The 2005 Galápagos humpback whale expedition: a first attempt to assess and characterise the population in the Archipelago

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ABSTRACT
It has been known for some time that humpback whales (Megaptera novaeangliae) occur in waters of the Galápagos Islands, an oceanic archipelago located 1,000km west of Ecuador, South America (1°S, 91°W), but their presence there has been poorly documented. Although presumed, no linkage has been established between Galápagos and southeast Pacific humpback whales (Breeding Stock G), the nearest breeding stock. An expedition to Galápagos was carried out between 31 August and 10 September 2005 to document the presence of humpback whales, their distribution, and their relationship to other stocks in the Pacific. Surveys covered 722km of the central and southern parts of the archipelago. Only one adult with a newborn calf was found at Santa Fé Island (0°47’S, 90°05.1’W), yielding an encounter rate of 0.27 whales per 100km of survey. A hydrophone with a response frequency range of 0.25–25kHz was dropped 25 times, but no whale sounds were heard. A skin sample was obtained by darting of the adult at Santa Fé, and was used for genetic analysis of the mtDNA control region. The haplotype of the Galápagos specimen has been found in a few individuals sampled previously off Colombia, Ecuador and the Antarctic Peninsula, thus establishing at least some degree of relatedness with Breeding Stock G. The observations, combined with a compilation of historical and recent sighting information in the archipelago, support the idea that Galápagos is a breeding area for the species. Further studies are needed to establish the level of discreteness, size and other basic aspects of the Galápagos humpback whale population.

KEYWORDS: SOUTH AMERICA; GALÁPAGOS ISLANDS; BREEDING GROUNDS; HUMPBACK WHALE; SURVEY-VESSSEL; OPPORTUNISTIC SIGHTINGS; GENETICS

INTRODUCTION
The importance of the Galápagos Islands for large cetaceans has been known for a long time, particularly for sperm whales (Physeter macrocephalus; Townsend, 1935; Whitehead and Hope, 1991). However, in the past few decades, a number of scientific expeditions have highlighted the importance of the archipelago’s waters for several other cetacean species, including both baleen and toothed whales (Alava, 2002; Clarke, 1962; Clarke et al., 2002; Leveque, 1963; Loesch, 1966; Lytholm et al., 1992; Palacios, 1999; Palacios, 2003; Palacios et al., 2000; Whitehead, 1986). Despite the existence of confirmed observations of humpback whales (Megaptera novaeangliae) in Galápagos, mostly made by naturalist guides (Day, 1994; Jackson, 1993; MacFarland, 1977; Merlen, 1995), the low number of records suggests that the species is not common in the waters of the archipelago. This could be due not only to a potentially small population using the archipelago, but to a comparatively low search effort by the above-mentioned expeditions in the nearshore areas where humpback whales are expected to occur.

The nearest humpback whale population to Galápagos is the southeast Pacific stock (also referred to as Breeding Stock G, see IWC, 1998), which is distributed along the coast of western South America. A number of studies based on photo-identification (Acevedo et al., 2007; Flórez-González et al., 1998; Stevick et al., 2004) and genetics (Caballero et al., 2001; Félix et al., 2007; Olavarria et al., 2007), have identified the breeding areas for Stock G off northwestern South America, and the corresponding feeding areas off the Antarctic Peninsula and the Magellan Strait. However, so far no link has been established between Galápagos and South American humpback whales.

The ‘Galápagos Humpback Whale Expedition’ was conducted during the austral winter of 2005. The expedition aimed to establish the identity and status of the humpback whales that occur in Galápagos in order to create a knowledge baseline for management purposes. The study was made in the context of a long-term investigation of the southeast Pacific humpback whale stock that the Ecuadorian Foundation for the Study of Marine Mammals (Fundación Ecuatoriana para el Estudio de Mamíferos Marinos, FEMM) has been conducting along the coast of Ecuador since 1991 (Félix and Haase, 2005; Félix and Haase, 2001). The most relevant findings from this expedition are presented here and a molecular comparison is made with continental whales in a first attempt to establish the identity of Galápagos humpback whales. A compilation of historical and recent humpback whale records in Galápagos are also presented to provide a clearer picture of the distribution and temporal occurrence of the species within the archipelago. This effort is highly relevant to one of the key aspects highlighted in a regional conservation strategy recently designed for the southeast Pacific humpback whale population (Floréz-Gonzáles et al., 2007), which calls for the generation of basic information from less-studied areas within the breeding grounds that could be considered critical for the species.

