A preliminary overview of skin and skeletal diseases and traumata in small cetaceans from South American waters

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ABSTRACT

Miscellaneous lesions of the skin and skeletal system, and external traumata were observed in 558 of 7,400 specimens of 12 odontocete species from the waters of Colombia, Ecuador, Peru, Chile, Argentina, Uruguay, Brazil and Venezuela examined in 1984-2007. Tattoo skin disease (TSD), lobomycosis-like and cutaneous diseases of unknown aetiology seem to be emerging in several populations and, in some cases, may be associated with chemical and organic water pollution. TSD was observed in eight species from the SE Pacific and SW Atlantic. Lobomycosis-like disease was found only in coastal *Tursiops truncatus* but in four countries (Colombia, Ecuador, Peru and Brazil). All affected specimens were encountered in the vicinity of major ports, cities or shrimp farms. Whitish velvety cutaneous marks associated with scars occurred in coastal *T. truncatus* (Peru), *Sotalia guianensis* (Brazil) and a *Pseudorca crassidens* (Ecuador). Large, rounded lesions were seen in a calf *Cephalorhynchus eutropia* (Chile) and a *Cephalorynchus commersonii* (Argentina). Cutaneous wounds and scars as well as body traumata related to net entanglements and boat collisions were observed in 62 dolphins and porpoises from both oceans. Traumata resulted in deformations as well as in the partial or complete amputation of the dorsal fin, flippers and flukes in 14 cases. Fractures of the skull, ribs and vertebrae thought to be caused by violent, fisheries-related interactions or boat collisions were seen in single individuals of *Delphinus capensis* (Peru), *Lagenorhynchus obscurus* (Peru), *Ziphius cavirostris* (Uruguay) and *S. guianensis* (Venezuela). Prevalence of osteopathology in dolphins and porpoises from Peru and Brazil ranged widely, from 5.4% to 69.1%. In four small cetacean species from Peru cranial lytic lesions were the most frequently observed disease (5.4%-40.5%), followed by hyperostosis and ankylosing spondylitis in offshore (31%) and inshore (15.4%) *T. truncatus*. Fractures and other bone traumata were seen in 47.2% of the axial skeletons of *S. guianensis* collected along the northern coast of Rio de Janeiro State in 1987-1998. A high prevalence (48.4%, N=31) of, apparently congenital, malformations of the cervical vertebrae observed in a 2001-2006 sample may be linked to a hypothetical genetic bottleneck in this population. Malformations with deficient ossification would increase susceptibility to fractures of vertebrae. This study demonstrates the need for focussed research on the effects of human activities on the spread of infectious and other diseases in small cetaceans, particularly in near-shore populations that inhabit a highly degraded coastal environment

INTRODUCTION

More than half (57.7%) of the 71 odontocete species of the world inhabit marine and fresh waters of South America (SA). There, as in many other areas, they face a host of threats including incidental mortality in fisheries, direct exploitation, vessel strikes as well as habitat degradation and loss, and a significant number of populations are considered vulnerable. Especially for the latter, any source of enhanced natural or anthropogenic related mortality or morbidity should be of concern.

Although dedicated research of the epizootiology of infectious diseases is still in an early phase in South American cetaceans, a number of viruses, bacteria and disease-causing macro-parasites have been documented in several species (see Table 1). Some have the potential for significant adverse impacts on population abundance by increasing natural mortality (e.g. cetacean morbilliviruses, *Crassicauda* spp. nematodes and, possibly, cetacean poxviruses) or by negatively affecting reproduction (e.g. *Brucella* spp., *Phocoena spinipinnis* papillomavirus type 1) (Van Bressem and Van Waerebeek, 1996, Van Bressem *et al.,* 1996, 1998, 1999, 2001a,b, 2006a, 2007a,b). *Brucella* spp. and cetacean poxviruses could represent a zoonotic threat (Van Bressem *et al.,* 1993; 2001a). Miscellaneous non-infectious diseases, lesions, anomalies and traumas are also commonly found in SA small cetaceans (e.g. Ramos *et al*., 2001; Sánchéz *et al*., 2002; Van Bressem *et al*., 2000, 2006b; Flores *et al*., 2005; Mendonça de Souza *et al*., 2006; Laeta *et al*., 2006; Flach, 2006) and may also have a negative impact on reproduction, impair feeding or cause premature death (Ramos *et al*., 2001; Van Bressem *et al*., 2000, 2006b; Sánchez *et al*., 2002; Laeta *et al*., 2006, Siciliano *et al*., 2007). Anthropogenic activities may influence the course of diseases as well as directly cause traumas and lesions (Van Bressem *et al*., 1994, 1999, 2001b; Ross, 2002; Viddi *et al*., 2005; Flach, 2006). Besides their potential to kill outright, many types of fisheries may also provoke serious injuries and stress as well as influence the outcome of host-parasite interactions in the animals that survive the encounter (Clark *et al*., 2006; Van Bressem *et al*., 1994, 1999, 2006b). Polychlorinated biphenyls (PCBs) and related compounds might contribute to the severity of viral epizootics through toxicity at the level of the immune system (Aguilar and Borrel, 1994; Ross, 2002).
While a not insignificant number of pathology case studies have been implemented in South America, mainly over the past 15 years, no comprehensive overview of progress has so far been undertaken. In an effort to improve our understanding of pathological agents and processes that may co-determine modal health and potentially influence net recruitment and, indirectly, population size, we analysed data for twelve species of small cetaceans from the waters of eight South American countries and placed them in an epizootiological context. We further attempt to evaluate whether human activities may be contributing to traumas and malformations or may facilitate the spread of certain infectious diseases.

MATERIAL AND METHODS

Study areas and species

In the period 1984-2007 the authors studied gross pathological evidence in about 7,400 free-ranging, stranded and captured small cetaceans belonging to 12 species from the waters of Colombia, Ecuador, Peru, Chile, Argentina, Uruguay, Brazil and Venezuela (Table 2). Voucher data include images, field notes, museum specimens (skeletons) and others. Conditions of individuals studied ranged from 1 to 5 (Geraci and Lounsbury, 1993) but most were alive or freshly dead. A database including 55 parameters for each specimen presenting lesion(s) was compiled. The presence of suspected environmental factors (fisheries, vessel collisions, fish farms, sewage, pollution or any other type of coastal habitat encroachment) in the vicinity of each studied population's habitat was noted. Some subsets of data were previously presented at conferences (Bolaños-Jiménez and Bermúdez, 1996; Flores *et al*., 2005; Siciliano *et al*., 2005; Viddi *et al*., 2005; Flach, 2006; Laeta *et al*., 2006; Mendonça de Souza *et al*., 2006), used in a Master thesis (Fragoso, 2001; Montes-Iturrizaga, 2003) or published (Ramos *et al*., 2001; Montes *et al*., 2004; Van Bressem *et al*., 2006b).

Skeletal material

The skulls and skeletons of 354 dolphins and porpoises from Ecuador, Peru, Uruguay, Brazil and Venezuela (Table 2) were examined for the presence of osteopathology and abnormalities. Particular attention was paid to Crassicaudiasis, apparently irreversible, basket-like cranial lesions caused by *Crassicauda* spp. nematodes because of high potential health impact including lethality (e.g. Perrin and Powers, 1980; Raga *et al*., 1982, Dailey, 1985). Skeletal material is deposited at reference collections including the Museo de Delfines (Pucusana, Peru), Áreas Costeras y Recursos Marinos (ACOREMA, Pisco, Peru), Grupo de Estudos de Mamíferos Marinhos da Região dos Lagos (GEMM-Lagos, Brazil), Universidade Estadual do Norte Fluminense-LCA (Brazil), Museu de Zoologia da Universidade de São Paulo (Brazil), Museo de Ballenas (FEMM, Ecuador), Museo EBRG, Ministerio del Ambiente (MINAMB, Venezuela), Exhibición Museo del Mar (Maldonado, Uruguay). Individuals were considered cranially mature with advanced fusion in the frontal-supraoccipital or premaxillary-maxillary sutures or in at least 2 of 5 other indicative cranial sutures (Van Waerebeek, 1992, 1993).

Freshly dead specimens

Carcases of 6,127 small cetaceans from Ecuador, Peru and Brazil were examined, predominantly under field conditions (e.g. fish markets and beaches), for macroscopical lesions, malformations and cutaneous diseases. Observations were opportunistic in Peru till 1990. Dedicated research in 1993-95 allowed unbiased prevalence rates to be estimated for bycaught dusky dolphins (*Lagenorhynchus obscurus*), offshore and inshore common bottlenose dolphins (*Tursiops truncatus*), long-beaked common dolphins (*Delphinus capensis*) and Burmeister's porpoises (*Phocoena spinipinnis*). Sexual maturity was determined, in females, from the presence of at least 1 corpus luteum or corpus albicans in one of the ovaries, or evidence of lactation or pregnancy (visible foetus), in males if seminal fluid was detected macroscopically in at least one freshly cut epididymis. 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 these populations (Reyes and Van Waerebeek, 1995; Van Waerebeek *et al*., 1990; Van Bressem *et al*., 2006b).

