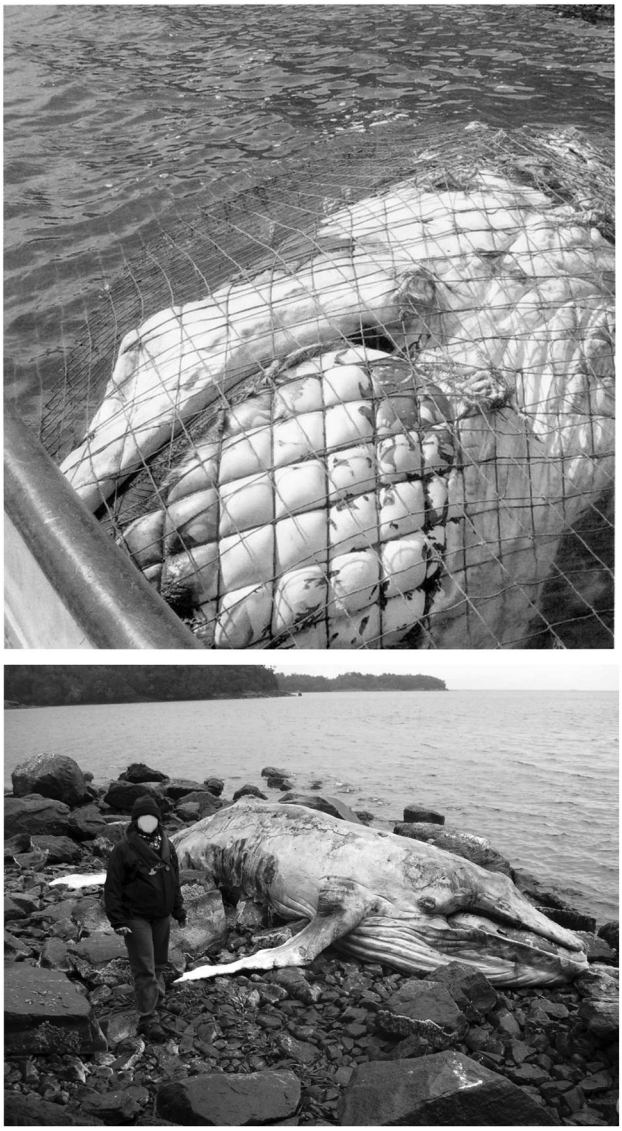

Figure 4. Humpback whale calf by-caught on a salmon farm net in northern Patagonia. Upper panel shows entangled whale's left hand-side head with swollen tongue protruding; Lower panel shows the same animal beached nearby; notice its small size in relation to the person standing.

Conservation of whales and other less emblematic species can be achieved by motivating

the adoption of better practices among those engaged in activities with the worst environmental impact. The aim should be to maintain a healthy and functional ecosystem under a legal structure such as a multiple-use marine protected area (MUMPA), based on an integrated conservation plan (Hucke-Gaete *et al*., 2010). To safeguard a specific population, an optimal protected area would encompass that population's year-round distribution (Reeves, 2000). However, for many large marine predators, the year-round distribution of a population may span entire ocean basins, as is particularly the case for blue and humpback whales observed in the Chiloense Ecoregion.

The question therefore becomes whether limited spatial protection of specific parts of a species' range is worthwhile. The answer is very likely yes, for even if a predator used the protected area for only a portion of its life span, this would reduce the frequency with which each individual is exposed to certain impacts and diminish the overall cumulative impact of other threats. It is desirable that the attainment of such a needed conservation strategy is guided by consensus, participation and support of local communities, stakeholders and authorities.

Because of the highly dynamic characteristics of marine ecosystems, research and monitoring data must be an important aspect in the future management and administration of this potential MUMPA that should form part of a regional network that protects seas where critical life-history stages of whales, such as breeding, calving, maternal care, feeding and migration, take place. It appears to stand to reason that Chile needs to step-up its marine conservation initiatives to succeed in accomplishing national and international commitments related to environmental sustainability and the intimately related issue of human welfare (Sachs *et al*., 2009).