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MATERIAL AND METHODS

Study area
The Galápagos archipelago is formed by a group of 13 large islands (>10km²), six smaller islands, and over 100 islets and rocks (Jackson, 1993; Snell et al., 1996). It is located 1,000km west of the coast of Ecuador, South America (1°S, 91°W) (Fig. 1). The islands are surrounded by narrow shelves and abrupt slopes, with some shallow areas in the central part of the archipelago. In the outer areas, depth increases rapidly to 3,000m or more, particularly in the western and southern regions. A marine protected area extending 40 n.miles (74.1km) from the baseline surrounding the entire archipelago and covering an area of about 138,000km², was established in 1998 as the ‘Galápagos Marine Resources Reserve’ (Heylings et al., 2002). The highly productive waters of the archipelago, especially on the western side (Palacios, 2002; Palacios et al., 2006), create favourable conditions for a high abundance and diversity of marine mammals (Palacios and Salazar, 2002; Palacios, 2003).

Historical and recent records
In preparation for the expedition previous records of humpback whales from three sources were compiled as follows.

(1) Townsend Whaling Charts (Townsend, 1935). Capture locations within Galápagos waters were extracted from monthly maps containing 2,883 humpback whale catch records from North American (‘Yankee’) pelagic whale vessel logbooks dating from 1761 to 1920. Each record in the charts corresponds to the location of a whaling ship on a day when one or more whales were taken, and does not necessarily reflect the number of whales caught. These data are available in digital format from the Wildlife Conservation Society (http://www.wcs.org/sw-high_tech_tools/landscapeecology/townsend_charts).

(2) Sighting locations collected in Galápagos waters by scientific observers aboard tuna fishing vessels (Archer et al., 2002; Buckland et al., 1992) and research vessels (Hill et al., 1991; Kinzey et al., 1999) under programmes conducted by the Southwest Fisheries Science Center (SWFSC) of the US NOAA/National Marine Fisheries Service. Sightings collected by a team from Dalhousie University, Canada while conducting sperm whale research in Galápagos (Smith and Whitehead, 1999; Whitehead, 1986) were also included.

(3) Weekly reports by licensed naturalist guides to the Galápagos National Park (GNP) and from a ‘Sightings Logbooks Program’ created under an inter-institutional agreement between the GNP and the Charles Darwin Foundation (CDF). The objective of this programme is to establish a uniform reporting standard and to improve the quality of information reported by the different users of the Galápagos Marine Resources Reserve. Sightings logbooks are distributed among users, to be completed whenever cetacean sightings are recorded. Tour vessels operating in the Reserve must follow established routes to visitor sites and carry aboard naturalist guides trained in marine mammal identification. About 40 vessels currently participate in the programme. The programme was officially implemented in 2001, but it contains records starting from 1995. The reports are quality-controlled for errors and are entered into a database maintained by the CDF (Salazar and Hernandez, 2000). For mapping purposes, the geographic coordinates for records for which only the approximate locality was reported were georeferenced using the GIS software ArcView 3.2 with the animal movement extension. Throughout the text, these positions are referred to as ‘estimated’ to differentiate them from exact positions obtained directly in the field, which are referred to as ‘instrument’.

Surveys
Between 31 August and 10 September 2005, ten surveys were conducted in the central part of the archipelago aboard four different vessels: three small boats (6–8m in length)
with outboard engines, and the 12m sailboat ‘Bronzewing’, which was used as a live-aboard platform for seven days. Daily trips lasted 5–12h depending on weather conditions and on finding a safe place to overnight. Surveys were carried out over the shelf of several islands in areas where the presence of humpback whales had previously been reported. Trips plans were made and updated on a daily basis, based on the progress made during the day. For this purpose, the navigation Chart IOA 21 (INOCAR, Ecuador) and a GPS Garmin 60™ were used. In the case of the small boats, observations were made from the cabin’s rooftop, about 2–2.5m above the waterline. Boats moved at an average speed of 12kt (22.2km h–1). On the sailboat, which was powered by a small inboard diesel engine, observers were located on the main deck, both at the bow and amidships, at an average height of 1.5m above the waterline. The sailboat’s speed ranged between 5 and 7kt (9.3–13km h–1).

Sea state conditions were fairly constant during the study period, ranging between 2 and 3 on the Beaufort scale. When conditions worsened, sighting effort was stopped (this occurred twice). During the observation periods, information on group size and composition, position, heading, speed and general behaviour was obtained. Photographs were taken with a digital camera equipped with a 70–300mm zoom lens.

