

# Migrations of individually identified humpback whales between the Antarctic Peninsula and South America

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## ABSTRACT

Considerable uncertainty exists regarding the migratory destinations of humpback whales (*Megaptera novaeangliae*) from the Antarctic Peninsula region and the breeding grounds off the coasts of South America. Evidence is presented on the migratory patterns of Antarctic humpback whales based upon movements of individuals identified by natural markings as part of a large-scale international collaboration. Recapture rates were compared between animals from the low latitude breeding and calving areas along the northeastern ( $n=288$ ) and northwestern ( $n=325$ ) margins of South America with those identified in the high-latitude feeding areas in the region of the Antarctic Peninsula ( $n=535$ ). The number of individuals re-sighted in the Antarctic Peninsula differed dramatically between eastern and western South America ( $\chi^2=40.98, p=1.5 \times 10^{-10}$ ). No individuals from Brazil were re-sighted in either the Antarctic Peninsula or off western South America. In contrast, 43 individuals from western South America were identified off the Antarctic Peninsula. These findings suggest that the northwest coast of South America represents an important breeding ground destination for at least some of the humpback whales that feed near the Antarctic Peninsula, but provide no support for movement between the Antarctic Peninsula and the east coast of South America.

KEYWORDS: HUMPBACK WHALE; SOUTH AMERICA; ANTARCTIC; MIGRATION; PHOTO-ID

## INTRODUCTION

In the Southern Hemisphere, humpback whales (*Megaptera novaeangliae*) feed in Antarctic waters during austral summer, and migrate to tropical areas for breeding and calving during the austral winter (for a species review see Clapham and Mead, 1999). Historically, six management areas for baleen whales in Antarctic waters were defined by the International Whaling Commission based principally on the density of commercial catches, but also on limited data on individual movements based on tag returns and limited data on pigment variations (reviewed by Donovan, 1991). More recently, seven geographically defined breeding and calving areas have been identified (Rice, 1998; IWC, 1998). The patterns of movement within some seasonal habitats and/or the migratory destinations of individuals have been examined by tagging with Discovery tags (e.g. Chittleborough, 1965) and by identification by natural markings (e.g. Kaufman *et al.*, 1990; Stone *et al.*, 1990; Garrigue *et al.*, 2002). Discovery tagging was principally conducted in Areas IV and V (70°E to 170°W) and the breeding areas at corresponding longitudes leading to better documentation of migratory behaviour in these waters. In

contrast, information on the long-distance movements of individuals from Antarctic Areas I and II (0° to 120°W) is more limited.

The waters of Area II were one of the principal areas of humpback whaling during the early years of the modern Southern Hemisphere industrial whale fishery (Tonnessen and Johnsen, 1982). Over 50,000 humpback whales were reported taken between 1909 and 1915, principally in the waters around South Georgia (Mackintosh, 1942). Antarctic humpback whaling in Area I was of considerably less importance, presumably reflecting a smaller pre-whaling population in the region (Mackintosh, 1965). On the breeding grounds, catches were made on both sides of South America by the 19<sup>th</sup> century non-mechanised whale fishery (Kellogg, 1929; Scammon, 1874; Townsend, 1935) and later by industrial whaling operations (Mackintosh, 1965; Tonnessen and Johnsen, 1982). A total of 1,542 humpbacks were taken off Paraíba, northeastern Brazil prior to 1963 and at least 10 were taken off Arraial do Cabo, Rio de Janeiro State, southeastern Brazil between 1960-1963 (Paiva and Grangeiro, 1965). A small-boat fishery in Abrolhos Bank, northeastern Brazil, killed an unknown number of humpbacks. The last whale harpooned was in

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1929 (Lodi, 1992). Along the western coast of South America, land stations in Peru and Chile processed 2,281 humpback whales between 1908 and 1975 (Clarke, 1980).

Much of the exploitation in these areas occurred before the advent of systematic collection of biological data on catches and before the development of the Discovery tag (Brown, 1978), limiting the amount of data available for analysis. Only one long-distance recovery of a Discovery tag has been reported for Area I (Dawbin, 1964) and none for Area II. The end of legal hunting of humpback whales in the Southern Hemisphere in 1963-1964 (Best, 1993) effectively ended the use of Discovery marks for the study of humpback movements. Illegal and unreported catches were numerous and widespread in the Southern Hemisphere both before and after the end of legal hunting (Tonnessen and Johnsen, 1982; Yablokov, 1994), but by their very nature these resulted in few data. Only two re-sightings have been reported between the Antarctic Peninsula and Colombia based upon natural markings (Garrigue *et al.*, 2002; Stone *et al.*, 1990). Considerable uncertainty exists, therefore, regarding the specific migratory destinations of humpbacks from the Antarctic Peninsula region and the breeding grounds off the coasts of South America.

This paper presents evidence of the migratory patterns of humpback whales between the high-latitude feeding areas in the region of the Antarctic Peninsula and the low-latitude breeding and calving areas along the eastern and western margins of South America. These results are based upon movements of individual whales identified by natural markings as part of a large-scale international collaboration.

