

FOR CONSIDERATION BY THE SCIENTIFIC COMMITTEE OF
THE INTERNATIONAL WHALING COMMISSION
MADEIRA, PORTUGAL JUNE 2009

Photo-identification comparison of humpback whales from the Antarctic Peninsula/Strait of Magellan and French Polynesia, (Breeding Stock F)

Renee Albertson-Gibb¹, Jorge Acevedo^{2,3}, Carlos Olavarría^{2,3}, Anelio Aguayo-Lobo^{2,4}, M. Michael Poole⁵ and C. Scott Baker¹

1. Marine Mammal Institute, Oregon State University, Newport, Oregon USA

2. Proyecto INACH 163 Ecología de Cetáceos Antárticos. Instituto Antártico Chileno, Punta Arenas, Chile

3. Fundación Centro de Estudios del Cuaternario. Avda. Bulnes 01890, Punta Arenas, Chile

4. Instituto Antártico Chileno. Plaza Muñoz Gamero 1055, Punta Arenas, Chile.

5. Marine Mammal Research Program, BP 698 98728 Maharepa, Moorea, French Polynesia

ABSTRACT

In light of the recent documentation of humpback whale migration between American Samoa and the Antarctic Peninsula, we undertook a comparison of individual identification photographs from French Polynesia and the Antarctic Peninsula and Strait of Magellan. The French Polynesia catalogue (n=439) spans 1995-2007 seasons, and the Antarctic Peninsula/Strait of Magellan catalogues (n=369) include the 1994/1995 season through the 2007/2008 season. These three photographic catalogues were compared by two researchers independently to search for possible matches between the two regions. No conclusive matches were found, although some photos were marginal quality. Given the sample size, this is not conclusive evidence against some whales migrating to the Antarctic Peninsula from the French Polynesia breeding ground. However, it does suggest that the Antarctic Peninsula is not the primary migratory destination of the French Polynesia breeding stock (Stock Fii).

INTRODUCTION

At present, little is known about the humpback whale migratory connections of breeding stocks E and F in the South Pacific. For management purposes the IWC (Report SC-58-Rep-5 2006) considers South Pacific humpback whale migration as generally between breeding stocks E-G and the Antarctic feeding areas directly south of them. However, documented connections of specific breeding grounds to specific feeding areas are relatively few, and those that are known are not always directly north-south (Figure 1). Two genotype matches were recently found between Tonga and Area I (Steel *et al.* 2008), and several *Discovery* marks were recovered from Areas in the Antarctic that were not directly south of the breeding area at which they were implanted (Dawbin 1966; Figure 1). In September 2006 a satellite tag was implanted in a humpback whale in the Cook Islands (breeding stock F) and in December 2006 the whale was subsequently located on the border of Area VI and Area I demonstrating at least some whales may travel in a southeasterly direction to adjacent feeding areas (Hauser *et al.* in review). In addition, in 2008 a photo-identification match was found between American Samoa (border of breeding stock E/F) and the Antarctic Peninsula (Robbins *et al.* 2008).

Humpback whales along the west coast of South America (breeding stock G) are genetically distinct from other breeding stocks in the South Pacific, including breeding Stock F (mtDNA control region $F_{ST} = 0.076$), and are genetically very similar to whales from the Antarctic Peninsula (mtDNA control region $F_{ST} = 0.001$) (Olavarría *et al.* 2007; Albertson-Gibb *et al.* 2008). Humpback whales from the Antarctic Peninsula migrate mainly along the west coast of

South America to Ecuador and Colombia (Acevedo *et al.* 2008; Albertson-Gibb *et al.* 2008; Castro *et al.* 2008; Olavarría *et al.* 2007; Stevick *et al.* 2004; Caballero *et al.* 2001; Flórez-González *et al.* 1998; Stone *et al.* 1990), while it is suggested a high proportion of the Strait of Magellan humpback whales migrate to Central America (Panama and Costa Rica) (Acevedo *et al.* 2007; Acevedo *et al.* 2008).

French Polynesia lies almost directly north of Antarctic Area VI (Figure 1). Humpback whales have been observed in all of French Polynesia's archipelagoes, however the island of Rurutu in the Austral Islands and Moorea in the Society Islands appear to have the highest concentrations of whales and that is where most field work has been carried out (Poole 2006). Although some limited exchange has been documented between French Polynesia and other breeding stocks in the South Pacific, there are no documented accounts of migratory connections between this region and any Antarctic feeding areas.