A hydrophone model C10 (Cetacean Research Technology) with a response frequency range of 0.25–25kHz and a digital voice recorder Archos G-Mini 120 were used for listening and recording whale songs. The hydrophone was used on an irregular basis, in some cases every 60min of survey, especially on the small boats. Aboard the sailboat, the hydrophone was used sporadically at the beginning and end of the daily surveys.

**Results**

### Molecular analysis

A skin sample was obtained from a humpback whale at Santa Fé Island with a Barnett crossbow equipped with a 60cm-long arrow and modified tips (see Lamberty, 1987). The biopsy was preserved in a solution of dimethylsulfoxide saturated in sodium chloride. Approximately a 520bp fragment of the mitochondrial DNA control region was amplified via the Polymerase Chain Reaction (PCR) using standard reaction conditions (Palumbi, 1996; Satki et al., 1988). For the PCR, the primer combination t-Pro-whale (5’-TCACCCAAAGCTGRARTTCTA-3’) and Dlp8 (5’CCATCGWGATGTCTTATTTAAGRGGAA-3’) was used (Baker et al., 1998; Olavarría et al., 2007). The PCR profile used was as follows: an initial denaturation at 95°C for 2min; 36 cycles of 94°C for 30s, 55°C for 1min, 72°C for 1.30min; and a final extension at 72°C for 5min. Free nucleotides and primers were removed from the PCR products using shrimp alkaline phosphatase and exonuclease I (ExoI, USB) and directly sequenced in both directions using the standard protocols of Big Dye terminator sequencing chemistry on an ABI 3100 automated capillary sequencer (Perkin Elmer).

A 480bp fragment was analysed for haplotype determination. The sequence was manually edited and aligned using Sequencer 4.1 software (Gene Codes Corporation). The control region haplotype was defined using MacClade (Maddison and Maddison, 2000) and compared with haplotypes previously defined for other humpback whale populations in the South Pacific (Caballero et al., 2001; Félix et al., 2007; Olavarría et al., 2006; Olavarría et al., 2007). Haplotype nomenclature follows Olavarría et al. (2007).

### Visual and acoustic survey effort

The surveyed areas covered waters around the following islands: west and north of San Cristóbal; east and north of Floreana; and western (Isabela) side of the archipelago, although whales were also seen over the shelf of all main islands except for Pinta.

The frequency distribution of sightings per month (including sightings involving adult-calf pairs) is shown in Fig. 2. Humpback whales were recorded over ten different months, with a clear peak between July and October, and with fewer records in May, June and November. In addition, 11 sightings (12.5%) were made between January and April, including two female-calf pairs.

### Table 1

| Date          | Survey                  | Duration (hr) | Distance (km) |
|---------------|-------------------------|---------------|---------------|
| 31/08/05      | West and NW sides of San Cristóbal | 7.90          | 100.50        |
| 01/09/05      | San Cristóbal-Santa Fé-Santa Cruz                      | 6.16          | 74.50         |
| 03/09/05      | Santa Cruz-Santa Fé                                      | 5.21          | 38.60         |
| 04/09/05      | Santa Fé-Floreana                                       | 9.25          | 72.50         |
| 05/09/05      | Floreana - southeast of Isabela                          | 11.83         | 91.39         |
| 06/09/05      | SE of Isabela-Rábida                                      | 11.48         | 72.28         |
| 07/09/05      | Rábida-Baltra                                          | 10.13         | 58.61         |
| 08/09/05      | Baltra - north of Santa Cruz                             | 6.21          | 37.63         |
| 09/09/05      | West of Santa Cruz-Puerto Ayora                          | 7.71          | 93.99         |
| 10/09/05      | Santa Cruz-San Cristóbal                                 | 5.40          | 82.36         |
| **Total**     |                                                        | **81.33**     | **722.36**    |

Fig. 2. Frequency distribution per month of historical and recent humpback whale records in the Galápagos Islands for groups containing adults only and adult/calf pairs.
Santa Fé; north of Floreana; southeast of Isabela; north, west and south of Santa Cruz; southeast of Santiago; and the waters between them (Fig. 3). The total distance covered was 722.36km and the total navigation time was 81.33hr (Table 1). The hydrophone was dropped for 5min (±1min) at 25 different sites (Fig. 3), but no sounds were heard during the entire expedition.

