POST-MORTEM INVESTIGATIONS ON STRANDED DOLPHINS AND PORPOISES FROM HONG KONG WATERS

Authors: Parsons, E. C. M., and Jefferson, T. A.

Source: Journal of Wildlife Diseases, 36(2) : 342-356

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-36.2.342

Journal of Wildlife Diseases, 36(2), 2000, pp. 342–356

POST-MORTEM INVESTIGATIONS ON STRANDED DOLPHINS AND PORPOISES FROM HONG KONG WATERS

E. C. M. Parsons[1,2] **and T. A. Jefferson**[3,4,5]

[1] SEAQUEST, 7 Highfield, Dulcote, Wells, Somerset BA5 3NX, England
[2] Current address: The Hebridean Whale and Dolphin Trust, 28 Main Street, Tobermory, Isle of Mull, Argyll PA75 6NU, Scotland, UK (e-mail: hwdt@sol.co.uk)
[3] Ocean Park Conservation Foundation, Ocean Park, Aberdeen, Hong Kong, People's Republic of China
[4] Current address: Southwest Fisheries Science Center, NOAA, NMFS, P.O. Box 271, La Jolla, California 92038, USA
[5] Corresponding author (e-mail: sclymene@aol.com.)

ABSTRACT: Stranded cetaceans reported from the territorial waters of Hong Kong during the period May 1993 to March 1998 were examined to establish factors that may have contributed to their death. During the current study, 28 Indo-Pacific hump-backed dolphins (*Sousa chinensis*), 32 finless porpoises (*Neophocaena phocaenoides*), and four bottlenose dolphins (*Tursiops truncatus*) were necropsied. Bacteria (15 species) were isolated from nine animals. Of these bacteria, 47% were of possible fecal origin reflecting the high level of sewage contamination in Hong Kong's waters. One finless porpoise displayed wounds caused by a shark attack, and two female finless porpoises presented prolapsed uteri. At least 10 finless porpoises showed evidence of moderate to heavy lungworm infections (*Halocercus pingi*), and this appears to have been a factor contributing to death in at least six animals. Evidence suggesting blunt traumatic injury (probably caused by boat collisions) was found in six cetaceans (three finless porpoises and three hump-backed dolphins). Signs of fishery-related mortality were detected in at least nine animals (six hump-backed dolphins, two finless porpoises, and one bottlenose dolphin). Of these two human-caused mortality types, pre-existing disease or bacterial infection were detected in 29% of cases. Results indicate that human factors may have played a significant role in the death of at least 15 animals (32% of hump-backed dolphins, 15% of finless porpoises, and 25% of bottlenose dolphins).

Key words: Bottlenose dolphin, finless porpoise, Indo-Pacific hump-backed dolphin, mortality, necropsy, *Neophocaena phocaenoides,* pathology, *Sousa chinensis, Tursiops truncatus.*

INTRODUCTION

The Hong Kong Special Administrative Region of the People's Republic of China is situated adjacent to the Pearl River Estuary, on the south coast of the Chinese province of Guangdong (centered at 22°20′N, 114°10′E). To date, 16 species of cetaceans have been reported from Hong Kong's territorial waters (Parsons et al., 1995; Parsons, 1997a). Of these species, two are resident in Hong Kong: the Indo-Pacific hump-backed dolphin (*Sousa chinensis*) and the finless porpoise (*Neophocaena phocaenoides*). The remainder of the species recorded from Hong Kong are probably from offshore South China Sea populations.

The first published record of a cetacean stranding in Hong Kong (in 1955) was made by Romer (1958) and this paper remained the only account of Hong Kong's cetacean fauna until 1973, when an official scheme to report cetacean sightings and strandings was initiated by the Agriculture and Fisheries Department (AFD) of the Hong Kong Government (Canton Road, Jordan, Hong Kong). The stranding network in operation within Hong Kong has enabled researchers to study the occurrence of cetacean species in the area (Parsons et al., 1995), details of feeding habits (Parsons, 1997a; Jefferson, 2000), levels of pollutant contamination (Parsons, 1998a; Parsons and Chan, 1998; Jefferson, 2000), life history (Jefferson, 2000), stock structure (Jefferson, 2000), stranding rates (Parsons, 1998b) and whether or not cetacean populations are threatened by disease or human activities (Parsons, 1997a; Jefferson, 2000). This paper summarizes and discusses the results of investigations conducted during the period May 1993 to March 1998.