Free-ranging dolphins

The prevalence of evident dermatologic disease, gross body deformations and traumas, including extensive scarring or mutilation, was studied in 989 free-ranging dolphins (Tables 2 & 3) from images taken during photo-identification surveys from small boats (Félix, 1997; Bolaños-Jiménez *et al*., 1998; Flach, 2006; Reyes *et al*., 2002; Flores *et al*., 2005; Viddi *et al*., 2005). Dolphins were individually identified from natural marks (Würsig and Jefferson, 1990). The maturity (calf, juvenile, adult) of estuarine dolphins (*Sotalia guianensis*) from Sepetiba Bay, Brazil, and *T. truncatus* from Bahía Málaga and surroundings, Colombia, was estimated from relative body size and behavioural clues (Wells *et al*., 1980; Shane, 1990). Maturity of Atlantic spotted dolphins (*Stenella frontalis*) from Venezuelan waters was deduced from Herzing (1997). Dedicated surveys to assess the presence of skin conditions and traumas were conducted in the Chilean dolphin (*Cephalorhynchus eutropia*), Peale's dolphin (*Lagenorhynchus australis*) and *T. truncatus* from Chile as well as in *S. guianensis* from Sepetiba Bay, Brazil (Viddi *et al*., 2005; Flach, 2006). Populations of inshore *T. truncatus* from Paracas (Peru), the Gulf of Guayaquil, (Ecuador) and Santa Catarina (Brazil) have been the objects of long-term field research (Félix, 1997; Reyes *et al*., 2002; Flores *et al*., 2005). In these cases, prevalence of disease and trauma could be estimated with precision.

Sexual and ontogenetic variation

With sample sizes permitting, we examined whether disease prevalence varied with sex and sexual or cranial maturity as a proxy for age. 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 (≤ 0.05) was verified with chi-square contingency tests or 2-tailed Fisher's exact tests (Swinscow, 1981).

RESULTS

Cutaneous diseases, wounds, scars and traumata were observed in large numbers of small cetaceans from Colombia, Ecuador, Peru, Chile, Argentina, Brazil and Venezuela (Tables 2 & 3). All populations and ecotypes of *T. truncatus* from South America had skin diseases. Due to the very large amount of data and time restriction we have limited this preliminary analysis to the following diseases that are likely of highest concern in relation to environmental factors and anthropogenic effects.

Cutaneous diseases

Tattoo skin disease (TSD)

TSD is characterized by very typical, irregular, grey, black or yellowish, stippled lesions that may occur on any part of the body but show a preferential corporal distribution depending on the species (Van Bressem and Van Waerebeek, 1996). The prevalence of tattoo positive dolphins and porpoises from the SE Pacific and SW Atlantic is presented in Table 3. TSD is likely endemic in Peruvian small cetaceans and affect predominantly juveniles in the Delphinidae. The earliest confirmed record in Peru is in a *D. capensis* landed in 1986 (Van Bressem *et al*., 2006b). The apparent low prevalence in inshore *T. truncatus* from the Bay of Paracas is likely related to the fact that photo-identification images permit only dorsal parts of the body to be examined and that tattoos may be difficult to spot on the dark grey skin. The disease is also present in the short-beaked dolphin (*Delphinus delphis*) from Ecuador and, possibly, in the Commerson's dolphin (*Cephalorhynchus commersonii*) from Argentinian Patagonia. In inshore *C. eutropia* from southern Chile and *S. guianensis* from Sepetiba Bay (23°S, 44°W), southern Rio de Janeiro State (RJ), tattoos were only observed in adults (Fig. 1a,b). TSD was not detected 91 *S. guianensis* accidentally caught off northern RJ in 1988-2004 (Van Bressem *et al*., 2003a; Di

Beneditto, pers. commn 2006) but may represent a threat for this population through contacts with dolphins from Southern RJ.

Large, rounded cutaneous lesions

Large rounded lesions with an orange or dark outline and a light inner colour were seen in a *C. commersonii* from Argentinian Patagonia in 2001 and a calf *C. eutropia* from southern Chile in 2003 (Fig 2a,b). Their irregular rounded shape evoked surinfected tattoo lesions seen, for instance, in a calf *T. truncatus* from the Sado Estuary, Portugal (Van Bressem *et al*., 2003b) but their aetiology is unknown. The lesions were extensive in both dolphins and the calf apparently died six weeks after the lesions were first seen. A similar but much smaller orange, rounded skin mark was seen in another *C. commersonii*. These marks had never been observed in these species and areas before and were not seen in other small cetaceans examined during this study.

Whitish velvety lesions

Whitish lesions with a velvety appearance and associated with unrelated wounds, scars and tooth rakes were observed on the back, dorsal fin and flukes of inshore *T. truncatus* from the Bay of Paracas, two adult *S. guianensis* from Sepetiba Bay and a false killer whale (*Pseudorca crassidens*) from Santa Elena (Ecuador) (Table 3; Fig 3a,b). In *P. crassidens*, the lesions were negative for fungal infection and were thought to be of bacterial aetiology.

Lobomycosis-like disease (LLD)

Whitish to slightly pink, verrucous lesions, often in pronounced relief, that may ulcerate and evoke lobomycosis (Migaki *et al*., 1971) were observed in free-ranging inshore *T. truncatus* from Colombia, Ecuador, Peru and Brazil (Table 3; Fig 4a,b). The lesions were either disseminated or localized and affected the dorsal fin, dorsum, tailstock and flukes. In Bahía Málaga and surroundings (Colombia), LLD was observed in two adults from a group of six in August 2005, one of a group of five in February 2006 and one of 10 in June 2006. It is possible that at least one of the two affected *T. truncatus* was repeatedly sighted. One *T. truncatus* sighted off Callao, Peru's main port, in December 2006 showed extensive lobomycosis-like lesions. Importantly, despite observations at hundreds of both captured and free-ranging individuals by CEPEC and ACOREMA scientists along the entire Peruvian coast (unpublished data; Reyes *et al*., 2002), this condition was never seen in the period 1984-2005, hence LLD is considered an emerging disease in Peru.

Vesicular lesions

Vesicles were seen in an adult female *T. truncatus* (Fig. 5) from Palena, Chile in December 2003. Several ulcerated lesions were observed on the flanks of a *T. truncatus* stranded in RJ in March 2007. Ulcerative dermatitis caused by *Aeromonas hydrophila* was described in *T. truncatus* (Cusick and Bullock, 1973). A calicivirus (cetacean calicivirus 1) caused ulcerative vesicular lesions in two captive Atlantic *T. truncatus* (Smith *et al*., 1983). Further studies to identify the aetiology of these lesions are ongoing.

Traumas related to human activities

A large percentage of the cutaneous wounds, scars and other traumas observed in all populations studied was likely related to net entanglements and to a lesser extent to boat collisions (Tables 4 & 5). The lesions affected the head, trunk and appendages. In 14 cases involving *T. truncatus* (both ecotypes, Peru), *P. spinipinnis* (Peru), *S. guianensis* (Brazil) and *Stenella frontalis* (Venezuela) the dorsal fin, flippers and flukes were severely injured resulting in partial or complete amputations and deformations (Fig 6a, Table 5). Remains of nylon gillnets were found in four *S. guianensis* from Sepetiba Bay (Fig 6b) and one from northern RJ (Ramos *et al*., 2001). Wounds and scars possibly inflicted by propellers in a number of species are currently under study, in an effort to identify confirmed cases (see Van Waerebeek *et al.*, 2006).

Lesions of the skeleton.

Lesions of the skeleton were classified into four categories (Table 6). Prevalence of osteopathology ranged from a low 5.4% (*P. spinipinnis*, Peru) up to 69.1% (*T. truncatus*, Peru offshore).

Malformations

Brazil. Among 53 *S. guianensis* collected in 1987-1998 in northern RJ, congenital malformations affected 7.6% of the skulls and 9.4% of axial skeletons (Table 6). They affected the maxillaries, premaxillaries, mandibles, occipital, cervical and thoracic vertebrae, sternum and ribs. Three mature females had malformations of the whole skeleton. Malformations of the axial skeleton characterized by an incomplete closure of the vertebral arch of the seventh cervical vertebra and sometimes associated with the presence of cervical ribs, were observed in 48.4% of 31 *S. guianensis* gathered in 2001-2006 (Fig 7). Most (66.7%) affected specimens were immature. The spinal processes of some thoracic and caudal vertebrae were abnormally curved in an immature female inshore *T. truncatus* from the same region.

Peru. Congenital malformations of the skull were observed in *L. obscurus*, *D. capensis* and inshore *T. truncatus* but not in *P. spinipinnis* and offshore *T. truncatus* (Table 6). The malformations involved the whole crania of a *L. obscurus* (Fig. 8) and a *D. capensis* (Van Bressem *et al*., 2006b). In other dolphins lesions were benign (brachygnathia, prognathism, beak deviation) and likely did not interfere with feeding or other vital activities.

Fractures and other traumas

Brazil. Among 53 *S. guianensis* in 1987-1998 along northern RJ, the following percentages showed fractures affecting L6-L8 (15.1%), ribs (20.8%), scapula (1.9%), caudal vertebrae (5.7%), thoracic vertebrae (3.8%), C3 (5.7%), C7 (3.8%). Among *S. guianensis* gathered in the same region in 2001-2006, fractures of the hemi-arches of C7, T1 and T2 were observed in a mature specimen of unknown sex (3.2%). These injuries may have been inflicted by con-specific or inter-specific interactions (see e.g. Jepson and Baker, 1998), fishery interactions or resulted from congenital defects and functional stress (Fragoso, 2001; Laeta *et al*., 2006). In the 1987-1998 sample, lesions of the skull associated with remains of fishing gear were seen in two mature dolphins. Finally, a perforation like from a sharp fish spine or bone was observed in the palatine of a juvenile male. An adult male *T. truncatus* (GEMM-081) stranded alive in RJ in 2005 had several fractures of the ribs that had incompletely healed, resulting in pseudo-arthrosis. It had also a deep cut in the fourth and fifth thoracic vertebrae, possibly caused by a piercing object and suffered osteomyelitis (see below).

Peru. Among four species, prevalence of fractures and traumas in by-caught specimens varied from 0% in *P. spinipinnis* to 7.7% in inshore *T. truncatus* (Table 6). Healed or non-healed fractures were encountered in the mandibles of a *L. obscurus*, a *D. capensis*, two inshore *T. truncatus* and three offshore *T. truncatus*, all adults (Fig 9), possible results of violent con-specific or inter-specific interactions, or fishing gear. In two other cases the injuries were clearly anthropogenic. A *L. obscurus* was shot in the head and the impact of the bullet was seen in the right maxillary, right pterygoid and left mandible. Two holes (diameters 15 and 5 mm) with irregular edges, likely inflicted by a piercing object, perforated the occipital bone close to the left condyle in a mature male *D. capensis* (Van Bressem *et al*., 2006b). The non-healed fracture and a large hole behind the posterior teeth in the mandible of a mature *T. truncatus* may also have an anthropogenic origin.