Encounter rate
The only humpback whale observation made during the expedition was near Santa Fé Island (0°47.6’S, 90°05.1’W) (Fig. 3). The group was made up of an adult with a small calf, probably a couple of weeks old judging by its very small size and the light grey colour of its skin (Fig. 4). The pair was found over a shallow area of less than 20m in depth, northwest of the island. According to the navigation chart IOA 21, Santa Fé Island has a shelf of 100m in depth extending some 10km on its southeast side, but in the northwest part, where the pair was found, the shelf only extends out to about 3km. However, the sighting was made over a shallow flat area marked on the navigation chart as 13m depth and with an area of about 3–4km². Photographs of the dorsal fins were taken since none of the animals showed their flukes. The encounter rate for humpback whales during this expedition was of 0.276 whales per 100km of survey.

Control region haplotype
The Galápagos haplotype was identified as SP61, which has previously been found in one individual from mainland Ecuador (Félix et al., 2007), one from Colombia (Olavarria et al., 2007) and two from the Antarctic Peninsula (Olavarría et al., 2006).

DISCUSSION
Relative abundance and habitat use
While the GNP-CDF database was useful in establishing that humpback whales may be found in nearshore waters throughout the archipelago, further interpretation is complicated due to three sources of bias in this data set: (1) recording does not follow a systematic effort, making it impossible to obtain estimates of relative abundance; (2) the same animal(s) could be reported by more than one observer at sites visited by multiple vessels in a short time period; and (3) the reports came from lots of observers with different levels of experience in identifying whale species, increasing the possibility of misidentification.

The 2005 ‘Galápagos Humpback Whale Expedition’ was the first attempt to quantify the presence of this species in the archipelago. Nevertheless, during the study period, it was not possible to survey all the sites where humpback whales have been reported previously (Fig. 1), particularly the highly productive areas between Isabela and Fernandina Islands. The survey was limited to the central, southern and southeastern parts of the archipelago, over the shelf of several islands and the deep-water zone between them.
extensive areas of the archipelago remained unsurveyed, the findings should not be considered representative of the entire archipelago.

There was a large difference in whale density in the surveyed areas in Galápagos compared to the breeding areas off mainland Ecuador, where the encounter rate was 59 times higher during the same season (Félix et al., 2004). It should be recognised, however, that survey conditions were not the same between these two areas, since sea state conditions are slightly better and faster boats are used at the mainland sites. Despite these differences, the data presented herein support the notion that Galápagos contains a low density of humpback whales, as previous reports have suggested (Day, 1994; Merlen, 1995). It is possible that humpback whales were never abundant in Galápagos, considering that 19th century American whalers concentrated their effort on humpback whales in the continental waters of Panamá, Colombia and Ecuador, while the Galápagos Islands were considered a major whaling area for sperm whales (Townsend, 1935).

A low humpback whale density seems to be characteristic of oceanic archipelagos in the South Pacific. For instance, Gannier (2004) reported encounter rates between 0.35 and 1.54 whales per 100km of survey in French Polynesia, which is between 1.3 and 5.7 times higher than for the Galápagos Islands. Although Gannier primarily used a similar 12m sailboat, both studies also used data obtained from other types of vessels. Therefore, caution should be exercised with this interpretation, as the data are probably not fully comparable. It is also known that humpback whales show a clustered distribution around archipelagos, with sites of high concentration of animals and extended zones of low densities. In Hawai‘i, for example, there is high density in a shallow area known as the Penguin Bank and also in the Four Island area off Maui (Herman and Antinoja, 1977; Salden, 1988). In the Caribbean, 85% of the entire North Atlantic population concentrates for breeding at Silver and Navidad Banks off the northern Dominican Republic (Winn et al., 1975), although whales can be found as far south as the Lesser Antilles (Swartz et al., 2003). While it is not implausible that such a type of distribution may occur in Galápagos, it seems unlikely that local high whale concentrations have passed unnoticed in an area with such a high level of tourism activities.

A determining factor for the low encounter rate may have been the low observation height onboard the vessels. However, the lack of song detection is supportive of a low whale density at the time of the survey. An alternative explanation to the low encounter rate may have included the lack of song detection. Reports of humpback whales have been found in Northeast Pacific humpback whales overlap in waters off Panamá and Costa Rica (Acevedo-Gutiérrez and Smultea, 1995; Rasmussen et al., 2007), and possibly as far south as southern Colombia, where two haplotypes from a North Hemisphere stock have been found (Caballero et al., 2001). This possibility is that these whales did not migrate and remained during the entire year around Galápagos. The high local productivity, especially in the western part of the archipelago (Palacios, 2002; Palacios et al., 2006), could provide food for non-migrating animals, as has been proposed in other tropical areas with intense upwelling (Papastavrou and Van Waerebeek, 1997). One of these areas is the coast of Perú, a few hundred kilometers southeast of Galápagos, where humpback whales have been reported throughout the entire year (Ramírez, 1988).

