

VENTRAL FLUKE PIGMENTATION OF HUMPBACK WHALE *MEGAPTERA NOVAEANGLIAE* POPULATION AT THE FRANCISCO COLOANE MARINE PARK, STRAITS OF MAGELLAN, CHILE.

PATRONES DE COLORACIÓN DE COLA DE LAS BALLENAS JOROBADAS *MEGAPTERA NOVAEANGLIAE* DEL PARQUE MARINO FRANCISCO COLOANE, ESTRECHO DE MAGALLANES, CHILE.

Jorge Gibbons*, Juan J. Capella** & Yerko A. Vilina***

Humpback whale, *Megaptera novaeangliae* (Borowski, 1871), is widely distributed with three main populations (North Pacific, North Atlantic and Southern Oceans), and several stocks recognized within them (Mackintosh 1965). In the South Pacific, three main stocks of Humpback whales have been proposed (Stocks E, F and G) which include several breeding grounds (or substocks). The western stock (E) comprises the breeding grounds of East Australia (E(i)), New Caledonia (E(ii) 1) and the kingdom of Tonga (E(ii) 2). The central stock (F) comprises the recently discovered Cook Island (Hauser *et al.* 2000) and the French Polynesia breeding grounds (Poole 2002). Finally, the eastern stock (G) includes whales breeding along the coasts from north Perú to south Panamá (Flórez-González *et al.* 1998). For stock E (i) the feeding ground is located from

110°E to unclear limits (Antarctic Areas IV y V). For the stock G, the previously known feeding grounds are located at Antarctic Area I (Stone *et al.* 1990, Stevick *et al.* in press¹).

Rosenbaum *et al.* (1995), compared populations of Eastern Australia, western Australia, Colombia, West Indies, México, Hawaii and Japan, and provided evidence that geographic differences in ventral fluke pigmentation reflect population sub-divisions in this species. In addition, Aguayo-Lobo *et al.* (1998)² and Dalla Rosa *et al.* (2001) found similarities between fluke coloration of the western Antarctic Peninsula and the tropical southeast Pacific (Colombia).

Humpback whale occurs in Patagonian fjords, Chile (Gibbons *et al.* 1998) and recently, a new summer feeding ground for the Southeastern Pacific Humpback whales

* Instituto de la Patagonia, Universidad de Magallanes. jorge.gibbons@umag.cl

** Fundación Yubarta, Colombia

*** Universidad Santo Tomás.

- 1 Aguayo, A., C. Olavarría, R. Bernal, L. Medrano, D. Torres & A. Larrea. (1998). Patrones de coloración de la población de ballenas jorobadas *Megaptera novaeangliae* australisque se alimenta en los estrechos Bransfield y de Gerlache y aguas adyacente, Antártica. Resúmenes XVIII Congreso Ciencias del Mar. Iquique, Chile. 63 – 64.
- 2 Stevick, P., A. Aguayo, J. Allen, I.C. Avila, J. Capella, C. Castro, K. Chater, M. H. Engel, F. Félix, L. Flórez-González, A. Freitas, B. Haase, M. Llano, L. Lodi, E. Muñoz, C. Olavarría, E. Secchi, M. Scheidat & S. Siciliano. (In Press). A note on the migrations of individually identified humpback whales between the Antarctic Peninsula and South America. *Journal of Cetacean Research and Management* xxx.

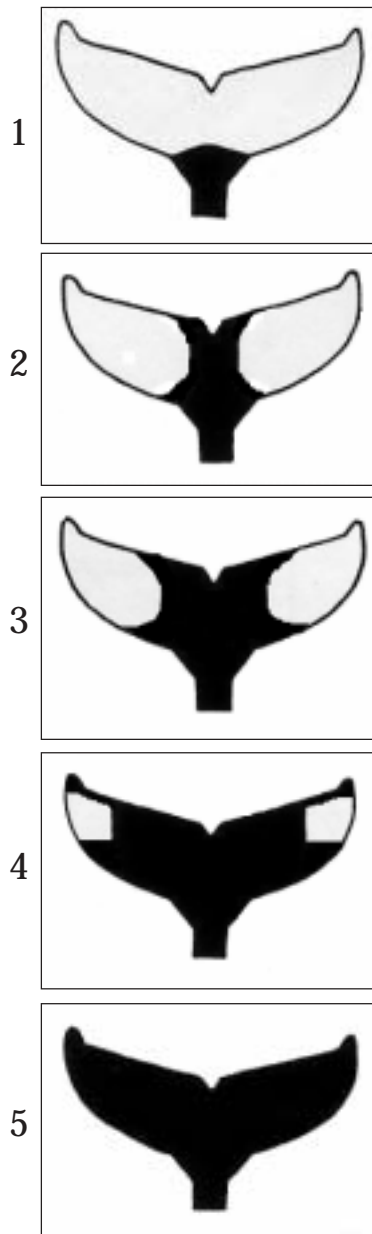


Fig. 1. Schematic draws of the five classes of ventral fluke pigmentation patterns of humpback whales, ranging from white (1) to black (5). Fluke photographs were categorized on the basis of this rank values.

