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CETACEAN REMAINS AND STRANDINGS IN THE GALÁPAGOS ISLANDS, 1923-2003

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Abstract – A compilation of data on cetacean remains and strandings found on the shores of the Galápagos Islands, eastern equatorial Pacific, for the period 1923-2003 is presented. Information is available for 87 records belonging to 13 species. Four species account for 71% of the records: *Tursiops truncatus*, *Globicephala macrorhynchus*, *Delphinus delphis*, and *Ziphius cavirostris*. Visitor sites and the vicinity of population centers yielded most of the records; no other geographic pattern was evident in the strandings. The stranding record reflects the odontocete communities of nearshore and upwelling environments in the Galápagos. Morphometric and meristic measurements are presented for 17 skulls belonging to *T. truncatus*, *Stenella attenuata*, *D. delphis*, and *S. coeruleoalba*. The measurements for *T. truncatus* are consistent with the offshore ecotype, although in the Galápagos the species predominantly occupies the nearshore environment. The stomach contents of a young *Z. cavirostris* included seven species of cephalopod and two crustaceans. Mass strandings of *Z. cavirostris* (n=2) and *G. macrorhynchus* (n=2) have been witnessed and documented, while remains of multiple individuals found together on the beach suggest additional mass strandings of *Pseudorca crassidens*, *S. attenuata*, *T. truncatus*, and *G. macrorhynchus*. Some of the records could be attributed to confirmed or presumed interaction with human activities including industrial-scale fishing, pollution, and loud sound sources.

Resúmen – Se presenta una recopilación de datos sobre restos y varamientos de cetáceos encontrados en las costas de las islas Galápagos, Pacifico oriental ecuatorial, para el período 1923-2003. Hay información disponible para 87 registros pertenecientes a 13 especies. Cuatro especies comprenden el 71% de los registros: *Tursiops truncatus*, *Globicephala macrorhynchus*, *Delphinus delphis*, y *Ziphius cavirostris*. La mayoría de los registros provienen de sitios de turismo o son aledaños a centros de población. No hubo otros patrones geográficos evidentes en los varamientos. El registro de varamientos representa las comunidades de odontocetos típicas de ambientes costeros y de surgencia en Galápagos. Se presentan mediciones morfométricas y merísticas para 17 cráneos pertenecientes a *T. truncatus*, *Stenella attenuata*, *D. delphis*, y *S. coeruleoalba*. Las mediciones para *T. truncatus* son consistentes con el ecotípo oceánico, aunque en Galápagos la especie ocupa predominantemente el ambiente costero. Los contenidos estomacales de un juvenil de *Z. cavirostris* incluyeron siete especies de cefalópodo y dos de crustáceo. Varamientos en masa de *Z. cavirostris* (n=2) y *G. macrorhynchus* (n=2) han sido presenciados y documentados, mientras que restos de múltiples individuos encontrados juntos en la playa sugieren varamientos en masa adicionales para *Pseudorca crassidens*, *S. attenuata*, *T. truncatus*, y *G. macrorhynchus*. Algunos de los regístros pudieron atribuirse a interacciones confirmadas o posibles con actividades humanas incluyendo pesca industrial, polución, y fuentes fuertes de sonido.

Keywords: Galápagos Islands; eastern equatorial Pacific; strandings; *Tursiops truncatus*; offshore ecotype; *Globicephala macrorhynchus*; *Delphinus delphis*; *Ziphius cavirostris*; diet.

Introduction

The Galápagos Islands, a province of Ecuador, have been a National Park since 1959. In 1998, the Special Law for Galápagos legally recognized the Marine Resources Reserve (initially promulgated by a presidential decree in 1986) as a protected area, and expanded its boundaries from 15 to 40 nautical miles around the archipelago (Bensted-Smith, 1998; Plan de Manejo de Conservación y Uso Sustentable para la Reserva Marina de Galápagos, 1999). Both the islands and the surrounding waters have also been declared Natural Heritage Sites by UNESCO. Most of the archipelago has been set aside for conservation, except for the areas that were inhabited when the Park was created. These include the townships of Puerto Ayora, in Santa Cruz; Puerto Baquerizo Moreno, in San Cristóbal; Puerto Villamil, in Isabela; Puerto Velasco Ibarra, in Floreana; and Puerto de Baltra, Baltra. However, the Galápagos National Park Service has established 48 visitor sites throughout the archipelago that are part of regular nature tours (Jackson, 1993). In addition, teams of local and visiting scientists routinely conduct work throughout the archipelago under the coordination of the Charles Darwin Research Station, in Puerto Ayora.

The waters of the Galápagos Marine Reserve are renowned for their unique ecosystems and biological diversity. Whales in these waters have a special status, as they are also protected under the provisions of a Whale Sanctuary established in 1990 by Ecuador's Ministry of Industries, as part of an initiative that declared all territorial waters a "natural refuge" where whale hunting is prohibited (Evans, 1991; Merlen, 1992). Although relatively abundant, cetaceans are elusive animals that present many challenges to the researcher. Thus, cetaceans have been less studied than other Galápagos fauna. A notable exception is the sperm whale (*Physeter macrocephalus*), which has been extensively studied by a team led by Dr. Hal Whitehead of Dalhousie University, Canada (*e.g.*, Whitehead, 2003).

In this context, documentation of beach-cast specimens in a remote oceanic archipelago such as the Galápagos not only provides a record of occurrence for an equatorial region, but also a wealth of data that can potentially reveal local adaptations by some species to take advantage of the habitat

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and rich forage provided by the nearshore environment. In addtion, such studies can provide valuable data for large expanses of ocean, where life histories and occurrence patterns may differ from those of cetaceans found along the more accessible continental shores. The main purposes of this study are (1) to provide a compilation of information available on cetacean specimens from the Galápagos Islands that can be of use in future studies, and (2) to characterize the cetacean fauna of this archipelago, albeit through the biased lens of the stranding record. Documentation of several live-stranding events is also presented and discussed. While remains of the endemic sea lion (*Zalophus wollebaeki*) and fur seal (*Arctocephalus galapagoensis*) are quite abundant on Galápagos shores, the focus of the present paper is on cetaceans. Analyses of pinniped specimens are the topic of a separate study (S. K. Salazar, unpublished data).

Material and Methods

A comprehensive documentation of osteological cetacean remains found on the shores of the Galápagos Islands through 2003 was undertaken. Material available in the reference collection of the Charles Darwin Research Station (CDRS) and other private collections in Puerto Ayora was studied. The vertebrate section in the reference collection of the CDRS museum is part of an agreement between the Ecuadorian Government and the University of Wisconsin Zoological Museum (UWZM) to collect, preserve, transport, and maintain scientific specimens from Ecuador. Prepared specimens are divided between institutions in Ecuador (*i.e.*, the Catholic University in Quito, the Natural History Museum of Ecuador, and the CDRS) and the UWZM, in Madison, Wisconsin, U.S.A. (E.E.Pillaert, pers. comm.).

Information on specimens housed in collections outside the Galápagos was gathered during visits by one of us (Palacios) or through correspondence with the curators of the collections. Live strandings were investigated through interviews with persons who had first-hand accounts of the events or through published descriptions. Finally, extensive surveys of much of the coastlines specifically looking for marine mammal specimens were conducted by one of us (Salazar) in 2001 and in 2002.

The information gathered was arranged for presentation in tabular form, as follows. Table 1 is a summary of the total number of records by species. Table 2 lists the information available for each specimen. Entries are grouped by species and ordered chronologically. Fields in this table include a record number, a catalog number for each specimen, species scientific name, type of material available, collection date, collection locality, notes / observations, and name of collector and bibliographic source (if published). Information on remains that have been reported but for which no specimens have been preserved is presented in table 3. Some of these have been intentionally left in the field to await soft tissue decomposition and will eventually be incorporated into collections. For others, large size makes it inconvenient to transport and house at the CDRS reference collection.

Measurements of morphometric and meristic characters were performed by one of us (Palacios) on skulls of the following species: bottlenose dolphin (*Tursiops truncatus*, n=8), pantropical spotted dolphin (*Stenella attenuata*, n=4), short-beaked common dolphin (*Delphinus delphis*, n=4) and striped dolphin (*S. coeruleoalba*, n=1). A total of thirty-six characters was assessed for each skull (Tables 4-6). Thirty-five of these characters follow Schnell *et al.* (1985) and Van Waerebeek *et al.* (1990) (Nos. 1-16, 19-22, 24-38), and one character was added (No.39: 'width of occipital condyles'). Whenever possible measurements were recorded to the nearest 0.1mm with dial calipers (Nos. 4-8, 15-27, 34-35, 37-39), and others were taken to the nearest 0.5mm using a measuring tape (Nos. 1-3, 9-14, 28, 33, 36). Caution needs to be exercised when interpreting these data quantitatively, however, as many of the skulls were severely damaged or worn out. The skulls have been collected over a period of many years, most of them after being exposed to the surf, the rocks and the sun for considerable time; some of them have also spent time buried to let the soft tissues decompose and be removed by scavengers, resulting in some deterioration of the bony tissue. For skulls with incomplete or absent tooth rows, the alveoli were counted and these are given as tooth counts. However, some skulls were worn out (or broken at the tips) to the extent that not all the alveoli were evident. In these cases, the maximum number of alveoli that could be counted is given (with a + symbol indicating that more teeth were present), and whenever possible an estimate of the total number of teeth per row is given in parentheses. When bones were missing or were broken, but an approximate estimate of the character could still be made, it is given in square brackets. Character No.3, 'length of rostrum from pterygoid', often involved making this estimation. Fusion of premaxilla with maxilla at the distal end of the rostrum, an indicator of cranial maturity (Dailey and Perrin, 1973; but see Perrin and Heyning, 1993), was noted for skulls of *S. attenuata*, *D. delphis*, and *S. coeruleoalba*.

External measurements were also available for six bottlenose dolphins (five females, one male), one male short-beaked common dolphin, and one female Cuvier's beaked whale (*Ziphius cavirostris*). These measurements are presented in table 7.

Results

Cetacean remains

Eighty-seven records were documented for the period 1923-2003, belonging to 13 species (Table 1). These include: bottlenose dolphin (n=25; 28.7%), short-finned pilot whale (*Globicephala macrorhynchus*, n=16; 18.4%), short-beaked common dolphin (n=11; 12.6%), Cuvier's beaked whale (n=10; 11.5%), Risso's dolphin (*Grampus griseus*, n=6; 6.9%), sperm whale (n=5; 5.7%), pantropical spotted dolphin (n=3;

3.4%), rough-toothed dolphin (*Steno bredanensis*, n=3; 3.4%), striped dolphin (n=2; 2.3%), dwarf sperm whale (*Kogia sima*, n=2; 2.3%), false killer whale (*Pseudorca crassidens*, n=1; 1.1%), ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*, n=1; 1.1%), and Bryde's whale (*Balaenoptera edeni*, n=1; 1.1%). A timeline of the number of reports by year is shown in figure 1.

Santa Cruz Island had the highest number of records (30%), followed by Isabela (14%, the island with the longest coastline), while the other 10 islands from which remains have been found ranged between 1 and 6% (Figure 2). A significant proportion of records (25%) was of unknown provenance. Maps showing the stranding locations for all specimens with known origins are presented in figures 3-6. Photographs of the most representative specimens are shown in figures 7-9.