Recently however, there has been more documentation on connections between whales in Breeding Stock F and whales along the coast of South America. A genotype match has been identified between French Polynesia (Stock F) and Colombia (Stock G) (Donoghue *et al.* 2008), presenting the possibility that some whales from French Polynesia may migrate to the Antarctic Peninsula. In this report, we present a collaborative comparison of individual humpback whale fluke photographs to explore possible migratory connections between French Polynesia and the Antarctic Peninsula/Strait of Magellan (AP/SM).

MATERIALS AND METHODS

Sample Collection

Using the natural markings on the ventral side of the flukes to identify individual whales (Katona *et al.* 1979), identification photographs were collected from the three study sites. The photo-identification surveys were carried out opportunistically in French Polynesia beginning in 1990 with dedicated surveys beginning in 1999. These surveys were generally conducted within 500 meters of shore during the austral winter between the months of July through November. However, surveys are conducted year round for other species, and if whales were seen outside of these months every effort was made to attain photographs of the flukes. In the AP/SM dedicated boat surveys have been conducted annually. In the Antarctic Peninsula these surveys are conducted between December and February, and in the Strait of Magellan they are conducted between December and May.

Photo-identification catalogues

Photos were reconciled within regions annually by the primary catalogue holders, and new individual whales were assigned a unique number for identification purposes. Beginning in 1999 as part of the South Pacific Whale Research Consortium's interchange comparison, French Polynesia photographs have been compared annually with all other Oceania breeding grounds (stocks E and F). In order to decrease the human error rate of our comparison, two researchers compared all photos independently of each other.

RESULTS

Photo matching

A total of 439 French Polynesia photographs were compared against 276 photographs from the Antarctic Peninsula (AP) and 93 photographs from the Strait of Magellan (SM) (Table 1). A possible match was first identified by Jorge Acevedo in November of 2008 between Antarctic Peninsula INACH photo 076 taken January 12, 1997 and French Polynesia photo 0014 taken in

September 2000. These photos were later examined by members of the South Pacific Whale Research Consortium at the annual meeting in February 2009. It was agreed that there were similarities between the two photographs however, it could not be concluded that this was a match due to poor clarity of the French Polynesia photo. No other putative matches were found between the two catalogues, by either of the two independent researchers.

Probability of capture

If the number of migrants between French Polynesia and the AP/SM was small, then the likelihood of not discovering a match between these two areas would be large despite the current sample sizes. To illustrate this we calculated the probability of discovering a migrant as a function of how many whales could be actually migrating from French Polynesia to the AP/SM. For population sizes we used the following abundance estimates for French Polynesia, (Breeding Stock Fii, $N_{2009} = 1,800$ CI 1,197-2,970; Albertson-Gibb *et al.* unpublished) and AP/SM (Breeding Stock G, $N_{2006} = 6,847$ CI 5,243-8,632; IWC Report 2008). A modification of the Lincoln-Petersen estimate will yield the probability of capturing at least one migrant, $n=1$:

$$\text{Equation 1} \quad \frac{(N_A)(m)}{M} = x$$

The actual AP/SM sample size is a ratio:

Number of direct migrants divided by AP/SM population size = (N_A)

French Polynesia photo catalogue sample size = k

AP/SM photo catalogue sample size = m

French Polynesia population size = M

Subtracting this answer from 1 will yield (y) the probability of NOT capturing at least one migrant assuming $n=1$

$$\text{Equation 2} \quad 1-x = y$$

Raising y to the power of the French Polynesia photo catalogue sample size (k) yields (z) the probability of NOT capturing any migrants over the entire sample

$$\text{Equation 3} \quad y^k = z \text{ probability of NOT capturing any migrants}$$

Subtracting this answer from one yields the probability of capturing any migrants over the entire sample

$$\text{Equation 4} \quad 1-z = \text{probability of capturing any migrants}$$

DISCUSSION

Although the possibility exists of migratory movements between breeding stock F and the Antarctic Peninsula, similar to that detected between American Samoa (border of breeding stock E/F) and the Antarctic Peninsula (Robbins *et al.* 2008) we documented no such connection here. Despite making 161,991 comparisons, no conclusive matches were found between French Polynesia and the AP/SM. Only one possible French Polynesia-Antarctic Peninsula match was found, and due to the poor clarity of one of the photos we cannot confidently conclude that it is indeed a match. However, given the known limitations of photo-identification matching, in particular the limited number of whales sampled, and the ~12% error rate occurring in some photos of low clarity (Stevick *et al.* 2001), these findings do not rule out the possibility of whales from French Polynesia traveling to the Eastern South Pacific waters. Assuming French Polynesia and the Antarctic Peninsula are separate stocks with only a few migrants ($n < 50$) traveling between regions the likelihood of matching one of the few migrants between these regions is less

than 0.5, despite the fact that the catalogues contain a substantial number of individuals (Figure 2).