population found at Straits of Magellan was described (Gibbons *et al.* 2003). It is located near 2000 km closer to their breeding grounds than the previously known feeding grounds at western Antarctic Peninsula (Stone *et al.* 1990, Gibbons *et al.* 2003).

In this study, we determined the

proportion of white and black coloration present on the flukes of the Humpback whales at Straits of Magellan, and compare our results with those of other Humpback whales breeding and feeding populations from Pacific Ocean basin (Perry *et al.* 1988, Rosenbaum *et al.*, 1995, Aguayo-Lobo *et al.* 1998, Straley &

Gabriele, 1998, Dalla Rosa *et al.* 2001)

in order to support its proposed migratory relationship with Colombian breeding ground (Gibbons *et al.* 2003, Acevedo *et al.* 2004, Sabaj *et al.* 2004).

Fluke photographs were collected in the area of the Francisco Coloane Marine Park (53°37'S, 72°21'W) and adjacent waters, at North West Straits of Magellan, Chile. Photographs selected for analysis showed > 80% ventral fluke with good or excellent photographic quality. Fluke photographs were assessed by eye and assigned rank values on 1 to 5, based on the proportions of white and black colouration present on the flukes respectively (Allen *et al.* 1994, Rosenbaum *et al.* 1995) (Fig. 1). Whales photographed more than once were ranked only once. The distribution of pigmentation classes among breeding and feeding aggregations was analyzed using the nonparametric Kruskal-Wallis test statistics which utilize rank ordering. The multiple pairwise comparisons were made using post-hoc nonparametric (Nemenyi test at $p < 0.01$) (Zar 1999).

Fluke pigmentation differed significantly among the 12 areas (Kruskal-Wallis $H = 1432.36$, $df = 11$, $n = 3841$, $p < 0.01$). Multiple pairwise comparisons revealed that population of Straits of Magellan was significantly different from those of western South Pacific (Australia) and Eastern and Western North Pacific (Mexico, Hawaii, Japan, Western and Southeastern Alaska) (Table 2). In addition, aggregations of humpback whales of Colombia (1 and 2), Straits of Magellan and Western Antarctic Peninsula (1 and 2) not differed significantly ($p \gg 0.01$) in ventral fluke pigmentation from each other (Table 2).

This study demonstrate uniformity in pigmentation among the seasonal concentration of humpback whales from stock G. The ventral fluke pigmentation patterns from the Straits of Magellan had higher frequency of lighter pigmented flukes, with an average of 2.25 ($n =$

TABLE 1. Frequency of ventral fluke pigmentation patterns of humpback from breeding and feeding areas in the Pacific ocean region. Categories: 1 = 100% white, 2= 75% white, 3= 50% white, 4= 25% white and 5= 100% black.

Area	Total (n)	% Fluke pigmentation categories					Reference
		1	2	3	4	5	
Eastern Australia	224	83.0	13.4	2.7	0.9	0	Rosenbaum <i>et al.</i> 1995
Western Australia	191	87.4	5.8	3.1	1.1	2.6	Rosenbaum <i>et al.</i> 1995
Colombia (1)	460	40.9	27.2	14.1	9.8	8.0	Fundación Yubarta, unpublished catalog
Straits of Magellan	57	42.0	26.3	12.3	3.5	15.8	This study
Colombia (2)	180	36.1	22.8	22.8	10.5	7.8	Rosenbaum <i>et al.</i> 1995
Western Antarctic Peninsula (1)	116	40.5	18.1	15.5	16.4	9.5	Aguayo Lobo <i>et al.</i> 1998
Western Antarctic Peninsula (2)	116	27.6	25.0	22.4	15.5	9.5	Dalla Rosa <i>et al.</i> 2001
Mexico	796	7.7	13.8	19.5	23.2	35.8	Rosenbaum <i>et al.</i> 1995
Hawaii	583	8.9	7.4	18.7	21.8	43.2	Rosenbaum <i>et al.</i> 1995
Japan	178	5.1	7.9	15.7	23.0	48.3	Rosenbaum <i>et al.</i> 1995
			Average				
							1.21
							1.26
							2.17
							2.25
							2.31
							2.36
							2.54
							3.65
							3.83
							4.02

TABLE 2. Multiple pairwise comparisons of mean ranks by nonparametric statistic (Nemenyi test). Significant differences were determined at p= 0.01 with critical Z value of 3.79. Symbol (*) indicates statistical significant differences detected in ventral fluke pigmentation ranks between populations and bold number no statistical significance.