Venezuela. A hole (ca.110 mm^2) was observed in the right mandible behind the posterior teeth in a *S. guianensis* found dead along the shore of the Gulf of Venezuela. A piercing object or a gun bullet have been suggested as possible cause (Bolaños-Jiménez and Bermúdez, 1996).

Uruguay. A cranially mature female Cuvier's beaked whale *Z. cavirostris* stranded in Laguna Garzon at an indeterminate date in 1998-2000 had healed fractures in the two posterior most lumbar vertebrae, two anterior most caudal vertebrae, and in three ribs. In the mandible a pseudo-arthrosis was seen. The whale possibly had suffered a collision with a boat some time before it died. A cranially mature *P. crassidens* found in Laguna Garzon in the same period had fractures in two ribs.

Lytic lesions

Osteomyelitis and osteolysis. Osteomyelitis is characterized by non-specific acute or chronic, localized or generalized, bone infection accompanied by bone destruction or dissolution (osteolysis) and new bone formation. Prevalence of such lesions is given in Table 7. Osteomyelitis and osteolysis mostly affected mandibles, maxillaries and premaxillaries in Peru (Fig 10a). In one *D. capensis*, osteomyelitis also affected the pterygoid and palatine. In *S. guianensis*, osteomyelitis and/or osteolysis were seen in the stylohyoid (one case), the occipital condyles and atlas-axis block, the scapulae (two cases) and in the lumbar and caudal vertebrae (two cases). Osteomyelitis related to periodontal disease was also seen in the right mandible of a *S. guianensis* from Venezuela. Some osteolysis was observed in one scapula of a *Z. cavirostris* (Fig 10b) stranded in Laguna Garzon and in an inshore immature, female *T. truncatus* found along the coast of RJ in 2001. Symmetrical bone proliferation with intense bone remodelling affecting the bone surface and marrow was seen at the site were the ribs had been broken in *T. truncatus* GEMM-081 from Brazil. These lesions may have resulted from bacterial infection introduced during piercing injuries.

Periodontal lysis.

Periodontal lysis (Table 7) may be caused by caries and abcesses of the dental roots and were seen in mature and immature odontocetes (Fig 11). They were responsible for 6.1% (*D. capensis*)-100% (*P. spinipinnis*) of the cases of osteolysis and osteomyelitis observed in skulls from Peru, Brazil and Venezuela.

Crassicaudiasis.

Crassicaudiasis was detected in all species except *P. spinipinnis* (Fig. 12; Table 7). Possible *Crassicauda* lesions were also seen in the pterygoids of a mature *S. guianensis* from northern RJ. The pterygoids were the bones most frequently affected in all species but in *L. obscurus* where only the alisphenoid, basioccipital and frontal were damaged. Prevalence of *Crassicauda* spp. lesions varied significantly (χ^2 = 22,32, df= 4, P = 0.0015) according to the species and ecotypes, being (χ^2 = 10,46, df= 1, P = 0.0012) higher in *D. capensis* and offshore *T. truncatus* (Table 7). In *D. capensis*, prevalence did not vary significantly (Fisher's; P = 0.8) 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 (χ^2 = 0.177, 1 df, p = 0.67) in cranially immature (22.7%, n = 22) and adult (27.3%, n = 66) dolphins (Van Bressem *et al*., 2006b). The same may be true in offshore *T. truncatus* but sub-samples were too small to verify this hypothesis (Table 8).

Degenerative bone diseases.

Degenerative bone diseases (hyperostosis, spondylitis) were seen in all species examined with the exception of *P. spinipinnis*, and were especially frequent (31%) in offshore *T. truncatus* from Peruvian waters (Table 6).

Hyperostosis

Hyperostosis, a condition characterized by diffuse or localised bone overgrowth sometimes concurrent with bone rarefaction was noticed in skulls from inshore and offshore *T. truncatus* (Fig. 13a), *L. obscurus* and *D. capensis* from Peru as well as in an inshore *T. truncatus* from northern RJ and on the ribs and vertebrae of a *P. crassidens.* In Peruvian *T. truncatus*, this condition always affected the occipital and less frequently the nasals, maxillaries and frontal. Hyperostosis was benign or severe, affecting the whole skull. Prevalence of this condition in four sub-samples of offshore *T. truncatus* is given in Table 8. In offshore *T. truncatus*, prevalence of hyperostosis seemed to be higher in mature males than in immature males and mature females. However, significance could not be statistically tested due to small sample sizes. Hyperostosis occurred in three immature and one mature inshore *T. truncatus* of unknown sex.

Ankylosing spondylitis (AS)

AS is a syndrome including new bone formation, loss of bone density and often resulting in the fusion of two or more vertebrae or the atlas ankylosing with the occipital bone, as well as other abnormal ankylosing processes (Sweeny *et al*., 2005). It was encountered in both *T. truncatus* ecotypes from Peruvian waters (Fig. 13b). Prevalence of AS was 3.9% in inshore and 9.5% in offshore dolphins. All affected specimens had also hyperostosis. The only inshore dolphin with AS was a young immature (176 cm) of unknown sex. All its cervical vertebrae were fused and the atlas had started to fuse with the occipital. Among the offshore, prevalence was the highest in mature males (Table 8). Possible AS was also observed in an immature *D. delphis* and a mature *T. truncatus* collected in 1998-1999 in the northern Gulf of Guayaquil.

DISCUSSION

In this paper we report on the emergence of some infectious and congenital diseases in small cetaceans from SA waters as well as on lesions and traumas due to encounters with boats and nets.

Tattoo skin disease is caused by poxviruses that belong to a newly discovered genus of *Chordopoxvirinae*, but have a common, most immediate ancestor with terrestrial poxviruses of the genus *Orthopoxvirus* (Flom and Houk, 1979; Geraci *et al.,* 1979; Bracht *et al.,* 2006). The virus is thought to induce humoral immunity that may protect calves from the disease (Smith *et al*., 1983; Van Bressem and Van Waerebeek, 1996). TSD was known only in odontocetes until 2006 when it was first reported from a bowhead whale (Bracht *et al.,* 2006). Here we reported for the first time on the presence of TSD in *S. guianensis* from Sepetiba Bay, *C. eutropia* from southern Chile and *C. commersonii* from Argentina, thus extending the number of species susceptible to the disease. We also demonstrated that it is present from Ecuador to the Northern Chilean Patagonia in the SE Pacific and from Argentina to Brazil in the Western South Atlantic. The epidemiological status of TSD in *S. guianensis* and *C. eutropia* is unknown and should be explored further. Though cetacean poxviruses do not apparently cause high mortality when endemic (Van Bressem *et al*., 1999), they could represent a significant threat to naive populations.

The appearance of velvety skin marks as well as of large, rounded lesions in dolphins from Peru, Chile, Argentina and Brazil, we suggest, may be related to poor water quality. The bay of Paracas is heavily contaminated by organic material released by fish-meal factories and surrounding towns, resulting in severe water eutrophication (PNUMA/CONAM; 2006). The factories also release phosphorus and organic nitrogen as well as caustic soda used to clean the machines (J.C. Reyes, pers. observations). The southern Fjords of Chile are home to salmon fish farms that are expanding at increasing speed and release biological and chemical contaminants directly into the ocean (Moore and Wieting, 1999; Kemper *et al*., 2003). Sepetiba Bay is home to two large ports and is characterized by chemical and organic pollution as well as water eutrophication (Copeland *et al*., 2003; Molisani *et al*., 2004).

Lobomycosis is caused by a yeast-like organism known as *Lacazia loboi* (Taborda *et al*., 2003) (syn. *Loboa loboi;* Caldwell *et al*., 1975). It naturally affects human beings and dolphins (*T. truncatus* and *S. guianensis*). In humans, it is a self-limited, chronic fungal infection of the skin endemic in rural regions in South and Central

America. The natural reservoir of *L. loboi* is unknown but soil and vegetation seem to be likely sources of infection (Honda *et al*., 2007). Patients with lobomycosis may have immunoregulatory disturbances that could be responsible for the lack of pathogen containment (Honda *et al*., 2007; Vilani-Moreno *et al*., 2005). In *T. truncatus* from the southern part of the Indian Lagoon, Florida, the disease was associated with an impaired immune function possibly caused by anthropogenic factors. Variation in salinity and water temperature may also play a role (Reif *et al*., 2006). During the present study lobomycosis-like disease was only seen in inshore populations of *T. truncatus*. Those from Colombia, Ecuador and Santa Catarina, Brazil inhabited waters situated close to mangroves and places of low salinity. All affected *T. truncatus* inhabited waters surrounding large ports and cities and, in the case of Guayaquil, also harbouring intense shrimp farming activities. These waters are heavily polluted by chemicals and biological contaminants (CPPS, 2000; CVC, 2003; UNEP, 2005; WHO/UNICEF/WSSCC. 2001). It is quite likely that the various chemical pollutants affect the immune system of inshore dolphins as described in cetaceans elsewhere (Aguilar and Borrel, 1994; Jepson *et al*., 1999; Smyth *et al*., 2000). The cities also discharge untreated wastewater directly into the estuary and oceans. The waters of the Bay of Málaga and surroundings, Gulf of Guayaquil, Florianopolis and Lima contain extremely high levels of fecal coliforms (CPPS, 2000; CVC, 2003; FEEMA 2007) indicative of organic contamination and considered a major health threat to humans. In Brazil, the first case of lobomycosis was observed in an adult female *T. truncatus* stranded in Laguna, Santa Catarina in 1990 (Simões-Lopes *et al*., 1993). Laguna (28°30’S; 48°55’W) is located between Baía Norte (27°50’S, 48°58’W) and Tramandaí Estuary (29°58’S, 50°07’W). It is possible that LLD is endemic in the coastal population of *T. truncatus* from this area. The infection may represent a threat to possibly susceptible *S. guianensis* (de Vries and Laarman, 1973; Flores *et al*., 2005). Though the organism found in dolphins may not be the same as in humans (Haubold *et al*. 2000), the disease may be zoonotic and care should be taken when manipulating affected dolphins (Symmers, 1983). Fishermen work close to the dolphins during cooperative mullet fishing in Laguna and Tramandaí Estuary (Simões-Lopes *et al*., 1998) and may be at risk of infection. Indications are that in Peru lobomycosis-like disease is a recently emerging disease in inshore bottlenose dolphins. Further research on the aetiology and trends of skin diseases in small cetaceans from SA is urgently needed, including periodic surveys to assess the presence of cutaneous lesions and body traumas and the analysis of existing image databases.

