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Diseases, lesions and malformations in the long-beaked common dolphin *Delphinus capensis* from the Southeast Pacific

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ABSTRACT: Miscellaneous lesions of the head, skull, teeth, trunk, appendages, skin and genital tract were observed in 120 of 930 long-beaked common dolphins *Delphinus capensis* taken in fisheries off Peru between 1985 and 2000. Seven subsamples were defined according to the varying field sampling protocols. Forty-two dolphins showed at least 2 types of injuries or diseases affecting 1 or more organs. The majority (5 of 7) of traumas encountered were diagnosed as caused by violent, fisheries-related interactions, and the skin in 20.4% of specimens (n = 54) showed healed scars from such interactions. Prevalences of malformations and traumas of crania (n = 103) were 2.9 and 1.9%, respectively. Lytic cranial lesions were present in 31.1% of dolphins (n = 103) and accounted for 84.2% of all bone injuries. Skull damage diagnostic for *Crassicauda* sp. infestation was encountered in 26.5% of dolphins (n = 98) and did not differ among sex and age classes. *Crassicauda* sp. and tooth infections were responsible for, respectively, 78.8 and 6.1% of the lytic lesions. Adult dolphins showed a high prevalence of worn and broken teeth (35%, n = 20) as well as damaged alveoli (20%, n = 70). Prevalence of 'paired teeth', a congenital condition, was 9.4% (n = 32). Lesions of the head, body and appendages were present in 10 dolphins and included traumas, deformations (e.g. scoliokyphosis and brachygnathia) and chronic mastitis. Ovarian cysts suggestive of follicular cysts were observed in 1 of 24 females. Chronic orchitis affected 1 of 78 males. Of 12 dolphins 2 had vesicular lesions of the penis. Prevalence of cutaneous lesions, abnormalities and scars ranged between 1.8% (n = 56) and 48.2% (n = 27).

KEY WORDS: *Delphinus capensis* · Diseases · Skull · *Crassicauda* sp. · Skin · Malformations · Fisheries interactions · Traumas · Ovarian cysts · Orchitis

INTRODUCTION

As part of a comprehensive study of the biology of common dolphins (genus *Delphinus*) in Pacific South America, we investigated the occurrence of diseases and lesions in various organs and tissues, as well as congenital malformations, in the long-beaked common dolphin *D. capensis*.

In the Southeast Pacific Ocean, *Delphinus capensis* is known to inhabit neritic waters characterised by strong upwelling off Peru and Chile, south to at least 28°S (Sanino et al. 2003a). This species is 1 of several

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delphinids that has suffered high levels of mortality in various types of fisheries in coastal Peru from at least about 1987 until the present (Van Waerebeek & Reyes 1994, Van Waerebeek et al. 1997, 1999, 2002). In contrast, short-beaked common dolphins *D. delphis* are only occasionally landed. Their habitat off the coast of Peru is essentially oceanic, which puts them infrequently in the path of fisheries that operate on the continental shelf out of Peruvian ports, resulting in comparatively low mortality levels and very few specimens available for necropsy.

We previously documented infections by morbilliviruses, poxviruses and *Brucella* sp. in *Delphinus capensis* from coastal Peru (Van Bressem & Van Waerebeek 1996, Van Bressem et al. 1998a, 2001a). Lesions of the skull as well as genital and lingual warts, possibly caused by papillomaviruses, were also reported on previously (Van Bressem et al. 1996, 2001b). This paper describes diseases, lesions, traumas and malformations of the skull, head, trunk and appendages as well as of the skin and genital tract. It aims to improve our knowledge of pathological factors that may influence modal health, net recruitment and, thus indirectly, population size, and to stimulate further research into possible implications for management. Published information on diseases in common dolphins worldwide is critically reviewed.

MATERIALS AND METHODS

Almost all study specimens of *Delphinus capensis* were captured by local fishermen in coastal waters off Peru in the period 1985 to 2000, either in artisanal drift gillnets, purse-seine nets set for small schooling fishes, or using harpoons. Specimens were collected or examined in a 1050 km coastal strip, stretching from Playa Chucho, Paracas Reserve (13° 48′ S, 76° 24′ W), in south central Peru, to Parachique (05° 34′ S, 80° 52′ W), northern Peru. Biological and pathological data and samples were either collected *in situ* at the wharves where the dolphins were landed or while beach-combing. A total of 930 individuals were examined, including 2 critically injured females landed alive and euthanized, 867 fresh carcasses (most less than 24 h post-mortem, condition 2; see Geraci & Lounsbury 1993) and miscellaneous remains (condition 3 to 5) of another 61 individuals. Seven main subsamples (A–G) were defined, due to the unpredictable availability of carcasses and organs, variable field conditions and differing research priorities of the participating scientists. Population biologists studied any aberrant morphology so as to exclude individual or population-linked variation, before it was classified as a congenital malformation or other pathology.

Dolphin specimens. Maturity, an important factor in epidemiological considerations, was recorded as accurately as possible. Dolphins were considered cranially mature when advanced fusion was present in the frontal-supraoccipital suture or in at least 2 of 6 other indicative cranial sutures (Van Waerebeek 1992, 1993).

Females were classified as sexually mature if the ovaries showed at least 1 corpus luteum (CL) or corpus albicans (CA), or if lactation or pregnancy (visible foetus) was evident (Van Waerebeek et al. 1994). Field results were validated in the laboratory for 17 females by transverse sectioning of ovaries according to standard techniques (e.g. Perrin et al. 1976). The sexual maturity of 59 males was examined by histology of testes and epididymides (Hohn et al. 1985). In the absence of histological results, males were considered sexually mature if seminal fluid was detected in at least one freshly cut epididymis during macroscopical examination in the field. When sexual maturity status could not be determined directly, it was inferred based on a preliminary approximation for the mean standard body length (SL) at sexual maturation for this population, i.e. males below 215 cm and females below 200 cm were assumed immature, while males above 220 cm and females above 210 cm were considered mature (CEPEC unpubl. data). Females and males measuring 200 to 210 and 215 to 220 cm, respectively, were classified as of unknown sexual maturity.

Crania and teeth. The crania of 103 specimens (73 complete skulls, 30 calvariae) of long-beaked common dolphins landed or washed ashore dead, on the Peruvian coast in 1986 to 2000 (Table 1), were examined for the presence of bone lesions and abnormalities, including the typical, apparently irreversible basket-like lesions caused by the nematodes *Crassicauda* spp. (e.g. Raga et al. 1982, Dailey 1985). Skulls are deposited at the Museo de Delfines (Pucusana) and the research collection of 'Areas Costeras y Recursos Marinos' (ACOREMA, Pisco), in Peru.

Teeth and tooth alveoli were checked for lesions in 2 samples of 23 and 103 dolphins, respectively (Table 1). The presence of 'paired teeth' (a congenital malformation, see below) was also studied in 10 fresh dolphins (Table 1) caught off Cerro Azul in 1993, and 1 skull (MFB-221) of this sample was collected.

Head, trunk and appendages. The complete, fresh carcasses of 859 long-beaked common dolphins were examined by at least one of the authors between 1985 and 1994. The prevalence of lesions, malformations and abnormalities was estimated separately for 2 subsamples, depending on the researchers, sampling periods and the ports where the animals were landed.

Subsample A: External features, including lesions and abnormalities, were examined by K.V.W. and J.C.R. in 314 dolphins (Table 1) taken off central

Table 1. *Delphinus capensis.* Composition of samples and subsamples from Peru examined for lesions and diseases from 1985 to 2000. The terms 'Immature', 'Mature' and 'Unknown' refer to cranial maturity for the 'Crania and teeth' sample unless otherwise indicated, and to sexual maturity for all other samples. N: number

	Total	Males				Females				Undetermined sex			
	N	N	Immature	Mature	Unknown	N	Immature	Mature	Unknown	N	Immature	Mature	Unknown
Crania and teeth													
Crania	103	33	2	31	0	11	2	9	0	59	18	28	13
Tooth alveoli	103	34	2	32	0	11	2	9	0	58	18	29	11
Teeth (skull)	23	10	0	10	0	3	0	3	0	10	1	7	2
Teeth (fresh carcass)[a]	10	9	8	1	0	1	0	0	1	0	0	0	0
Head, trunk and appendages													
Subsample A	314	179	144	19	16	135	82	20	33	0	0	0	0
Subsample B	545	355	267	64	24	190	127	34	29	0	0	0	0
Skin													
Subsample C	314	179	144	19	16	135	82	20	33	0	0	0	0
Subsample D	27	16	16	0	0	11	11	0	0	0	0	0	0
Subsample E	56	44	34	10	0	12	10	0	2	0	0	0	0
Genital tract													
Subsample F	102	78	42	35	1	24	10	14	0	0	0	0	0
Subsample G	126	61	45	16	0	65	51	14	0	0	0	0	0

[a]Sexual maturity determined

Peru and Chimbote (09° 05′ S, 78° 36′ W; 1 individual) between 1985 and 1989.

