MOVEMENTS OF HUMPBACK WHALES BETWEEN ECUADOR AND CENTRAL AMERICA, WINTERING AREA OF THE BREEDING STOCK G

FERNANDO FÉLIX[1], KRISTIN RASMUSSEN[2], FRANK GARITA[3], BEN HAASE[1] AND ANNE SIMONIS[1]

[1]Fundación Ecuatoriana para el Estudio de mamíferos Marinos (FEMM). PO Box 0901-11905, Guayaquil, Ecuador
[2] Panacetacea, David, Chiriqui, Panama
[3] Asociación Ambiental Vida, Costa Rica

Autor e-mail contact: fernandofelix@hotmail.com

ABSTRACT

We compared catalogues of photo-identified humpback whales of three research groups working in the Eastern and Southeastern Pacific region. Whales were photographed between 1991 and 2008. The entire dataset included 1,387 individuals: 1,289 from Ecuador and 98 from Costa Rica-Panama. Four matches were found between these areas, all of them were inter-year re-sightings. The largest span of time between sightings was 11 years. Our data confirms that the wintering area of the Breeding Stock G extends approximately 3,000km along the coasts of at least five countries from north of Peru to Costa Rica. A larger sample from the northern breeding area would be important to improve our knowledge on whales' migration behavior, which would have implications for management and population modeling.

KEY WORDS: South America, humpback whales, breeding grounds, photo-ID, movements.

INTRODUCTION

It has been known for a long time that the breeding grounds of the Southeast Pacific humpback whales (*Megaptera novaeangliae*), referred to as Breeding Stock G (IWC, 2006), were located between the Panama Bight and Ecuador (Townsend, 1935; Dawbin, 1966). Studies in the past two decades have confirmed the importance of sites along the coasts of Ecuador, Colombia, Panama and Costa Rica as breeding and nursing areas for this stock (Flórez-González, 1991; Scheidat *et al*., 2000; Félix and Haase, 2001, Acevedo-Gutierrez and Smultea, 1995, Rasmussen *et al*., 2007).

Most of the available information on migrating whales from this population is related to large scale seasonal movements. A direct association has been established between whales breeding in tropical areas on the west coast of Central and South America with those using feeding sites located in southern Chile (Acevedo *et al*., 2007), western Antarctic Peninsula (Stone, *et al*., 1990, Stevick *et al*., 2004, Rasmussen *et al.* 2007; Castro *et al*., 2008) and the Weddel Sea (Dalla-Rosa *et al*., 2008). However, few efforts have been made to monitor whale movements within the breeding area. Individual movements up to 560km between nearby areas in Panama, Colombia, Ecuador and Peru suggested that the species have a continuous distribution in such coastal areas (Flórez-González *et al*., 1998). Some additional information on matches between Ecuador, north and south Colombia, and Costa Rica was presented by Castro *et al*. (2008).

Available information on stock structure based on the haplotype frequency of individuals sampled in Colombia, Chile, Ecuador and Antarctic, indicates that the population has a panmictic distribution (Olavaria *et al.*, 2007; Felix *et al*., 2009), although females seem to have a more complex migratory behavior than males (Félix *et al*., 2009). Conversely, studies based on photo-identification suggest some degree of heterogeneity in the distribution of this population in the breeding area. Thus, Félix *et al*. (in press) when modeling the population based on photo-identified individuals in Ecuador, found that not all individuals passing through this area would have the same probability to be photographed. Acevedo *et al*. (2007) found a higher relationship between whales feeding at Magellan Strait with those breeding in Panama than with those breeding in Ecuador and Colombia.

Here we present information on matches of individuals recorded in coastal waters of Ecuador and Costa Rica-Panama, sites located in the northern and southern boundaries of the wintering area of the Breeding Stock G. Our data showed that some whales visited these areas in different years.

METHODOLOGY

The study area

The study area includes five sites in three countries: two in Ecuador, two in Costa Rica and one in Panama (Figure 1). The distance between the surveyed sites along the coast is approximately 2,500km.