Skin injuries, body traumas and bone fractures caused by interaction with fisheries and boats were seen in inshore and offshore small cetaceans from both oceans. Severe traumas due to fishing devices likely resulted in secondary mortality of unassessed numbers of escaping but injured dolphins and porpoises. Therefore, total fisheries-related small cetacean mortality is thought to be higher than can be accounted for by the tallying of landed specimens. A number of fractures of ribs, vertebrae and mandibles may be the result of boat collisions, however other potential sources including post-mortem damage on carcasses must be eliminated (Van Waerebeek *et al*., 2006). Propellers caused deep wounds on the body of several dolphins and porpoises from Peru, Chile and Brazil and Venezuela. Both boat collisions and net entanglements are likely to cause great stress in surviving animals. Stress may depress the immune system and favour the development of infectious diseases as well as cause damages of the circulatory system and kidneys (e.g. Van Bressem *et al*., 1994; Cowan and Curry, 2002).

Various osteolytic lesions of the skull were common in several species of dolphins and porpoises in Peru and Brazil. Periodontitis and dental diseases as well as *Crassicauda* spp. infestation were firmly or tentatively diagnosed as the cause of a high percentage of these lesions in several species. Adult roundworms *Crassicauda* spp. infest the cranial sinuses 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). They were not seen in *P. spinipinnis* from Peru. In the other species the highest prevalence was observed in the offshore/pelagic specimens. Interestingly, in offshore *T. truncatus* and *D. capensis*, mature and immature specimens were equally affected. The primary questions to evaluate differential mortality from skulls is whether the bone lesions remain extant long after the nematodes have died, and whether re-infection is likely. In spotted dolphins (*Stenella attenuata*) from the Eastern Tropical Pacific, prevalence was higher in younger animals, which was attributed to mortality caused by *Crassicauda* spp. infestation in young dolphins (Perrin and Powers, 1980). In *P. spinipinnis*, periodontal and dental diseases were responsible for all the lytic injuries. Periodontal and dental diseases are likely a consequence of tooth decay, infection 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 may have caused considerable pain in the affected dolphins and porpoises. Osteolysis occured also in the the vertebrae and scapulae of several species. The origin of these leions is unknown but may be bacterial. *Brucellae* are known to circulate among Peruvian *D. capensis* and may have caused orchitis and vertebral lesions in one specimen (Van Bressem *et al*., 2006b).

Degenerative diseases including hyperostosis and AS were especially prevalent in offshore *T. truncatus* from Peru. Among these dolphins, there is some indication that hyperostosis may occur more frequently in adult males than in others but appreciably larger samples are required for testing. If confirmed, the hypothesis that the disease might be related to physiological (hyperbaric) stress associated with feeding at greater depths in adult males than in immatures and females would deserve further study. Hyperostosis seems also to be linked with the development of ankylosing spondylitis. Prevalence of AS was similar in mature and immature male offshore *T. truncatus*. The only inshore dolphin with AS was a young immature. The aetiology of AS in humans is still poorly understood, but a strong genetic influence exists and approximately 90-95% of patients with AS have the tissue antigen human leukocyte antigen B27 (Dougados, 2005). Unknown environmental factors (bacterial infection in humans) may trigger the development of AS in individuals genetically predisposed. Hyperbaric stress related to deep diving may represent one of those factors in offshore *T. truncatus* and other species with similar feeding habits. Prevalence of AS was 21% in 52 long-finned pilot whales (*Globicephala melas*) from the Northwest Atlantic (Sweeny *et al.*, 2005). Degenerative diseases called 'spondylitis' and 'spondylosis deformans' were previously described in small odontocetes (reviewed by Kompanje, 1995a,b).

The high prevalence of congenital bone malformations in *S. guianensis* from northern Rio de Janeiro is of great concern and likely indicates a genetic bottleneck in this population. The malformations possibly facilitated the occurrence of fractures seen in the vertebrae of this species (Fragoso, 2001; Laeta *et al.*, 2006; this paper). The estuarine dolphins from Sepetiba Bay (southern Rio de Janeiro) present infectious skin diseases and constitute a high percentage of incidental non-lethal captures in gillnets that may however result in severe injuries and traumas, high stress levels and secondary mortality which goes unaccounted for. Besides, in both southern and northern Rio de Janeiro, the waters are heavily contaminated by industrial and domestic wastes (FEEMA, 2007). Altogether findings indicate that these populations of estuarine dolphins are in poor health and stress the need to further closely monitor their health status and to increase and enforce conservation measures.

We conclude that odontocetes from South American waters 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. Interactions with artisanal and industrial fisheries as well as boat collisions are thought to be the principal cause of debilitating physical traumas in several populations.The feasibility of applying fishing gear modifications and other potential by-catch mitigation measures, including regulatory instruments, should be re-evaluated in South America as one of the most relevant issues for the enhanced conservation of marine mammal populations. Besides, aquaculture, fish factories, untreated wastewater as well as chemical pollution are supposed to play an important role in the detoriation of cetacean population health and in facilitating the emergence of new diseases.

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FIGURES

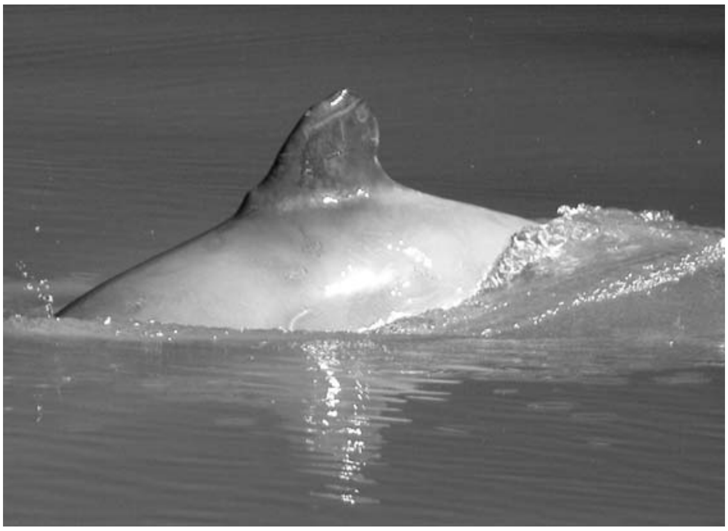

Figure 1a. Tattoo lesions in an adult *Cephalorhynchus eutropia* from Southern Chile.

Figure 1b. Tattoo lesions and emaciation in an adult *Sotalia guianensis* from Sepetiba Bay (Brazil).

Figure 2a. Large, rounded lesions in a calf *Cephalorhynchus eutropia* from Northern Patagonia (Chile).

Figure 2b. Large rounded lesions in a *Cephalorhynchus commersonii* from Patagonia (Argentina).

Figure 3a. Whitish, velvety lesions associated with a deep wound in an adult *Sotalia guianensis* from Sepetiba Bay (Brazil).

Figure 3b. Whitish, velvety lesions associated with scars in an inshore *Tursiops truncatus* from Paracas Bay (Peru).

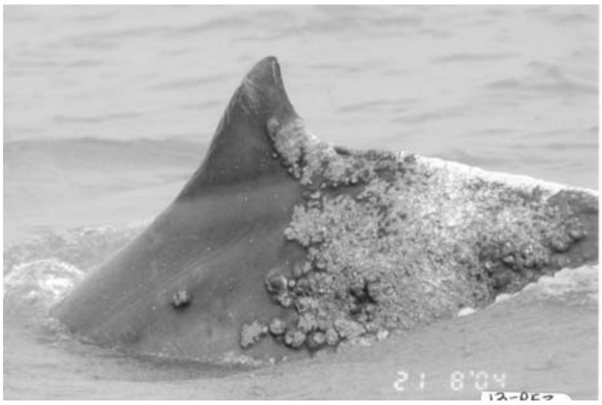

Figure 4a. Lobomycosis-like in an adult, inshore *Tursiops truncatus* from Santa Catarina (Brazil).

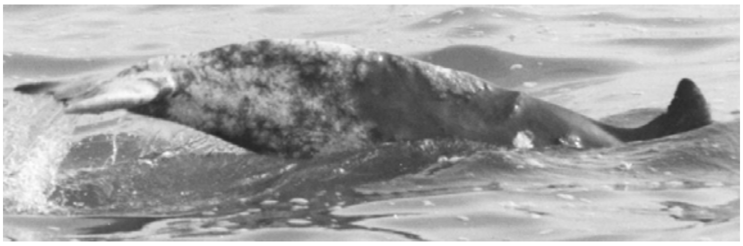

Figure 4b. Lobomycosis-like in an estuarine *Tursiops truncatus* from the Gulf of Guayaquil (Ecuador).

Figure 5. Vesicles on the skin of a female *Tursiops truncatus* from Southern Chile.