The molecular biology study showed a relationship between Galápagos humpback whales and Breeding Stock G, since the same haplotype has been found in Colombia, Ecuador and the Antarctic Peninsula. However, the Galápagos haplotype was not among the most common ones found in Breeding Stock G, as it has only been found four times in about 400 samples from the southeast Pacific and the Antarctic Peninsula (Félix et al., 2007; Olavarria et al., 2007). Genetic (Félix et al., 2007; Olavarria et al., 2006), and photo-identification (Acevedo et al., 2007) studies indicated that Breeding Stock G shows some degree of heterogeneity in its distribution, with at least two well-defined subunits. The possibility that Galápagos humpback whales could be part of a discrete subunit with a high degree of exchange with the continental population cannot be excluded. Genetic differentiation between continental and insular populations has been found in Northeast Pacific humpback whales breeding at the Revillagigedo Archipelago, relative to whales breeding along central mainland Mexico, only 700km apart (Urban et al., 2000). Further sampling and analysis are needed to establish the degree of discreteness, genetic variability and the main lineages in Galápagos, among other key population parameters.

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**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. Mammal Sci.* 11(4): 554–60.

Acevedo, J., Rasmussen, K., Félix, F., Castro, C., Llanro, M., Secchi, E., Saborio, M.T., Aguayo-Lobo, A., Haase, B., Scheidet, M., Dulla Rosa, L., Olavarría, C., Forestell, P., Acuña, P., Kaufman, G. and Paste, L.A. 2007. Migratory destinations of humpback whales, *Megaptera novaeangliae* from the Magellan Strait feeding ground, southeast Pacific. *Mar. Mammal Sci.* 23(2): 453–63.

Alava, J.J. 2002. Registro y abundancia relativa de mamíferos marinos durante el cruce oceánico inusual B1/Orion en las islas Galápagos y sus alrededores. *Acta Oceanogr fica del Pacífico* 11(1): 165–72. [In Spanish].

Archer, F., Gerrodette, T. and Jackson, A. 2002. Preliminary estimates of the annual number of sets, number of dolphins chased, and number of dolphins captured by stock in the tuna purse-fishery in the eastern tropical Pacific, 1971–2000. US Dep. Commer. NOAA-NMFS-SWFCSC Admin. Report L3-02-10. 28pp.

Baker, C.S., Flórez-González, L., Abberthy, B., Rosenbaum, H.C., Slade, R.W., Capella, J. and Bannister, J.L. 1998. Mitochondrial DNA variation and maternal gene flow among humpback whales of the Southern Hemisphere. *Mar. Mammal Sci.* 14(4): 721–37.

Buckland, S.T., Cattach, K.L. and Anguauti, A.A. 1992. Estimating trends in abundance of dolphins associated with tuna in the eastern tropical Pacific Ocean, using sightings data collected on commercial tuna vessels. *Fish. Bull.* 90: 1–12.

Caballero, S., Hamilton, H., Jaramillo, H., Capella, J., Flórez-González, L., Olavarría, C., Rosenbaum, H.C., Guhl, F. and Baker, C.S. 2001. Genetic characterisation of the Colombian Pacific Coast humpback whale population using RAPD and mitochondrial DNA sequences. *Memos. Queensland Mus.* 47: 459–64.

Clarke, R. 1962. Whale observation and whale marking off the coast of Chile in 1958 and from Ecuador towards and beyond the Galápagos Islands in 1959. *Norsk Hvistendahlins* 51(7): 265–87.

Clarke, R., Félix, F., Paliza, O. and Brtnik, P. 2002. Ballenas y delfines observado por la expedición Ballenas Libres durante el cruce oceánico CO-II-01 entre Guayaquil y las Islas Galápagos del 17 Septiembre al 9 de octubre de 2001. *Acta Oceanográfica del Pacífico* 11(1): 135–55. [In Spanish]

Day, D. 1994. List of cetaceans seen in Galapagos. *Noticias de Galápagos* 53: 5–6.

Ersts, P.J. and Rosenbaum, H.C. 2003. Habitat preference reflects social organization of humpback whale (*Megaptera novaeangliae*) in a wintering ground. *J. Zool., London.* 260: 337–45.

Félix, F. and Haase, B. 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. *J. Cetacean Res. Manage.* 7(1): 21–29.

Félix, F., Haase, B., Bearon, B., Torres, S. and Falconi, J. 2004. Scientific and educational activities in Ecuador during 2004. Report to the Whale and Dolphin Society, England, December 2004. 28pp. [Available from: www.wdcs.org].