Costa Rica-Panama. Dedicated surveys were conducted on the west coast of Costa Rica in the northern (between 10º and 11º N) and southern (between 9.5º and 8.3º N) parts of the country in the period 2001 – 2008. Opportunistic identification photographs were also collected since 1993. In Panama, surveys were conducted in the Gulf of Chiriquí in western Panama (82.8 º - 81.5 ºW, 7.5 ºN)in the period 2002-2007. In general, the surface waters off the Pacific coast of Central America are classified as Tropical Surface Waters, with relatively lesser salinities (<34 psu), greater temperatures (>27° C), and lesser variation in seasonal temperature (Fiedler 1992). Both Costa Rica and Panama have a relatively narrow continental shelf

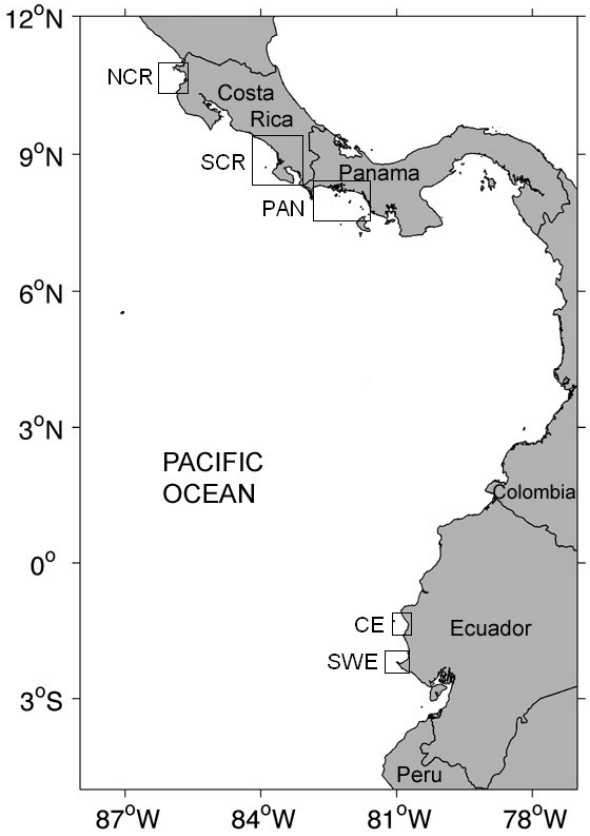

Figure 1. Sites surveyed during the study period: NCR (Northern Costa Rica, SCR (Southern Costa Rica), PAN (Western Panama), CE (Central Ecuador, Puerto Lopez-La Plata Island-Puerto Cayo); and SWE (Southwestern Ecuador, Salinas).

Ecuador. Two sites in the central part of the country were monitored: Puerto Lopez-La Plata Island-Puerto Cayo (1991-1997, 2000) (1º20'S, 80º55'W) and Salinas (2001-2008) (2º10'S, 81ºW). The coast of Ecuador is located in a transition zone between the cold and productive water from the south (Humboldt Current) and the warm low-productive water from the north (Panama Current). It is also characterized by a narrow continental shelf.

Source of the information

Photographs of whale flukes have been used as a standard methodology for individual identification of humpback whales by several research groups in the Eastern and Southeastern Pacific region (see a review by Flórez-González, *et al*., 2007). For the purpose of this work, the digitized catalogs belonging to three institutions from Costa Rica, Ecuador and Panama were analyzed in search of common individuals. Photographs were taken on board different vessels, including whale-watching boats and small boats specifically for research. The Ecuadorian dataset includes photographs from the period 1991-2008, and the Costa Rica-Panama dataset includes the period 1993-2008. The monitoring effort in most cases was rather opportunistic. The information comes from 1,493 sightings and 672hours of observation in Ecuador, and 228 sightings over a surveyed distance of 8,462km in Costa Rica-Panama (Table 1).