ZONE	MEAN	Jap	SE Ala	Haw	Mex	W Ala	Ant 2	Ant 1	Col 2	Str M	Col 1	W Aus	E Aus
Japan	2515.3	-	-	-	-	-	-	-	-	-	-	-	-
South Eastern Alaska	2501.5	0.15	-	-	-	-	-	-	-	-	-	-	-
Hawai	2379.3	1.43	2.05	-	-	-	-	-	-	-	-	-	-
Mexico	2248.9	2.90	4.61*	2.16	-	-	-	-	-	-	-	-	-
Western Alaska	2136.3	2.69	3.04	1.98	0.93	-	-	-	-	-	-	-	-
Antarctic Peninsula 2	1458.7	7.98*	9.50*	8.16*	7.17*	4.41*	-	-	-	-	-	-	-
Antarctic Peninsula 1	1342.2	8.86*	10.56*	9.20*	8.22*	5.17*	0.80	-	-	-	-	-	-
Colombia 2	1302.9	10.34*	13.16*	11.38*	10.33*	5.93*	1.18	0.30	-	-	-	-	-
Straits of Magellan	1287.5	7.27*	8.00*	7.09*	6.32*	4.57*	0.95	0.30	0.09	-	-	-	-
Colombia 1	1217.1	13.26*	19.99*	16.80*	15.88*	7.35*	2.10	1.09	0.88	0.45	-	-	-
Western Australia	608.73	16.50*	21.30*	19.15*	18.35*	10.97*	6.51*	5.62*	6.02*	4.05*	6.37*	-	-
Eastern Australia	576.98	17.40*	23.09*	20.67*	19.93*	11.48*	6.95*	6.03*	6.54*	4.32*	7.08*	0.29	-

57) and 80.6% of whales photographed in categories 1, 2 and 3 of flukes rank (Table 1). The comparison revealed great similitude in Southeast Pacific: between 81.7 to 82.2% of whales photographed at Colombia and between 74.1 to 75.0% at western Antarctic Peninsula had categories 1 to 3 (Table 1). The analysis in this study confirm data on genetic structure that shows Humpback whales from Straits of Magellan, strongly differentiate from those of Eastern Australia and Western Australia, but not from those at Colombia (Sabaj *et al.* 2004) and Antarctic Peninsula (Olavarría *et al.* 2000). On the other hand, the population differentiation is consistent with previous information from photographic identification in the sense that there are not exchange of humpback whales among western and eastern South Pacific (Garrigue *et al.* 2002). Also, similitude among North Pacific humpback whales fluke coloration is consistent with the known interchange between their feeding and breeding grounds (Calambokidis *et al.* 2001).

ACKNOWLEDGMENTS

This study was supported and funded by Universidad de Magallanes (Grant 021500), Fundación Yubarta/WWF- project N° 9L0808.07, Universidad Santo Tomás (Grant INV-5-03-01) and Whalesound Ltda. We are grateful to Carlos Valladares, Luis Berteá, Jaime Cárcamo, Derek Corcoran, Javiera Martínez, Cristián Cerutti, Carlos Seguel, Ana M^a Salas, M^a José Pérez, Sofía Guerrero, Carla Genta, Valeria Sabaj and Javier Alonso for fieldwork assistance. We thank also to Isabel Avila, Viviana, Peña, Patricia Falk, Lilián Flórez-González, Julio Herrera and Isabel C. Tobón for assistance in photographic laboratory and statistical analyses.

