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Return movement of a humpback whale between the Antarctic Peninsula and American Samoa: a seasonal migration record

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ABSTRACT: Humpback whales *Megaptera novaeangliae* are seasonal migrants that mate and calve at low latitudes and feed at mid- to high latitudes. Connections between most Southern Hemisphere breeding and feeding areas are not well understood, but are critical for assessing stock structure and human impacts. Photo-identification was performed to identify the feeding grounds of an Endangered sub-population that breeds in the central South Pacific Ocean (CSP). Identification photographs were obtained from 159 ind. at American Samoa and compared to 3508 Southern Hemisphere humpback whales in the Antarctic Humpback Whale Catalogue (AHWC), including 1352 from Antarctic feeding grounds. Two individuals from American Samoa were seen on 3 occasions at the Antarctic Peninsula. This is the first known feeding site for American Samoa and one of few reliably identified for the CSP. AHWC #2950 was confirmed to have undertaken a round-trip movement of no less than 18 840 km, spanning 108 longitudinal degrees. This represents the largest mammalian migration known to date and a departure from historical assumptions about CSP migratory patterns. The frequency, causes, and fitness implications of such movements have yet to be determined. However, distance is the only known extrinsic barrier to humpback whale movement within oceans, and so maximum individual range is 1 factor potentially affecting population exchange and colonization of new habitats. The movement documented here may place this Endangered sub-population at risk if conservation efforts are relaxed in unidentified parts of its range. Yet, the ability of humpback whales to undertake such extensive movements may have also contributed to the apparent recovery of some populations versus other historically exploited whale species.

KEY WORDS: Migration · Humpback whale · Photo-ID · Spatial distribution · Conservation

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INTRODUCTION

Humpback whales *Megaptera novaeangliae* are seasonal migrants that divide the year between low lati-

tude breeding grounds and mid- to high-latitude feeding grounds. In the South Pacific, humpback whales mate and calve in tropical waters ranging from the east coast of Australia to South America. The International

Whaling Commission (IWC) recognizes 3 distinct South Pacific breeding stocks and sub-stocks with limited longitudinal exchange (IWC 1998, Olavarría et al. 2007). Historically, individuals within a breeding stock were assumed to migrate more or less directly south to a corresponding Antarctic management area. However, the only 2 Discovery Tags (uniquely marked steel cylinders fired into live whales and recovered from carcasses in order to study whale movement during the whaling era) reliably linking central South Pacific Ocean (CSP) breeding areas to Antarctic feeding areas involved horizontal displacements of 10° and 90° (Table 1). More recent studies have detected considerable horizontal movement within the CSP (Garrigue et al. in press) as well as on Antarctic feeding grounds (Dalla Rosa et al. 2008). However, new data on seasonal migrations from the CSP have been limited (Hauser et al. 2010, D. Steel et al. unpubl. [Paper SC/60/SH 13 presented to the International Whaling Commission, IWC, Scientific Committee, May 2008. Available from the IWC.]).

Southern Hemisphere humpback whales were heavily depleted by commercial whaling in the 19th and 20th centuries (Chapman 1974, Clapham & Baker 2002). Although the International Union for the Conservation of Nature (IUCN) no longer considers this

species to be at risk of global extinction (Reilly et al. 2008), CSP populations have recently been elevated to an Endangered status (Childerhouse et al. 2008). Consequently, their range, migratory connections and critical habitats are of particular concern.

Here, we report the first known feeding site for humpback whales from American Samoa, one breeding area in the CSP. This finding involves the largest seasonal migration on record for a mammal, both in terms of its distance and horizontal displacement. It has potential implications for both the management of this endangered population and the resilience of this species.

MATERIALS AND METHODS

Humpback whale surveys were conducted annually in the near-shore waters of Tutuila, the main island of American Samoa, between 2003 and 2008. In total, 159 individual humpback whales were identified from the ventral pigmentation and shape of the flukes using established techniques (Katona & Whitehead 1981). Fluke images and associated data were shared with several institutions, including the Antarctic Humpback Whale Catalogue (AHWC). They were visually compared to

Table 1. *Megaptera novaeangliae*. Published humpback whale movements between central South Pacific (CSP) breeding grounds and International Whaling Commission Antarctic management areas. The 2 'Movement' columns give the respective areas, with geographical coordinates (where reported), and dates for the start and end of the recorded movements. Two additional Discovery Tags indicated migration between the CSP and Antarctic Areas IV or I, but the former was listed as a fin whale when tagged (Mikhalev & Tormosov 1997) and the latter could not be linked to a specific catch location (IWC 1998). AHWC: Antarctic Humpback Whale Catalogue