Photographs were compared directly on a computer screen using widespread software to handle images. Those photographs considered unsuitable for comparison due to poor quality (blurred, inappropriate angle) or containing only one side of the fluke were not taken into account. The comparison included only non-calf individuals. After the screening process, photographs of 1,387 individuals remained for the analysis: 1,289 from Ecuador and 98 from Costa Rica-Panama.

Table 1. Effort deployed in the surveyed sites: Ecuador (1991-2008) and Costa Rica-Panama (2001-2008).

SITE	TOTAL
Ecuador	
Trips	705
Sightings	1,493
Navigation time (h)	1,639
Observation time (h)	672
Costa Rica-Panama	
Trips	81
Sightings	228
Total distance surveyed (km)	8,462

RESULTS

The comparison of photographs produced four matches; all of them corresponded to inter-year re-sightings (Table 2 and Figure 2). The four individuals were recorded in Ecuador in four different years (1996, 2002, 2005 and 2008). In contrast, in Costa Rica-Panama the four animals were recoded in 2007, year in which 51% of the records were made in this area. The maximum time elapsed between sightings was 11 years (Ind. 145/KR1049). In both sites the four whales in common have been recorded only once. This is correct for my two whales.

Table 2. Sighting dates of the animals in common from Ecuador and Costa Rica-Panama, and time between sightings.

ID Number	Sighting date Ecuador	Sighting date Costa Rica	Years
Ind. 145/ KR 1049	10-Aug-96	10-Aug-07	11
Ind. 270/ ALDIA 1089	04-Aug-02	2007	5
Ind. 659/FGA 1091	15-Jul-05	23-Aug-07	2
Ind. 1327/KR 1057	03-Aug-08	28-Jul-07	1