Figure 6a. Deformation of dorsal fin in an inshore *Tursiops truncatus* from the Bay of Paracas (Peru).

Figure 6b. Remains of a nylon twines encroached in a large scar on the anterior basis of the dorsal fin and healing lesion on the tailstock of an adult *Sotalia guianensis* form Sepetiba Bay (Brazil).

Figure 7. Congenital malformations in the seventh cervical vertebra of a *Sotalia guianensis* from Northern RJ (Brazil).

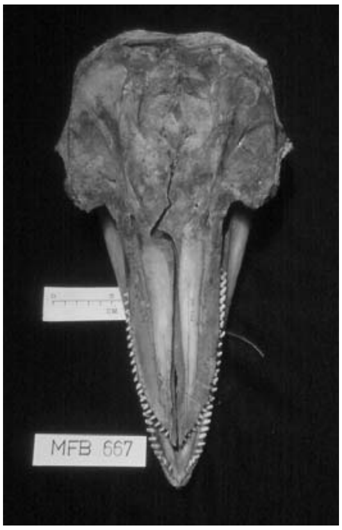

Figure 8. Complete skull malformation in an adult *Lagenorhynchus obscurus* (Peru).

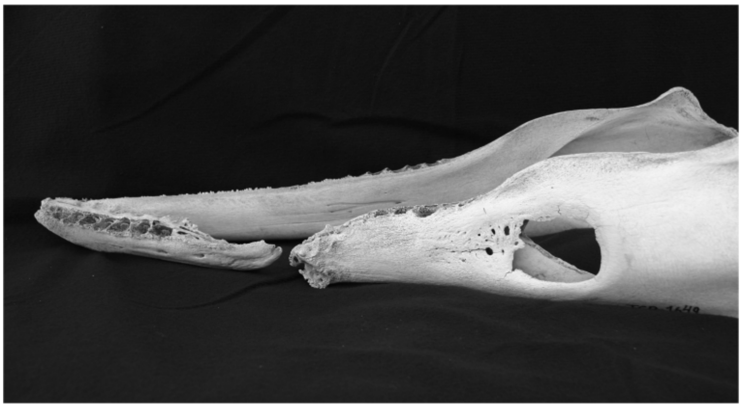

Figure 9. Complete fracture of the left mandible together with a large, possibly lytic lesion in an adult offshore *Tursiops truncatus* (Peru).

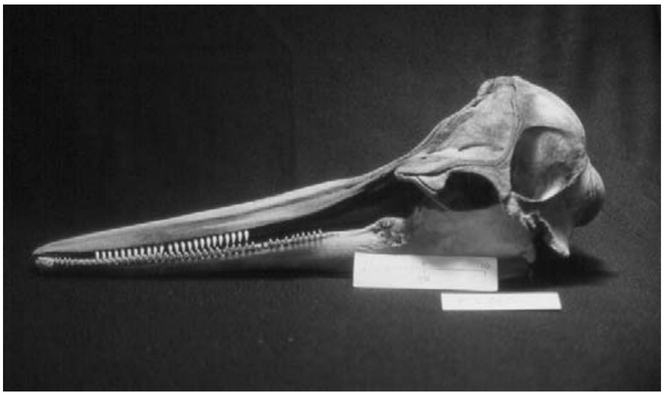

Figure 10a. Osteomyelitis in the left mandible of a mature *Delphinus capensis* (Peru).

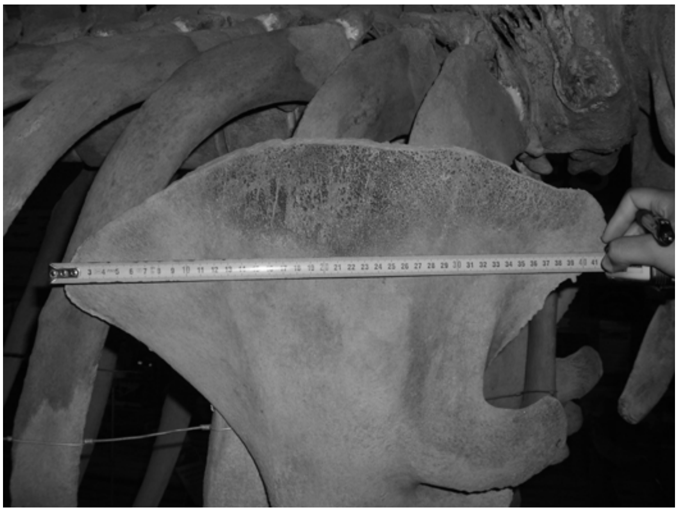

Figure 10b. Osteolysis in the scapula of a mature *Ziphius cavirostris* (Uruguay).

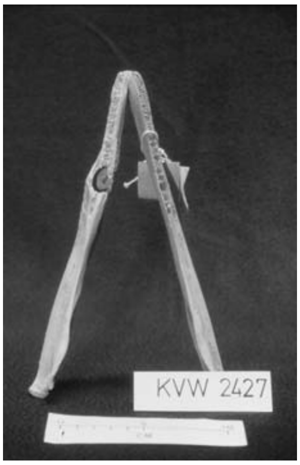

Figure 11. Periodontal lytic disease in a mature *Phocoena spinipinnis* (Peru).

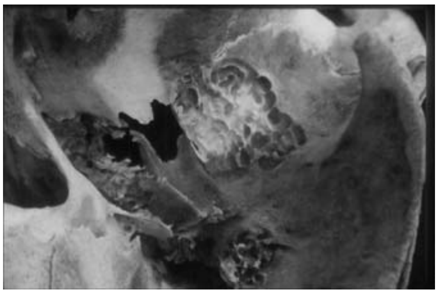

Figure 12. *Crassicauda* sp. lesions in the skull of an immature offshore *Tursiops truncatus* (Peru).

Figure 13a. Hyperostosis in a mature offshore *Tursiops truncatus* (Peru).

Figure 13b. Ankylosing spondylitis in a mature offshore *Tursiops truncatus* (Peru).

Species	Country, area	Disease, pathoanatomical diagnosis or symptomatology	Suspected related environmental factor	Source
Cephalorhynchus eutropia	Chile, N Patagonia	Rounded large cutaneous marks	aquaculture	Viddi *et al*., 2005; this paper
Cephalorhynchus eutropia	Chile, N Patagonia	Tattoo skin disease	aquaculture	Viddi *et al*., 2005; this paper
Cephalorhynchus commersonii	Argentina, Patagonia	Rounded large cutaneous marks		Crespo and Klaich, unpublished data; this paper
Cephalorhynchus commersonii	Argentina, Patagonia	Tattoo skin disease		Crespo and Klaich, unpublished data; this paper
Delphinus capensis	Brazil	Diffuse skeletal hyperostosis		Siciliano *et al*., 2005
Delphinus capensis	Peru	Tattoo skin disease- poxvirus infection		Van Bressem and Van Waerebeek, 1996; Van Bressem *et al*., 2006a
Delphinus capensis	Peru	Miscellaneous cutaneous lesions		Van Bressem *et al*., 2006b
Delphinus capensis	Peru	Skin discoloration		Van Bressem *et al*., 2006b
Delphinus capensis	Peru	Cutaneous scars	fishery interactions	Van Bressem *et al*., 2006b
Delphinus capensis	Peru	Genital warts		Van Bressem et al., 1996
Delphinus capensis	Peru	Genital diseases		Van Bressem *et al*., 2006b
Delphinus capensis	Peru	Cetacean morbillivirus infection		Van Bressem *et al*., 1998
Delphinus capensis	Peru	*Brucella* sp. infection		Van Bressem *et al*., 2001a
Delphinus capensis	Peru	Skull lesions and malformations		Van Bressem *et al*., 2006b
Delphinus capensis	Peru	Human-inflicted skull traumas	fishery interactions	Van Bressem *et al*., 2006b
Delphinus capensis	Peru	Lesions of the head, trunk and appendages	fishery interactions	Van Bressem *et al*., 2006b
Delphinus capensis	Peru	Dental and periodontal diseases		Van Bressem *et al*., 2006b
Delphinus delphis	Chile	Bacterial pneumonia		Sanino *et al*., 2003
Delphinus delphis	Ecuador	Tattoo skin disease		This paper
Delphinus delphis	Ecuador	Ankylosing spondylitis		This paper
Feresa attenuata	Peru	Skull lesions		Montes-Iturrizaga, 2003
Globicephala melas	Peru	Dental and periodontal diseases		Montes *et al*., 2004
Globicephala macrorhynchus	Peru	Dental and periodontal diseases		Montes *et al*., 2004
Globicephala macrorhynchus	Peru	Skull lesions		Montes *et al*., 2004
Grampus griseus	Peru	Dental and periodontal diseases		Montes *et al*., 2004
Lagenodelphis hosei	Brazil	Cetacean morbillivirus infection		Van Bressem *et al*., 2001b
Lagenorhynchus obscurus	Peru	Tattoo skin disease- poxvirus infection		Van Bressem and Van Waerebeek, 1996; Van Bressem *et al*., 2006a
Lagenorhynchus obscurus	Peru	Herpesvirus skin infection		Van Bressem *et al*., 1994
Lagenorhynchus obscurus	Peru	Genital papillomas- papillomavirus infection		Van Bressem *et al*., 1996; Cassonnet *et al.*, 1998
Lagenorhynchus obscurus	Peru	Genital diseases		Van Bressem *et al*., 2000
Lagenorhynchus obscurus	Peru	Cetacean morbillivirus infection		Van Bressem *et al.*, 1998
Lagenorhynchus obscurus	Peru	*Brucella* sp. infection		Van Bressem *et al*., 2001a
Lagenorhynchus obscurus	Peru	Skull lesions and malformations		Montes *et al*., 2004; this paper
Lagenorhynchus obscurus	Peru	Dental and periodontal diseases		Montes *et al*., 2004; this paper
Lagenorhynchus obscurus	Peru	Human-inflicted skull traumas	fishery interactions	Montes *et al*., 2004; this paper
Lagenorhynchus australis	Chile	Wounds from propeller on left flank, close to tailstock	vessel strike	Viddi, unpublished data; this paper
Mesoplodon peruvianus	Peru	Skull lesions		Montes-Iturrizaga, 2003
Orcinus orca	Brazil, RJ	Osteochondromatosis		Siciliano *et al*., 2007
Phocoena spinipinnis	Peru	Cetacean morbillivirus infection		Van Bressem *et al*., 1998
Phocoena spinipinnis	Peru	Dental and periodontal diseases		Montes *et al.,* 2004; this paper
Phocoena spinipinnis	Peru	Tattoo skin disease-poxvirus infection		Van Bressem and Van Waerebeek, 1996; Van Bressem *et al*., 2006a
Phocoena spinipinnis	Peru	Genital warts- papillomavirus infection		Van Bressem *et al*., 1996; Van Bressem *et al*., 2007
Phocoena spinipinnis	Peru	*Brucella* sp. infection		Van Bressem *et al*., 2001a
Phocoena spinipinnis	Peru	Skull lesions		Montes *et al.*, 2004; this paper
Pseudorca crassidens	Uruguay	Fractures	boat collision	This paper
Pseudorca crassidens	Uruguay	Hyperostosis and osteomyelitis		Castiñeira Latorre and Möller, unpublished data; this paper
Pseudorca crassidens	Ecuador	Whitish skin lesion(s)		Félix and Haase, personal observations; this paper
Sotalia guianensis	Brazil, RJ	Human-inflicted skin and skull traumas	fishery interactions	Ramos *et al*., 2001
Sotalia guianensis	Brazil, RJ	Vertebral destructive lesions, possibly due to tuberculosis		Siciliano *et al*., 2005
Sotalia guianensis	Brazil, RJ	Miscelleanous bone lesions		Laeta *et al*., 2006; this paper
Sotalia guianensis	Brazil, RJ	Miscellaneous lesions of the vertebral column		Mendonça de Souza *et al*., 2006; this paper
Sotalia guianensis	Brazil, RJ	Whitish velvety skin lesions		Flach, 2006; this paper
Sotalia guianensis	Brazil, Sepetiba Bay	Scars and skin lesions	fishery interactions	Flach, 2006; this paper