The management of the humpback whale breeding stocks is dependent on an understanding of the connections between the breeding regions and feeding areas, and to what degree whales are mixing in the feeding and breeding areas. Recent satellite tagging studies near the Antarctic Peninsula have found that movement in the feeding areas can include quite extensive distances traveled, presumably in response to prey distribution (Dalla Rosa *et al.* 2008). Given that there seems to be great complexity in humpback whale population structure (Calambokidis *et al.* 2001), possible migratory connections that are not directly north-south should continue to be investigated. Long term photo-identification studies and genetic analyses can provide accurate definition of stocks and migration between them, which is essential to the recovery of the South Pacific humpback whale population.

ACKNOWLEDGEMENTS

The authors wish to thank the International Fund for Animal Welfare for providing funding for the fieldwork in French Polynesia. Rochelle Constantine, Claire Garrigue and the South Pacific Whale Research Consortium kindly provided information on photo matches between the South Pacific breeding regions. Alana Alexander assisted with the mathematical formulas needed to create the graph in figure 2.

LITERATURE CITED

- Acevedo J., Rasmussen K., Félix F., Castro C., Llano M., Secchi E., Saborío M., Aguayo-Lobo A., Haase B., Scheidat M., Dalla-Rosa L., Olavarría C., Forestell P., Acuña P., Kaufman G. and Pastene LA. (2007) Migratory destinations of humpback whales from the Magellan Strait feeding ground, Southeast Pacific. *Marine Mammal Science* 23(2): 453-463.
- Acevedo J., Allen J., Castro C., Félix F., Rasmussen K., Flórez-González L., Aguayo-Lobo A., Secchi E., Llano M., Garita F., Forestell P., Haase B., Capella J., Dalla Rosa L., Ferrina D., Plana J., Tobón IC., Kaufman G., Flak P., Scheidat M. & Pastene LA (2008) Migratory destination of humpback whales from the Eastern South Pacific population as revealed by photo-identification analysis. Paper SC/60/SH20 presented to the IWC Scientific Committee, June 2008 (unpublished). 8pp. [Available from the Office of this Journal]
- Albertson-Gibb, R., C. Olavarría, D. Steel, L. Florez-González, C. Garrigue, N. Hauser, M. Poole, M. Anderson, J. Bannister, J. Jackson, C. Antolik, and C. S. Baker (2008) Mixed-Stock Analysis of Humpback Whales (*Megaptera novaeangliae* Kursive) from Antarctic Feeding Areas and South Pacific Breeding Grounds. Paper SC/60/SH15 presented to the IWC Scientific Committee, June 2008 (unpublished). 6pp. [Available from the Office of this Journal]
- Caballero, S., Hamilton, H., Jaramillo, C., Capella, J. and 5 others (2001) Genetic characterisation of the Colombian Pacific coast humpback whale population using RAPD and mitochondrial DNA sequences. *Memorial Queensland Museum* 47: 459-464.
- Calambokidis, J., Steiger, G.H., Straley, J.M., Herman, L.M., Cerchio, S., Salden, D.R., Urbán, J., Jacobson, J.K., vonZiegesar, O., Balcomb, K.C., Gabrielle, C.M., Dahlheim, M.E., Uchida, S., Ellis, G., Miyamura, Y., Ladrón de Guevara, P.P., Yamaguchi, M., Sato, F., Mizroch, S.A., Schlender, L., Rasmussen, K., Barlow, J., Quinn II, TJ (2001) Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science* 17:769-794
- Castro, C., Acevedo J., Allen J., Dalla Rosa L., Flórez-González L., Aguayo-Lobo A., Rasmussen K., Llano M., Garita F., Forestell P., Secchi E., García-Godos I., Ferrina D., Kaufman G., Scheidat M. & Pastene LA (2008) Migratory movements of humpback whales (*Megaptera novaeangliae*) between Machalilla National Park, Ecuador and Southeast Pacific. Paper SC/60/SH23 presented to the IWC Scientific Committee, June 2008 (unpublished). 6pp. [Available from the Office of this Journal]