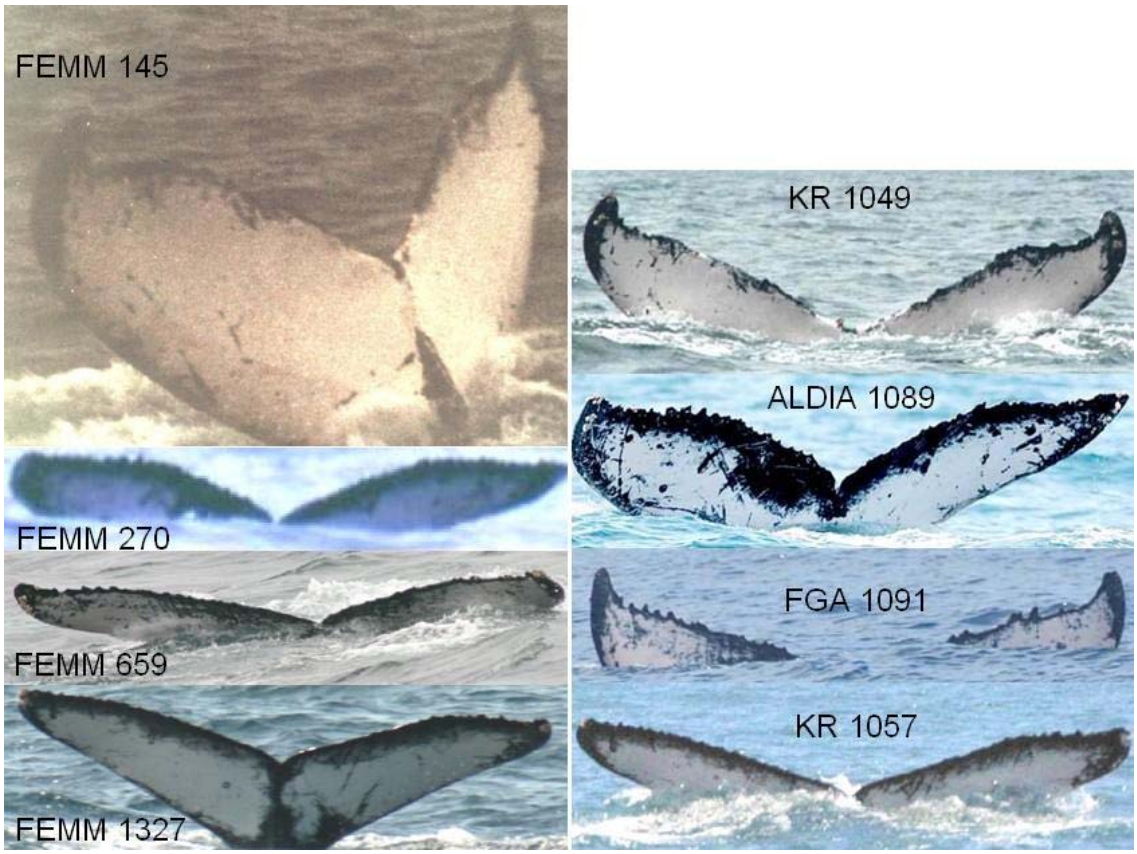

Figure 2. Photographs and ID numbers of the common individuals between Ecuador (left column) and Costa Rica-Panama (right column).

In all eight cases when the four whales in common between Ecuador and Costa Rica-Panama were recorded, they were part of groups of adults, competitive groups or were escorting cows with calves (Tables 4 and 5). In Ecuador these animals were part of relatively large groups of adults (average 4.25 inds/group, *SD* = 1.08), but in Costa Rica-Panama area they were part of smaller groups (mean 2.75 inds/group, *SD* =0.96).

Table 4. Groups to which common individuals belonged to when were recorded in Ecuador.

Ecuador		**Remarks**
ID	Group size	
Ind. 145	4	Adults
Ind. 270	6	Competitive group
Ind.659	3	Adults
Ind. 1327	4	Adults

Table 5. Groups to which common individuals belonged to when were recorded in Costa Rica-Panama.

Costa Rica-Panama		**Remarks**
ID	Group size	
KR 1049	2	Adults
ALDIA 1089	2	Adults
FGA 1091	4	Competitive group
KR 1057	3	Escort of a cow/calf pair

DISCUSSION

Our results confirm that some whales of the Breeding Stock G frequent the coasts of Ecuador, Costa Rica and Panama during the breeding season. While our records refer only to inter annual re-sightings, it is not excluded that some whales could frequent these sites during the same season. Alternatively, whales may visit those areas on a year to year basis, as suggested by Flórez-González *et al*. (1998).

Both migratory route and movements of whales once in the breeding area are poorly known for this stock. Data available indicate that the species shows a complete coastal distribution north of the northwestern coast of Peru (6ºS) (Félix and Haase, 2005). This means that the breeding area of this stock extends approximately 3,000km along the coasts of at least five countries from Peru to Costa Rica. It is not clear, however, whether the whale distribution is continuous or irregular along the extended coastline. Some progress have been made recently in establishing a relationship between whale distribution and environment variables in this area, allowing some level of prediction on preferred sites of whales (e.g. Félix and Haase, 2005; Rasmussen *et al*., 2007; Oviedo and Solís, 2006; Félix and Botero, 2009).

The lack of within year re-sightings between the northern and southern parts of the breeding area suggests that the whales passing through Ecuador toward Costa Rica-Panama are in transit. This is consistent with the findings of Felix *et al*. (in press) and Acevedo *et al*. (2007) who found some evidence of heterogeneity in the distribution of the stock in the breeding area. Furthermore, whales going north to Costa Rica may take a shorter offshore route; the straight distance between the south of Ecuador and north of Costa Rica is 1,500km, almost a half than that bordering the coast. Nevertheless, the few records of humpback whales in oceanic waters in the eastern tropical Pacific suggest that these movements are rather uncommon (Félix and Haase, 2005).

Although it was not possible to establish the sex or reproductive status of whales in common between Ecuador and Costa Rica-Panama, indirect information on the size and type of groups they belonged to at both sites suggests that they were adult males. Differences in the time spent in this breeding area has not been established according to sex or reproductive status, but the low within year re-sighting rates reported in several sites of the Southeast Pacific (see Flórez-González, *et al*. 2007) suggests that whales are moving continuously within the breeding area. In that sense, Southeastern humpback whales have similar behavior as whales breeding in the Hawaiian archipelago, where whales of all classes make extensive movements within the archipelago during the breeding season (Cerchio *et al*., 1998, Mate *et al*. 1998).