LITERATURE CITED

- Acevedo, J., A. Aguayo-Lobo, K. Rasmussen, F. Félix, M. Llano, J. Allen, C. Olavarría, P. Acuña & L. Pastene 2004. Migratory destination of humpback whales, *Megaptera novaeangliae* (Borowski 1781), of the Magellan Strait feeding ground. Report to the Scientific Committee of the International Whaling Commission, Sorrento, Italy, IWC SC/56/SH22.
- Allen J., H. Rosenbaum, S. Katona, P. Clapham & D. Mattila 1994. Regional and sexual differences in fluke pigmentation of humpback whales (*Megaptera novaeangliae*) from the North Atlantic Ocean. *Canadian Journal of Zoology* 72: 274-279.
- Calambokidis, J., G. Steiger, J. Straley, L. Herman, S. Cerchio, D. Salden, J. Urbán, J. Jacobsen, O. Von Ziegesar, K. Balcomb, C. Gabriele, M. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladrón de Guevara, M. Yamaguchi, F. Sato, S. Mizroch, L. Schlender, K. Rasmussen, J. Barlow & T. Quinn II 2001. Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science* 17: 769-794.
- Dalla Rosa, L., E. Secchi, P. Kinas, M. Santos, M. Martins, A. Zerbini & C. Bethlem 2001. Photo-Identification of humpback whales, *Megaptera novaeangliae*, off the Antarctic Peninsula: 1997/98 to 1999/2000. *Memoirs of the Queensland Museum* 47(2): 555-561.
- Flórez-González, L., J. Capella, B. Haase, G. A. Bravo, F. Félix & T. Gerrodette 1998. Changes in winter destinations and northernmost record of Southeastern Pacific humpback whales. *Marine Mammal Science* 14(1): 189-196.
- Garrigue, C., A. Aguayo, V.L.U. Amante-Helweg, C.S. Baker, S. Caballero, P. Clapham, R. Constantine, J. Denkinger, M. Donoghue, L. Flórez-González, J. Greaves, N. Hauser, C. Olavarría, C. Pairoa, H. Peckham & M. Poole 2002. Movements of humpbacks whales in Oceania, South Pacific. *Journal of Cetacean Research and Management* 4(3): 255-260.
- Gibbons, J., J. Capella, R. Matus & L. Guzmán 1998. Presencia de la ballena jorobada, *Megaptera novaeangliae* (Balaenopteridae), en los canales Patagónicos de Chile. *Anales Instituto Patagonia*, Serie Cs. Nat. (Chile), 26: 69-75.
- Gibbons, J., J. Capella & C. Valladares 2003. Rediscovery of a humpback whale, *Megaptera novaeangliae*, feeding ground

- in the Straits of Magellan, Chile. *Journal of Cetacean Management*, 5, 203-208.
- Hauser, N., H. Peckham & P. Clapham 2000. Humpback whales in the Southern Cook Island, South Pacific. *Journal of Cetacean Research and Management* 2(3): 159-164.
- Mackintosh, N. A. 1965. *The stocks of whales*. Bouckland Foundation Book, Londres. 232pp.
- Olavarría, C., C.S. Baker, L. Medrano, A. Aguayo, S. Caballero, L. Flórez-González, J. Capella, H. Rosenbaum, C. Garrigue, J. Greaves, J. Bannister, M. Jenner & C. Jenner. 2000. Stock identity of Antarctic Peninsula humpback whales inferred from mtDNA variation. *Report to the Scientific Committee of the International Whaling Commission*, Adelaide, Australia, IWC SC/52/IA15.
- Perry, A., J. Mobley, C. S. Baker & L. Herman (Eds.) 1988. *Humpback whales of the Central and Eastern North Pacific*. A catalog of individual identification photographs. University of Hawaii Sea Grant College Program, Honolulu, USA.
- Poole, M. 2002. Occurrence of humpback whales (*Megaptera novaeangliae*) in French Polynesia in 1988-2001. *Report to the Scientific Committee of the International Whaling Commission*, Berlín, Germany, IWC SC/54/H14.
- Rosenbaum, H., P.J. Clapham, J. Allen, M. Nicole-Jenner, C. Jenner, L. Flórez González, J. Urbán, P. Ladrón G., K. Mori, M. Yamaguchi & C.S. Baker 1995. Geographic variation in ventral fluke pigmentation of humpback whale (*Megaptera novaeangliae*) populations worldwide. *Marine Ecology Progress Series* 124: 1-7.
- Sabaj, V., Y. Vilina, S. Guerrero, J. Capella, J. Gibbons & C. Valladares 2004. Genetic structure of the recently discovered feeding ground of humpback whales at Straits of Magellan, Chile. *Report to the Scientific Committee of the International Whaling Commission*, Sorrento, Italy, IWC SC/56/SH19.
- Stone, G.S., L. Flórez-González & S. Katona 1990. Whale migration record. *Nature* 346 (6286): 705.
- Straley, J. & C. Gabriele 1998. *Humpback whales of Southeastern Alaska*. University of Alaska Southeast and Glacier Bay National Park and Preserve, Alaska, USA.
- Zar, J. H. 1999. *Biostatistical analysis*. Fourth Edition. Prentice-Hall, Inc. New Jersey, USA. 663 pp.