Sotalia guianensis	Brazil, Sepetiba Bay	Nodule on the right side behind dorsal fin		Flach, 2006; this paper
Sotalia guianensis	Brazil, Sepetiba Bay	Tattoo skin disease (poxvirus)		This paper
Sotalia guianensis	Brazil, Baía Norte	Scars and skin lesions	fishery interactions	Flores, unpublished data
Sotalia guianensis	Venezuela	Periodontitis, osteomyelitis		This paper
Stenella coeruleoalba	Ecuador	Lesions of the alveoli		F.Félix, personal observations; this paper
Stenella frontalis	Venezuela	Beak deformation		This paper
Stenella frontalis	Venezuela	Extensive skin lesion on left flipper		This paper
Stenella frontalis	Venezuela	Amputation of dorsal fin	vessel strike	This paper
Tursiops truncatus (coastal)	Colombia, Bahía Málaga	Lobomycosis-like disease	biological and chemical pollution	This paper
Tursiops truncatus (coastal)	Ecuador, Guayaquil Gulf	Lobomycosis-like disease	pollution, aquaculture	This paper
Tursiops truncatus (coastal)	Ecuador	Ankylosing spondylitis		Amador and Aguirre, unpublished data
Tursiops truncatus (coastal)	Ecuador	Skin discolouration	aquaculture	F. Félix, personal observations; this paper
Tursiops truncatus (coastal)	Peru	Tattoo skin disease (poxvirus)		Van Bressem and Van Waerebeek, 1996; Van Bressem *et al*. 2006a; this paper
Tursiops truncatus (coastal)	Peru	*Brucella* sp. infection		Van Bressem *et al*., 2001a
Tursiops truncatus (coastal)	Peru	Skull lesions and malformations		Montes, 2003; Montes *et al*., 2004; this paper
Tursiops truncatus (coastal)	Peru	Ankylosing spondylitis		Montes *et al*., 2004
Tursiops truncatus (coastal)	Peru	Dental and periodontal diseases		This paper
Tursiops truncatus (coastal)	Peru, Paracas	Whitish velvety skin lesions	fish processing plants	Reyes and Echegaray, unpublished data; this paper
Tursiops truncatus (coastal)	Peru, Callao	Lobomycosis-like disease	biological and chemical pollution	This paper
Tursiops truncatus (coastal)	Chile, Palena	Skin disease	aquaculture	Viddi *et al*., 2005
Tursiops truncatus (coastal)	Brazil, Santa Catarina	Lobomycosis-like disease	biological and chemical pollution	This paper
Tursiops truncatus (offshore)	Peru	Tattoo skin disease- poxvirus infection		Van Bressem and Van Waerebeek, 1996; Van Bressem *et al*., 2006a
Tursiops truncatus (offshore)	Peru	Genital papillomas		Van Bressem *et al*., 1996
Tursiops truncatus (offshore)	Peru	Ovarian cysts		Van Bressem *et al*., in prep.
Tursiops truncatus (offshore)	Peru	Cetacean morbillivirus infection		Van Bressem *et al*., 1998
Tursiops truncatus (offshore)	Peru	*Brucella* sp. Infection		Van Bressem *et al*., 2001a
Tursiops truncatus (offshore)	Peru	Skull lesions		This paper
Tursiops truncatus (offshore)	Peru	Spondylitis ankylosing		Montes *et al*., 2004; this paper
Tursiops truncatus (offshore)	Peru	Dental and periodontal diseases		Montes *et al*., 2004; this paper
Tursiops truncatus (offshore)	Peru	Lesions of the head, trunk and appendages		This paper
Tursiops truncatus (offshore)	Peru	Skin discoloration		Van Bressem *et al*., in prep.
Tursiops truncatus (unknown stock)	Argentina, Patagonia	Uterine adenocarcinoma		Sánchez *et al*., 2002
Tursiops truncatus (unknown stock)	Argentina, Patagonia	Tattoo-like skin lesions		Sánchez *et al*., 2002
Tursiops truncatus (unknown stock)	Brazil, Florianopolis	Lobomycosis-like disease		Flores *et al*., 2005; this paper
Tursiops truncatus (unknown stock)	Brazil	Cutaneous abcsesses on the back		Flores *et al*., 2005
Tursiops truncatus (unknown stock)	Brazil, RJ	Lesions of scapula		Siciliano *et al*., 2005
Tursiops truncatus (unknown stock)	Peru	Genital papillomas- papillomavirus infection		Van Bressem *et al*., 1996; Cassonnet *et al.*, 1998
Ziphius cavirostris	Uruguay	Fractures	Boat collision	Castiñeira Latorre and Möller, unpublished data; this paper

Table 1. Overview of known infectious and non-infectious diseases of odontocetes from South American waters.

Species	Habitat	Sampling area	Sampling period	Specimens	Total Nber examined	Nber observed alive or fresly dead	Nber observed skeletal material	Total Nber with lesions	Diseases, traumas, lesions and malformations affecting:		
									bones	skin	body parts
Cephalorhynchus commersonii	neritic	Puerto Deseado, AR	2001-2007	Free-ranging	unknown	3	0	3	0	3	0
Cephalorhynchus eutropia	inshore/estuarine	N Patagonia, CL	2003-2004	Free-ranging	13	13	0	4	0	4	0
Delphinus capensis	offshore/neritic	entire coastline, PE	1985-2000	By-caught	930	859	103 skulls & calvariae	120	38	98	11
Delphinus delphis	unknown	N Gulf of Guayaquil and central coast, EC	1992 & 1998	Stranded	28	27	1 skeleton	2	1	1	0
Lagenorhynchus australis	inshore/estuarine	N Patagonia, CL	2003-2004	Free-ranging	45	45	0	1	0	1	0
Lagenorhynchus obscurus	offshore/neritic	entire coastline, PE	1984-2001	By-caught and stranded	4281	4251	46 skulls & calvariae	172	13	143	18
Phocoena spinipinnis	inshore/neritic	entire coastline, PE	1985-1999	By-caught porpoises	902	872	37 skulls & calvariae	97	3	87	17
Pseudorca crassidens	offshore/pelagic	Santa Elena, EC	1992	Stranded	28	28	0	1	0	1	0
Pseudorca crassidens	offshore/pelagic	Laguna Garzon, UY	1998-2000	Stranded	1	0	1	1	1	0	0
Sotalia guianensis	inshore/neritic	N Rio de Janeiro, BR	1987-1998	By-caught and stranded	53	0	53 whole skeletons	34	34	0	0
Sotalia guianensis	inshore/neritic	N Rio de Janeiro, BR	2001-2006	By-caught and stranded	31	0	31 axial skeletons	15	15	0	0
Sotalia guianensis	inshore/neritic	Sepetiba Bay, BR	2005-2006	Free-ranging	168	168	0	20	0	14	8
Sotalia guianensis	inshore/neritic	Estado Zulia, VE	1995	By-caught	unknown	0	1 skull	1	1	0	0
Stenella frontalis	inshore/neritic	Aragua, VE	1996-2000 & 2005	Free-ranging	100-400	100-400	0	3	0	1	2
Tursiops truncatus	inshore	Bahía Málaga and surroundings, CO	2005-2006	Free-ranging	5-10	5-10	0	2-4	0	2-4	0
Tursiops truncatus	inshore/estuarine	Gulf of Guayaquil, EC	1990-1991	Free-ranging	441	441	0	8	0	8	0
Tursiops truncatus	inshore	central coast, PE	2006	Free-ranging	unknown	1	0	1	0	1	0
Tursiops truncatus	inshore	entire coastline, PE	1984-2000	By-caught and stranded	37	19	26 skulls & calvariae	14	10	1	3
Tursiops truncatus	inshore	Paracas Bay, PE	1997 & 2004-2006	Free-ranging	70	70	0	8	0	6	3
Tursiops truncatus	inshore/neritic	N Patagonia, CL	2003-2004	Free-ranging	2	2	0	1	0	1	0
Tursiops truncatus	inshore	Santa Catarina, BR	1993-2004	Free-ranging dolphins	39	39	0	2	0	2	0
Tursiops truncatus	inshore/estuarine	Tramandaí Estuary, Rio do Sul, BR	2004-2005	Free-ranging dolphins	10[a]	10	0	2	0	2	0
Tursiops truncatus	offshore & inshore	N Rio de Janeiro, BR	2001-2007	By-caught and stranded	9	1	8 skeletons	5	5	1	0
Tursiops truncatus	offshore/pelagic	entire coastline, PE	1984-2000	By-caught and stranded	85	68	42 skulls & calvariae	40	29	12	10
Tursiops truncatus	unknown	northern Gulf of Guayaquil, EC	1999	Bone remains	4	0	4 axial skeletons	1	1	0	0
Ziphius cavirostris	offshore/pelagic	Laguna Garzon, UY	1998-2000	Stranded	1	0	1	1	1	0	0