Reports of dead animals that do not strictly involve beach-cast or live-stranding events, but that we considered appropriate to list are also included in tables 2 and 3. Such is the case of a male short-finned pilot whale observed floating off western Isabela in April 1988 (Record No. 80, Table 3) (Le Boeuf *et al.*, 1988), or the female Cuvier's beaked whale found floating WNW of Isabela on 4 March 1994 (Record No. 8, Table 2), after it had been killed by killer whales (*Orcinus orca*) (Palacios *et al.*, 1994*a*, *b*). The stomach contents of this specimen contained mostly squid beaks (*Mastigoteuthis dentata*, *Megalocranchia* spp., *Histioteuthis heteropsis*, *Cranchia scabra*, *Ommastrephes bartrami*, *Liocranchia reinhardti*, and *Pholidoteuthis* spp.), but also mesopelagic crustaceans (*Gnatophausia ingens* and *Acanthephyra* sp.). Several individuals of the pseudostalked barnacle (*Xenobalanus globicipitis*) were attached to the trailing edge of the flukes. A photograph showing the coloration pattern of this animal is presented in figure 9d.

An unusual event occurred during one of the highest tides of 2003, when a group of four bottlenose dolphins, including a mother-calf pair, entered a coastal lagoon system known as Concha y Perla, near Puerto Villamil, Isabela (Record No. 84, Table 3). Apparently trapped and unable to find food inside the lagoon, the animals' behavior changed from active and curious during the first week to evasive and listless during the second week. The first animal to die was the mother, on 28 April (about 12 days after entering the lagoon, around 14-16 April). The second animal died on 3 May (~17 days), and the third one on 4 May (~18 days). The body of the calf was never found. Large quantities (5-6lb) of mangrove leaves were found inside the stomachs of two of the animals that were necropsied, as well as wooden sticks, synthetic foam, and plastic remains (Salazar *et al.*, 2003).

Morphometrics and meristics

Eight beach-cast bottlenose dolphin skulls (Table 4) ranged between 450 and 518mm for condylobasal length, 220 and 270mm for postorbital width, 97.6 and 121mm for length of the temporal fossa, and between 66.8 and 86.4mm for width of the temporal fossa. The number of teeth on the upper left tooth row ranged between 21 and 25. The width of one tooth from a 279-cm female was 6.2mm (Record No. 46, Table 2). The total length of the three females that died in the Concha y Perla lagoon (Record No. 84, Table 3) ranged between 258 and 330cm (the animal accompanied by the calf).

Table 1. Number of records by species, as documented in tables 2 and 3. The number of individuals involved in each record and the number of skulls available are also listed.

SCIENTIFIC NAME	COMMON NAME	RECORDS		INDIVIDUALS		SKULLS	
		No.	%	No.	%	No.	%
Tursiops truncatus	bottlenose dolphin	25	28.7	34	27.2	26	34.2
Globicephala macrorhynchus	short-finned pilot whale	16	18.4	34	27.2	11	14.5
Delphinus delphis	short-beaked common dolphin	11	12.6	11	8.8	9	11.8
Ziphius cavirostris	Cuvier's beaked whale	10	11.5	13	10.4	10	13.2
Grampus griseus	Risso's dolphin	6	6.9	6	4.8	5	6.6
Physeter macrocephalus	sperm whale	5	5.7	5	4.0	2	2.6
Stenella attenuata	pantropical spotted dolphin	3	3.4	5	4.0	4	5.3
Steno bredanensis	rough-toothed dolphin	3	3.4	3	2.4	3	3.9
Kogia sima	dwarf sperm whale	2	2.3	2	1.6	2	2.6
Stenella coeruleoalba	striped dolphin	2	2.3	2	1.6	2	2.6
Pseudorca crassidens	false killer whale	1	1.1	6	4.8	1	1.3
Mesoplodon ginkgodens	ginkgo-toothed beaked whale	1	1.1	1	0.8	0	0.0
Balaenoptera edeni	Bryde's whale	1	1.1	1	0.8	1	1.3
Balaenoptera sp.	rorqual	1	1.1	2	1.6	0	0.0
TOTAL		87	100.0	125	100.0	76	100.0

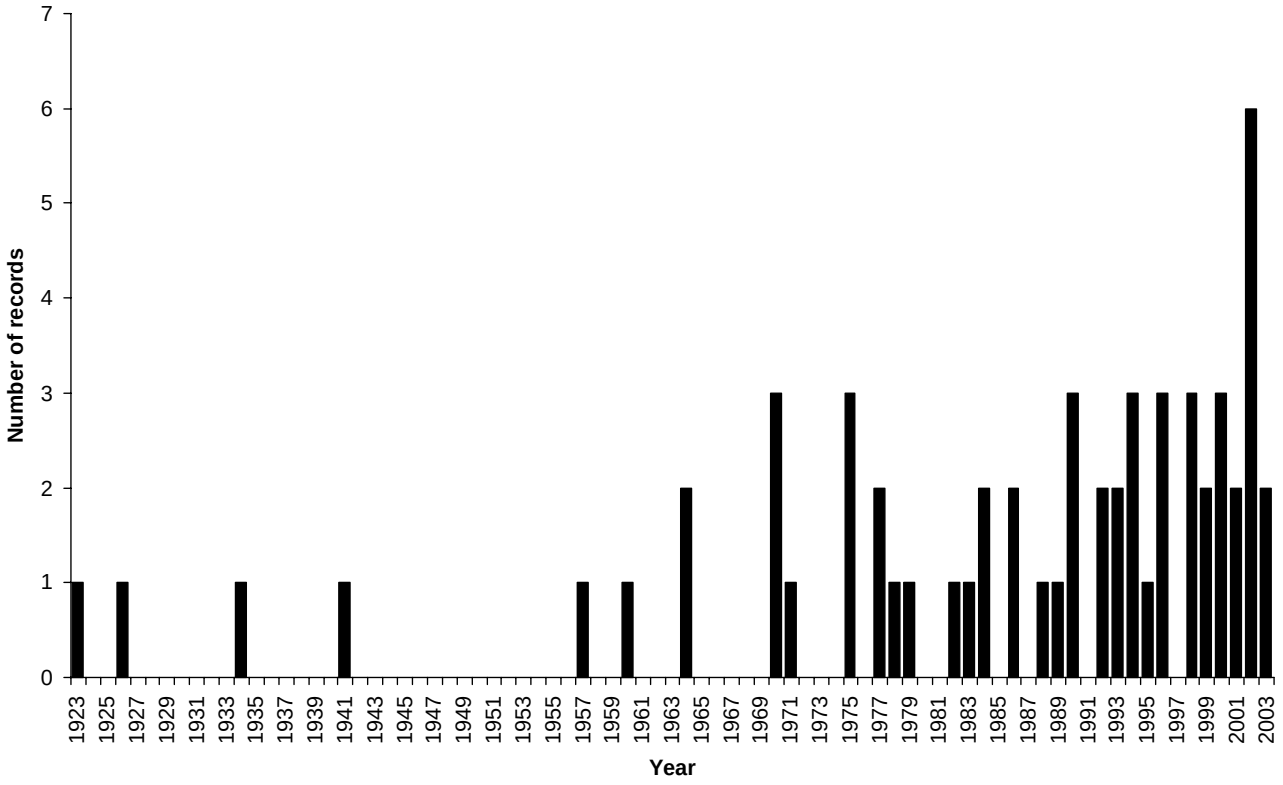

Figure 1. Number of records of cetacean remains from the Galápagos Islands by year for the period 1923-2003.

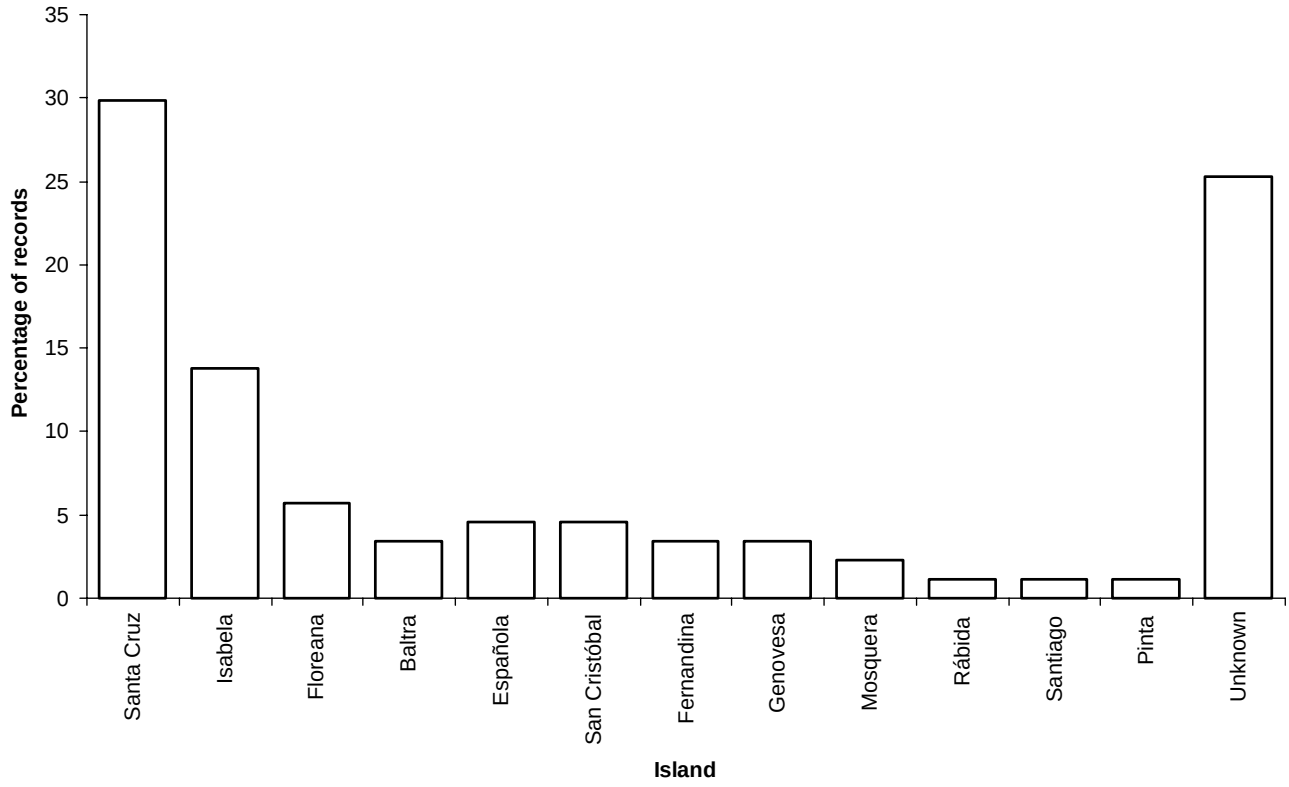

Figure 2. Proportion of records of cetacean remains, by island, in the Galápagos Archipelago, 1923-2003.

Table 2. Osteological specimens of cetaceans from the Galápagos Islands that have been catalogued or are in private collections.