Félix, F., Caballero, S. and Olavarría, C. 2007. A preliminary assessment of the genetic diversity in humpback whales (*Megaptera novaeangliae*) from Ecuador and population differentiation with other Southern Hemisphere breeding grounds and feeding areas. Paper SC/59/S11 presented to the IWC Scientific Committee, May 2007, Anchorage, USA (unpublished). [Paper available from the Office of this Journal]. 11pp.

Flórez-González, L., Avila, I.C., Capella, J.C., Falk, P., Félix, F., Gobbo, J., Guzman, H.M., Haase, B., Herrera, J.C., Peña, V., Santillan, L., Tobon, I.C. and Van Waerebeek, K. 2007. Estrategia para la Conservación de la Ballena Jorobada del Pacífico Surdeste. Lineamientos para un plan de acción regional e iniciativas nacionales, Fundacion Yubarta, Cali, Colombia. 106pp. [In Spanish].

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. Mammal Sci.* 14(1): 189–96.

Gannier, A. 2004. The large-scale distribution of humpback whales (*Megaptera novaeangliae*) wintering in French Polynesia during 1997–2002. *Aquat. Mamm.* 30(2): 227–36.

Herman, L.M. and Antinoga, R.C. 1977. Humpback whales in the Hawaiian breeding waters: population and pod characteristics. *Sci. Rep. Whales Res. Inst., Tokyo* 29: 59–85.

Heylings, P., Bensted-Smith, R. and Altamirano, M. 2002. Zonificacion e historia de la Reserva Marina de Galapagos. pp.10–21. In: Danulat, E. and Edgar, G.J. (eds). *Reserva Marina de Galapagos, Linea Base de la Biodiversidade*. Fundación Charles Darwin-Servicio Parque Nacional Galapagos, Santa Cruz, Galapagos, Ecuador. [In Spanish].

Hill, P.S., Jackson, A. and Gerrodette, T. 1991. Report of a marine mammal survey of the eastern tropical Pacific aboard the research vessel *McArthur* July 28–December 6, 1990. US Dep. Commer. NOAA Tech. Memos. NOAA-TM-NMFS-SWFCSC-159. 142pp.

International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:53–118.

Jackson, M.H. 1993. *Galapagos, a Natural History*. University of Calgary Press, Calgary, Canada. 315pp.
### Appendix 1

Table with 89 historical and recent records of humpback whales in the Galápagos Islands, including date, geographic coordinates, group composition, nearest island, specific locality and sources. Position denotes whether the geographic coordinates were obtained in the field with an instrument or estimated subsequently using GIS software based on the nearest locality reported (i.e. georeferenced). Note that the records from the Townsend Whaling Charts correspond to the location of a whaling ship on a day when one or more whales were taken, and that they only reported the month but not the year.