Bringing about this change goes well beyond Chile's moral stewardship obligation. In fact, keeping its seas healthy constitutes a critical priority for a large proportion of the population which derives value from the seas, such as those engaged in fishing, fish farming, tourism and recreation, shipping and transport. By affecting trophic chains and polluting the waters with both chemicals and noise, humans are threatening the very livelihoods of coastal populations.

Conserving Chile's marine natural heritage will require a high level of political will, accompanied by ambitious government plans and funding. This goal will also benefit from more fluent communication between policy-makers, scientists, NGOs, and other stakeholders. A 'sea of change' in its political dynamics will be necessary for Chile to look after its valuable seas in a sustainable manner.

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REFERENCES

Acevedo J. 2005. Distribución, filopatría, residencia e identidad poblacional de la ballena jorobada, Megaptera novaeangliae, que se alimentan en las aguas del estrecho de Magallanes, Chile. MSc Thesis, Universidad de Magallanes, Chile.

Acevedo J, Aguayo-Lobo A, Pastene L. 2006. Filopatría de la ballena jorobada (*Megaptera novaeangliae* Borowski, 1781), al área de alimentación del estrecho de Magallanes. *Revista de Biología Marina y Oceanografía* **41**: 11–19.

Aguayo-Lobo A, Torres D, Acevedo J. 1998. Los Mamíferos Marinos de Chile: I. Cetacea. *Serie Científica INACH* **48**: 19–159.

Allison C. 2010. International Whaling Commission Summary Catch Database Version 5.0. Available from the IWC Secretariat. [1 October 2010].

Avaria S, Cáceres C, Muñoz P. 2004. Distribución del microfitoplancton marino entre el Golfo Corcovado y el Estero Elefantes en la primavera de 1998 y en el verano de 1999 (Crucero Cimar 4 Fiordos). *Ciencia y Tecnología del Mar* **27**: 17–47.

Barendse J, Best PB, Thornton M, Pomilla C, Rosenbaum HC, Henríquez L. 2010. Migration redefined? Seasonality, movements and group composition of humpback whales Megaptera novaeangliae off the west coast of South Africa. *African Journal of Marine Science* **32**(1): 1–22.

Best P, Sekiguchi K, Findlay KP. 1995. A suspended migration of humpback whales *Megaptera novaeangliae* on the west coast of South Africa. *Marine Ecology Progress Series* **118**: 1–12.

Branch TA, Stafford KM, Palacios DM, Allison C, Bannister JL, Burton CLK, Cabrera E, Carlson CA, Galletti Vernazzani B, Gill PC, *et al*. 2007. Past and present distribution, densities and movements of blue whales in the Southern Hemisphere and adjacent waters. *Mammal Review* **37**: 116–175.

Buschmann AH, López DA, Medina A. 1996. A review of the environmental effects and alternative production strategies of marine aquaculture in Chile. *Aquacultural Engineering* **15**: 397–421.

Buschmann A, Cabello F, Young K, Carvajal J, Varela DA, Henríquez L. 2009. Salmon aquaculture and coastal ecosystem health in Chile: analysis of regulations, environmental impacts and bioremediation systems. *Ocean and Coastal Management* **52**: 243–249.

Cabello C. 2006. Heavy use of prophylactic antibiotics in aquaculture: a growing problem for human and animal health and for the environment. *Environmental Microbiology* **8**: 1137–1144.

Calambokidis J, Steiger GH, Evenson JR, Flynn KR. 1996. Interchange and isolation of humpback whales off California and other North Pacific feeding grounds. *Marine Mammal Science* **12**: 215–226.

Clapham PJ. 2000. The humpback whale: seasonal feeding and breeding in a baleen whale. In *Cetacean Societies: Field Studies of Dolphins and Whales*, Mann J, Connor RC, Tyack P, Whitehead HP (eds). University of Chicago Press: Chicago; 173–196.