Subsample B: External features of 545 dolphins (Table 1) captured off central and northern Peru from 1990 to 1994 were examined by several CEPEC scientists. Greater attention was paid to anomalies and injuries in this period than in the 1985 to 1989 period.

Skin. Although dolphins were examined for injuries since 1985, cutaneous marks were not recorded systematically until late 1989. From 1991 onwards we routinely investigated skin lesions (excluding tooth rakes) in *Delphinus capensis*. Three subsamples were defined according to the research focus, the sampling period and the port of landing.

Subsample C: The external features of 314 dolphins (Table 1) caught off central Peru (all but 1 from Chimbote) in 1985 to 1989 were examined by K.V.W. and J.C.R.. Skin marks were reported opportunistically.

Subsample D: Twenty-seven freshly dead dolphins (Table 1) landed at Ancon (11° 47′ S, 77° 11′ W) in 1991 and 1992, were visually checked by A.G.G. for the presence of skin injuries. However, natural history and port monitoring, not skin diseases, were the research priorities and few lesions were photographed. A bias towards positive specimens may have occurred and prevalence of lesions is probably overestimated.

Subsample E: The integument of a random sample of 56 dolphins (Table 1), taken off central Peru and northern Peru (n = 2) in 1993 and 1994, was examined for tattoos (irregular, grey, black or yellowish, stippled skin lesions caused by poxviruses; Van Bressem & Van Waerebeek 1996) and other skin marks by several of the authors of the current study (M.F.B., K.V.W., K.O.S., A.G.G.). This unbiased sample provides reliable prevalence data.

Genital tract.

Subsample F: The ovaries of 24 females and the testes of 78 males were checked in the field for the presence of lesions and abnormalities (Table 1). Of these, the gonads of 18 females and 60 males were also studied by histology. The penises of 12 dolphins (3 mature, 9 immature) were inspected for genital warts (Van Bressem et al. 1996) and other lesions. All animals were landed at ports of central and northern Peru between 1987 and 1994.

Subsample G: Data on genital tract lesions were gleaned from standardised specimen datasheets and miscellaneous field notes archived at the CEPEC field station. They related to 65 females and 61 males (Table 1) taken off central Peru between 1985 and 1992.

Laboratory protocols. Representative tissue samples were fixed in a 10% buffered formaldehyde solution, dehydrated in a graded series of ethanol and embedded in paraffin wax. Tissue sections (5 µm) were stained with haematoxylin and eosin (H&E). Ultrathin sections of skin lesions from 5 long-beaked common dolphins (Subsample D) were screened for virus particles by transmission electron microscopy (TEM), following methodology described in Van Bressem et al. (1993a).

Prevalence and statistical testing. We examined whether the prevalence of lesions varied with sex and sexual or cranial maturity (as a proxy for age). To determine potential age-relatedness of skull injuries and malformations, we divided the sample into cra-

nially mature and immature individuals. Where the alterations observed could not with certainty be classified as pathological, the relevant specimens were excluded from statistical tests; hence, the differences in some sample sizes. Prevalence refers to the amount of lesions and disease in samples and subsamples at the time of examination, without distinction between old and new cases (Thrusfield 1986). Significance of differences in prevalence ($\alpha = 0.05$) was verified with chi-square contingency tests or 1-tailed Fisher's exact tests (Swinscow 1981).

RESULTS

A review of earlier studies of diseases in *Delphinus* spp. worldwide is compiled in Table 2. In the present study, miscellaneous lesions of the skull, teeth, head, trunk, appendages, skin and genital tract were observed in 120 out of 930 dolphins. Forty-two specimens had at least 2 types of lesions that affected 1 or more organs/tissues. When pooled with previously published data on lingual and genital warts (Van Bressem et al. 1996), this number increased to 48 (Table 3). A large, fully mature male (KVW-2403) had injuries in at least 6 different organs (Table 3). Violent interactions with fishing gear or human actions, including clubbing, were considered the cause of severe traumas observed in the skull, on the head, trunk and appendages in 5 of 7 dolphins (see below).

Lesions of the skull

***Crassicauda*-caused cranial lesions.** Round, lytic bone lesions with a basket-like appearance, typically associated with *Crassicauda* spp. infestation, were found in the cranial sinuses of 18 adults, 5 immatures and 3 dolphins of unknown maturity (Table 4, Fig. 1). The pterygoid bones were affected in 96% of the 26 positive dolphins. The frontal, alisphenoid, palatine, maxillary and exoccipital bones were occasionally altered. *Crassicauda* injuries were extensive in 3 of 5 immature and in 4 of 18 infested adults.

Osteomyelitis. Acute or chronic bone infection characterised by bone destruction and new bone formation was observed in 2 mature dolphins (Table 4). In 1 skull (KVW-2401) ca. 50 mm of irregular new bone, including 2 thorn-like protuberances and a 7 × 7 mm fenestration, was visible on the left pterygoid and palatine. Further, bone lysis deformed the outer edge of the left maxillary for over 55 mm at the base of the rostrum.

Another skull (KVW-2400) showed a large area (35 × 24 mm) of bone destruction on the latero-dorsal side of the left mandible, behind the tooth row (Fig. 2). The bone lining the area had a rough aspect with several longitudinal depressions, each about 4 mm deep.

Osteolysis. Cranial bone lysis that did not seem related to *Crassicauda* nematode infestation was detected in 5 dolphins (Table 4).

In a cranially mature male (JAS-17), a channel-like fistula vertically traversed the left maxillary, dorsally from tooth alveolus #16 to open into the buccal cavity (Fig. 3a). Adjacent lytic lesions on the buccal side of both maxillaries and on the right premaxillary were likely the continuation of the fistula (Fig. 3). Several alveoli on the left maxillary were occluded and, at 2 sites, interalveolar septa were replaced by spongiform bony tissue. The fistula and other lytic lesions likely originated from caries and spreading infection. Similarly, in another mature male (RBC-19), a small channel (4 × 5 mm) perforated the left maxillary buccal dorsally at alveolus #33, probably also the result of tooth infection.

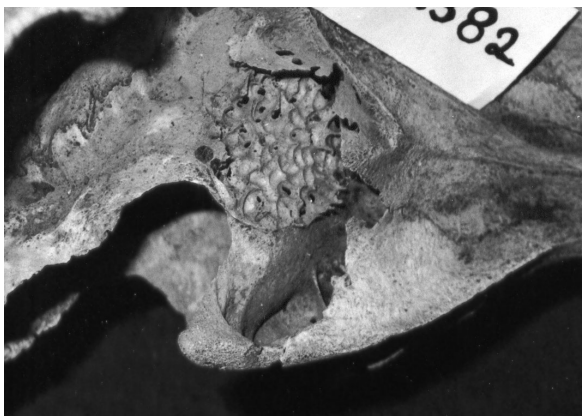

Fig. 1. *Delphinus capensis. Crassicauda* lesions in the right pterygoid of a cranially adult dolphin (KVW-2382)

Fig. 2. *Delphinus capensis.* Large area of osteomyelitis on the latero-dorsal side of the left mandible of a mature dolphin (KVW-2400)

Table 2. *Delphinus delphis and D. capensis.* Worldwide review of diseases and lesions. NE = northeast, SE = southeast, NW = northwest, UK = United Kingdom