| Date       | Lat/Long          | Adults | Calves | Total | Island    | Locality                      | Position | Source                        |
|------------|-------------------|--------|--------|-------|-----------|--------------------------------|----------|-------------------------------|
| June       | 0°24.3’N; 91°17.6’W |        |        |       | Isabela   | Offshore capture N of Isabela | Estimated | Townsend (1935)               |
| July       | 0°30.3’S; 87°46.9’W |        |        |       | Isabela   | Offshore capture ENE of San Cristóbal | Estimated | Townsend (1935)               |
| July       | 1°15.6’S; 91°20.4’W | 1      |        | 1     | Bartolomé | Capture of Isabela            | Estimated | Townsend (1935)               |
| August     | 0°16.6’S; 90°33.0’W | 1      |        | 1     | Isabela   | Bahía Elizabeth               | Instrument | SWFSC tuna vessel            |
| 16/07/1979 | 0°38.0’S; 91°24.0’W | 1      |        | 1     | Isabela   | Offshore sighting SE of Floreana | Instrument | SWFSC research vessel        |
| 23/09/1990 | 1°40.1’S; 89°14.8’W | 1      |        | 1     | Marchena  | Punta Suárez                  | Estimated | GNP-CDF database              |
| 24/09/1990 | 0°15.1’S; 90°25.6’W | 1      |        | 1     | Española  | Puerto Egas                    | Estimated | GNP-CDF database              |
| 07/11/1998 | 0°02.2’S; 90°53.6’W | 2      |        | 2     | Isabela   | Tortuga Is.                   | Estimated | GNP-CDF database              |
| 24/05/1999 | 0°12.9’S; 90°53.0’W | 2      |        | 2     | Santiago  | Bahía                          | Estimated | GNP-CDF database              |
| 24/05/1999 | 0°23.7’S; 90°43.9’W | 2      |        | 2     | Rábida    | Bahía                          | Estimated | GNP-CDF database              |
| 07/1999    | 1°12.8’S; 90°26.6’W | 1      |        | 1     | Floreana  | Bahía Post Office             | Estimated | GNP-CDF database              |
| 07/1999    | 1°09.9’S; 90°26.0’W | 1      |        | 1     | Floreana  | Bahía Post Office             | Estimated | GNP-CDF database              |
| 08/1999    | 1°11.5’S; 90°24.3’W | 2      |        | 2     | Floreana  | Bahía Post Office             | Estimated | GNP-CDF database              |
| 02/08/1999 | 0°08.9’S; 90°23.4’W | 2      |        | 2     | Floreana  | Bahía Post Office             | Estimated | GNP-CDF database              |
| 03/10/1999 | 1°10.9’S; 90°28.5’W | 2      |        | 2     | Genovesa  | Back side of cliff            | Estimated | GNP-CDF database              |
| 21/10/1999 | 0°13.4’S; 89°55.0’W | 2      |        | 2     | Floreana  | Bahía Post Office             | Estimated | GNP-CDF database              |
| 11/11/1999 | 0°07.3’S; 90°25.6’W | 2      |        | 2     | Floreana  | Bahía Post Office             | Estimated | GNP-CDF database              |
| 02/04/2000 | 0°15.5’S; 91°27.2’W | 1      |        | 1     | Fernandina| Stranding at Punta Espinoza   | Estimated | GNP-CDF database              |
| 06/08/2000 | 0°42.9’S; 90°12.3’W | 1      |        | 1     | Santa Cruz| Garrapatero                   | Estimated | GNP-CDF database              |
| 13/10/2000 | 0°24.0’S; 91°20.4’W | 1      |        | 1     | Isabela   | Canal Boviar                   | Estimated | GNP-CDF database              |
| 22/07/2001 | 0°48.0’S; 90°18.0’W | 1      |        | 1     | Santa Cruz| Outside Bahía Academia        | Estimated | GNP-CDF database              |
| 26/07/2001 | 0°28.9’S; 90°18.8’W | 1      |        | 1     | Baltra    | Canal de Itabaca              | Estimated | GNP-CDF database              |
| 28/07/2001 | 1°22.5’N; 91°51.0’W | 1      |        | 1     | Wolf      |                                 | Estimated | GNP-CDF database              |
| 08/2001    | 0°40.1’N; 91°58.5’W | 1      |        | 1     | Darwin    |                                 | Estimated | GNP-CDF database              |
| 04/08/2001 | 0°21.2’N; 91°48.0’W | 1      |        | 1     | Wolf      | Bahía de Ancieta               | Estimated | GNP-CDF database              |
| 04/08/2001 | 0°30.5’S; 90°11.6’W | 1      |        | 1     | Santa Cruz| Baltra-Rocas Gordon            | Estimated | GNP-CDF database              |
| 07/08/2001 | 0°31.0’S; 90°30.5’W | 1      |        | 1     | Santa Cruz| In front of Cerro Dragón       | Instrument | GNP-CDF database              |
| 11/08/2001 | 1°23.5’N; 91°46.4’W | 1      |        | 1     | Wolf      |                                 | Estimated | GNP-CDF database              |
| 12/08/2001 | 1°22.8’N; 90°49.2’W | 1      |        | 1     | Offshore capture N of Pinta    | Instrument | GNP-CDF database              |
| 16/08/2001 | 0°17.1’S; 91°22.3’W | 1      |        | 1     | Isabela   | Caleta Tagus                   | Estimated | GNP-CDF database              |
| 31/08/2001 | 0°48.2’S; 90°02.3’W | 1      |        | 1     | Santa Fé | Bahía Santa Fé                 | Estimated | GNP-CDF database              |
| 09/2001    | 0°28.5’S; 90°13.9’W | 1      |        | 1     | Santa Cruz| Canal Itabaca-Isla Plazas      | Estimated | GNP-CDF database              |
| 15/09/2001 | 0°15.1’N; 91°38.3’W | 1      |        | 1     | Isabela   | Roça Redonda                   | Estimated | GNP-CDF database              |
| 18/09/2001 | 0°52.0’S; 89°37.0’W | 1      |        | 1     | San Cristóbal| Outside Puerto Baquerizo Moreno| Instrument | GNP-CDF database              |
| 22/09/2001 | 0°15.5’S; 90°31.8’W | 1      |        | 1     | Bartolomé |                                 | Estimated | GNP-CDF database              |
| 10/2001    | 1°13.5’S; 90°23.0’W | 1      |        | 1     | Floreana  |                                 | Estimated | GNP-CDF database              |
| 01/10/2001 | 1°42.7’N; 91°59.1’W | 1      |        | 1     | Darwin    | Arco de Darwin                 | Estimated | GNP-CDF database              |
| 02/10/2001 | 0°11.3’S; 91°28.8’W | 1      |        | 1     | Isabela   | Bahía Banks                    | Estimated | GNP-CDF database              |
| 12/10/2001 | 1°38.1’N; 92°00.4’W | 1      |        | 1     | Darwin    | Arco de Darwin                 | Estimated | GNP-CDF database              |
| 22/10/2001 | 1°08.3’S; 90°28.3’W | 1      |        | 1     | Floreana  | Punta Cormorant                | Estimated | GNP-CDF database              |
| 22/10/2001 | 0°45.8’S; 90°17.8’W | 1      |        | 1     | Santa Cruz| Bahía Academia                 | Estimated | GNP-CDF database              |
| 30/10/2001 | 1°12.8’S; 90°29.9’W | 1      |        | 1     | Floreana  | Corona del Diablo              | Estimated | GNP-CDF database              |