## METHODS

Individual humpback whales were identified from photographs of the natural markings and permanent scars on the ventral side of the flukes (Katona *et al.*, 1979). A

collection of identification photographs from throughout the Southern Hemisphere is maintained at College of the Atlantic, Bar Harbor, Maine USA. This Antarctic Humpback Whale Catalogue (AHWC) is a collaborative effort involving numerous individual or institutional contributors. The majority of photographs were collected by research groups or by naturalists and tourists aboard cruise ships or whalewatching vessels. Because of the opportunistic nature of this collection there is considerable spatial and temporal variability in the distribution of sightings. Photographs included in these analyses were taken between 1984 and 2002. Photographic comparison was conducted as described in Katona and Beard (1990).

Analyses reported here utilised samples from three geographic regions (Fig. 1). The feeding area sample comprised photographs collected between 1981 and 2002 along the west coast of the Antarctic Peninsula, extending approximately from Elephant Island (61°01'S, 45°54'W) to Detaille Island (66°50'S, 66°50'W). All sightings were near the coast of the Peninsula or the adjacent islands. Most sightings are from Area I. A small number of sightings near the tip of the Peninsula were made east of 60°W and therefore in Area II, but no distinction is made in this analysis between animals sampled in the different management areas. Photographs from the eastern coast of South America were collected from Brazil from 1988 to 1999 principally in the waters around Abrolhos Marine National Park (17°20'-18°10'S, 38°35'-39°20'W) at Abrolhos Bank, and Cabo de Sao Tome (22°S, 40°W). Along the western margin of South America, most photographs were taken near Isla Plata off Machalilla National Park (01°16'S, 81°06'W) on the coast of Ecuador from 1988 to 2000 (Félix and Haase, 2001; Scheidat *et al.*, 2000), and off Colombia from 1986 to 2000 primarily in the region of Isla Gorgona in the Gorgona Island National Park (02°47'N, 78°18'W) (Flórez-González, 1991).

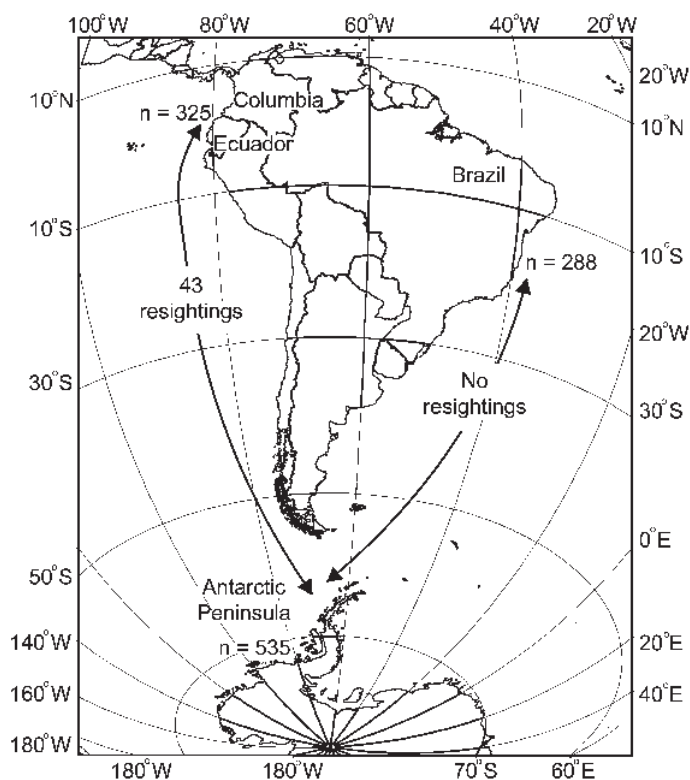


Fig. 1. Regions where photographs were collected, sample sizes and numbers of re-sightings. Arrows serve to connect potential migratory endpoints and are not intended to indicate routes of travel.

The rate of errors in identification by natural markings, and thus the re-sighting rate, is related to the quality of photographs used in comparison (Stevick *et al.*, 2001). In these analyses only differences in photographic quality between eastern and western South America will produce bias in the results. The distribution of the poorest quality photographs does not differ significantly between the samples from these two areas ( $\chi^2=2.18$ ,  $p=0.14$ ). The proportion of the poorest quality photographs is slightly higher in the sample from the west coast (west 0.24, east 0.18). Thus the probability of missing a re-sighting because of poor photographic quality is greater in the region with the higher re-sighting rate, and so any bias resulting from photo quality differences is conservative in this case. Therefore photographs of all qualities are included in order to maximise the available sample size.