Species	Type of disease	Ocean province	Source
	Organic diseases (excluding bones)		
D. delphis ponticus	Fibroma on surface of right testis	Black Sea	Birkun et al. (1999)
D. delphis	Multicentric cholangiocarcinoma	Coasts of UK	Baker (1992)
D. delphis	Cystic pancreas	Coasts of UK	Baker (1992)
D. delphis	Interstitial nephritis	Coasts of UK	Baker (1992)
D. delphis	Hydrocephalus	Coasts of UK	Baker (1992)
D. delphis	Vaginal calculi	NE Atlantic, coasts of UK, NE Pacific	Sawyer & Walker (1977), Baker (1992), Lopez & Benavente (1993)
D. delphis	Gastric leiomyoma	NE Pacific	Cowan et al. (1986)
D. delphis	Cardiac lesions	NE Pacific	Cowan et al. (1986)
D. delphis	Arteriosclerosis	NE Pacific	Cowan et al. (1986)
D. delphis	Vaginal mass	NE Pacific	Benirschke et al. (1984)
D. delphis	Epididymal abcess associated with *Monorygma* sp.	NE Pacific	Cowan et al. (1986)
D. delphis	Leydig cell tumour (testes)	NE Pacific	Cowan et al. (1986)
D. delphis	Gastric ulceration	NE Pacific, coasts of UK	Cowan et al. (1986), Baker (1992)
D. delphis	Hepatitis	Port Philip Bay, Australia (Indian Ocean)	Dixon (1984)
D. delphis	Bacterial pneumonia	SE Pacific	Sanino et al. (2003b)
	Lesions of the bones		
D. delphis	Malformations of the cranium, traumatic lesions of vertebrae	Port Philip Bay, Australia (Indian Ocean)	Dixon (1984)
D. delphis	Fibrous osteodistrophy	NE Pacific	Flom et al. (1978)
D. capensis	*Crassicauda* sp. lesions in pterygoids, frontals, alisphenoids, palatines, maxillaries and exoccipitals	SE Pacific	Van Bressem et al. (2001b), Montes-Iturrizaga (2003), present study
D. capensis	Osteomyelitis in pterygoid, palatine, mandible	SE Pacific	Van Bressem et al. (2001b), Montes-Iturrizaga (2003), present study
D. capensis	Osteolysis of the maxillaries and premaxillaries	SE Pacific	Van Bressem et al. (2001b), Montes-Iturrizaga (2003), present study
D. capensis, *D. delphis*	Traumas (healed fractures and perforations)	SE Pacific	Van Bressem et al. (2001b), Montes-Iturrizaga (2003), Sanino et al. (2003b); present study
D. capensis	Congenital and acquired malformations (maxillaries, premaxillaries and mandibles)	SE Pacific	Van Bressem et al. (2001b), Montes-Iturrizaga (2003), present study
	Dental and periodontal diseases		
D. capensis, *D. delphis*	Broken, worn and missing teeth	Coasts of the UK, SE Pacific	Baker (1992), Montes-Iturrizaga (2003), present study
D. capensis	Paired teeth	SE Pacific	Present study
D. capensis	Occluded alveoli	SE Pacific	Montes-Iturrizaga (2003), present study
	Infectious diseases		
D. capensis, *D. delphis*	Morbillivirus infection	SW Indian Ocean, East Pacific, NW Atlantic, NE Atlantic, Mediterranean Sea, coasts of NW Europe	Duignan et al. (1995), Reidarson et al. (1998), Van Bressem et al. (1993b, 1998a,b, 2001c), Visser et al. (1993)
D. delphis ponticus	Morbillivirus infection	Black Sea	Birkun et al. (1999)
D. capensis	Tattoo skin disease (poxvirus)	SE Pacific	Van Bressem & Van Waerebeek (1996)
D. capensis	Genital warts (possibly papillomavirus)	SE Pacific	Van Bressem et al. (1996)
D. capensis, *D. delphis*	*Brucella* sp. infection	SE Pacific, NE Atlantic, North Sea	Ross et al. (1996), Jepson et al. (1997), Van Bressem et al. (2001a)
D. delphis	Dolphin rhabdovirus-like virus (DRV) infection	Likely coasts of NW Europe (specific origin not given)	Osterhaus et al. (1993)
Delphinus spp.	Pneumonia	NE Pacific, coasts of UK	Cowan et al. (1986), Baker (1992)
Delphinus spp.	Bacterial enteritis	Unknown (captive individual)	Sweeney & Ridgway (1975)

Table 3. *Delphinus capensis.* Multiple lesions in dolphins from Peruvian waters. Specimens (n = 48) are ordered by standard body length (SL). Initials AGG, JAS, JCR, KOS, KVW and MFB refer to authors of the present study. RBC = Ruth Bello Calvo, ACO = Areas Costreas y Recursos Marinos, imm = immature, mat = mature, indet = indeterminate. Parentheses indicate that sexual maturity was inferred from SL

Specimen	Date (d/mo/yr)	Locality (collected)	Sex	SL (cm)	Cranial maturity	Sexual maturity	Organs affected	Lesions
AGG-591	18/2/92	Ancon	F	152.5	indet	imm	Skin	Tattoos, punctiform marks
AGG-405	5/9/91	Ancon	F	167.5	indet	imm	Body, skin	Chronic fibriotic reaction on tailstock, kyphosis, tattoos
AGG-603	25/2/92	Ancon	F	171	indet	imm	Body, skin	Punctiform marks on the whole body, very thin animal
KOS-123	19/6/93	Cerro Azul	F	174.5	indet	(imm)	Skin	Tattoos, 3 scars on tailstock
KVW-522	11/1/87	Pucusana	F	184.5	indet	imm	Head, skin	Scar behind left eye, broken and healed mandibular ramus
MFB-228	6/6/93	Cerro Azul	M	184.5	indet	(imm)	Skin	Tattoo, 2 scars on head and left flank
AGG-575	17/11/91	Ancon	F	186	indet	imm	Skin	Tattoos, punctiform marks on the whole body
MFB-232	6/6/93	Cerro Azul	M	188.5	indet	(imm)	Skin	Tattoos, scar on head
AGG-592	18/2/92	Ancon	M	191.5	indet	imm	Skin	Tattoos, punctiform marks on the whole body
MFB-219	15/5/93	Cerro Azul	M	192	indet	imm	Teeth, skin, genital slit	Tattoos, scar on head, genital papilloma, paired teeth
MFB-297	21/8/93	Cerro Azul	F	192	indet	(imm)	Skin	Tattoos, large scar on tailstock
MFB-226	4/6/93	Cerro Azul	M	>194	indet	(imm)	Skin	Tattoos, dark circles on the belly and right flank
AGG-735	27/2/93	Culebras	F	196	indet	(imm)	Skin	Tattoos, punctiform marks on the head
MFB-264	8/8/93	Cerro Azul	M	197	indet	(imm)	Skin	Tattoos, scar on tailstock
MFB-265	8/8/93	Cerro Azul	M	197	indet	(imm)	Skin	Tattoo, scar on the right flank
MFB-258	8/8/93	Cerro Azul	M	197.5	indet	(imm)	Skin, genitals	Tattoos, scar on head, genital papilloma
AGG-576	17/11/91	Ancon	F	198	indet	(imm)	Skin	Remains of tattoos, punctiform marks on the whole body
KOS-94	2/6/93	Cerro Azul	M	198	indet	imm	Skin	Tattoos, scar
AGG-606	1/3/92	Ancon	M	199.5	indet	imm	Skin	Tattoos, punctiform marks all over the body
MFB-269	8/8/93	Cerro Azul	M	199.5	indet	(imm)	Skin	Tattoos, punctiform marks on belly
MFB-312	27/10/93	Cerro Azul	M	200	indet	(imm)	Skin	Tattoos, dark circles, scars on head and right flipper
MFB-675	9/7/94	Cerro Azul	M	200.5	indet	imm	Skin, penis	Tattoos, vesicular lesion on penis, anomalous skin pigmentation of left flipper
MFB-86	26/3/93	Cerro Azul	M	200.5	indet	imm	Skin	Tattoos, coronet marks on the belly, scar on left flipper
MFB-220	15/5/93	Cerro Azul	F	202	indet	indet	Teeth, beak, genital slit	Brachygnathia, paired teeth, genital papilloma
MFB-281	12/8/93	Cerro Azul	M	204	indet	(imm)	Skin	Tattoos, scar on flipper
MFB-510	18/5/94	Cerro Azul	M	207	indet	imm	Penis, skin	Tattoos, round skin marks on flanks and belly, vesicular lesions on penis
MFB-218	15/5/93	Cerro Azul	M	209	indet	imm	Skin	Tattoos, scar on head
MFB-87	26/3/93	Cerro Azul	F	210	indet	indet	Skin	Tattoos, 1 scar on right flank
MFB-508	17/5/94	Cerro Azul	M	210.5	indet	imm	Skin	Tattoos, round skin marks on belly
MFB-191	13/5/93	Cerro Azul	F	211.5	mat	mat	Skull, ovary	Crest on rostrum, multicystic left ovary
MFB-259	8/8/93	Cerro Azul	M	214	indet	imm	Skin	Tattoos, dark circles on belly
MFB-230	6/6/93	Cerro Azul	M	221	indet	(mat)	Skin, genitals	Dark circles, scar, genital papillomas
MFB-229	6/6/93	Cerro Azul	M	224.5	mat	mat	Skin, body	Tattoos, dark circles on left flank and belly, emaciated
MFB-142	15/4/93	Cerro Azul	M	226.5	mat	mat	Skull, alveoli, skin	Tattoos, 1 alveolus closed, extensive *Crassicauda* sp. lesions in left pterygoid
KVW-2404	31/5/94	Pucusana	M	228.5	mat	mat	Teeth, skin, tongue	Broken teeth, round marks on belly, lingual warts
RBC-21	26/3/93	Chimbote	M	234	mat	mat	Skull, alveoli, flipper	Insertion of flipper broken, lesions of alveoli, congenital malformation of the beak
AGG-761	12/8/93	Chimbote	M	236.5	mat	mat	Skin	Tattoos, punctiform marks on the back
KOS-90	1/6/93	Cerro Azul	F	239.5	mat	mat	Skull	Lesions of the alveoli, broken teeth
RBC-17	26/3/93	Chimbote	M	240	mat	mat	Skull, alveoli	Lesions of the alveoli, *Crassicauda* sp. lesions in right pterygoid

Table 3. (continued)