Clapham PJ, Mead JG. 1999. Megaptera novaeangliae. *Mammalian Species* **604**: 1–9.

Dawbin WH. 1966. The seasonal migratory cycle of humpback whales. In *Whales, Dolphins and Porpoises*, Norris KS (ed.). University of California Press: Berkeley; 145–170.

Flórez-González L. 1991. Humpback whales *Megaptera novaeangliae* in the Gorgona Island, Colombian Pacific breeding waters: population and pod characteristics. *Memoirs of the Queensland Museum* **30**: 291–295.

Folke C, Kautsky N, Troell M. 1994. The costs of eutrophication from salmon farming: implications for policy. *Journal of Environmental Management* **40**: 173–182.

Fortt A, Cabello F, Buschmann A. 2007. Residuos de tetraciclina y quinolonas en peces silvestres en una zona costera donde se desarrolla la acuicultura del salmón en Chile. *Revista Chilena de Infectología* **24**: 14–18.

Gabriele CM. 1997. Comparison of humpback whale group dynamics between Hawai'i and Alaska. In *Report of the Workshop to Assess Research and Other Needs and Opportunities Related to Humpback Whale Management in the Hawaiian Islands*, Payne PM, Phillips B, Nitta E (eds). US Department of Commerce, NOAA Technical Memo: 31–37.

Gibbons J, Capella J, Valladares C. 2003. Rediscovery of a humpback whale (*Megaptera novaeangliae*) feeding ground in the Straits of Magellan, Chile. *Journal of Cetacean Research and Management* **5**: 203–208.

Harmer SF. 1931. Southern whaling. *Proceedings of the Linnaean Society of London* **142**: 85–163.

Hucke-Gaete R. 2004. Distribución, preferencia de hábitat y dinámica espacial de la ballena azul en Chile: 1997–2004. PhD Thesis, Universidad Austral de Chile, Chile.

Hucke-Gaete R. 2011. Whales might also be an important component in Patagonian fjord ecosystems: Reply to Iriarte *et al*. *Ambio* **40**: 104–105.

Hucke-Gaete R, Osman LP, Moreno CA, Findlay KP, Ljungblad DK. 2004. Discovery of a blue whale feeding and nursing ground in southern Chile. *Proceedings of the Royal Society of London Series B* **271**: S170–S173.

Hucke-Gaete R, Viddi FA, Bello ME. 2005. Blue whales off southern Chile: overview of research achievements and current conservation challenges. IWC Scientific Committee paper, SC/57/SH5, Ulsan, Korea S. [available from the International Whaling Commission, www.iwcoffice.org].

Hucke-Gaete R, Álvarez R, Navarro M, Ruiz J, Lo Moro P, Farías A. 2010. Investigación para Desarrollo de Área Marina Costera Protegida Chiloé-Palena-Guaitecas. Final Report FNDR-BID TURISMO Cód. BIP No. 30040215–0, Gobierno Regional de Los Lagos, Chile.

Iriarte JL, González HE, Nahuelhual L. 2010. Patagonian fjord ecosystems in southern Chile as a highly vulnerable region: problems and needs. *Ambio* **39**: 463–466.

Jurasz CM, Jurasz VP. 1979. Feeding modes of the humpback whale, *Megaptera novaeangliae*, in Southeast Alaska. *The Scientific Reports of the Whales Research Institute* **31**: 69–83.

Katona S, Whitehead HP. 1981. Identifying humpback whales using their natural markings. *Polar Record* **20**: 439–444.

Katona SK, Beard JA. 1990. Population size, migrations and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. *Report of International Whaling Commission* (*Special Issue*) **12**: 295–305.

Kellogg R. 1929. What is known of the migration of some of the whalebone whales. Smithsonian Institution. Annual Report of the Board of Regents, 467–494.

Mackintosh NA. 1965. *The stocks of whales*. Fishing News (Books) Ltd: London.

Martinic M. 1973. Actividad lobera y ballenera en litorales y aguas de Magallanes y Antártica, 1868–1916. *Revista Estudios del Pacífico* **7**: 7–26.