## RESULTS

A total of 1,105 individuals was identified. Table 1 presents the number of individuals identified in each sampling region and the number of re-sightings between regions. There were eight individuals in common to the Ecuador and Colombia samples, and re-sightings to the Antarctic Peninsula from these two regions occurred at a similar rate ( $\chi^2=1.33$ ,  $p=0.25$ ). Movement of individuals between Ecuador and Colombia has been previously demonstrated (Flórez-González *et al.*, 1998). Thus, although approximately 470km separate the sampling areas off Colombia and Ecuador, these two samples were combined into a single western South America sample.

Table 1

The numbers of individual humpback whales identified in each of the sampling areas and the number of individuals re-sighted between areas.

Region	Individuals	AP	B	E
Antarctic Peninsula (AP)	535			
Brazil (B)	288	0		
Western South America (WSA)	325	43	0	
Ecuador (E)	254	32	0	
Colombia (C)	79	14	0	8

Re-sightings to the Antarctic Peninsula differed dramatically between eastern and western South America. No individuals from Brazil were re-sighted in either the Antarctic or off western South America. In contrast, 43 individuals from western South America were identified off the Antarctic Peninsula ( $\chi^2 = 40.98$ ,  $p=1.54 \times 10^{-10}$ ).

## DISCUSSION

Previous speculation on the migratory patterns of humpback whales from South American waters has been based primarily upon indirect evidence rather than on the movement of tagged individuals or shared genetic markers. For humpback whales generally, there is not a one-to-one correlation between feeding grounds and breeding grounds. Rather, individuals from different feeding areas may congregate at a common breeding area (Chittleborough, 1965; Katona and Beard, 1990; Calambokidis *et al.*, 2001; Stevick *et al.*, 2003) and individuals from different breeding areas may feed in the same area (Chittleborough, 1965; Calambokidis *et al.*, 2001). This complicates interpretation

of movement patterns when data are sparse, and different authors have reached contradictory conclusions.

There has been general agreement that humpback whales from the west coast of South America feed in Area I (Kellogg, 1929; Tomilin, 1957; Mackintosh, 1965; Slijper, 1979; Winn and Reichley, 1985; Evans, 1987). However some authors suggest a primary high-latitude destination in pelagic waters from 80°W to 120°W (Mackintosh, 1965; Winn and Reichley, 1985; Evans, 1987), while others propose a coastal distribution along the Antarctic Peninsula (Kellogg, 1929) or in the waters from the Peninsula west to about 80°W (Tomilin, 1957; Slijper, 1979). Few data have been available to bolster any of these suggestions. The single return for a Discovery tag to Area I was of an individual marked in Tonga recovered at 95°45'W in the Bellingshausen Sea (Dawbin, 1964). Surveys conducted between 1976/77 and 1987/88 have resulted in very low sighting rates for humpback whales from 80°W to 120°W, with substantially greater numbers observed near the Antarctic Peninsula (Kasamatsu *et al.*, 1996). Two re-sightings between the Antarctic Peninsula and Colombia have been documented based upon natural markings (Stone *et al.*, 1990; Garrigue *et al.*, 2002). In addition to the movements of individuals demonstrated here, the distribution of mitochondrial genetic markers supports a strong affinity between animals sampled to the west of the Antarctic Peninsula and those from Colombian waters, and a lack of affinity between these individuals and those sampled elsewhere in the Southern Hemisphere (Olavarría *et al.*, 2000; Caballero *et al.*, 2001).

Two principal opinions have been advanced regarding the high-latitude destination of individuals from Brazil. Most authors suggest a destination in Area II, commonly in the waters near South Georgia (e.g. Slijper, 1979; Tomilin, 1957). Others, however, indicate (with varying levels of uncertainty) movement by some individuals from Brazil to the Antarctic Peninsula area (Mackintosh, 1965; Slijper, 1979; Evans, 1987). Modern sighting and stranding patterns off Brazil do not support a coastal migration to or from waters to the southwest, but are more consistent with an offshore migration, suggesting a feeding area to the south or southeast (Siciliano *et al.*, 1999). The lack of re-sightings between Brazil and the Antarctic Peninsula is more consistent with the suggestion that humpback whales that breed in Brazil feed primarily in waters to the east of the Antarctic Peninsula. Because of the historical importance of humpback whaling near South Georgia, this region would appear to be a likely feeding area for whales breeding off Brazil (Mackintosh, 1965). However there is little evidence for any concentration of humpback whales in the region of South Georgia in recent years (Moore *et al.*, 1999), and the sighting rate for humpback whales during systematic surveys conducted from 1976/77 to 1987/88 is low in the waters between 20°W and 40°W (Kasamatsu *et al.*, 1996) where the highest historic concentration occurred (e.g. Slijper, 1979). Additionally, there has, to date, been little photographic coverage in Area II making it difficult to investigate movements of individuals in this region. Thus, the current feeding ground destination for Brazilian whales remains unknown (Siciliano *et al.*, 1999) and there is not a clear candidate region within Area II.

Our findings suggest that the northwest coast of South America represents an important breeding ground destination for at least some of the humpback whales that feed near the Antarctic Peninsula. In contrast, they provide no support for movement from the Antarctic Peninsula to the east coast of South America.

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