Specimen	Date (d/mo/yr)	Locality (collected)	Sex	SL (cm)	Cranial maturity	Sexual maturity	Organs affected	Lesions
MFB-529	22/5/94	Cerro Azul	M	240.5	mat	mat	Teeth, genitals	Paired teeth, genital papilloma
KVW-2403	31/5/94	Pucusana	M	241.0	mat	mat	Teeth, alveoli, skull, body, skin, testis	Lump on tailstock, orchitis, round marks on the belly, *Crassicauda* sp. lesions in right pterygoid, broken teeth, lesions of alveoli
RBC-19	26/3/93	Chimbote	M	241.5	mat	mat	Skull, alveoli	Lesions of the alveoli, lysis in left maxillary
ACO-63	1/8/98	Paracas	M	245	mat	(mat)	Alveoli, teeth	Lesions of the alveoli and teeth
JAS-17	24/6/93	Pucusana	M	247.5	mat	mat	Skull	Lesions of the alveoli, lysis of maxillaries and right premaxillary
MFB-149	17/4/93	Cerro Azul	M	252	mat	mat	Alveoli, teeth	Lesions of alveoli, broken teeth
KVW-2400	25/10/93	Chancay	indet	indet	mat	indet	Skull, teeth	Osteomyelitis of left mandible, broken teeth
MFB-174	25/4/93	Cerro Azul	indet	indet	mat	indet	Skull, teeth	Osteolysis of left maxillary, 1 broken tooth
MFB-741	13/1/95	Matacaballo	indet	indet	mat	indet	Skull, alveoli	Healed fracture of left mandible, *Crassicauda* sp. lesions, lesions of alveoli

In a mature dolphin (AGG-621), a 20 × 10 mm lytic lesion of the right maxillary communicated ventrally with the palatine sinus. A *Crassicauda* sp. aetiology was excluded as the lesion lacked the diagnostic basket-like osseous morphology.

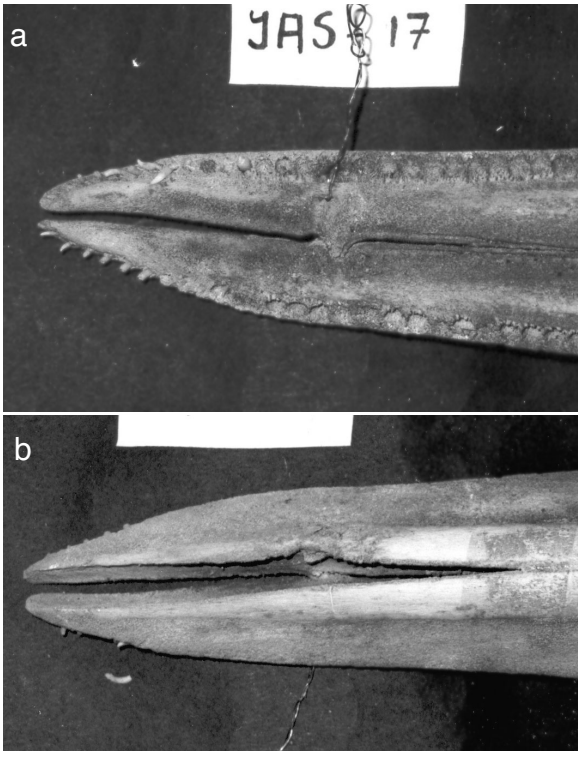

Fig. 3. *Delphinus capensis.* (a) Channel-like fistula traversing vertically the left maxillary and adjacent lytic lesions on the ventral side of both maxillaries and (b) on the right premaxillary are seen in cranially mature male JAS-17

In another mature dolphin (MFB-174), the left maxillary under the palatine keel was eroded over 24 mm and presented a perforating fistula lined by irregular bony tissue of unknown origin, possibly due to, or exacerbated by, a bacterial infection (Table 4, Fig. 4). A small, 8 mm wide fistula was located 60 mm from the neurocranium (Fig. 4). In a cranially immature dolphin (MFB-756) the distal extremities of the premaxillaries were partially dissolved and slightly deformed over a length of 71 mm (Fig. 5), but the aetiology here was unknown.

Congenital and acquired malformation. In JCR-1351, a cranially mature female dolphin, the distal half of the rostrum and lower jaw was curved upwards, its extremity forming an angle of approximately 45° relative to the normal rostrum axis (Fig. 6). Moreover, the mandible

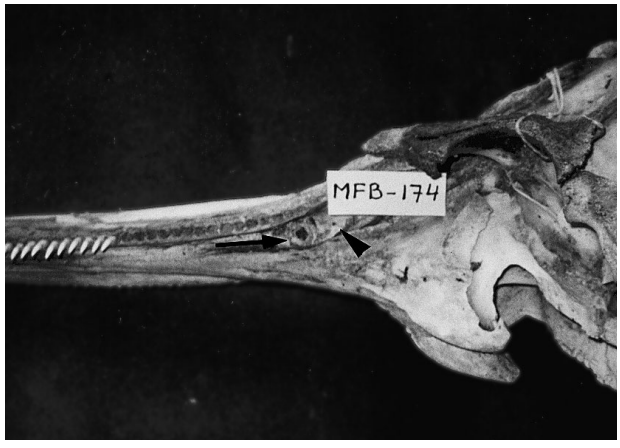

Fig. 4. *Delphinus capensis.* Area of bone erosion and perforating fistula (arrow) on the ventral side of the left maxillary, under the palatine keel in a mature dolphin of unknown sex (MFB-174). A small, 8 mm wide fistula is seen 60 mm closer to the neurocranium (arrowhead)

Table 4. *Delphinus capensis.* Lesions of the skull, head, trunk, appendages and genital tract found in 46 dolphins from Peruvian waters. Initials AGG, JAS, JCR, KVW and MFB refer to authors of the present study. RBC= Ruth Bello Calvo, LAS = Luis A. Santillan, MWC = Mark W. Chandler, ACO = Areas Costeras y Recursos Marinos. SL = standard body length, imm = immature, mat = mature, pub = pubescent, indet = indeterminate. Parentheses indicate that sexual maturity was inferred from SL; –: precise day of collection unknown