REC. NO.	CATALOG NO.	SPECIES	MATERIAL	DATE	LOCALITY	NOTES	COLLECTOR / SOURCE
1	CDRS V-1877	*Balaenoptera edeni*	skull and skeleton	Jun. 1995	Rábida	male	G. Merlen
2	Private collection	*Physeter macrocephalus*	skull and skeleton	1964	Punta Rocafuerte, Santa Cruz		G. Angermeyer, Puerto Ayora
3	Private collection	*Physeter macrocephalus*	skull	1970	Genovesa		J. Nelson, Hotel Galápagos, Puerto Ayora
4	LT-FCN-UG	*Kogia sima*	skull and skeleton	Mar. 1990	Quinta Playa, Isabela		E. Moreira and F. Félix, FEMM (Félix *et al.*, 1995; Muñoz-Hincapié *et al.*, 1998)
5	Private collection	*Kogia sima*	skull		N Santa Cruz		G. Angermeyer, Puerto Ayora (Muñoz-Hincapié *et al.*, 1998)
6	CDRS V-904	*Ziphius cavirostris*	skull	1 Mar. 1983	Baltra Harbor, Baltra	adult male. Mass-stranded	Robinson *et al.* (1983, 1984)
6	CDRS V-1020	*Ziphius cavirostris*	skull	1 Mar. 1983	Baltra Harbor, Baltra	500-cm female. Mass-stranded	Robinson *et al.* (1983, 1984)
7	CNG	*Ziphius cavirostris*	skull and skeleton	1992	Tortuga Bay, Santa Cruz	mounted at CNG	D. Day and G. Merlen
8	CDRS V-1879* (?)	*Ziphius cavirostris*	skull and lower jaw	4 Mar. 1994	found at sea, 52km WNW of Cape Berkeley, Isabela	410-cm female	Palacios et al. (1994*a*, *b*)
9	CDRS V-1878* (?)	*Ziphius cavirostris*	skull	May 1999	South Beach, Pinta	other bones in the site	S. Salazar
10	CDRS V-1870	*Ziphius cavirostris*	skull and skeleton	11 Apr. 2000	Tortuga Bay, Santa Cruz	mass-stranded	G. Merlen
11	Private collection	*Ziphius cavirostris*	skull				J. Nelson, Hotel Galápagos, Puerto Ayora
12	Private collection	*Ziphius cavirostris*	skull				G. Ribadeneira and M. Romoleroux
13	Private collection	*Ziphius cavirostris*	skull and skeleton		Santa Cruz (?)		G. Angermeyer, Puerto Ayora
14	CDRS V-1880*	*Ziphius cavirostris*	skull and lower jaw				
15	CDRS V-905	*Mesoplodon ginkgodens*	2 teeth	15 Jun. 1970	Bahia Darwin, Genovesa	360-cm male	Tj. de Vries (Palacios, 1996)
16	Private collection	*Globicephala macrorhynchus*	skull	1960-1970	Punta Rocafuerte, Santa Cruz		J. Nelson, Hotel Galápagos, Puerto Ayora
17	CDRS V-1018	*Globicephala macrorhynchus*	skull	Mar. 1975	N Santiago		P. Pritchard
18	CDRS V-1016	*Globicephala macrorhynchus*	skull	10 May 1986	Mosquera		

(*) Specimens not fully catalogued. Further details are available from Godfrey Merlen (gmerlen@yahoo.co.uk); (CDRS) Charles Darwin Research Station reference collection, Puerto Ayora, Galápagos, (CNG) Colegio Nacional Galápagos, Puerto Ayora, Galápagos, Ecuador, (LT-FCN-UG) Laboratorio de Taxidermía, Facultad de Ciencias Naturales, Universidad de Guayaquil, Ecuador.

REC. NO.	CATALOG NO.	SPECIES	MATERIAL	DATE	LOCALITY	NOTES	COLLECTOR / SOURCE
19	CDRS V-1620	*Globicephala macrorhynchus*	skull	Feb. 2000		maxilla without teeth	H. Snell
20	CDRS V-1097	*Globicephala macrorhynchus*	lower jaw and bones				
21	CDRS V-1017	*Globicephala macrorhynchus*	lower jaw and bones				
22	CDRS V-1019	*Globicephala macrorhynchus*	skull				
23	Private collection	*Globicephala macrorhynchus*	skull				M. Santos and P. Romoleroux, Puerto Ayora
24	Private collection	*Globicephala macrorhynchus*	skull		Santa Cruz (?)		G. Angermeyer, Puerto Ayora
25	CDRS V-1881*	*Globicephala macrorhynchus*	skull and lower jaw				
26	CDRS V-1882*	*Globicephala macrorhynchus*	skull and lower jaw				
27	CDRS V-1883*	*Globicephala macrorhynchus*	skull and lower jaw				
28	CDRS V-1884*	*Globicephala macrorhynchus*	skull and lower jaw				
29	AMNH 063986	*Pseudorca crassidens*	skull	29 Aug. 1923	Baltra (South Seymour)	6 skeletons found on the beach	1923 Harrison Williams Expedition (Beebe, 1924). See also Mitchell (1965)
29	AMNH 73670	*Pseudorca crassidens*	jaws and vertebrae	11 Oct. 1926	Baltra (South Seymour)	6 skeletons found on the beach originally in 1923	1923 Harrison Williams Expedition (Beebe, 1924). See also Mitchell (1965)
30	CDRS V-1889*	*Steno bredanensis*	skull and lower jaw				
31	CAS 12889	*Steno bredanensis*	skull and skeleton	21 Feb. 1964	Tortuga Bay, Santa Cruz	beach pick-up	1964 Galápagos International Project (Orr, 1965)
32	CDRS V-1873	*Steno bredanensis*	skull	Mar. 1999	Caleta Black, Isabela		G. Merlen
33	Private collection	*Grampus griseus*	skull	1960s	Santa Cruz		A. Gallardo, Tunel del Amor S.F., Bella Vista
34	CDRS V-1872	*Grampus griseus*	skull	1998	Puerto Ayora, Santa Cruz	juvenile	E. Espinoza, J. Peñaherrera, and T. Koester
35	Private collection	*Grampus griseus*	skull		Santa Cruz (?)		G. Angermeyer, Puerto Ayora
36	CDRS V-1885*	*Grampus griseus*	skull and lower jaw				
37	CDRS V-1886*	*Grampus griseus*	skull and lower jaw				
38	AMNH 73666	*Tursiops truncatus*	skull	11 Oct. 1926	Baltra (South Seymour)		Gregory-Beebe Expedition
39	USNM 258642	*Tursiops truncatus*	skull	30 Jan. 1934	Post Office Bay, Floreana	beach pick-up	Walker (1981)

(*) Specimens not fully catalogued. Further details are available from Godfrey Merlen (gmerlen@yahoo.co.uk); (AMNH) American Museum of Natural History, New York, U.S.A., (CAS) California Academy of Sciences, San Francisco, U.S.A., (CDRS) Charles Darwin Research Station reference collection, Puerto Ayora, Galápagos, (USNM) U.S. National Museum of Natural History, Washington, D.C., U.S.A.

REC. NO.	CATALOG NO.	SPECIES	MATERIAL	DATE	LOCALITY	NOTES	COLLECTOR / SOURCE
40	CNHM 51744	*Tursiops truncatus*	skull	1941	Academy Bay, Santa Cruz		Leon Mandel Expedition (Hershkovitz, 1963)
41	MVZ 125479	*Tursiops truncatus*	skull	19 Oct. 1957	San Cristobal	beach pick-up	Walker (1981)
42	CDRS V-944	*Tursiops truncatus*	skull	2 May 1977	Playa Negra, Floreana	female (?)	F. Trillmich
42	CDRS V-945	*Tursiops truncatus*	skull	2 May 1977	Playa Negra, Floreana	female (?)	F. Trillmich
43	UWZS 27309	*Tursiops truncatus*	skull and skeleton	15 May 1977	N Caleta Negra, Isabela		R. W. Tindle
44	CDRS V-950	*Tursiops truncatus*	skull and skeleton	2 Sep. 1984	Urbina Bay, Isabela		C. Valle and I. Stupakoff
45	CDRS V-946	*Tursiops truncatus*	skull	10 May 1986	Mosquera		D. Day
46	CDRS V-1183	*Tursiops truncatus*	skull and skeleton	2 Sep. 1993	Punta Estrada, Santa Cruz	279-cm female	R. Sangolquí (Lettevall *et al.*, 1993)
47	CDRS V-1875	*Tursiops truncatus*	skull	Sep. 1996	Douglas Cape, Fernandina		G. Merlen
48	CDRS V-1876	*Tursiops truncatus*	skull and bones	8 Dec. 1998	Darwin Bay, Genovesa	pregnant female. Skull burned by accident in Baltra	K. Fielsch and S. Salazar
49	CDRS V-1871_A	*Tursiops truncatus*	skull	6 Sep. 2000	Puerto Bravo, west side of Isabela	4 skulls, few other bones around	G. Merlen and M. Piu
49	CDRS V-1871_B	*Tursiops truncatus*	skull	6 Sep. 2000	Puerto Bravo, west side of Isabela	4 skulls, few other bones around	G. Merlen and M. Piu
49	CDRS V-1871_C	*Tursiops truncatus*	skull	6 Sep. 2000	Puerto Bravo, west side of Isabela	4 skulls, few other bones around	G. Merlen and M. Piu
49	CDRS V-1871_D	*Tursiops truncatus*	skull	6 Sep. 2000	Puerto Bravo, west side of Isabela	4 skulls, few other bones around	G. Merlen and M. Piu
50	CDRS V-1865	*Tursiops truncatus*	skull and skeleton	14 May 2001	Puerto Ayora, Santa Cruz	280-cm male	S. Salazar and J. Feingold (Salazar, 2001)
51	CDRS V-1866	*Tursiops truncatus*	skull	31 Aug. 2001	Punta Cevallos, Española	no other bones in the site	H. Jager
52	CDRS V-1867	*Tursiops truncatus*	skull	12 Mar. 2002	Punta Vicente Roca, Isabela	other bones in the site	S. Salazar
53	CDRS V-1869	*Tursiops truncatus*	skull and skeleton	7 Jun. 2002	Puerto Ayora, Santa Cruz	291-cm female	G. Jimenez and P. Zarate (Jimenez, 2002)
54	CDRS V-1868	*Tursiops truncatus*	part of the skull	1 Aug. 2002	Post Office Bay, Floreana	no other bones in the site	S. Salazar

(CDRS) Charles Darwin Research Station reference collection, Puerto Ayora, Galápagos, (CNHM) Chicago Natural History Museum, Chicago, U.S.A., (MVZ) Museum of Vertebrate Zoology, University of California, Berkeley, U.S.A., (UWZS) University of Wisconsin Zoological Skeleton at the UWZM, Madison, U.S.A.