ID	Movement		Distance		Time elapsed (yr)	Source
	Start	End	km	longitude (°)		
Discovery Tag 11201	Tonga 21° 02' S, 175° 08' W 17 Oct 1952	Area I 68° 01' S, 95° 45' W 3 Feb 1957	7413	90	4.3	Brown (1957)
Discovery Tags 19946-7	Area V 66° 37' S, 174° 48' E 28 Dec 1957	Tonga 21° 02' S, 175° 08' W 6 Aug 1958	5116	10	0.6	Dawbin (1959)
Satellite tag 22854	Cook Islands Not reported 10 Sep 2006	Area VI ^a 65° 06' S, 126° 57.1' W 23 Jan 2007	~5400 ^a	~33 ^a	0.4 ^a	Hauser et al. (2010)
AHWC# 3234	American Samoa 14° 22.83' S, 170° 45.81' W 3 Oct 2006	Area I 64° 39.91' S, 62° 39.22' W 6 May 2009	9406	108	2.6	Present study
AHWC# 2950	Area I 64° 35.13' S, 62° 29.35' W 28 Jan 2002	American Samoa 14° 12.30' S, 170° 33.85' W 2 Oct 2005	9426	108	3.7	Present study
AHWC# 2950	American Samoa 14° 12.30' S, 170° 33.85' W 2 Oct 2005	Area I 64° 51.89' S, 62° 29.12' W 16 May 2009	9414	108	3.6	Present study

^aThe authors concluded that this individual had not completed the migration and so these represent minimum values