A larger sample from the northern breeding area is required to establish more precisely within season movements and migration patterns of this population along the central Pacific. Such knowledge has important implications for management and population modeling.

ACKNOWLEDGEMENTS

FEMM team thanks tourist operators in Puerto López, Puerto Cayo and Salinas who allowed us to board their vessels for this study. The humpback whale research in Ecuador is supported by the Whale and Dolphin Conservation Society (WDCS). Research in Panama and Costa Rica was supported by the Packard Foundation, and the Earl and Ethel Myers Oceanic Trust. Michael Klein, the Klein Family and George Ravenscrofft assisted with logistical support in Panama. Daniel Palacios assisted in the field.

REFERENCES

Acevedo-Gutiérrez, A. and Smultea M.A. 1995. First records of humpback whales including calves at Golfo Dulce and Isla del Coco, Costa Rica, suggesting geographical overlap of northern and southern hemisphere populations. *Mar. Mamm. Sci.* 11:554-560.

Acevedo, J., Rasmussen, K., Félix, F., Castro, C., Llano, M., Secchi, E., Saborío, M.T. Aguayo-Lobo, A., Haase, B., Scheidat, M., Dalla-Rosa, L., Olavaria, C., Forestell, P., Acuña, P., Kaufman, G., and Pastene, L. 2007. Migratory destinations of the humpback whales from Magellan Strait feeding ground, Chile. *Marine Mammal Science* 23(2): 453-463.

Castro, C., Acevedo, J., Allen, J., Dalla Rosa, L., Flórez-González, L., Aguayo-Lobo, A., Rasmussen, K., Llano, M., Garita, F., Forestell, P., Sexy, E.R., García-Godos, I., Ferrina, D., Kaufman, G., Scheidat, M., and Pastene, L.A. 2008. Migratory movements of humpback whales (Megaptera novaeangliae) between Machalilla Nacional Park, Ecuador and Southeast Pacific. Paper SC/60/SH presented to the 60th Scientific Committee of the International Whaling Commission. Santiago, Chile, June 2008. 6p.

Cerchio, S., Gabriele, C.M:, Norris, T.F., and Herman, L.M. 1998. Movements of humpback whales between Kauai and Hawaii: implications for population structure and abundance estimation in the Hawaiian Islands. *Marine Ecology Progress Series* 175:13-22.

Dalla Rosa, L., F. Félix, P.T. Stevick, E.R. Secchi, J.M. Allen & K. Chater. 2008. Interchange of humpback whales between the South Orkney Islands (Weddell Sea) and the north-western coasts of South America and Antarctic Peninsula, confirmed by photo-identification. Paper SC/60/SH42 presented to the 60th Scientific Committee of the International Whaling Commission. Santiago, Chile, June 2008.

Dawbin, W.H. 1966. The seasonal migratory cycle of humpback whales. Pp 145-170. In Norris, K.S. (Ed.) *Whales, dolphins and porpoises*. Univ. Calif. Press, Berkeley, California. 789 p.

Félix, F. and Haase, H. 2001. The humpback whale off the coast of Ecuador, population parameters and behavior. *Revista de Biología Marina y Oceanografía,* 36(1):61-74.

Félix, F. and Haase, B. 2005. Distribution of humpback whales along the coast of Ecuador and management implications. *Journal of Cetacean Research and Management* 7(1):21-31.

Félix, F and Botero, N. 2009. Distribution and seasonal occurrence of humpback whales (*Megaptera novaeangliae*) cows with calves in coastal waters of Ecuador. Paper SC/61/SH2 presented to the 61 Scientific Committee of the International Whaling Commission, June 2009, Madeira, Portugal.

Félix, F., C. Castro, J. Laake, B. Haase & M. Scheidat. (in press). Abundance and survival estimates of the Southeastern Pacific humpback whale stock from 1991-2006 photo-identification surveys in Ecuador. *Journal of Cetacean Research and Management*, Special Issue.