Martinic M. 1977. Antecedentes históricos sobre la caza de cetáceos en Chile. *Anales del Instituto de la Patagonia, Punta Arenas (Chile)* **8**: 313–315.

Mizroch SA, Harkness SAD. 2003. *A test of computer-assisted matching using the North Pacific humpback whale (Megaptera novaeangliae)* tail flukes photograph collection. Alaska Fisheries Science Centre: Washington, DC.

Naylor RL, Goldburg RJ, Primavera JH, Kausty N, Beveridger MCM, Clay J, Folke C, Lubchenco J, Mooney H, Troell M. 2000. Effects of aquaculture on world fish supplies. *Nature* **405**: 1017–1024.

Papastavrou V, Van Waerebeek K. 1997. A note on the occurrence of humpback whales (*Megaptera novaeangliae*) in tropical and subtropical areas: the upwelling link. *Report of the International Whaling Commission* **47**: 945–947.

Pastene LA, Quiroz D. 2010. An outline of the history of whaling in Chile. In *International Center for Folk Culture Studies*: *Human Culture from the Perspective of Traditional Maritime Communities, International Symposium Report No. 1*. Kanagawa Shimbun Press: Kanagawa; 73–98.

Rasmussen K, Palacios DM, Calambokidis J, Saborío MT, Dalla Rosa L, Secchi ER, Steiger GH, Allen JM, Stone GS. 2007. Southern Hemisphere humpback whales wintering off Central America: insights from water temperature into the longest mammalian migration. *Biology Letters* **3**: 302–305.

Reeves RR. 2000. The Value of Sanctuaries, Parks, and Reserves (Protected Areas) as Tools for Conserving Marine Mammals. Final Report to the Marine Mammal Commission, contract number T74465385. Marine Mammal Commission, Bethesda, MD.

Ribeiro S, Viddi FA, Freitas TRO. 2005. Behavioral responses by Chilean dolphins (*Cephalorhynchus eutropia*) to boats in Yaldad bay, Southern Chile. *Aquatic Mammals* **31**: 234–242.

Sachs JD, Baillie J, Sutherland WJ, Armsworth PR, Ash N, Beddington J, Blackburn TM, Collen B, Gardiner B, Gaston K, *et al*. 2009. Biodiversity conservation and the millennium development goals. *Science* **325**: 1502–1503.

Silva N, Calvete C, Sievers HA. 1997. Características oceanográficas físicas y químicas de canales australes

chilenos entre Puerto Montt y laguna San Rafael (Crucero Cimar-Fiordo 1). *Ciencia y Tecnología del Mar* **20**: 23–106.

Spalding MD, Fox HE, Allen GR, Davidson N, Ferdaña ZA, Finlayson M, Halpern BS, Jorge MA, Lombana A, Lourie SA, *et al*. 2007. Marine ecoregions of the world: a bioregionalization of coast and shelf areas. *BioScience* **57**: 573–583.

Stevick PT, Allen J, Clapham PJ, Katona SK, Larsen S, Lien J, Mattila DK, Palsbøll PJ, Sears R, Sigurjónsson J, *et al*. 2006. Population spatial structuring on the feeding grounds in North Atlantic humpback whales (*Megaptera novaeangliae*). *Journal of Zoology* **270**: 244–255.

Thiele D, Chester ET, Moore SE, Sirovic A, Hildebrand JA, Friedlander AS. 2004. Seasonal variability in whale encounters in the Western Antarctic Peninsula. *Deep Sea Research II* **51**: 2311–2325.

Tønnessen JN, Johnsen AO. 1982. *The History of Modern Whaling*. University of California Press: Berkeley, CA.

Townsend CH. 1935. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica NY* **19**: 1–50.

Viddi FA, Hucke-Gaete R, Torres-Florez JP, Ribeiro S. 2010. Spatial and temporal variability of cetacean distribution in the fjords of northern Patagonia, Chile. *ICES Journal of Marine Science* **67**: 959–970.