Table 2. Composition of subsamples of small cetaceans examined in this study, including zoogeographic characteristics, sampling periods and the prevalence of diseases, malformations and traumas. Nber= number; N= Northern; [a] Ott, 2004.

Country & species	Habitat	Region	Sampling period	Specimens	Skin diseases					
					Tattoos		Velvety lesions		Lobomycosis-like	
					Nt	Prev	Nt	Prev	Nt	Prev
Colombia										
Tursiops truncatus	inshore	Bahía Málaga and surroundings	2005-2006	Free-ranging	-	-	-	-	5-10	10-33.3%
Ecuador										
Delphinus delphis	offshore/pelagic	central coast	1992	By-caught	11	9.1%	-	-	-	-
Tursiops truncatus	inshore/estuarine	Golf of Guayaquil	1990-1991	Free-ranging	-	-	-	-	441	1.6%
Pseudorca crassidens	offshore/pelagic	Santa Elena Peninsula	1992	Free-ranging	-	-	28	3.6%	-	-
Chile										
Cephalorhynchus eutropia	inshore/neritic	northern Patagonia	2003	Free-ranging	13	7.7-15.4%	-	-	-	-
Peru										
Lagenorhynchus obscurus	offshore/neritic	central coast	1993-1994	By-caught	196	34.7%	196	0%	196	0%
Tursiops truncatus	inshore/neritic	southern coast	2004-2006	Free-ranging	70	1.4%	70	7.1%	70	0%
Tursiops truncatus	offshore/pelagic	central coast	1993-1994	By-caught	12	41.6%	12	0%	12	0%
Phocoena spinipinnis	inshore/neritic	central coast	1993-1994	By-caught	77	62.3%	77	0%	77	0%
Delphinus capensis	offshore/neritic	central coast	1993-1994	By-caught	54	61.1%	54	0%	54	0%
Brazil										
Sotalia guianensis	inshore/neritic	Sepetiba Bay	2005-2006	Free-ranging	168	1.2%	168	1.2%	168	0%
Tursiops truncatus	inshore/neritic	Santa Catarina	1993-2004	Free-ranging	-	-	-	-	39	5.1%
Tursiops truncatus	inshore/estuarine	Tramandaí Estuary	2004-2005	Free-ranging	-	-	-	-	10	10%

Table 3. Prevalence (Prev) of skin diseases in odontocetes from South America. Nt = total number of specimens examined.

Country & Species	Region	Sampling period	Cutaneous wounds, scars and abcesses				Traumas of the body			
			Nt	Npos	Prev	HR	Nt	Npos	Prev	HR
Peru										
Delphinus capensis	Central coast	1990-1994	**54**	15	27.8%	20.4%	**545**	3	0.6%	66.7%
Lagenorhynchus obscurus	Central coast	1993-1994	**240**	13	5.4%	30.8%	**240**	4	1.7%	25%
Phocoena spinipinnis	Central coast	1991-1994	**106**	22	20.8%	45.5%	**106**	2	1.9%	50%
Tursiops truncatus, inshore	Central coast	1985-1989	-	-	-	-	**16**	3	18.8%	66.7%
Tursiops truncatus, inshore	Paracas Bay	2004-2006	**70**	1	1.4%	0%	**70**	3	4.3%	66.7%
Tursiops truncatus, offshore	Central coast	1985-1990	**52**	2	3.8%	0%	**52**	4	7.7%	28.6%
Tursiops truncatus, offshore	Central coast	1993-1994	**13**	2	15.4%	50%	**13**	1	7.7%	100%
Chile										
Lagenorhynchus australis	Northern Patagonia	2003	**45**	1	2.2%	100%	**-**	-	-	-
Brazil										
Sotalia guianensis	Sepetiba Bay	2005-2007	**168**	6	3.6%	100%	**168**	12	7.1%	75%
Venezuela										
Stenella frontalis	Venezuela	2005	**200**	1	0.5%	-	**200**	3	1.5%	100%
Stenella frontalis	Venezuela	1996-2000	**-**	-	-	-	**100-400**	1	0.25-1%	unknown

Table 4. Prevalence (Prev) of traumatas, scars and lesions in small cetaceans from South America and prevalence of possible human-related (HR) injuries. Nt= total number of specimens examined, Npos= number of positive.