Félix, F., Caballero, S. and Olavarría C. 2009. Genetic diversity and population structure of humpback whales (*Megaptera novaeangliae*) from Ecuador based on mitochondrial DNA analyses. Update of SC/59/SH11. Paper SC/61/SH1 presented to the 61 Scientific Committee of the International Whaling Commission, June 2009, Madeira, Portugal.

Fiedler P (1992) Seasonal climatologies and variability of eastern tropical pacific surfacewaters. NOAA tech report NMFS 109.

Flórez-González, L. 1991. Humpback whales *Megaptera novaeangliae* in the Gorgona Island, Colombian Pacific breeding waters: population and pod characteristics. *Mem. Queensl. Mus.* 30(2):291-295.

Flórez-González, L., Capella, J., Haase, B., Bravo, G.A., Félix, F. and Gerrodette, T. 1998. Changes in winter destinations and the northernmost record of southeastern Pacific humpback whales. *Mar. Mamm. Sci.* 14(1):189-196.

Flórez-González, L., Ávila, I.C., Capella J., Falk, P., Félix, F., Gibbons, J., Guzmán, H. M., Haase, B., Herrera, J. C., Peña, V., Santillán, L., Tobón, I. C., Waerebeek, K. V. 2007. *Estrategia para la Conservación de la ballena jorobada del Pacífico Sudeste. Lineamientos para un plan de acción regional e iniciativas regionales.* Fundación Yubarta. Cali, Colombia. 106pp. (In Spanish).

International Whaling Commission. 2006. Report of the Scientific Committee. Annex H, report of the Sub-Committee on other Southern Hemisphere whale stocks. Saint Kitts, June 2006. 24pp.

Mate, B.R. Gisiner, R, and Mobley, J. 1998. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. *Canadian Journal of Zoology* 76(5):863-868.

Olavarría, C., Baker, C.S., Garrigue, C., Poole, M., Hauser, N., Caballero, S., Flórez-González, L., Brasseur, M., Bannister, J., Capella, J., Clapham, P., Dodemont, R., Donoghue, M., Jenner, C., Jenner, M.N., Moro, D., Oremus, M., Paton, D., Rosenbaum, H. and Russell, K. 2007. Population structure of South Pacific humpback and the origin of the eastern Polynesian breeding grounds. *Mar. Ecol. Progr. Ser.*, 330:257-268.

Oviedo, L. and Solís, M. Underwater topography determines critical habitat for humpback whales near Osa Peninsula, Costa Rica: implications for marine protected areas. *Rev. Biol. Trop (Int. J. Trop. Biol*. ISSN-0034-7744), Vol 56 (2)

Rasmussen, K., Palacios, D.M., Calambokidis, J., Saborio, M.T., Rosa, L.D., Secchi, E.R., Steiger, G.H., Allen J.M. and Stone, G.S. 2007. Southern Hemisphere humpback whales wintering off Central America: insights from water temperature into the longest mammalian migration. *Biol. Lett.*, 3(3):302-305, doi: 10.1098/rsbl.2007.0067.

Scheidat, M., Castro, C., Denkinger, J., González, J. and Adelung, D. 2000. A breeding area for humpback whales (*Megaptera novaeangliae*) off Ecuador. *J. Cetacean Res. Manage*. 2(3):165-171.

Stevick, P., Aguayo, A., Allen, J., Avila, I.C., Capella, J., Castro, C., Chater, K., Engel, M.H., Félix, F., Flórez-González, L., Freitas, A., Haase, B., Llano, M., Lodi, L., Muñoz, E., Olavarría, C., Secchi, E., Scheidat, M. and Siciliano, S. 2004. A note on the migrations of individually identified humpback whales between the Antarctic Peninsula and South America. *Journal of Cetacean Research and Management* 6(2):109-113.

Stone, G.S., Flórez-González, L. and Katona, S. 1990. Whale migration record. *Nature* 346(6286):705.

Townsend C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica* 16:133-144.