REC. NO.	CATALOG NO.	SPECIES	MATERIAL	DATE	LOCALITY	NOTES	COLLECTOR / SOURCE
55	CDRS V-947	*Tursiops truncatus*	skull				
56	CDRS V-948	*Tursiops truncatus*	skull and right jaw				
57	CDRS V-951	*Tursiops truncatus*	skull and skeleton				
58	CDRS V-1623	*Tursiops truncatus*	skull				
59	Private collection	*Tursiops truncatus*	skull and skeleton		Santa Cruz (?)		G. Angermeyer
60	CDRS V-857	*Stenella attenuata*	skull	1 Mar. 1975	Punta Pitt, San Cristobal	previosuly misidentified as *D. delphis*	J. Webb (Palacios, 1995)
60	CDRS V-858	*Stenella attenuata*	skull	1 Mar. 1975	Punta Pitt, San Cristobal	previosuly misidentified as *D. delphis*	J. Webb (Palacios, 1995)
60	CDRS V-859	*Stenella attenuata*	skull	1 Mar. 1975	Punta Pitt, San Cristobal	previosuly misidentified as *D. delphis*	J. Webb (Palacios, 1995)
61	Private collection	*Stenella attenuata*	skull and skeleton	1979	Punta Cormorant, Floreana	male (?), live-stranded	D. Day and G. Schreyer, Puerto Ayora
62	UWZS 31501	*Stenella coeruleoalba*	partial skull and skeleton	6 Sep. 1990	Puerto Ayora, Santa Cruz	211-cm female, live-stranded	A. Izurieta and P. Whelan (Van Waerebeek *et al.*, 1998)
63	Private collection	*Stenella coeruleoalba*	skull	Jan. 1992	Tortuga Bay, Santa Cruz		F. Zambrano, Puerto Ayora (Van Waerebeek *et al.*, 1998)
64	CDRS V-1182	*Delphinus delphis*	skull and skeleton	7 Nov. 1993	Cabo Douglas, Fernandina	possibly killed by a tuna net	G. Merlen
65	CDRS V-1619	*Delphinus delphis*	skull	Mar. 1994	Gardner Bay, Española		H. M. Snell
66	CDRS V-591	*Delphinus delphis*	skull	Nov. 1982	Tortuga Bay, Santa Cruz		E. Andrade and F. Morán
67	CDRS V-1874	*Delphinus delphis*	skull	Sep. 1998	Isabela, norte		H. Vargas
68	Private collection	*Delphinus delphis*	skull and skeleton		Santa Cruz (?)		G. Angermeyer, Puerto Ayora
69	Private collection	*Delphinus delphis*	skull		Gardner Bay, Española		D. Day and G. Schreyer, Puerto Ayora
70	CDRS V-1887*	*Delphinus delphis*	skull and lower jaw				
71	CDRS V-1888*	*Delphinus delphis*	skull and lower jaw				
72	CDRS V-1890*	*Delphinus delphis*	skull				
73	CDRS V- 949	*Delphinus delphis (?)*	skeleton only	Jan. 1975	Punta Rocafuerte, Santa Cruz		F. C. Angermeyer

(*) Specimens not fully catalogued. Further details are available from Godfrey Merlen (gmerlen@yahoo.co.uk); (CDRS) Charles Darwin Research Station reference collection, Puerto Ayora, Galápagos, (UWZS) University of Wisconsin Zoological Skeleton at the UWZM, Madison, U.S.A.

Table 3. Cetacean remains for which no specimens are available or are still in the field.

REC. NO.	SPECIES	DATE	LOCALITY	NOTES	OBSERVER / SOURCE
74	*Balaenoptera* sp.	1971	Academy Bay, Santa Cruz	female with unborn fetus	MacFarland (1977)
75	*Physeter macrocephalus*	1989	W Punta Espinosa, Fernandina	skull and scattered bones still in the field	E. Pillaert and M. Ortuño
76	*Physeter macrocephalus*	26 Sep. 1990	Academy Bay, Santa Cruz	teeth collected by G. Merlen. Remains still in the field	M. Ortuño
77	*Physeter macrocephalus*	31 Oct. 2002	Between Tortuga Bay and Punta Estrada, Santa Cruz	1189-cm female. Remains still in the field	G. Merlen and S. Salazar
78	*Ziphius cavirostris*	Feb. 1996	Santa Cruz	young female	E. Simbaña
79	*Globicephala macrorhynchus*	12 May 1984	Puerto Baquerizo Moreno, San Cristobal	group of 18 animals	Ortíz-Crespo (1986)
80	*Globicephala macrorhynchus*	Apr. 1998	1km off Punta Moreno, Isabela	male	Le Boeuf *et al.* (1988)
81	*Globicephala macrorhynchus*	16 May 2003	Cuarta Playa, Isabela	two skulls and other bones in the field. Misidentified as *Orcinus orca*	R. C. Hasbún
82	*Grampus griseus*	1976-1978	Gardner Bay, Española	specimen collected for CDRS but apparently lost	D. Day
83	*Tursiops truncatus*	2 Jan. 2003	Barahona Bay, Isabela	350-cm adult	E. Wakefield and P. Sanz
84	*Tursiops truncatus*	Apr. 2003	Puerto Villamil, Isabela	four individuals (three females, one calf). Remains of adults still in the field	S. Salazar, J. Moreno and S. Landázuri (Salazar *et al.* 2003)
85	*Tursiops truncatus*	5 May 2003	Las Negritas, San Cristobal	two adults	E. Simbaña
86	*Stenella attenuata*	1996	Santa Cruz		D. Day
87	*Delphinus delphis*	19 Dec. 1994	Punta Cormorant, Floreana	214-cm male. Teeth collected by D. Day	D. Day

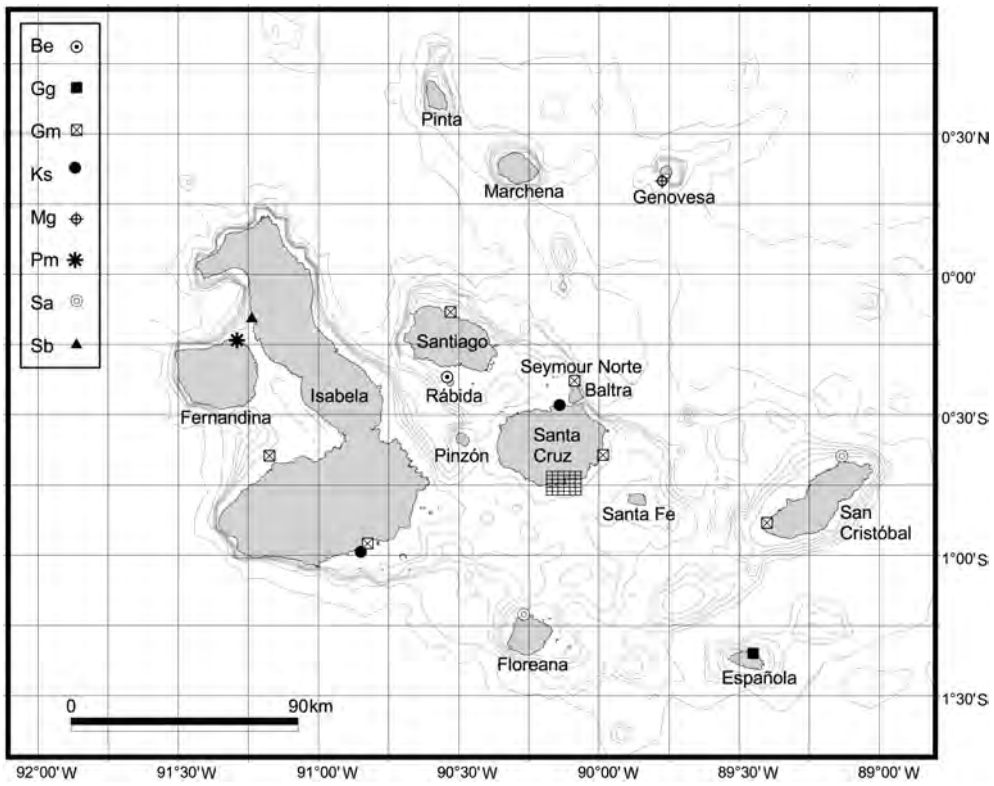

Figure 3. Locations where specimens of *B. edeni* (Be), *G. griseus* (Gg), *G. macrorhynchus* (Gm), *K. sima* (Ks), *M. ginkgodens* (Mg), *P. macrocephalus* (Pm), *S. attenuata* (Sa), and *S. bredanensis* (Sb) have been found. Locations for Academy Bay / Tortuga Bay (Santa Cruz), a localized area with high concentrations of strandings (hatched rectangle), are shown separately in figure 6. The 100, 200, 300, 400, 500, 1000, and 2000-m depth contours are shown.

Distal fusion of premaxilla with maxilla was evident in all four pantropical spotted dolphin skulls examined (Table 5), suggesting that these were adult animals (but see Perrin and Heyning, 1993). Condylobasal length ranged between 363 and 390mm, the length of the temporal fossa ranged between 58.8 and 70mm, and the width between 49.6 and 58.5mm. These values are within those reported for adult *S. attenuata* in the eastern Pacific (Perrin and Hohn, 1994; Perrin *et al.*, 1994*a*).

Rostral fusion was evident in three of the four short-beaked common dolphin skulls examined (Table 6). Condylobasal length ranged between 340 and 458mm, the length of the temporal fossa ranged between 49.3 and 74.2mm, and the width between 32.7 and 53.3mm. The ratio of rostrum length (from base) to zygomatic width ranged between 1.30 and 1.65 for the four skulls, which is in the upper range for the species in the eastern tropical Pacific (Evans, 1994). A male was 214cm in total length (Table 7), which is just above the average length of sexually mature short-beaked common dolphins in the eastern tropical Pacific (208cm) (Evans, 1994).

The only striped dolphin skull examined was broken at the tip (Figure 7b) and its condylobasal length (386.8mm) was below the minimum length (420mm) used by Perrin *et al.* (1994*b*) for measurements of adult and near-adult specimens. Still, many of the measurements in table 6 are within the range reported for the species. The length of the temporal fossa was 64.5mm, and the width 50.2mm. A female *S. coeruleoalba* that live-stranded in Puerto Ayora, Santa Cruz, on 6 September 1990 (Record No. 62, Table 2) measured 211cm.

Finally, the external measurements of the female Cuvier's beaked whale killed by killer whales on 4 March 1994 (Table 7) indicate that this was an immature specimen: the total length for this individual was 410cm, while the minimum reported length at sexual maturity is 550cm (Heyning, 1989).

Live strandings

Strandings of live cetaceans have been witnessed on seven occasions, involving 1 pantropical spotted dolphin in 1979 in Punta Cormorant, Floreana; 6 Cuvier's beaked whales in 1983 in Baltra; 18 short-finned pilot whales in 1984 in San Cristóbal; 1 striped dolphin in Puerto Ayora, Santa Cruz, on 6 September 1990; 4 short-finned pilot whales in Española in 1994; 1 Risso's dolphin in February 1998 in Academy Bay, Santa Cruz; and 4 Cuvier's beaked whales in 2000 in Santa Cruz.