Organs/ tissues affected	Specimen	Date (d/mo/yr)	Locality (collected)	Sex	SL (cm)	Sexual maturity	Cranial maturity
Skull							
Crassicauda sp. lesions in pterygoids, frontals, left palatine and right alisphenoid	ACO-17	29/5/98	Playa Chucho	indet	145	(imm)	imm
Crassicauda sp. lesions in pterygoids, left frontal and right palatine	JAS-26	25/10/93	Chancay	indet	indet	indet	imm
Crassicauda sp. lesions in pterygoids, right alisphenoid and right frontal	KVW-2381	15/1/93	Pacasmayo	indet	indet	indet	imm
Crassicauda sp. lesions in left pterygoid	ACO-21	29/5/98	Lagunilla	indet	indet	indet	imm
Crassicauda sp. lesions in both pterygoids	LAS-5	6/8/99	Salaverry	indet	indet	indet	indet
Crassicauda sp. lesions in right pterygoid	JAS-175	27/11/99	Sechura	indet	indet	indet	indet
Crassicauda sp. lesions in right pterygoid	MFB-770	22/1/99	Puerto Rico	indet	indet	indet	indet
Crassicauda sp. lesions in pterygoids	MWC-26	15/12/87	Peru	indet	indet	indet	mat
Crassicauda sp. lesions in left pterygoid and left exoccipital	MFB-159	21/4/93	Chimbote	F	228	mat	mat
Crassicauda sp. lesions in pterygoids	KVW-2425	5/11/95	Pimentel	indet	indet	indet	mat
Crassicauda sp. lesions in pterygoids	AGG-619	22/10/92	Huarmey	indet	indet	indet	mat
Crassicauda sp. lesions in pterygoids	KVW-2382	17/1/93	Santa Rosa	indet	indet	indet	mat
Crassicauda sp. lesions in left frontal	KVW-2426	5/11/95	Santa Rosa	indet	indet	indet	mat
Crassicauda sp. lesions in left maxillary and right pterygoid	MFB-137	15/4/93	Cerro Azul	M	237.5	mat	mat
Crassicauda sp. lesions in left pterygoid	KVW-643	27/7/87	Pucusana	F	215	(mat)	mat
Crassicauda sp. lesions in left pterygoid	KVW-2423	5/11/95	San Jose	indet	indet	indet	mat
Crassicauda sp. lesions in left pterygoid	MFB-142	15/4/93	Cerro Azul	M	226.5	mat	mat
Crassicauda sp. lesions in left pterygoid	MFB-109	30/3/93	Cerro Azul	M	231	mat	mat
Crassicauda sp. lesions in pterygoids	KVW-2399	25/10/93	Chancay	indet	indet	indet	mat
Crassicauda sp. lesions in right pterygoid	KVW-2000	27/12/89	Sechura	indet	indet	indet	mat
Crassicauda sp. lesions in right pterygoid	KVW-2391	22/1/93	Besique	indet	236	(mat)	mat
Crassicauda sp. lesions in right pterygoid	RBC-17	26/3/93	Chimbote	M	240	mat	mat
Crassicauda sp. lesions in right pterygoid	KVW-2403	31/5/94	Pucusana	M	241	mat	mat
Crassicauda sp. lesions in pterygoids	MFB-250	13/6/93	Cerro Azul	indet	indet	indet	imm
Congenital malformation of the skull	JCR-1351	15/4/88	Pucusana	F	207	imm	mat
Crest on the rostrum	MFB-191	13/5/93	Cerro Azul	F	211.5	mat	mat
Healed fracture of left mandible; *Crassicauda* sp. lesions in left pterygoid	MFB-741	13/1/95	Matacaballo	indet	indet	indet	mat
Osteolysis in left maxillary	RBC-19	26/3/93	Chimbote	M	241.5	mat	mat
Osteolysis in maxillaries and right premaxillary; *Crassicauda* sp. lesions in pterygoids	JAS-17	24/6/93	Pucusana	M	247.5	mat	mat
Osteolysis in the left maxillary	MFB-174	–/4/93	Cerro Azul	indet	indet	indet	mat
Osteolysis of the distal extremity of the premaxillaries	MFB-756	16/7/98	Pucusana	indet	indet	indet	imm
Osteolysis of the right maxillary	AGG-621	26/10/92	Casma	indet	indet	indet	mat
Osteomyelitis and osteolysis of left pterygoid and palatinum	KVW-2401	–/4/94	Chancay	indet	indet	indet	mat
Osteomyelitis and osteolysis of left mandible	KVW-2400	25/10/93	Chancay	indet	indet	indet	mat
Slight lateral deviation of the snout	RBC-21	26/3/93	Chimbote	M	234	mat	mat
Traumatic lesions in the occipital	KVW-994	13/12/87	Pucusana	M	229	imm	mat
Head, trunk and appendages							
Chronic fibrotic reaction on tail stock and kyphosis	AGG-405	5/9/91	Ancon	F	167.5	imm	indet
Deformation of the backbone	KVW-1426	16/6/88	Pucusana	F	171.5	(imm)	indet
Deformation of the dorsal fin	KVW-582	19/6/87	Pucusana	M	244	mat	indet
Healed fracture of right mandibular ramus	KVW-522	11/1/87	Pucusana	F	184.5	(imm)	imm
Healed lesions of the rostrum	MFB-189	13/5/93	Cerro Azul	M	232	mat	mat
Brachygnathia	MFB-220	15/5/93	Cerro Azul	F	202	indet	indet
Insertion of flipper broken	RBC-21	26/3/93	Chimbote	M	234	mat	mat
Insertion of flipper broken	RBC-22	26/3/93	Chimbote	F	233	mat	mat
Mastitis	KVW-523	11/1/87	Pucusana	F	191	imm	indet
Nodule on tail stock	KVW-2403	31/5/94	Pucusana	M	241	mat	mat
Genital tract							
Chronic orchitis	KVW-2403	31/5/94	Pucusana	M	241.0	mat	mat
Ovarian cysts	MFB-191	13/5/93	Cerro Azul	F	211.5	mat	mat
Vesicular lesions on the penis	MFB-510	18/5/94	Cerro Azul	M	207	imm	indet
Ucerated lesion on the penis	MFB-675	9/7/94	Cerro Azul	M	200.5	imm	indet

Fig. 5. *Delphinus capensis.* Osteolysis of the distal extremities of the premaxillaries in a cranially immature dolphin of indeterminate sex (MFB-756)

was 10 mm shorter than the maxillaries and premaxillaries (brachygnathia). The tooth rows, especially on the maxillaries, were abnormally oriented outward.

The skull of a mature male (RBC-21) showed a slight lateral deviation at the distal extremity of the mandible. In a mature female (MFB-191), an unusual $50 \times 3 \times 2$ mm crest was present on the distal half of the left maxillary.

Traumatic lesions. In a mature specimen (MFB-741), the thickened proximal extremity of the left mandibular ramus stood out ventrally from the surrounding bone and presented a dark lateral line, presumably of re-ossification. The ramus apparently had suffered a fracture that subsequently healed.

Two holes (diameters 15 and 5 mm) with irregular edges, likely inflicted by a blunt object, perforated the occipital bone close to the left condyle in a mature male (KVW-994, Fig. 7), harpooned off central Peru.

Fig. 6. *Delphinus capensis.* Congenital malformation of the rostrum in cranially mature female JCR-1351

Fig. 7. *Delphinus capensis.* Two abnormal holes with irregular edges in the occipital bone of mature male KVW-994

Epidemiology. Cranial lesions and abnormalities (excluding alveoli and teeth) were observed in 36 of 103 dolphins (35%). The skulls of the 4 cranially immature individuals were normal. Prevalences of malformations and traumas were 2.9 and 1.9%, respectively. Lytic lesions, including those caused by *Crassicauda* sp. and those associated with osteomyelitis, occurred in 32 of 103 dolphins (31.1%) and accounted for 84.2% of all injuries. Osteolysis and osteomyelitis occurred as frequently in cranially adult females (22.2%, n = 9) as in males (22.6%, n = 31) and therefore sexes were pooled. Prevalence of these lesions was similar ($\chi^2 = 0.331$, 1 df, p = 0.56) in adults (33.8%, n = 68) and immatures (27.3%, n = 22). *Crassicauda* sp. cranial bone damage was diagnosed in 26.5% of skulls (n = 98)[1]. There was no significant difference (Fisher's, p = 0.8) in prevalence of crassicaudiasis between cranially adult females (25%, n = 8) and males (19.4%, n = 31), allowing pooling of sexes. Prevalence of *Crassicauda* cranial bone damage was similar ($\chi^2 = 0.177$, 1 df, p = 0.67) in cranially immature (22.7%, n = 22) and adult (27.3%, n = 66) dolphins. *Crassicauda* sp. infestation caused 78.8% of the observed lytic lesions (n = 33).

Dental and periodontal diseases. Teeth were broken or damaged in 9 individuals (7 adults, 2 of unknown maturity). Four of these also showed lesions of the alveoli. In a large, cra-

[1]The presence/absence of *Crassicauda* sp. lesions could not be ascertained in 5 of the 103 skulls; hence, they were excluded from the statistical analysis

nially adult male (ACO-63), 23 teeth were severely worn and broken.

One to 4 sets of 'paired teeth' (2 teeth, typically of unequal size, in parallel at a single alveolus locus) were observed on both maxillaries in 2 of 10 freshly dead dolphins that were landed together (Table 3). Two paired teeth were also present on the right maxillary of an adult skull but not in cranial material of 21 other dolphins (Table 3). The alveoli of 16 dolphins were enlarged or partially/totally filled by new, cancellous bone formation. Both maxillaries and mandibles were affected. The number of occluded alveoli per individual varied from 1 to 60.

Dental and periodontal infections were responsible for at least 6.1% of all the lytic lesions of the skull. Acquired tooth lesions were found in 39.1% of specimens (n = 23), paired teeth in 9.4% (n = 32). Partially or fully occluded alveoli were observed in 16 of 103 (15.5%) dolphins. Fourteen were cranially adult, while the maturity of the 2 others was unknown. Prevalence of lesions of the alveoli was 20% in 70 cranially mature skulls. Two of 9 (22.2%) adult females and 11 of 32 (34.4%) adult males were affected.

Lesions of the head, trunk and appendages

Subsample A.

Head backbone and appendages: Serious injuries and deformations of the backbone, dorsal fin and head were observed in 3 of 314 (0.95%) long-beaked common dolphins (Table 4). The distal end of the right mandibular ramus showed a healed fracture in an immature female (KVW-522). A mature male (KVW-582) had a seriously twisted dorsal fin, and an immature female (KVW-1426) suffered scoliokyphosis, a posterior and laterally deformed spine.

Mastitis: A nodule was sampled from tissues associated with the mammaries of an immature female (KVW-523). Microscopic findings included inflammation of the acinar and ductular tissue associated with diffuse, focally severe lympho-plasmacytic infiltrate. Several large granulomas contained hyaline material and numerous giant cells. The lesion was diagnosed as chronic mastitis and could have been caused by parasites (e.g. *Crassicauda* sp.) or a bacterial infection. However, no evidence of parasitism was found.

Subsample B.

Backbone and appendages: Injuries and externally visible deformations of the spine and tailstock were only observed in 2 of 545 (0.37%) dolphins (Table 4). An immature female (AGG-405) with severe kyphosis at thorax height also had a large nodule on the left side of the tailstock. Microscopic examination of the module revealed a subcutaneous mass of fibrous tissue containing a sparse infiltrate of inflammatory cells. Some muscle tissue was caught up in the general inflammatory reaction and fibrosis, but there was no evidence of any 'primary' muscle disease. The nodule was diagnosed as a chronic fibrotic reaction due to an infection or a trauma. This animal was also afflicted by a severe poxvirus infection as revealed by an unusually high density of 'tattoo' skin lesions spread over its entire body. The second case, a mature male (KVW-2403), had a large nodule on the right side of the tailstock, with a large, lytic lesion affecting at least 1 caudal vertebra. The same animal was ill with chronic orchitis (see section 'Genital lesions' below).