Cont.
| Date       | Lat/Long                | Adults | Calves | Location                      | Position          | Source               |
|------------|-------------------------|--------|--------|-------------------------------|-------------------|----------------------|
| 17/03/2002 | 1°10.9'S; 90°22.1'W     | 1      |        | 4.3 mi from Floreana          | Estimated         | GNP-CDF database     |
| 22/04/2002 | 0°03.5'S; 91°33.8'W     | 1      |        | Est. from Bahia Banks         | Instrument        | GNP-CDF database     |
| 08/09/2002 | 1°09.9'S; 90°30.5'W     | 1      | 1      | Bahia Post Office             | Estimated         | GNP-CDF database     |
| 30/09/2002 | 0°10.0'S; 91°30.0'W     | 1      | 1      |                     | Instrument        | GNP-CDF database     |
| 03/11/2002 | 1°23.1'N; 91°48.8'W     | 1      |        |                  | Instrument        | GNP-CDF database     |
| 26/07/2003 | 0°30.9'S; 90°29.4'W     | 1      | 1      |                  | Instrument        | GNP-CDF database     |
| 29/07/2003 | 0°23.7'S; 90°18.8'W     | 1      | 1      |                  | Estimated         | GNP-CDF database     |
| 12/08/2003 | 0°15.1'N; 91°25.1'W     | 1      | 1      |                  | Instrument        | GNP-CDF database     |
| 24/08/2003 | 1°20.0'S; 89°44.0'W     | 1      | 1      |                  | Estimated         | GNP-CDF database     |
| 19/05/2004 | 0°34.7'S; 91°08.3'W     | 2      |        |                  | Estimated         | GNP-CDF database     |
| 01/08/2004 | 0°37.3'S; 91°08.6'W     | 1      | 1      |                  | Estimated         | GNP-CDF database     |
| 14/08/2004 | 1°19.3'S; 89°46.6'W     | 1      | 1      |                  | Estimated         | GNP-CDF database     |
| 28/08/2004 | 1°21.0'S; 89°34.7'W     | 1      | 1      |                  | Estimated         | GNP-CDF database     |
| 31/08/2004 | 1°08.3'S; 90°32.5'W     | 1      |        |                  | Estimated         | GNP-CDF database     |
| 10/10/2004 | 0°39.0'S; 91°11.2'W     | 1      | 1      |                  | Estimated         | GNP-CDF database     |
| 24/10/2004 | 0°33.1'S; 91°10.9'W     | 1      | 1      |                  | Estimated         | GNP-CDF database     |
| 13/03/2003 | 0°11.6'S; 91°17.8'W     | 1      |        |                  | Estimated         | GNP-CDF database     |
| 24/06/2003 | 0°07.5'S; 89°10.0'W     | 1      |        |                  | Estimated         | GNP-CDF database     |
| 11/11/2005 | 0°30.9'S; 90°25.4'W     | 1      |        |                  | Estimated         | GNP-CDF database     |
| 19/08/2005 | 1°21.0'S; 90°32.5'W     | 1      | 1      |                  | Estimated         | GNP-CDF database     |
| 10/03/2007 | 0°17.0'N; 89°58.0'W     | 1      | 1      |                  | Estimated         | GNP-CDF database     |