More detailed information is available on four of these strandings. On 1 March 1983, six Cuvier's beaked whales entered Caleta Aeolian, a small bay where Puerto de Baltra is located, on Baltra Island. The animals eventually stranded on a sandy beach, where a large male and a smaller animal were apparently

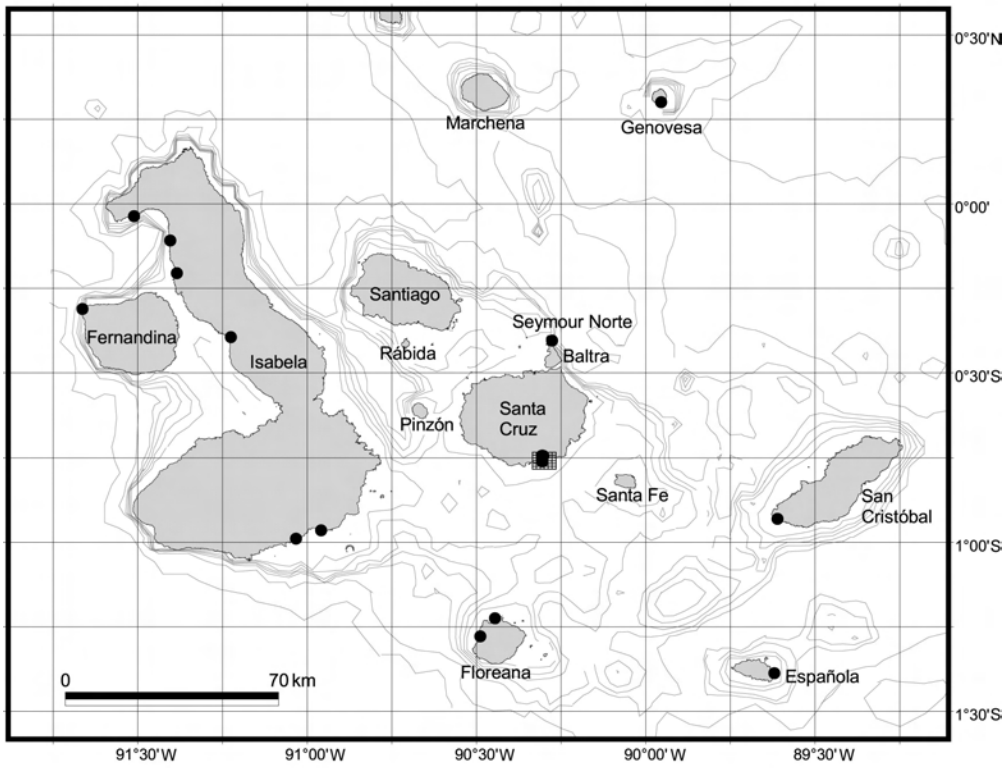

Figure 4. Locations where specimens of *T. truncatus* have been found. See figure 6 for an expanded view around Academy Bay / Tortuga Bay (Santa Cruz) (hatched rectangle). Depth contours are as in figure 3.

injured by steel pilings. Two of the whales left the bay soon after the death of the large male, while the other two restranded in shallow water several times before leaving the area. The second injured whale (a 5m female) also died, but the rest only sustained superficial scrapes (Robinson *et al.*, 1983; 1984). A photograph showing the coloration pattern of the head of the large male was published in Robinson *et al.* (1984) and reprinted in color in Minasian *et al.* (1984). The skulls of the two individuals that died are shown in figure 8d.

A second mass stranding of Cuvier's beaked whales was recorded on 11 April 2000 at 0600 h. The event occurred in Tortuga Bay, Santa Cruz, to the north of the beach known as Playa Brava. Four adults were involved. Two individuals were stranded on rocks, but they were pushed off the beach in to deeper waters by volunteers. These whales apparently swam off, as they were not seen again. The only individual that stranded on sand died after about two hours. This whale was a 510-cm female. A necropsy was performed on this animal, finding several squid beaks in the stomach (G.Merlen and S.K.Salazar, unpublished data). The fourth whale did not strand, but was seen off the beach.

The first of two mass strandings of short-finned pilot whales occurred on 12 May 1984, when a group of 18 individuals entered the shallow waters of Wreck Bay, San Cristóbal, and after several hours run aground on a small sandy beach in front of the town of Puerto Baquerizo Moreno. Despite the efforts of the townspeople to return them to deeper water, the animals restranded and died (Ortíz-Crespo, 1986).

The second event took place in Punta Suarez, Española, on 19 February 1994. According to a written account, four short-finned pilot whales (one male and three females) had been seen swimming erratically in the shallow waters of the bay just before running aground. Once they became stranded, several naturalist guides and the crew of the tour boats that were visiting the area pushed them back to the ocean. The animals sustained many scratches and wounds from the barnacle-encrusted rocks and it is not known whether they survived (Ortuño, 1994).

In addition to the witnessed live-stranding events, skeletal remains of multiple individuals found together are highly suggestive of mass strandings. Such examples include six false killer whale skeletons found in Baltra on 29 August 1923 (Record No. 29, Table 2) (Beebe, 1924); three pantropical spotted dolphin skulls (Record No. 60, Table 2) found in San Cristóbal on 1 March 1975; two bottlenose dolphin skulls found in Floreana on 2 May 1977 (Record No. 42, Table 2); four bottlenose dolphin skulls found in Isabela on 6 September 2000 (Record No. 49, Table 2); two bottlenose dolphin skulls found in San Cristóbal on 5 May 2003 (Record No. 85, Table 3); and two pilot whale skulls and other bones found in Isabela on 16 May 2003 (Record No. 81, Table 3).

Table 4. Cranial measurements (in mm) and meristics of eight skulls of *Tursiops truncatus* from the Galápagos Islands, Ecuador. Catalog numbers are given.

CHARACTER	CDRS V-944	CDRS V-945	CDRS V-946	CDRS V-947	CDRS V-948	CDRS V-950	CDRS V-951	CDRS V-1183
1. Condylobasal length	514.0	492.5	450.0	467.0	454.0	468.0	509.0	518.0
2. Length of rostrum (from base)	293.0	274.0	243.0	258.0	250.0	264.0	287.0	286.0
3. Length of rostrum (from pterygoid)	343.0	[315]	[296]	[310-320]	[305]	314.0	[350-360]	362.0
4. Width of rostrum (at base)	142.4	143.7	129.3	-	116.9	123.3	148.6	130.0
5. Width of rostrum (at 1/4 length)	110.0	101.2	98.3	-	89.0	96.6	103.1	97.4
6. Width of rostrum (at 1/2 legth)	89.8	82.5	82.4	-	74.5	80.5	85.1	81.1
7. Width of premaxilla (at 1/2 length)	53.4	41.5	44.3	-	47.1	48.2	48.8	46.2
8. Width of rostrum (at 3/4 length)	70.0	62.5	66.8	-	55.9	62.0	65.8	58.8
9. Preorbital width	231.0	215.0	216.0	-	192.0	204.0	235.0	213.0
10. Postorbital width	259.0	250.0	249.0	220.0	223.0	234.0	[256]	270.0
11. Skull width (at zygomatic process)	257.0	244.0	232.0	220.0	208.0	225.0	256.0	205.0
12. Skull width (at parietals)	205.0	203.0	185.0	189.0	182.0	195.0	208.0	200.0
13. Height of braincase	160.0	155.0	160.0	155.0	145.0	135.0	150.0	135.0
14. Length of braincase	145.5	147.6	140.5	146.0	138.5	143.0	146.0	162.0
15. Maximum width of premaxilla	91.1	91.5	92.1	-	83.4	84.8	100.9	88.9
16. Width of external nares	60.8	59.2	56.1	-	52.6	56.3	58.1	56.8
19. Length of temporal fossa	121.0	105.8	100.6	98.2	97.6	100.0	+117.8	110.8
20. Width of temporal fossa	86.4	77.1	79.1	71.8	66.8	71.6	81.6	82.7
21. Orbital length	68.8	65.7	64.5	64.1	60.5	61.8	53.7	69.8
22. Length of antorbital process	58.4	60.7	60.5	-	49.1	57.5	-	66.4
24. Width of internal nares	78.0	77.4	75.1	68.9	67.5	68.9	-	74.9
25. Length of left tympanic cavity	62.6	64.6	65.2	57.9	56.7	60.6	70.4	73.4
26. Length of rigth tympanic cavity	66.9	65.5	68.0	57.1	55.7	63.7	-	72.0
27. Width at pterygoid sutures	86.9	82.0	70.0	70.4	74.4	73.4	66.0	89.4
28. Length of upper toothrow	242.5	225.2	196.0	217.0	200.0	220.0	237.0	245.0
29. No. of teeth (upper left toothrow)	23	25	+20 (21)	+20 (22)	22	+21 (22)	+19	24
30. No. of teeth (upper right toothrow)	23	24	+19 (21)	+19 (22)	21	+21 (22)	+21	23
31. No. of teeth (lower left toothrow)	-	-	-	-	-	-	-	23
32. No. of teeth (lower right toothrow)	-	-	-	-	+19 (20)	-	-	23
33. Length of lower toothrow	-	-	-	-	193.0	-	-	-
34. Height of ramus	-	-	-	-	81.2	-	-	93.4
35. Tooth width	-	-	-	-	-	-	-	6.2
36. Length of ramus	-	-	-	-	379.0	-	-	445.0
37. Mandibular condyle width	-	-	-	-	23.2	-	-	24.2
38. Maximum width of palatine	62.5	61.0	57.2	-	49.2	51.6	57.7	41.5
39. Width of occipital condyles	111.8	108.4	107.0	94.7	97.9	92.0	97.2	109.8

Table 5. Cranial measurements (in mm) and meristics of four skulls of *Stenella attenuata* from the Galápagos Islands, Ecuador.

	CHARACTER	CDRS V-857	CDRS V-858	CDRS V-859	Rec.No. 61
1.	Condylobasal length	390.0	380.0	363.0	+374.5
2.	Length of rostrum (from base)	228.0	224.0	212.0	+208.0
3.	Length of rostrum (from pterygoid)	284.0	260.0	256.5	+261.0
4.	Width of rostrum (at base)	85.4	84.3	81.2	87.2
5.	Width of rostrum (at 1/4 length)	59.9	62.1	64.6	63.5
6.	Width of rostrum (at 1/2 legth)	46.6	47.7	46.6	49.5
7.	Width of premaxilla (at 1/2 length)	25.8	28.7	26.1	23.1
8.	Width of rostrum (at 3/4 length)	39.4	35.5	38.8	40.1
9.	Preorbital width	150.7	151.6	150.7	156.2
10.	Postorbital width	165.0	163.5	164.5	168.0
11.	Skull width (at zygomatic process)	160.0	157.2	153.4	167.0
12.	Skull width (at parietals)	160.0	144.5	135.2	140.2
13.	Height of braincase	119.3	122.5	118.5	101.0
14.	Length of braincase	105.0	109.2	107.2	114.0
15.	Maximum width of premaxilla	62.9	68.2	67.9	70.9
16.	Width of external nares	41.6	41.9	41.5	43.0
19.	Length of temporal fossa	58.8	70.0	61.9	65.5
20.	Width of temporal fossa	49.6	54.2	51.9	58.5
21.	Orbital length	50.5	47.5	46.6	51.3
22.	Length of antorbital process	39.9	39.9	39.9	38.1
24.	Width of internal nares	48.9	45.6	46.5	47.2
25.	Length of left tympanic cavity	45.5	50.0	47.9	45.3
26.	Length of rigth tympanic cavity	47.7	47.1	47.1	45.7
27.	Width at pterygoid sutures	47.9	43.9	42.0	49.7
28.	Length of upper toothrow	206.0	195.0	+182.0	+176.0
29.	No. of teeth (upper left toothrow)	+35 (45)	+40	+35	+35
30.	No. of teeth (upper right toothrow)	45	40	+30	+27
31.	No. of teeth (lower left toothrow)	41	41	–	39
32.	No. of teeth (lower right toothrow)	40	+38 (41)	+41 (42)	40
33.	Length of lower toothrow	196.0	204.0	189.0	200.0
34.	Height of ramus	55.9	56.0	58.6	55.8
35.	Tooth width	2.5	–	–	–
36.	Length of ramus	337.0	330.0	316.5	345.0
37.	Mandibular condyle width	12.8	13.3	13.0	13.3
38.	Maximum width of palatine	33.4	42.8	35.5	33.0
39.	Width of occipital condyles	79.8	68.2	77.4	93.7

Record number is given for uncatalogued specimens.