- Dalla Rosa, L., Secchi, E.R., Maia, Y.G., Zerbini, A., Heide-Jorgensen, M.P (2008) Movements of satellite-monitored humpback whales on their feeding ground along the Antarctic Peninsula. *Polar Biology* 31: 771-781.
- Dawbin, W.H. 1966. The seasonal migratory cycle of humpback whales. Pages 145-171 in K.S. Norris, ed. Whales, dolphins and porpoises. University of California Press, Berkeley.
- Donoghue, M (2008) Report of the Annual Meeting of the South Pacific Whale Research Consortium. Paper SC/60/SH21 presented to the IWC Scientific Committee, June 2008 (unpublished). 14pp. [Available from the office of this journal]. (Times New Roman 10 pt)
- Florez -Gonzalez L., Capella J., Haase B., Bravo G.A., Felix F. & Gerrodette T (1998) Changes in winter destinations and the northernmost record of southeastern pacific humpback whales. *Marine Mammal Science* 14(1)189-196.
- Franklin, W., Franklin, T., Brooks, L., Gibbs, N., Childerhouse, S., Smith, F., Burns, D., Paton, D., Garrigue, C., Constantine, R., Poole, M.M., Hauser, N., Donoghue, M., Russell, K., Mattila, D., Robbins, J., Oosterman, A., Leaper, R., Baker, S. & Clapham P (2008) Migratory movements of humpback whales (*Megaptera novaeangliae*) between Eastern Australia and the Balleny Islands, Antarctica, confirmed by photo-identification. Paper SC/60/SH2 presented to the IWC Scientific Committee, June 2008 (unpublished). 6pp. [Available from the Office of this Journal]
- Hauser, N., Zerbini, A., Geyer, Y., Heide-Jorgensen, M-P. & Clapham, P (2009) Movements of satellite-monitored humpback whales, *Megaptera novaeangliae*, from the Cook Islands *Marine Mammal Science* in press. (Times New Roman 10 pt)
- Jenner, K.C.S., Jenne, M.N.M. & McCabe, K.A (2001) Geographical and Temporal Movements of Humpback whales in Western Australian Waters. *APPEA Journal* 749-764.
- Katona, S., Baxter, B., Brazier, O., Kraus, S., Perkins, J. & Whitehead, H (1979) Identification of humpback whales by fluke photographs. In: Winn HE, Olla BL (eds) *Behavior of Marine Animals*, Vol. 3. Plenum Press, New York, p 33-44
- International Whaling Commission Report on southern hemisphere humpback whales (2006). SC-58-Rep 5. [Available from the Office of this Journal].
- International Whaling Commission Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks (SH) (2008) Annex H. 30 pp. [Available from the Office of this Journal]
- Olavarria, C., Baker, C.S., Bannister, J., Brasseur, M., Caballero, S., Capella, J., Clapham, P., Dodemont, R., Donoghue, M., Jenner, C., Jenner, M.M., Moro, D.J., Florez-González, L., Hauser, N., Oremus, M., Paton, D., Poole, M., Rosenbaum, H. & Russell, K (2007) Population structure of South Pacific humpback whales and the origin of the eastern Polynesian breeding grounds. *Marine Ecology Progress Series*. 330: 257-268.
- Poole, M. 2006. An update on the occurrence of humpback whales in French Polynesia. Paper SC/A06/58 presented to the IWC Scientific Committee, June 2006 (unpublished). 12 pp. [Available from the Office of this Journal]
- Robbins J., Dalla Rosa, L., Allen, J.M., Mattila, D.K. & Secchi, E.R (2008) Humpback whale photo-identification reveals exchange between American Samoa and the Antarctic Peninsula, and a new mammalian distance record. Paper SC/60/SH5 presented to the IWC Scientific Committee, June 2008 (unpublished). 4 pp. [Available from the Office of this Journal]
- Steel, D., Garrigue, C., Poole, M., Hauser, N., Olavarria, C., Flórez-González, L., Constantine, R., Caballero, S., Thiele, D., Paton, D., Clapham, P., Donoghue, M. & Baker, C.S (2008) Migratory connections between humpback whales from South Pacific breeding grounds and Antarctic feeding areas demonstrated by genotype matching. Paper SC/60/SH13 presented to the IWC Scientific Committee, June 2008 (unpublished). 9pp. [Available from the Office of this Journal]
- Stevick, P.T., Palsbøll, P.J., Smith, T.D., Bravington, M.V. & Hammond, P.S (2001) Errors in identification using natural markings: rates, sources and effects on capture-recapture estimates of abundance. *Canadian Journal of Fisheries Aquatic Science* 58:1861-70.
- Stevick, P.T., Aguayo-Lobo, A., Allen, J., Avila, I.C., Capella, J., Castro, C., Chater, K., Dalla Rosa, L., Engel, M.H., Félix, F., Flórez-González, L., Freitas, A., Haase, B., Llano, M., Lodi, L., Muñoz, E., Olavarria, C., Secchi, E., Scheidat, M. & Siciliano, S (2004) Migrations of individually identified humpback whales between the Antarctic Peninsula and South America. *Journal of Cetacean Research and Management* 6: 109-113.
- Stone, G., Flórez-González, L. & Katona, S (1990) Whale migration record. *Nature* 346: 705.