Severely torn tissues, apparently with dislocated glenoid articulation in at least 1 flipper, in 2 mature dolphins (RBC-21 and -22) landed together, were presumably the result of the traumatic net-entanglement that caused their death.

Rostrum: Fibrous tissue (5 mm) protruded from the left distal extremity of the beak as well as from the left mouth gape in an adult male (MFB-189). We believe these were healed lesions. A female of unknown sexual maturity (MFB-220) had brachygnathia and also presented another congenital malformation, namely 4 sets of paired teeth on both maxillaries.

Cutaneous lesions

Tattoo skin lesions.

Subsample C: Tattoo skin lesions were distributed over the entire body of a cranially immature female (KVW-276). Caught off Pucusana in January 1986, this individual represents the earliest confirmed report of tattoo skin disease in cetaceans from the eastern South Pacific.

Subsample D: Tattoos were seen in 13 (7 males, 6 females) of 27 dolphins (48.2%) taken off Ancon in 1991 and 1992. All were sexually immature.

Subsample E: The epidemiology of tattoo skin disease in 46 *Delphinus capensis* of this subsample was reported in Van Bressem & Van Waerebeek (1996).

Punctiform marks.

Subsample D: Dark grey or black points perceptible to the touch, with or without a pit in the centre (Fig. 8) were observed in 12 (7 females, 5 males) of 27 (44.4%) dolphins examined. All were immature. The marks were restricted to the head in 3 cases and generalised in the others. Poxvirus particles were found by TEM (D. Dekegel and G. Van Heule, pers. comm. to M.F.B, May 1991) in samples of skin marks, described in field notes as 'tenuous points with a faint depression', scattered over the whole body of male AGG-573, which did not show typical tattoos. Punctiform marks on the other dolphins were not examined by TEM.

Subsample E: Punctiform marks were reported in 3 of 56 (5.35%) dolphins landed at Cerro Azul and Culebras. The positive specimens included 2 males and a female, all immature.

Round marks.

Subsample D: Many tenuous, light grey, round marks, up to 40 mm in diameter and distributed over the whole body, were observed in an immature male (AGG-567, Fig. 9a). Examination by TEM revealed unidentified parasites and viral particles (D. Dekegel and G. Van Heule, pers. comm. to M.F.B, May 1991).

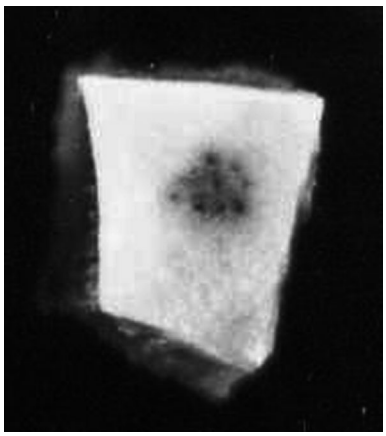

Fig. 8. *Lagenorhynchus obscurus.* Punctiform marks sampled in a Peruvian dusky dolphin (AGG-577), showing skin with identical pathomorphism diagnosed as punctiform marks in *Delphinus capensis* in the present paper

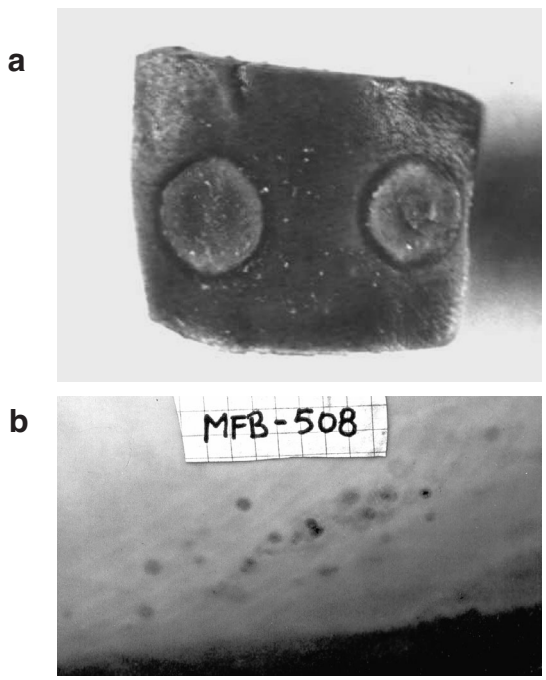

Fig. 9. *Delphinus capensis.* (a) Round skin marks sampled in immature male AGG-567. (b) Round skin marks on the belly of immature male MFB-508

Subsample E: A few (1 to 5) to many (20 to 30) of light to dark grey marks up to 10 mm in diameter were observed ventrally and on the flanks of 7 of 56 specimens (12.5%, Fig. 9b). All affected dolphins were males and 2 of them were sexually mature.

Dark circle lesions.

Subsample E: A few (1 to 5) to many (more than 20) dark circles measuring about 2 mm in diameter dotted the belly and flanks of 5 of 56 (8.93%) dolphins. The skin inside the circles was of the same colour as the healthy skin. The affected animals included 2 adults and 3 immatures, all males. One adult (MFB-229) showed a very high number of dark circle lesions, a low density of tattoo marks and was noticeably thin. Interestingly, 3 of the affected dolphins were landed on the same day.

Coronet marks.

Subsample E: One to 3 marks that appeared as rounded crowns, hence referred to as coronet marks, were found on the belly of a female of unknown sexual maturity and an immature male caught off Cerro Azul in 1993. Prevalence of coronet marks was 3.6% (n = 56).

Scars.

Subsample C: Large scars were seen on the head of a male (KVW-546) and a female (KVW-522), both sexually immature. A white area (3.5 cm) underside of the left fluke in another immature female (JCR-1573) may represent a scar or a discoloration of unknown aetiology.

Subsample E: Whitish-grey scars that had likely not been caused by bites or tooth rakes from conspecifics or other large animals were observed in 15 of 54[2] (27.8%) dolphins. All but 1 male were sexually immature. Prevalence of scars was not significantly different ($\chi^2 = 0.5$, df = 1, p = 0.48) between females (36.4%, n = 11) and males (25.6%, n = 43). Only a few (1 to 4) of these scars were present on the head, flanks, flippers or tailstock. They measured between 28 × 15 mm and 85 × 30 mm. A small abscess was associated with 1 scar in an immature female. In 11 of the 15 dolphins, or 20.4% of the long-beaked common dolphins examined for scars, the appearance, size and location suggested that the scars were the remnants of wounds inflicted during interactions with fisheries.

Anomalous pigmentation.

Subsample E: The distal extremity of the left flipper of an immature male (MFB-675) bore small white spots of unknown origin, although the skin looked otherwise smooth and healthy. Prevalence of this type of anomalous pigmentation was 1.8% (n = 56).

[2]Two dolphins of Subsample E were not examined for scars

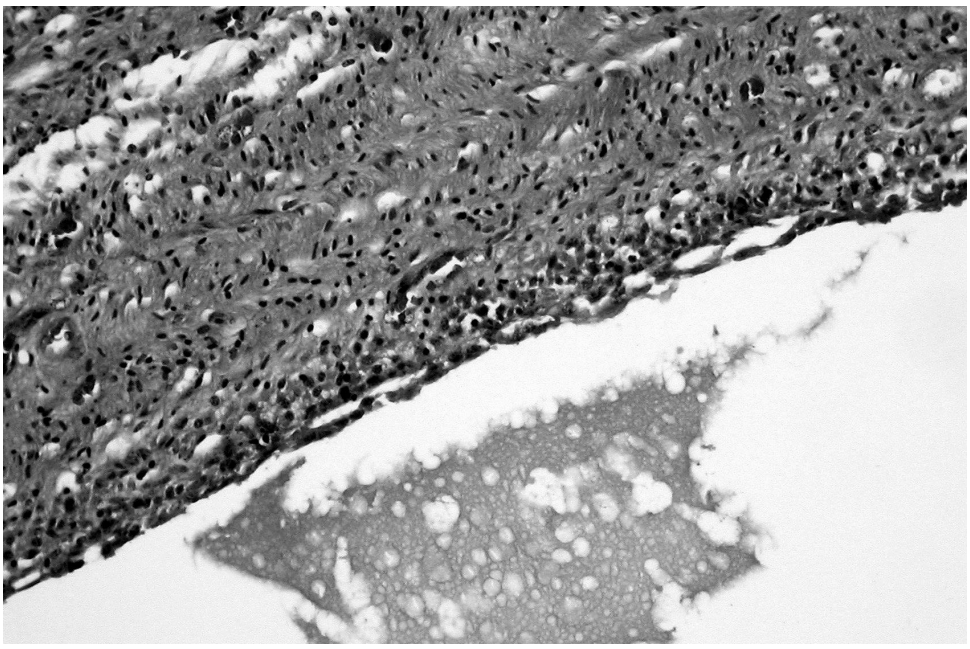

Fig. 10. *Delphinus capensis.* Follicular cyst in the ovary of lactating dolphin MFB-191. Cyst is lined by a thin layer of granulosa cells and contains proteinaceous fluid