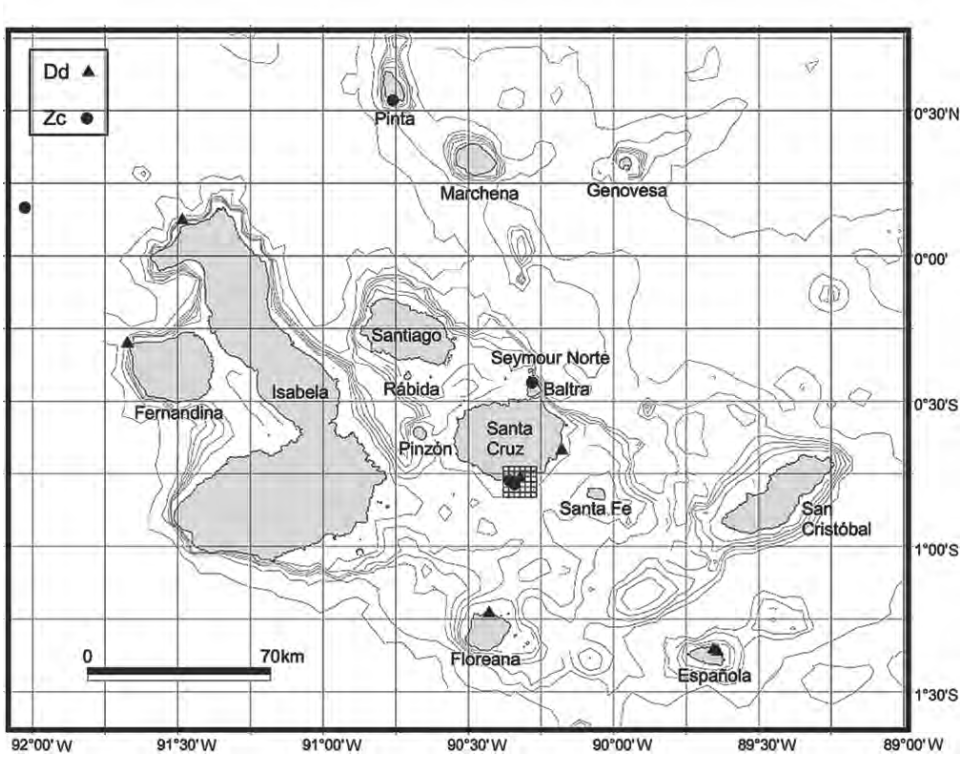

Figure 5. Locations where specimens of *D. delphis* and *Z. cavirostris* have been found. See figure 6 for an expanded view around Academy Bay / Tortuga Bay (Santa Cruz) (hatched rectangle). Depth contours are as in figure 3.

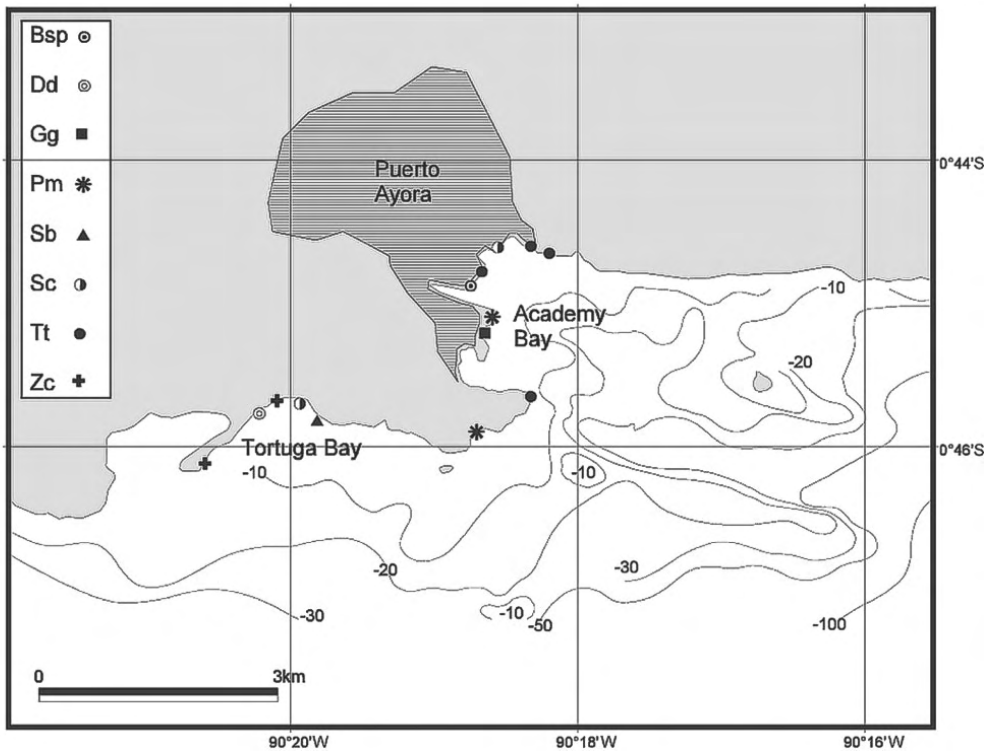

Figure 6. Locations where specimens of *Balaenoptera* sp (Bsp), *D. delphis* (Dd), *G. griseus* (Gg), *P. macrocephalus* (Pm), *S. bredanensis* (Sb), *S. coeruleoalba* (Sc), *T. truncatus* (Tt), and *Z. cavirostris* (Zc) have been found in the Academy Bay / Tortuga Bay area (Santa Cruz). Depth contours are indicated.

Table 6. Cranial measurements (in mm) and meristics of four skulls of *Delphinus delphis* and one of *Stenella coeruleoalba* from the Galápagos Islands, Ecuador.

CHARACTER	CDRS V-591	CDRS V-1182*	CDRS V-1619*	Rec.No. 69*	Rec.No. 63
1. Condylobasal length	340.0	442.0	+458.0	375.0	386.8
2. Length of rostrum (from base)	192.0	270.0	+273.0	214.0	+208.5
3. Length of rostrum (from pterygoid)	235.0	321.0	320.0	254.0	273.5
4. Width of rostrum (at base)	75.7	87.5	95.4	93.6	109.3
5. Width of rostrum (at 1/4 length)	50.0	62.1	64.8	61.1	73.0
6. Width of rostrum (at 1/2 legth)	40.7	53.3	54.0	50.7	64.5
7. Width of premaxilla (at 1/2 length)	20.9	23.0	23.1	23.1	30.0
8. Width of rostrum (at 3/4 length)	30.1	39.7	42.6	40.8	59.6
9. Preorbital width	133.8	179.0	171.0	168.0	182.0
10. Postorbital width	147.5	169.0	190.0	185.0	211.0
11. Skull width (at zygomatic process)	135.5	164.0	180.0	164.0	215.0
12. Skull width (at parietals)	136.6	160.0	200.0	170.0	177.0
13. Height of braincase	110.8	117.5	123.0	114.6	132.8
14. Length of braincase	104.5	114.0	110.8	110.1	117.0
15. Maximum width of premaxilla	62.1	73.5	72.1	75.0	89.3
16. Width of external nares	38.1	49.5	42.8	46.1	43.6
19. Length of temporal fossa	49.3	60.3	74.2	61.2	64.5
20. Width of temporal fossa	32.7	53.3	49.6	51.0	50.2
21. Orbital length	46.6	51.6	54.5	48.5	56.0
22. Length of antorbital process	32.8	44.4	39.5	46.8	58.3
24. Width of internal nares	40.0	56.1	36.4	52.5	58.0
25. Length of left tympanic cavity	42.0	46.3	45.0	47.3	53.8
26. Length of rigth tympanic cavity	41.0	47.1	44.0	49.0	50.9
27. Width at pterygoid sutures	37.3	53.5	55.5	49.8	60.7
28. Length of upper toothrow	164.0	230.0	-	+153.0	+173.0
29. No. of teeth (upper left toothrow)	+40 (50)	+43	+47	+25	+30 (35)
30. No. of teeth (upper right toothrow)	+40 (50)	+46 (48)	+46	-	+24
31. No. of teeth (lower left toothrow)	+39 (45)	48	-	+39	-
32. No. of teeth (lower right toothrow)	+40 (47)	+48 (50)	-	-	-
33. Length of lower toothrow	150.0	232.0	-	+180.0	-
34. Height of ramus	50.6	64.1	-	66.7	-
35. Tooth width	2.3	2.9	-	-	-
36. Length of ramus	284.0	+387.0	-	+334.0	-
37. Mandibular condyle width	12.6	15.5	-	16.3	-
38. Maximum width of palatine	25.0	21.8	26.7	25.1	40.0
39. Width of occipital condyles	73.2	90.6	82.5	87.6	87.6

Record number is given for uncatalogued specimens; (*) indicates distal fusion of premaxilla with maxilla.

Table 7. External measurements (in cm) for six bottlenose dolphins (see Table 2), a male short-beaked common dolphin, and a female Cuvier's beaked whale (see Table 3).

MEASUREMENT	*T. truncatus*						*D. delphis*	*Z. cavirostris*
	CDRS V-1183	CDRS V-1865	CDRS V-1869	Rec.No. 84	Rec.No. 84	Rec.No. 84	Rec.No. 87	CDRS V-1879
Total length	279	280	291	330	281	258	214	410
Girth (at pectoral fins)	–	143	–	–	114.5	112	–	221
Snout to blowhole	–	–	–	–	34	35.7	–	39
Snout to gape	–	–	12	–	–	–	–	28
Throat grooves length	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32
Flipper length (anterior)	–	40	–	43	33.9	33	–	39
Flipper length (posterior)	–	–	–	–	–	–	–	31
Flipper width	17.8	14.2	–	19	13.3	15	9.3	11.5
Fluke width	58.4	–	–	56.7	63.2	61.6	49	105
Fluke length	–	19.5	–	–	–	–	–	24.5
Fluke notch to anus	78.7	–	–	–	–	–	61	–
Blowhole to base of dorsal fin	87.6	–	–	–	–	–	–	–
Umbilicus to anus	70.5	–	–	–	–	–	–	–
Width between base of flippers	25.4	–	–	–	–	–	–	–
Center of eye to center of ear	7.6	–	–	–	–	–	–	–
Dorsal fin height	–	–	–	–	24	26.6	15.5	20
Dorsal fin base length	–	38	–	–	37.8	42.2	43	29
No. teeth, lower right jaw	23	–	21	–	–	–	43	1
No. teeth, upper right jaw	23	–	21	–	–	–	46	N/A

Record number is given for uncatalogued specimens.

Discussion

Stranding record

Although sperm whales and fur seals were heavily exploited in the Galápagos during the 1800s, no scientific specimens exist from that era. The first recorded specimens date from 1923, when the skeletons of six false killer whales were found by W. Beebe on Baltra Island, during a New York Zoological Society Expedition (Beebe, 1924). Several other scientific expeditions collected additional specimens (Table 2), but it was not until 1964, when the CDRS was established and began its scientific and conservation work, that the number of specimens started to increase (Figure 1). Since then, scientists engaged in different research activities throughout the archipelago have found and collected the majority of specimens (62%), while naturalist guides have been an important source of reports (15%). Local inhabitants have also collected a portion of the specimens (14%) near the populated areas (*e.g.*, Figure 6), but they often keep them as decorative items rather than deposit them in the CDRS collection in spite of existing rules from the Park that prohibit the unauthorized removal of any object (sand, rocks, bones) or organisms from the islands. Unification of these 'private collections' is recommended from the standpoint of general access and proper curation. Additionally, specimens are often found with their teeth removed or otherwise desecrated (*e.g.*, Merlen, 1993), so there is a clear need for education in the local communities about the scientific and educational value of intact marine mammal specimens.