Table 1. Antarctic Peninsula (INACH), and Strait of Magellan (CEQUA) and French Polynesia humpback whale photo-identification catalogues used in the comparison of the Feeding Regions and Breeding Stock.

Year	Instituto Antártico Chileno (INACH) Feeding Region Area I		Centro de Estudios del Cuaternario (CEQUA) Feeding Region Area I		French Polynesia Breeding Stock Fii	
	Number of Individuals	Time Period	Number of Individuals	Time Period	Number of Individuals	Time Period
(1994) 1995	23	Dec.-Jan.	--	--	2	July -Nov.
1996	40	Jan.-Feb.	--	--	5	July -Nov.
1997	46	Jan.-Feb.	--	--	17	July -Nov.
1998	20	Jan.- Feb.	--	--	9	July -Nov.
1999	39	Jan.-Feb.	--	--	46	July -Nov.
2000	--	--	--	--	29	July -Nov.
2001	--	--	--	--	27	July -Nov.
2002	--	--	--	--	42	July -Nov.
2003	--	--	11	March	59	July -Nov.
(2003) 2004	--	--	27	Dec.-Mar.	62	July -Nov.
(2004) 2005	--	--	28	Dec.-April	52	July -Dec.
(2005) 2006	55	January	16	Dec.- May	28	July -Nov.
(2006) 2007	9	January	11	Dec.-June	61	July -Dec.
2008	44	Jan.-Feb.	--	--	--	--
Total	276		93		439	

Figure 1 Figure 1. Map of South Pacific humpback whale migratory connections of genotype data (solid line) and Discovery mark and satellite data (dashed line) and photo-identification (dotted line) (Donaghue *et al.* 2008; Steel *et al.* 2008; Acevedo *et al.* 2008; Acevedo *et al.* 2007; Stevick *et al.* 2004; Franklin *et al.* 2008; Jenner *et al.* 2001; Hauser *et al.* in press;).

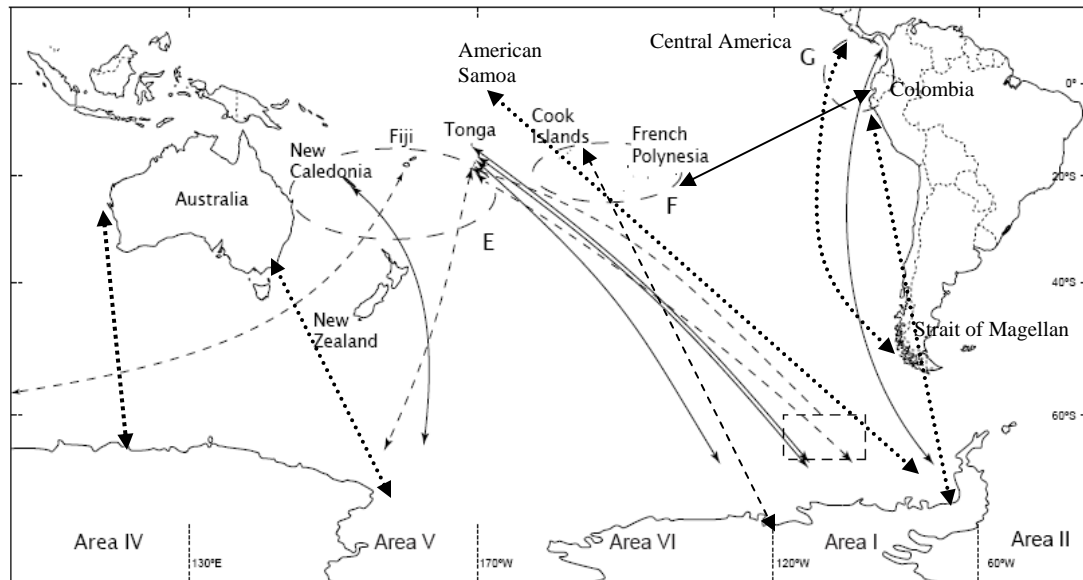


Figure 2. The probability of identifying a humpback whale by photo identification capture recapture in both the feeding and breeding region based on the assumed population size and the number of total individual photographs in the catalogues from both French Polynesia and the Antarctic Peninsula/Strait of Magellan.