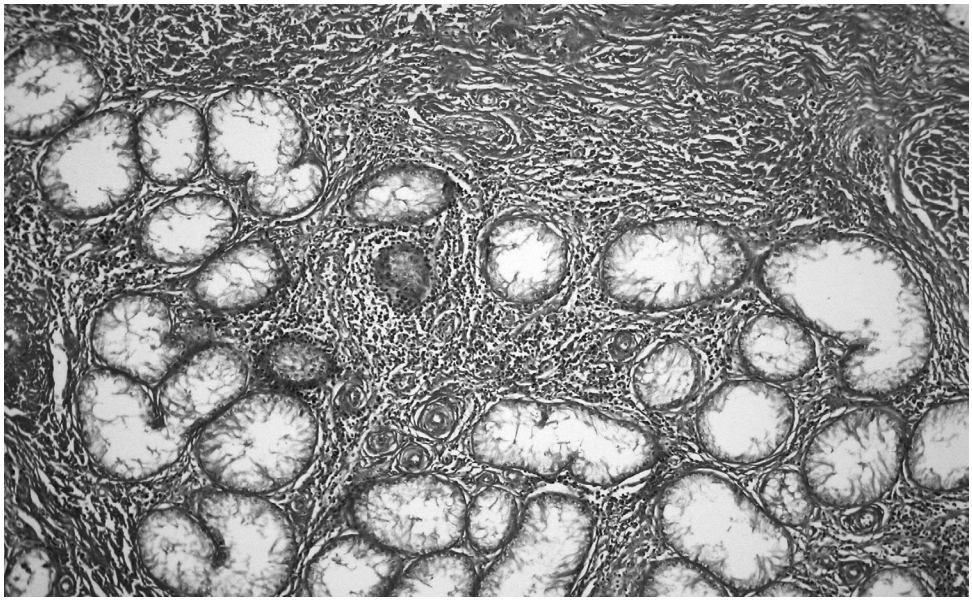

Fig. 11. *Delphinus capensis.* Orchitis in adult male KVW-2403. There is a degeneration of the seminiferous tubules, mononuclear cell infiltration and fibroplasia

Genital lesions

Subsample F.

***Ovarian cysts*:** A large cyst (19 × 17 × 15 mm) projected from the left ovary of a lactating dolphin (MFB-191, Table 4). When the ovary was sliced, several smaller cysts were detected, all of which contained a gelatinous material. A corpus luteum (10 × 10 mm) contained a similar gelatinous mass. Histological findings included the presence of several cysts of variable size lined by thin layers of epithelium with abundant basophilic cytoplasm (Fig. 10) which were suggestive of follicular cysts. No abnormal cystic structures were noted in the ovaries of 23 other females. Prevalence of ovarian cysts in this sample was 4.2%.

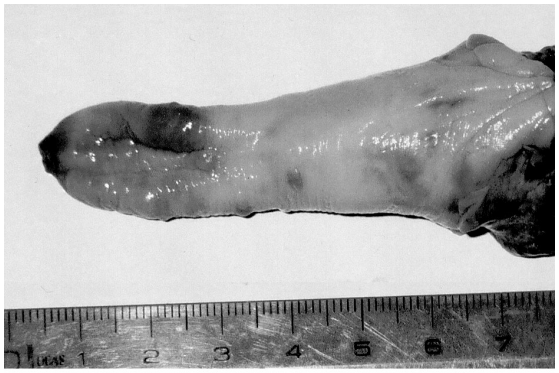

Fig. 12. *Delphinus capensis.* Several congested zones and some small vesicles on the penis of immature dolphin MFB-510. Ruler in cm

Orchitis: Two abscesses affected the right testis of a sexually mature male (KVW-2403) (Table 4). Microscopic changes in a sample of 1 abscess included marked fibroplasia and mild diffuse lympho-plasmacytic inflammatory cell infiltration (Fig. 11). Many seminiferous tubules were degenerated, or necrotic and mineralised. Degenerate and necrotic tubules contained large numbers of macrophages and neutrophils. A few necrotic ductules were mineralised. The lesion was diagnosed as chronic orchitis with severe fibroplasia. This dolphin also had a hard mass on the right side of its tailstock (see above). Prevalence of orchitis was 1.3% in this sample (n = 78).

Vesicular lesions of the penis: Several congested zones and some small vesicles were present on the penis of an immature dolphin (MFB-510, Fig. 12). A white and ulcerated vesicle was visible at the basis of the penis of another immature animal (MFB-675, Table 4). Macroscopically, the vesicles did not resemble the genital warts previously described in this species (Van Bressem et al. 1996) but rather resembled genital herpesvirus lesions. Prevalence of penile vesicular lesions was 16.7% (n = 12).

Subsample G. There was no mention of lesions of the genital tract in the available database relating to 65 female and 61 male *Delphinus capensis.*

DISCUSSION

This study revealed miscellaneous lesions, diseases and malformations of the skull, teeth, head, trunk, appendages, skin and genital tract of *Delphinus capensis* from Peru. The highest prevalence of lesions was observed in the teeth (39.1%), skull (35%), penis (16.7%) and skin (up to 48.2%, depending on the type). Forty-two dolphins had at least 2 types of injuries that affected 1 or more organs. Multiple lesions of various organs have been described in the harbour porpoise *Phocoena phocoena*, short-beaked common dolphin *D. delphis*, striped dolphin *Stenella coeruleoalba*, common bottlenose dolphin *Tursiops truncatus* and Risso's dolphin *Grampus griseus* from British waters (Baker 1992, Baker & Martin 1992) as well as in belugas *Delphinapterus leucas* from the St Lawrence estuary (De Guise et al. 1995), to cite only a few.

Osteolysis was the most common lesion in the skull of *Delphinus capensis*. Infestation by *Crassicauda* sp. and tooth infections were responsible for 78.8 and 6.1% of observed osteolysis, respectively, the remainder being of unknown aetiology. Adult roundworms *Crassicauda* spp. infest the cranial sinuses of several species of small cetaceans, including *D. capensis* from Peruvian waters (Dailey 1985, K. Van Waerebeek et al. 1994 unpubl.) and produce the typical (apparently irreversible) perforating lytic bone lesions with a basket-like appearance that often deform pterygoids (Raga et al. 1982, Dailey 1985). In *D. capensis*, prevalence of *Crassicauda* sp. related skull damage was 26.5%. This was lower than the prevalence observed in offshore common bottlenose dolphins (68.8%, n = 16) occuring sympatrically but higher than the prevalence in a large sample of dusky dolphins *Lagenorhynchus obscurus* from Peru and Chile (0.37%, n = 267, Van Waerebeek et al. 1990, 1993) and a smaller, more recent sample from Peru (4.3% n = 46, Montes-Iturrizaga 2003). Interestingly, prevalence of *Crassicauda* sp. associated bone damage did not vary with cranial maturity status in *D. capensis*, and extensive lesions were observed in both mature and immature specimens. In spotted dolphins *Stenella attenuata* from the Eastern Tropical Pacific, prevalence was higher in younger animals, which was attributed to mortality caused by *Crassicauda* sp. infestation in young dolphins (Perrin & Powers 1980). Crassicaudiasis may not cause significant mortality in *D. capensis*. The lower prevalence of live worms (8%, n = 25) than bone lesions (26.5%, n = 98) suggests that dolphins may recover from infestation but remain marked (Van Waerebeek et al. 1994). The percentage of extensive lesions seemed higher in immature (60%, n = 5) than in mature (22.2%, n = 18) dolphins. No other worms have been associated with basket-like cranial bone lesions in cetaceans. Besides, *Stenurus* sp., another nematode that commonly infests the air sinuses of Delphinidae, was not found in *D. capensis* examined during this study (CEPEC unpubl. data).

Adult dolphins showed a high prevalence of worn and broken teeth as well as alveolar lesions. The latter are likely a consequence of tooth decay and loss (De Smet 1977). The loss of a large number of teeth with resulting damage to the alveoli and, eventually, lysis of

surrounding bone tissue, as seen in some dolphins (JAS-17 and RBC-19), may have caused considerable pain. De Smet (1977) reported that tooth lesions were common in a sample of 12 *Tursiops truncatus* from various ocean provinces and from captivity. Worn and missing teeth were also described in 5 of 32 (juveniles and adults) *Phocoena phocoena* from British waters (Baker & Martin 1992) and in at least 15 of 24 belugas from the St Lawrence estuary (De Guise et al. 1995). Periodontal disease is known from common bottlenose dolphin, dusky dolphin, short-finned pilot whale *Globicephala macrorhynchus*, long-finned pilot whale *G. melas*, Risso's dolphin, and Burmeister's porpoise *P. spinipinnis* from Peruvian waters (Montes-Iturrizaga 2003) as well as in belugas (De Guise et al. 1995). The presence of paired teeth in 2 dolphins landed together suggests that they were genetically related.