Most of the reports coincide with established visitor sites. No other pattern is evident in the geographic distribution of the strandings in general or for particular species (Figures 3-5). The area with the highest concentration of strandings was the stretch between Academy Bay and Tortuga Bay, on Santa Cruz (n = 14) (Figure 6). These locations are within the radius of influence of Puerto Ayora, the most populous town in the Galápagos, and paths leading to these sites are transited on a regular basis by locals and visitors alike. Similarly, the vicinity of Puerto Villamil, Isabela, has yielded several records (n=4). Considering that much of the Galápagos coastlines are quite rugged, the coincidence of stranding locations with visitor sites as well as with areas of human settlement may be related to their accessibility and sheltering from the open ocean, as ailing animals would probably tend to seek the protection of these same areas, eventually becoming stranded.

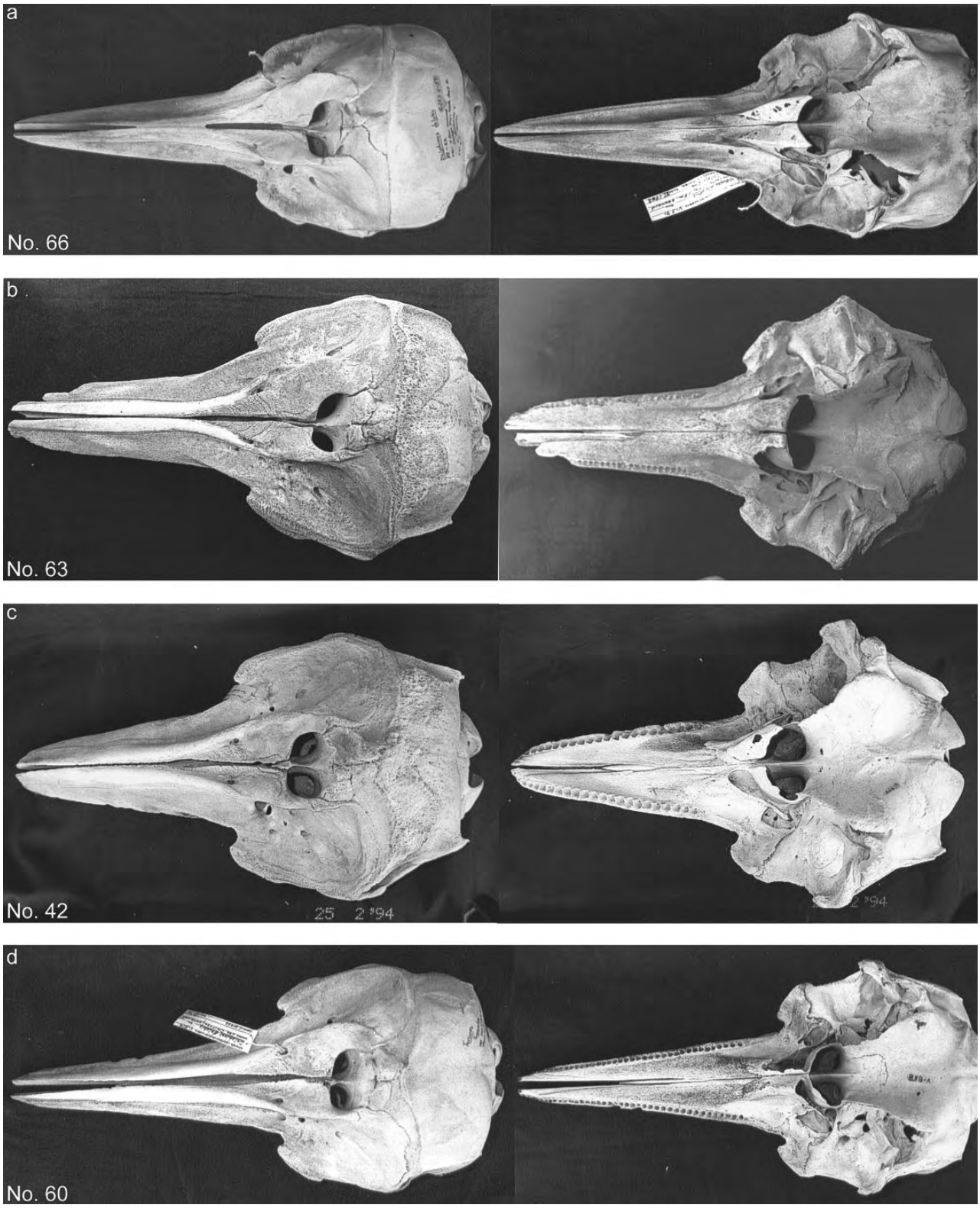

Figure 7. Dorsal and ventral views of skulls of the most common Galápagos delphinids: *D. delphis* (a), *S. coeruleoalba* (b), *T. truncatus* (c), and *S. attenuata* (d). Corresponding record numbers in table 2 are given. Photos: D.M.Palacios.

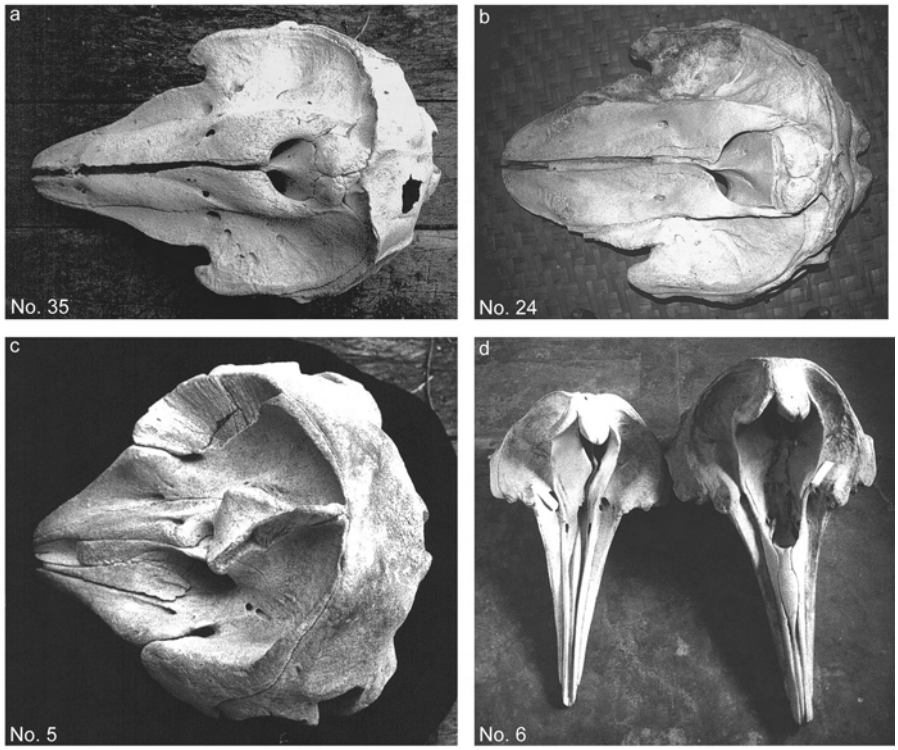

Figure 8. Dorsal views of skulls of medium-sized Galápagos odontocetes: *G. griseus* (a), *G. macrorhynchus* (b), *K. sima* (c), and *Z. cavirostris* (d). Corresponding record numbers in table 2 are given. Photos: D.M.Palacios.

No cetacean remains or strandings have been reported from Darwin, Wolf, or Marchena islands, and only one has been reported from Pinta. Although there are no visitor sites on these islands, the lack of records is probably not entirely due to low effort, and may be related to the steep, rugged coastlines that characterize these islands. Incidentally, Pinta has also yielded two of the three specimens of the South American sea lion (*Otaria flavescens*) that have been found in Galápagos. Both were found near Cape Ibbetson, and are part of the CDRS reference collection [V-926, reported in Wellington and de Vries (1976); and V-1166, found by F.Trillmich on 3 March 1993]. The third record is from Punta Nuñez, Santa Cruz [UWZS 31500, reported in Merlen (1993)]. All animals have been adult males.

The identified stomach contents of the immature female Cuvier's beaked whale provide some insight into the diet of this species in Galápagos waters. Five families of squid (Chiroteuthidae, Cranchiidae, Histioteuthidae, Ommastrephidae, and Pholidoteuthidae) of a wide range of sizes and habits, from benthopelagic to vertical migrators found in shallow waters at night, as well as two families of mesopelagic crustaceans (Lophogastridae and Oplophoridae), were represented. These results are consistent with recent studies that classify the species as a generalist among the deep-diving cetaceans (Santos *et al.*, 2001; MacLeod *et al.*, 2003). The majority of prey species taken by this individual has not been previously recorded in the diet of *Z. cavirostris* (see reviews by Heyning, 1989; Santos *et al.*, 2001; MacLeod *et al.*, 2003). This is probably because most stomach contents analyzed to date come from higher latitudes and virtually none from the equator.

Although our intention with this compilation was to make it as comprehensive as possible, we do not claim that it is complete. For instance, 13 of the specimens in table 2 have not been fully catalogued (those marked with an asterisk) and it is expected that further details will be available in the future. In addition, some specimens may still be in private collections to which we did not have access. Finally, we are aware of a number of commercial establishments in Puerto Ayora that display large cetacean bones, such as mandibles, ribs, and vertebrae that most probably belong to either sperm whales or Bryde's whales. Unfortunately, there is no reliable information associated with these bones and without skull identification the usefulness of these materials is reduced.

Comparison with the sighting record

Although at least 23 cetacean species have been identified in Galápagos waters, a recent compilation of sightings for the 28-year period 1973-2000 (Palacios, 2003) indicated that only 11 species are common (*i.e.*, those with > 20 sightings out of 2879 identified to species in his compilation). These are *S. attenuata* (n=519; 18%), *D. delphis* (n=456; 15.8%), *T. truncatus* (n=366; 12.7%), *B. edeni* (n=316; 11%), *S. longirostris* (n=303; 10.5%), *P.*

macrocephalus (n=284; 9.9%), *S. coeruleoalba* (n=247; 8.6%), *G. macrorhynchus* (n=131; 4.6%), *G. griseus* (n=117; 4.1%), *O. orca* (n=38; 1.3%), and *Z. cavirostris* (n=22; 0.8%). Maps showing the distribution of these species have been published in Palacios and Salazar (2002). Spotted and spinner dolphins represent a distinct community that occupies warm, stratified, and oligotrophic areas far to the north and south of the archipelago, while the rest of the species occupy the core waters of the Marine Reserve, which are characterized by cold, upwelling, and productive conditions (Palacios, 2002, 2003).

In comparison, of the 13 species in this study, four small and medium-sized odontocetes account for the majority of the stranding record (71.2%; Table 1): *T. truncatus*, *G. macrorhynchus*, *D. delphis*, and *Z. cavirostris*. The abundance of bottlenose dolphin specimens is explained by the fact that this is the most common species in inshore waters of the archipelago, as discussed in the next section. Short-finned pilot whales are relatively common in Galápagos waters, and the abundance of specimens is probably related to their well-known propensity to strand worldwide (Bernard and Reilly, 1999). Short-beaked common dolphins are the most common small cetacean in the upwelling environment (Palacios and Salazar, 2002), so it is not surprising that they would also show up in the stranding record. However, some of these specimens may have resulted from incidental mortality in tuna fishing operations, as will be discussed in the final section. The relatively large number of Cuvier's beaked whale specimens suggests that this species may be more common in Galápagos waters than the sighting record would indicate. This is likely due to the cryptic habits of the species, as similar conclusions are drawn from studies of this kind virtually anywhere within its distributional range (Heyning, 1989).