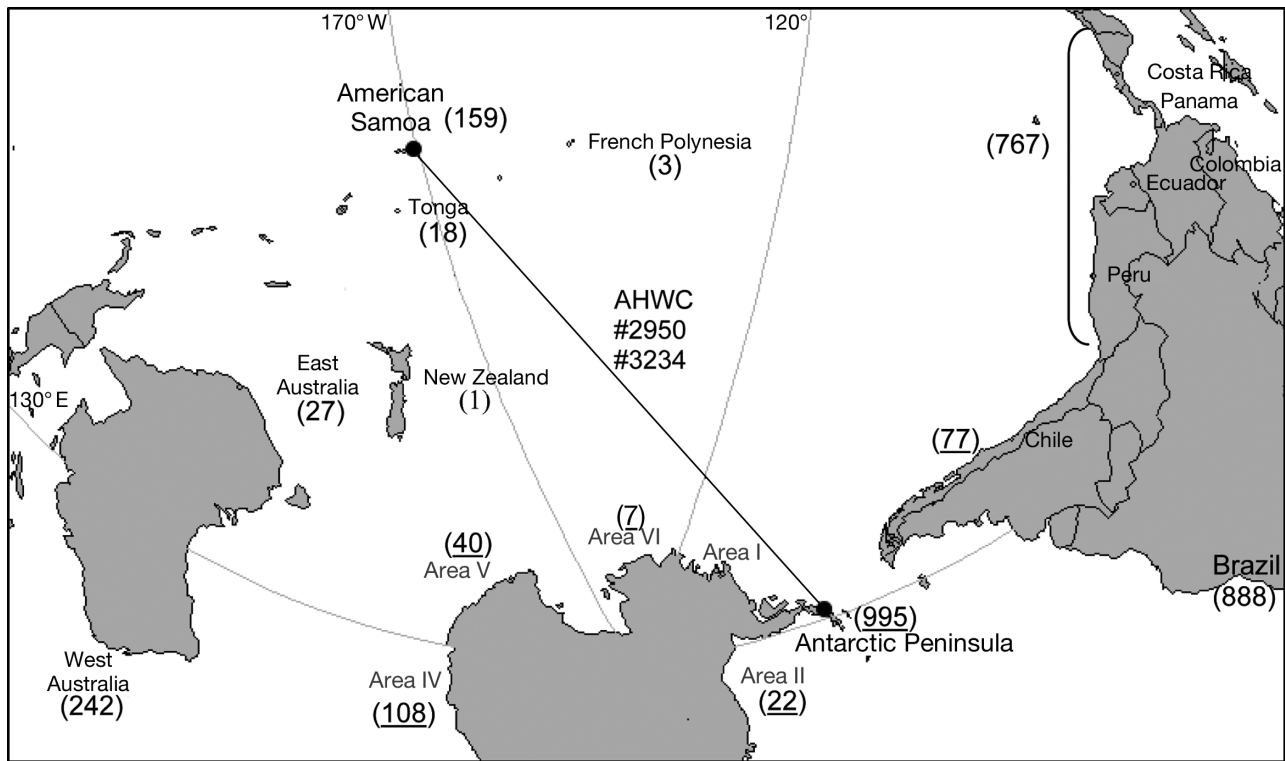


Fig. 1. *Megaptera novaeangliae*. Results of photographic matching between American Samoa and other Southern Hemisphere areas in the Antarctic Humpback Whale Catalogue (AHWC). The numbers of unique individuals are shown in parentheses by area, and feeding area samples are underlined. Antarctic Area III (117), St. Helena (2), Ghana (1), Gabon (78), South Africa (7), and Madagascar (226) are not shown. Regional sample sizes are not cumulative due to re-sightings of individuals between areas. The line between Costa Rica and Peru pools these areas to a total of 767 whales. The straight line indicates successful matches of 2 individuals (AHWC #2950 and #3234) between American Samoa and the Antarctic Peninsula. The largest 1-way distance between area sightings was 9426 km (108 longitudinal degrees). One individual undertook a round-trip movement from the Antarctic Peninsula with a minimum total distance of 18 840 km

3508 Southern Hemisphere humpback whales in the AHWC, including 1352 individuals photographed on Antarctic feeding grounds since 1981 (Fig. 1). Distances between matching sightings were calculated along a great circle route (Vincenty 1975, see www.movable-type.co.uk/scripts/latlong-vincenty.html). Sexes of matched individuals were determined by molecular genetics, as described in Olavarría et al. (2007)

RESULTS AND DISCUSSION

Photographic comparisons yielded 3 matches of 2 individuals (AHWC #2950, male, and #3234, female) between American Samoa and other Southern Hemisphere areas (Table 1). All matching photographs were from the Antarctic Peninsula in eastern Area I, 1 of 6 Antarctic management areas of the IWC. The minimum 1-way distance between area sightings ranged from 9406 to 9426 km and spanned 108 longitudinal degrees. AHW#2950 was photographed at the

Antarctic Peninsula both before and after its sighting at American Samoa, constituting a minimum round-trip distance of 18 840 km. Sightings of this individual at the Antarctic Peninsula were 7.3 yr and 31 km apart.

The Antarctic Peninsula is the first identified feeding ground for whales seen at American Samoa and one of very few confirmed for the CSP. Our results support historical evidence of CSP exchange with Antarctic Area I, which was once considered anomalous (Brown 1957). They also provide evidence of return movement to the Antarctic Peninsula from American Samoa. The Antarctic Peninsula is a well-established feeding ground for humpback whales that breed along the coast of western Central and South America (Stevick et al. 2004, Acevedo et al. 2007, Rasmussen et al. 2007). Our study yielded no direct matches between American Samoa and these other breeding areas (Fig. 1), and genetic analysis suggests little exchange between the CSP and South America (Olavarría et al. 2007). Given that the vast majority of the AHWC holdings from feeding grounds came from the Antarctic Peninsula,

we cannot exclude the possibility that less well-studied Antarctic areas are equally or more important to this population. However, our results confirm that this endangered population exhibits some degree of mixing with adjacent, non-endangered populations. Additional research is recommended to clarify CSP migratory destinations in order to accurately model population recovery and to provide adequate protection against modern impacts.

Our documented return trip of no less than 18 840 km is currently the longest movement on record for an individual mammal. One-way migration distances reported here exceed the previous mammalian migration record (also held by humpback whales; Rasmussen et al. 2007) by approximately 1000 km. One case of inter-ocean exchange between breeding grounds involved a greater absolute distance between sightings (Stevick et al. 2010), but did not necessarily involve a longer seasonal migration. Our results indicate that both sexes can undertake extensive movements. It remains to be seen how frequent these movements are, and how movements within seasonal habitats may have contributed to the migration distance documented here.

Population persistence and recovery depends, in part, on the flexibility of individuals to seek out resources on the necessary scale (Dolman & Sutherland 1995, Pichegru et al. 2010). Whereas some of the humpback whale breeding sites that were targeted by 19th century whaling remain at low density today, several major current breeding areas appear to have emerged more recently (Herman 1979, Reeves et al. 2001, Olavarria et al. 2007). It is conceivable that movements on the scale reported here, combined with a flexibility to colonize new habitats, may have played a role in the apparent recovery of humpback whales relative to other large whale species. These behaviors may also facilitate the response of this seasonal migrant to climate-related changes in the distribution of suitable habitats (e.g. Robinson et al. 2009). We cannot evaluate these hypotheses with available data, but recommend further study of the frequency, causes, and fitness implications of extreme movements in this species.

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