Cranial bone fractures were only found in the mandible of 1 of 75 complete skulls. This injury may have been inflicted by conspecific or interspecific interactions, or by fishing gear. Mandible fractures have been described in *Phocoena phocoena* and *Tursiops truncatus* from the North Sea as well as in *T. truncatus*, *Globicephala macrorhynchus* and *Lagenorhynchus obscurus* from the SE Pacific (van Bree & Duguy 1970, Montes-Iturrizaga 2003). Prevalence varied between 3.2% in 31 *L. obscurus* and 7.3% in 55 *T. truncatus* from Peru (Montes-Iturrizaga 2003).

Other traumas of the skull, body and skin in several specimens of Peruvian *Delphinus capensis* were likely caused by fishery interactions. In dolphin KVW-994, cranial perforations were possibly inflicted by blows to the head. The dolphin had been harpooned and was likely clubbed to death in the boat, a common fate of small cetaceans caught alive in Peru (K. Van Waerebeek, L. Chavez-Lisambart and I. Garcia-Godos unpubl. data). Two dolphins (RBC-21, RBC-22) presumably hurt their flippers while attempting to escape the nets that eventually killed them. Dolphins KVW-522 and MFB-189 likely escaped an earlier capture event but not without injuring their head. One female (AGG-405) showed a chronic subcutaneous fibrotic reaction on the tailstock, possibly due to a net-caused trauma. In at least another 11 dolphins caught off central Peru in 1993 and 1994, large scars observed on the trunk, appendages and head were thought to be remnants of harpoon wounds or self-inflicted injuries in the struggle to free themselves from fishing devices. White-grey scars on the back of several *D. capensis* caught off Ancon in 1991 and 1992 were believed to be healed harpoon wounds (I. Garcia-Godos unpubl. data). Severe traumas due to fishing devices likely resulted in secondary mortality of unassessed numbers of injured dolphins that managed to escape. Therefore, total fisheries-related dolphin mortality is thought to be higher than can be accounted for by the tallying of landed specimens. In Peru, long-beaked common dolphins were frequently captured by industrial purse-seiners, including directed sets, at least until 1994.

Although malformations of the skull and trunk were found in several individuals, their prevalence in the population was low. The most striking malformation was the, likely congenital, curvature of the rostrum of female JCR-1351. While this may have reduced this individual's ability to catch prey, the deformation was evidently viable. Other less spectacular congenital malformations of the skull and teeth were presumed to be of even less consequence to survival. It is unknown whether malformations of the dorsal fin and backbone were congenital or acquired. Deformities of the dorsal fin and backbone are known from the killer whale *Orcinus orca*, common dolphin (likely *Delphinus delphis*), *Tursiops truncatus* and Hector's dolphin *Cephalorhynchus hectori* (Wilson et al. 1997, Visser 1998, Berghan & Visser 2000). Classification and possible origins of backbone deformities in cetaceans are discussed in Berghan and Visser (2000).

Chronic mastitis, observed in 1 pubescent female, possibly arose from a parasitic (e.g. *Crassicauda* sp.) or bacterial infection. Acute and chronic mastitis are known from at least 6 other odontocetes including *Delphinus delphis*, Atlantic white-sided dolphin *Lagenorhynchus acutus*, *Stenella coeruleoalba*, *Tursiops truncatus*, *Delphinapterus leucas*, and *Globicephala melas* but not *D. capensis* (Sweeney & Ridgway 1975, Geraci et al. 1978, Raga & Balbuena 1993, Kuiken et al. 1994, De Guise et al. 1995, Di Guardo et al. 1995). The disease was caused by *Crassicauda* spp. in *L. acutus* and *G. melas*, while *Aeromonas hydrophila* and *Edwardsiella tarda* were isolated in a *D. leucas* and *T. truncatus*, respectively. *Crassicauda* spp. have not been extracted from the mammary glands of Peruvian small cetaceans, but very few mammaries have been examined in detail (Van Waerebeek unpubl. data).

Ovarian cysts (possibly follicular cysts) were found in a lactating female. Prevalence of ovarian cysts was 4.2% (n = 24), similar to that observed in *Lagenorhynchus obscurus* from the same region (3.06%, n = 98; Van Bressem et al. 2000). Ovarian cysts, including follicular and luteinized cysts, have also been reported from *L. obliquidens*, *Delphinapterus leucas* and *Stenella coeruleoalba* (Harrison et al. 1972, De Guise et al. 1995, Munson et al. 1998). The aetiology of follicular cysts is not known in dolphins. In cattle, aberration of the preovulatory surge of luteinizing hormone, either the absence or mistiming of the surge, is thought to cause this condition (McEntee 1990, Kennedy & Miller 1993).

The chronic orchitis in 1 adult male (KVW-2403) may be the origin of the bone lesions afflicting several cau-

dal vertebrae. Bacterial and fungal diseases of the urinary tract and testes are common sources of infection in animals suffering vertebral osteomyelitis (Kornegay & Barber 1980). Interestingly, infection by *Brucella* spp. may lead to vertebral osteomyelitis in humans and dogs (Kornegay & Barber 1980, Rajapakse 1995) as well as to orchitis in mammals. *Brucellae* are known to circulate among Peruvian *Delphinus capensis* (Van Bressem et al. 2001a) and may be a plausible cause for the orchitis and the vertebral lesions in KVW-2403. Among small cetaceans, orchitis was described only from the Amazon river dolphin *Inia geoffrensis* and *Tursiops truncatus* (Simpson & Gardner 1972, Sweeney & Ridgway 1975). Vertebral osteomyelitis was reported from a captive *T. truncatus* (Alexander et al. 1989).

The aetiology of vesicular lesions of the penis in 2 immature *Delphinus capensis* is unknown, but herpesviruses are possible agents. Members of the *Alphavirinae* subfamily cause vesicles, pustules and shallow ulcers in the genital tract of humans, bovines and horses (Whitley 1990, Fenner et al. 1993). Herpesviruses were also briefly reported in lesions of the cervix and penis of harbour porpoises (Ross et al. 1994**)**.

Besides tattoo skin lesions reported in the present paper and in Van Bressem & Van Waerebeek (1996), we encountered several other skin defects, most, however, of unknown aetiology. Poxvirus particles were detected by TEM in punctiform marks possibly analogous with ring lesions, the early form of tattoos (Geraci et al. 1979). In cetaceans, poxvirus particles have always been associated with tattoo and ring lesions (Flom & Houk 1979, Geraci et al. 1979, Van Bressem et al. 1993a). Tattoos and punctiform marks occurred together in some specimens (see Table 3). Herpes-like virus particles were demonstrated in skin marks also described as 'black points' on the rostrum of 2 *Lagenorhynchus obscurus* (Van Bressem et al. 1994) and may also have caused some of the punctiform marks in *Delphinus capensis*. Conceivably, lesions of at least 2 different aetiologies were included under the term 'punctiform marks' in 1991 and 1992, partly accounting for the difference in prevalence between Subsamples D (44.4%) and E (5.35%). Round marks were detected in Subsamples D and E. Unidentified parasites and virus particles were visible by TEM in samples taken from 1 dolphin. Additional samples should be studied by this technique in order to determine the aetiology of skin marks other than tattoos. The location, appearance, density and epidemiological features of the round marks and dark circles described in Subsample E suggest that they may be the same lesions at different developmental stages. Anomalous pigmentation seen in 1 dolphin was possibly due to piebaldness, a genetic melanisation defect also known as partial albinism (Comings & Odland 1966, Van Waerebeek 1992). Prevalence of this defect was low (1.8%). Anomalous pigmentation (including melanistic and all white coloration) was seen in 6.4% of 358 photo-identified common dolphins *Delphinus* sp. from Hauraki Gulf, New Zealand (Stocking & Visser 2005).

We conclude that long-beaked common dolphins from the Southeast Pacific are affected by a variety of acquired, congenital, traumatic, infectious and parasitic diseases. Some of these are severe and bound to impair normal vital functions and behaviour. Of all diseases encountered, morbillivirus, poxvirus and *Brucella* sp. infections, as well as *Crassicauda* sp. infestation, appear to have the highest potential for significant adverse impact on population abundance by increasing natural mortality and/or by negatively affecting reproduction (Perrin & Powers 1980, Van Bressem et al. 1999). Interactions with artisanal and industrial fisheries on Peru's continental shelf are responsible for the large majority of human-induced mortality, and are thought to be the principal cause of debilitating physical traumas in this dolphin population. The feasibility of applying fishing gear modifications and other potential by-catch mitigation measures, including regulatory instruments, should be re-evaluated in the region as one of the most relevant issues for the enhanced conservation of this marine mammal population.

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