Species & Specimens	Habitat	Date (d/mo/yr)	Locality	Sex	SL (cm)	SM	Lesions
Delphinus capensis							
AGG-405	Offshore/neritic	05/09/91	Central Peru	F	167,5	Imm	Nodule on tailstock: chronic fibrotic reaction due to infection or trauma
KVW-994	Offshore/neritic	13/12/86	Central Peru	M	229	Imm	Two holes with irregular edges in occipital bone close to left condyle
MFB-86	Offshore/neritic	26/3/93	Central Peru	M	200,7	Imm	Big scar on joint left flipper
MFB-189	Offshore/neritic	13/5/93	Central Peru	M	232	Mat	Scars on beak
MFB-218	Offshore/neritic	15/5/93	Central Peru	M	209	Imm	Scar on right mandibula below eye
MFB-219	Offshore/neritic	15/5/93	Central Peru	M	192	Imm	Scar on left side of head and on flipper
MFB-225	Offshore/neritic	27/5/93	Central Peru	F	>171	Imm	One scar on right side of melon (28x20mm)
MFB-228	Offshore/neritic	6/6/93	Central Peru	M	184,5	Imm	One scar (41x25mm) on right side of beak, below the eye
MFB-232	Offshore/neritic	6/6/93	Central Peru	M	188,5	Imm	One scar on right side of head (85x30mm).
MFB-258	Offshore/neritic	8/8/93	Central Peru	M	197,3	Imm	One scar on head
MFB-264	Offshore/neritic	8/8/93	Central Peru	M	197	Imm	One scar on right side of tail stock
MFB-281	Offshore/neritic	12/8/93	Central Peru	M	204	Imm	One scar on the joint of right flipper
MFB-297	Offshore/neritic	21/8/93	Central Peru	F	192	Imm	Large scar on tailstock
MFB-312	Offshore/neritic	27/10/93	Central Peru	M	200	Imm	One scar below right eye, another at the level of right flipper joint
Lagenorhynchus autralis							
FV-45	Inshore/estuarine	26/1/03	Northern Patagonia, CL	Unk	Unk	Mat	Wounds on left flank, close to tailstock
Lagenorhynchus obscurus							
MFB-107	Offshore/neritic	30/3/93	Central Peru	M	192,8	Mat	Scar at the corners of beak
MFB-252	Offshore/neritic	16/7/93	Central Peru	M	137	Calf	Tip of dorsal fin deformed
MFB-403	Offshore/neritic	17/11/93	Central Peru	F	194	Mat	Scar on left flipper
MFB-463	Offshore/neritic	8/12/93	Central Peru	F	191,5	Mat	Scars on internal and external side of left flipper.
MFB-535	Offshore/neritic	5/6/94	Central Peru	M	116,5	Calf	Healing linear wounds on right flank, below and in front of dorsal fin
MFB-806	Offshore/neritic	2/6/94	Central Peru	Unk	Unk	Unk	Fractures and traumas of right maxillary, right pterygoid and left mandible caused by a bullet
Phocoena spinipinnis							
KOS-270	Inshore/neritic	4/12/93	Central Peru	F	155,5	Mat	Two scars on the mouth corner
KOS-352	Inshore/neritic	14/7/94	Central Peru	M	161	Unk	Scars on the dorsal fin and dorsal side of tailstock
MFB-223	Inshore/neritic	27/5/93	Central Peru	M	159,6	Imm	Four parallel linear scars on left side separated by about 56-60 mm, another small one at the level of the left flipper joint
MFB-256	Inshore/neritic	4/8/93	Central Peru	M	146	Imm	One old scar on the left side of maxillary
MFB-415	Inshore/neritic	27/11/93	Central Peru	F	137	Imm	One scar on flipper.
MFB-461	Inshore/neritic	8/12/93	Central Peru	M	173,5	Mat	Scar on dorsal fin
MFB-467	Inshore/neritic	15/1/94	Central Peru	F	169	Mat	Linear scars on body
MFB-471	Inshore/neritic	16/1/94	Central Peru	M	176,2	Mat	Scar at insertion of dorsal fin
MFB-475	Inshore/neritic	19/1/94	Central Peru	M	176	Mat	One big healing wound at the insertion of left flipper, a second at the mouth gape and a third at the insertion of dorsal fin
MFB-534	Inshore/neritic	27/5/94	Central Peru	M	172,5	Mat	Deformed dorsal fin
MFB-666	Inshore/neritic	28/6/94	Central Peru	F	158	Unk	Long scars between flippers and and on left flank
Sotalia guianensis							
BB-154	Inshore/estuarine	23/7/95	Rio de Janeiro, BR	M	179	Mat	Lacerated skin lesions on rostrum as well as traumas affecting the maxillaris, pre-maxillaries and mandibles
MZUSP-25611	Inshore/estuarine	29/8/87	Rio de Janeiro, BR	F	195	Mat	Traumas affecting the maxillaries and mandibles, caused by nylon twines
SEP-003	Inshore/estuarine	7/6/05	Sepetiba Bay, BR	Unk	Unk	Mat	Deformed dorsal fin
SEP-004	Inshore/estuarine	18/9/05	Sepetiba Bay, BR	Unk	Unk	Mat	Deformed dorsal fin
SEP-005	Inshore/estuarine	8/9/05	Sepetiba Bay, BR	Unk	Unk	Mat	Deformed dorsal fin
SEP-1	Inshore/estuarine	7/11/06	Sepetiba Bay, BR	F	Unk	Imm	Lacerated skin lesions and traumas on the beak-nylon twines associated with these lesions
SEP-4	Inshore/estuarine	13/12/05	Sepetiba Bay, BR	Unk	Unk	Mat	Deep wound at the anterior basis of dorsal fin
SEP-5	Inshore/estuarine	30/4/06	Sepetiba Bay, BR	Unk	Unk	Mat	Healed wound with nylon twines in front of dorsal fin, cut on tailstock
SEP-6	Inshore/estuarine	30/4/06	Sepetiba Bay, BR	Unk	Unk	Mat	Large healed wound at the leading hedge of dorsal fin
SEP-8	Inshore/estuarine	6/6/06	Sepetiba Bay, BR	Unk	Unk	Mat	Deep net mark on back
SEP-9	Inshore/estuarine	1/6/06	Sepetiba Bay, BR	Unk	Unk	Mat	Scar on lower jaw
SEP-10	Inshore/estuarine	6/6/06	Sepetiba Bay, BR	Unk	Unk	Mat	Deep net marks on back behind head
SEP-11	Inshore/estuarine	1/6/06	Sepetiba Bay, BR	Unk	Unk	Mat	Remain of nylon twines at the anterior basis of dorsal fin
SEP-12	Inshore/estuarine	1/6/06	Sepetiba Bay, BR	Unk	Unk	Mat	Deformed dorsal fin
SEP -13	Inshore/estuarine	9/2/07	Sepetiba Bay, BR	Unk	Unk	Mat	Fishing gear attached in a wound on back, before dorsal fin
SEP-32	Inshore/estuarine	8/11/05	Sepetiba Bay, BR	Unk	Unk	Mat	Profound healed wound with nylon twines in front of dorsal fin
SEP-33	Inshore/estuarine	1/7/05	Sepetiba Bay, BR	Unk	Unk	Mat	Deep healed wound on the anterior basis of dorsal fin
EBRG-21069	Inshore/estuarine	19/9/95	Estado Zulia, VE	Unk	Unk	unk	Cavity of about 110mm^2 on the right mandible behind the last teeth
Stenella frontalis							
JBJ-SF-05-03	Inshore/neritic	15/9/05	Aragua, VE	Unk	Unk	Unk	Large wound on left flipper
JBJ-SF-05-04	Inshore/neritic	15/9/05	Aragua, VE	Unk	Unk	Unk	Partial amputation of dorsal fin and large scar on left side of the back
JBJ-SF-05-05	Inshore/neritic	15/9/05	Aragua, VE	Unk	Unk	Unk	Complete amputation of dorsal fin
Tursiops truncatus							
AJR-46	Inshore/neritic	29/3/86	Central Peru	M	277.5	Mat	Left flipper missing entirely: humerus had been severed earlier in life and healed
KVW-1061	Inshore/neritic	18/3/88	Central Peru	M	269.5	Imm	Tip of right flipper cut-off
PBD-29	Inshore/neritic	26/4/04	Paracas Bay, PE	Unk	Unk	Unk	Flukes partially amputated
PBD-007	Inshore/neritic	1997	Paracas Bay	Unk	Unk	Unk	A deep cut on the anterior border of the dorsal fin, near its anterior insertion.
JCR-673	Offshore/pelagic	31/1/86	Central Peru	M	288	Mat	Distal end of left flipper missing
JCR-1649	Offshore/pelagic	26/5/90	Central Peru	M	297	Mat	Broken mandible and presence of a large hole on the proximal part of mandible
KVW-352	Offshore/pelagic	26/4/86	Central Peru	M	272	Imm	Tip of left flipper missing
MFB-702	Offshore/pelagic	10/7/94	Central Peru	F	272	Mat	Scars all over body, right flipper partially amputated and healed
GEMM-81	Inshore/pelagic	26/6/05	Rio de Janeiro, BR	M	290	Mat	Fracture of ribs and deep cut in T4 & T5
Ziphius cavirostris							
ECL-1	Offshore/pelagic	19/1/07	Laguna Garzon, UY	F	600	Mat	Fractures of the mandible, vertebrae and ribs

Table 5. Traumas, scars and fractures possibly caused by interactions with fisheries and boats in small cetaceans from South American waters. SL= standard body length, SM= sexual maturity, Imm= immature, Mat= mature, Unk= unknown.

Country & Species	Habitat	Sampling period	Specimens	Bone remains	All lesions[a]	Lytic lesions	Degenerative diseases [b]	Traumas & fractures	Congenital malformations
Peru									
Lagenorhynchus obscurus	offshore/neritic	1984-2001	By-caught & stranded	46 skulls & calvariae	28.3%	15.2%	2.2%	4.3%	8.7%
Tursiops truncatus	inshore/neritic	1984-2000	By-caught & stranded	26 skulls & calvariae	38.5%	26.9%	15.4%	7.7%	3.8%
Tursiops truncatus	offshore/pelagic	1984-2000	By-caught & stranded	42 skulls & calvariae	69.1%	40.5%	31%	7.1%	0%
Phocoena spinipinnis	inshore/neritic	1985-1999	By-caught	37 skulls & calvariae	5.4%	5.4%	0%	0%	0%
Delphinus capensis	offshore/neritic	1985-2000	By-caught	103 skulls & calvariae	36.8%	32%	3.9%	1.9%	2.9%
Brazil									
Sotalia guianensis	inshore/neritic	1987-1998	By-caught & stranded	53 skulls	30.2%	18.9%	1.9%	5.7%	7.6%
Sotalia guianensis	inshore/neritic	1987-1998	By-caught & stranded	53 axial skeletons	51%	7.6%	0%[c]	47.2%	9.4%
Sotalia guianensis	inshore/neritic	2001-2006	By-caught & stranded	31 axial skeletons	48.4%	3.2%	0%	3.2%	48.4%
Tursiops truncatus	inshore & offshore	2001-2005	By-caught & stranded	8 skulls	37.5%	25%	12.5%	0%	0%
Tursiops truncatus	inshore & offshore	2001-2005	By-caught & stranded	8 axial skeletons	25%	12.5%	0%	12.5%	12.5%

Table 6. Prevalence of bone injuries in dolphins and porpoises from Peru and Brazil. [a] some specimens had several kind of lesions; [b] including only hyperostosis and AS, [c] cases of other degenerative diseases were reported in Fragoso (2001).

Country & Species	Habitat	Sampling period	Bone remains	Nt	*Crassicauda*	Lytic lesions osteomyelitis	osteolysis	PLD
Peru								
Delphinus capensis	offshore/neritic	1985-2000	Skulls	103	26.5% [b]	1.9%	4.9%	1%
Lagenorhynchus obscurus	offshore/neritic	1984-2001	Skulls	46	4.4%	0%	2.1%	8.7%
Phocoena spinipinnis	inshore/neritic	1985-1999	Skulls	37	0%	2.7%	5.4%	2.7%
Tursiops truncatus	inshore/neritic	1984-2000	Skulls	26	7.7%	7.7%	7.7%	15.4%
Tursiops truncatus	offshore/pelagic	1984-2000	Skulls	42	26.1%	4.8%	14.3%	16.7%[a]
Brazil								
Sotalia guianensis	inshore/neritic	1987-1998	Skulls	53	1.9%[c]	1.9%	0%	15.1%
Sotalia guianensis	inshore/neritic	1987-1998	Axial skeleton	53	-	7.6%	0%	-
Sotalia guianensis	inshore/neritic	2001-2006	Axial skeletons	31	-	3.2%	0%	-
Tursiops truncatus	inshore & offshore	2001-2005	Skulls	8	25%	0%	0%	unknown
Tursiops truncatus	inshore & offshore	2001-2005	Skeletons	8	-	12.5%	12.5%	-

Table 7. Prevalence of lytic injuries in small odontocetes from Peru and Brazil. Nt = total number of specimens, PLD= periodontal lytic disease; [a] this percentage may be an underestimate; [b] Nt = 98; [c] possible *Crassicauda* spp. infestation in one *Sotalia guianensis.*

		Crassicauda spp. lesions			Hyperostosis			Ankylosing spondylitis		
		Nt	**Npos**	**Prev**	**Nt**	**Npos**	**Prev**	**Nt**	**Npos**	**Prev**
Males	Immature	4	1	25%	4	1	25%	4	1	25%
	Mature	12	4	33.3%	12	8	66.7%	12	2	16.7%
Females	Immature	6	2	33.3%	6	1	16.7%	6	0	0%
	Mature	4	0	0%	4	1	25%	4	1	25%

Table 8. Prevalence (Prev) of *Crassicauda* spp., hyperostosis and ankylosing spondylitis in four sub-samples of offshore bottlenose dolphins from Peru. Nt = total number of specimens, Npos = number of positive.