Two species that are common in the sighting record but that had few stranding reports are the Bryde's whale and the sperm whale. This is difficult to explain, especially for the Bryde's whale, which is very common in the nearshore environments of the western part of the archipelago (Palacios and Salazar, 2002). It is possible that their large carcasses tend to break apart or sink rather than wash up on the shores. It is also possible that sick or injured animals of these species do not usually seek sheltered areas when in distress.

For rarely seen species like the rough-toothed dolphin and the false killer whale, their incidence in the stranding record may be related to weakened animals approaching the archipelago during anomalous conditions such as El Niño, when the upwelling habitat subsides. These species are primarily found in the warm waters of the eastern tropical Pacific (Wade and Gerrodette, 1993). They are also are relatively common around the Hawaiian archipelago[6] (*e.g.*, Mobley *et al.*, 2000). Dwarf sperm whales are known for their shy, inconspicuous nature, and like Cuvier's beaked whales, may be more common in Galápagos waters than the sighting record suggests. Lastly, with no confirmed sightings at sea (Palacios, 2003), the single osteological specimen of the ginkgo-toothed beaked whale is the only evidence of the occurrence of this species in the eastern tropical Pacific (Palacios, 1996).

Direct correspondence with the sighting record should not be expected, given the different biases associated with the two approaches (*i.e.*, inconspicuous and deep-diving species are typically not well represented in visual surveys, while stranding records may be biased by mortality events and propensity to strand). In spite of these biases, the composition of the stranding record appears to represent the odontocete communities inhabiting the nearshore and upwelling environments in the Galápagos, although not necessarily in the same rank order. Odontocetes also dominate the stranding record in other low-latitude island systems (*e.g.*, Mignucci-Gianonni *et al.*, 1999; Maldini, 2003).

Bottlenose dolphin: inshore or offshore ecotype?

Bottlenose dolphins associate with oceanic islands in the eastern tropical Pacific (Scott and Chivers, 1990), where they may take advantage of abundant coastal fishes (Acevedo and Würsig, 1991). However, it is not known whether these island-associating dolphins correspond to the offshore or to the inshore forms of other studies in the eastern Pacific (*e.g.*, Hershkovitz, 1963; Walker, 1981; Van Waerebeek *et al.*, 1990). The morphometric and meristic data presented here are most consistent with the offshore form. Yet, the sighting record in Galápagos waters indicates that although the species can be found in deep, offshore waters (usually in association with *G. macrorhynchus*; D.M.Palacios, unpublished data), the vast majority of the sightings is densely distributed over a shelf < 400m deep that groups the central islands (Palacios and Salazar, 2002). Thus, it is evident that the offshore ecotype primarily exploits inshore habitats within the Galápagos Archipelago. In contrast, bottlenose dolphins off the Cape Verde Archipelago (eastern tropical Atlantic), while presumed to belong to the offshore ecotype, occur only far from the coast (Reiner *et al.*, 1996). In other island situations, such as off the Bahamas (western tropical Atlantic), both inshore and offshore forms can be found (Rossback and Herzing, 1999).

Potential impact from human activities

Some of the specimens reported here bore signs of

[6] McSweeney, D.J., Baird, R.W., Webster, D.L., Ligon, A.D., Mackay, A.I., Antoine, L.K., and Gorgone, A.M. (2003) Inter-island differences in cetacean species composition in the main Hawaiian islands. Page 109 *in Book of Abstracts, 15th Biennial Conference on the Biology of Marine Mammals*, 15-19 December 2003, Greensboro, North Carolina, U.S.A.

mortality associated with human activities. For example, the field notes collected with the short-beaked common dolphin found on 7 November 1993 in Fernandina (Record No. 64, Table 2) mentioned that it was 'possibly killed by being caught by a tuna boat net since twisted 180° from head to tail'. Other evidence suggests that interaction with fishing operations may be a common source of mortality. In a widely publicized case, an estimated 50 bottlenose dolphins died after they were trapped in the net of a tuna vessel near the southern coast of Española on 31 May 2002 (Fishing Vessel Sighting Logbook Program, Galápagos National Park Service). Although the vessel was apprehended, it was set free a few months later without major sanctions in spite of the provisions of the Special Law for Galápagos that prohibit industrial-scale fisheries (*i.e.*, purse-seining and long-lining) from operating in waters of the Marine Reserve (see Altamirano and Aguiñaga, 2002). In a separate case, three dead bottlenose dolphins entangled in a fishing net were reported by a naturalist guide while engaged in diving activities around Wolf Island in March 2003 (Marine Mammal Sighting Logbook Program, Galápagos National Park Service and CDRS).

Also worthy of mention is the report of another naturalist guide who found a dead juvenile bottlenose dolphin floating in the water near Five Fingers Rocks, one mile away from Puerto Baquerizo Moreno, San Cristóbal, in January 2001, coincident with the spill of diesel and bunker fuel by the tanker M/V *Jessica* (Francisco and Salazar, 2001).

A single live capture has taken place in Galápagos waters. A bottlenose dolphin was taken off Tagus Cove, Isabela, on 20 November 1967 during an expedition by Scripps Institution of Oceanography aboard R/V *Alpha Helix*. The specimen was used in one of the early studies of the sound transmitting characteristics of the blubber and muscle in dolphins (Norris and Harvey, 1974). The animal was dissected to look at the bony structures of the jaw and the head, but no skeletal materials were preserved (K.S.Norris, *in litt*., 11 May 1996).

Finally, the live stranding of four Cuvier's beaked whales on 11 April 2000 (Record No. 10, Table 2) was coincident with an airgun seismic survey conducted by the R/V *Maurice Ewing*, a geophysical research vessel operated by the Lamont-Doherty Earth Observatory of Columbia University. The necropsy did not find evidence of acoustic trauma (*i.e.*, hemorrhage in acoustic fats, around the eyes or ear bones), although it did not examine the brain, which sometimes shows hemorrhages when animals have been exposed to intense sound fields. Although the location of the vessel was about 270nmi from the stranding site, it is quite possible that the whales were exposed to the sound close to the ship and subsequently swam to the stranding site[7]. Beaked whales are highly sensitive to loud noise and mass strandings of this kind have been linked to acoustic activities in other locations (Taylor *et al.*, 2004).

This evidence indicates that although protected by the special regulations of the Whale Sanctuary, cetaceans still face risks associated with a variety of human activities in waters of the Galápagos Marine Reserve. In particular, incidental mortality in interactions with fishing activities may be affecting populations of coastal species like the bottlenose dolphin to an unknown extent.

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[7] Further information on this stranding can be found at http://www.nmfs.noaa.gov/prot_res/PR2/ Health_and_ Stranding_Response_Program/Mass_Galapagos_Islands.htm.

[8] Available on line from the Institute of Geophysics and Planetary Physics at the Scripps Institution of Oceanography (http://topex.ucsd.edu/).

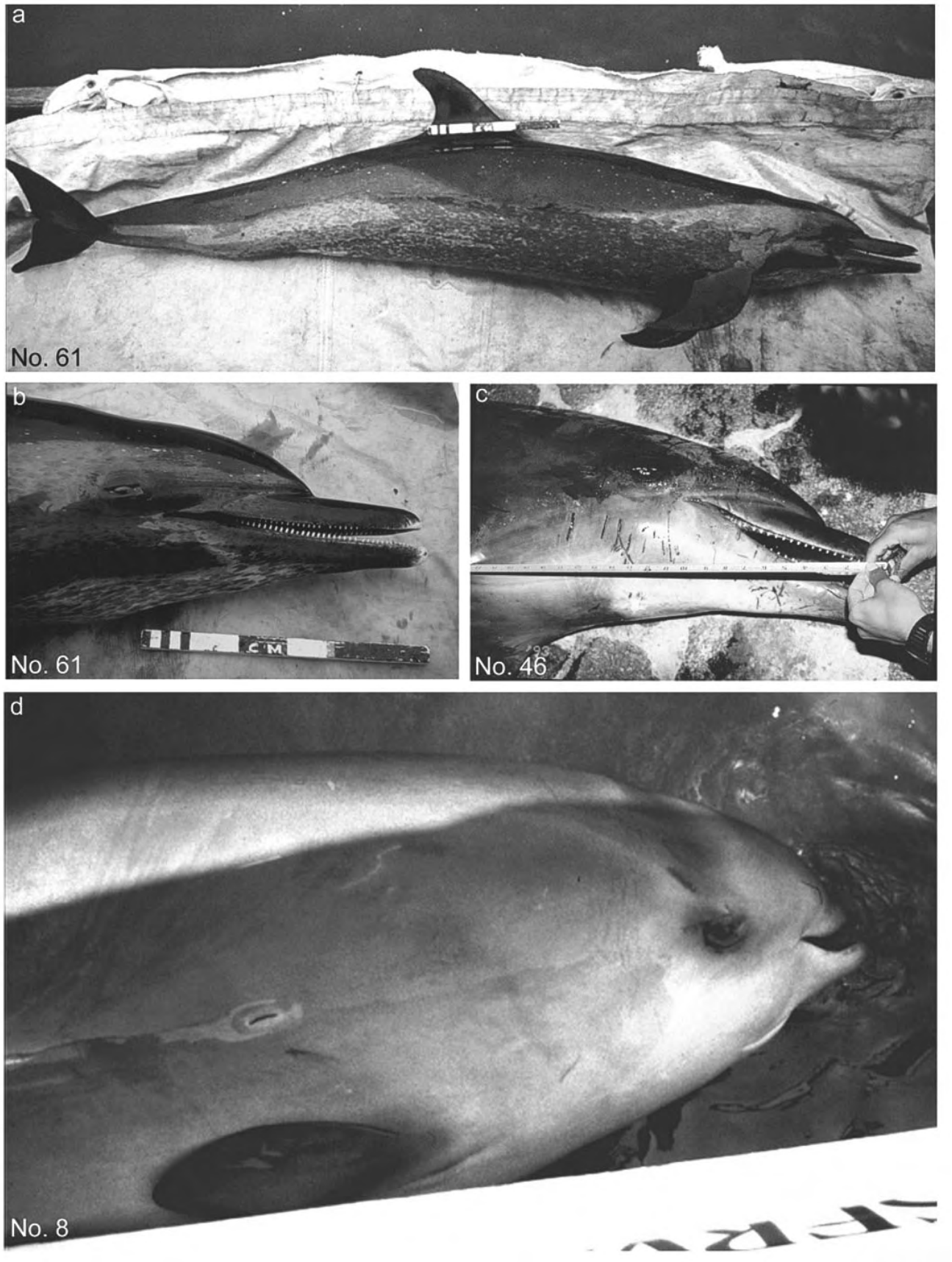

Figure 9. External views of fresh specimens of some Galápagos odontocetes depicting pigmentation patterns: *S. attenuata* (a, b), *T. truncatus* (c), and *Z. cavirostris* (d). Corresponding record numbers in table 2 are given. Photos: D.Day (a, b) and D.M.Palacios (c, d).

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