MATERIALS AND METHODS

In 1993, a dedicated program was initiated through the AFD, to record and examine dead cetaceans found in Hong Kong. Stranding protocols were drafted and circulated to Government departments that were likely to come into contact with stranded cetaceans. Bilingual posters were produced and distributed to suitable locations. In 1996 and 1997, this program was strengthened and greater effort was made to solicit stranding reports from the public.

An attempt was made to investigate every stranding report received. Stranded animals were categorized, according to their level of decomposition, as live strandings (code 1), freshly-dead (code 2), moderately decomposed (code 3), very decomposed (code 4), and mummified or skeletal remains (code 5) (Geraci and Lounsbury, 1993). Most of the carcasses were too badly-decomposed for detailed pathological analysis (codes 4, 5 and some code 3—see Table 1). In addition, some logistical difficulties in retrieving carcasses were encountered, which sometimes precluded a thorough examination.

Necropsies of stranded cetaceans were undertaken largely according to the protocols and methodologies outlined by Geraci and Lounsbury (1993) and Jefferson et al. (1994). More detailed necropsies were performed in collaboration with veterinarians from Ocean Park (Aberdeen, Hong Kong) and the AFD (AFD Veterinary Laboratory, Tuen Mun, Hong Kong). Samples collected for histopathological analysis were preserved in 10% formalin or, when not available, in 90% ethyl alcohol solutions. Bacteriological samples were taken using standard techniques (Geraci and Lounsbury, 1993) and cultured upon blood agar, TCBS and MacConkey plates at the Ocean Park Veterinary Department. Histopathology samples were examined at the AFD Veterinary Laboratory. Culturing of bacteria was carried out during nine necropsies, including those of three hump-backed dolphins, four finless porpoises, and two bottlenose dolphins (*Tursiops truncatus*). Parasites were examined under an electron microscope and were identified by R. Overstreet (Gulf Coast Research Laboratory, Ocean Springs, Mississippi, USA). Representatives of collected parasites were archived at the Ocean Park Veterinary Department. Cetacean ages were estimated by decalcifying, sectioning, and staining teeth from the middle of the lower jaw, following the procedures outlined in Myrick et al. (1983) and Hohn and Lockyer (1995).

RESULTS

Gross pathology

Sixty-four animals were examined and the findings from these necropsies are summarized in Table 1. Detailed findings from these examinations are discussed below.

Shark attack

One finless porpoise examined in Hong Kong (stranded 12/04/97) presented gross pathology which was consistent with a shark attack. There was a semi-circular laceration on the dorsal surface of the animal. The flukes, the caudal vertebrae and all of the internal organs below the pyloric stomach, posterior to the semi-circular laceration, were missing. An approximately 30 cm section of the thoracic vertebrae was isolated by fracturing at either end. Subdermal bruising and blubber liquefaction was apparent around the edges of the dorsal wound, the edges of which were scalloped. In addition, there were several superficial dermal wounds with narrow, parallel lacerations.

Uterine pathology

Two finless porpoises stranded in early 1997 presented pathological findings suggestive of uterine prolapses (stranding dates 23/01/97 and 26/01/97). The dermis and organs of the former were very pale and some hemorrhagic fluid was present in the abdominal cavity. The uteri of both animals were enlarged, engorged with blood vessels and were protruding through the genital slit. Another female porpoise (stranded 8/03/96) was discovered with a swollen, partly extruded and necrotic uterus (4–5 cm thick), which contained a large number of cysts (5–15 mm in diameter), within which were an arthropod parasite.

Boat strikes

Between 1993 and 1998, three hump-backed dolphin and three finless porpoise carcasses presented wounds consistent with blunt traumatic injury, probably caused by boat collisions. The first dolphin

TABLE 1. Summary of the biological parameters, the main pathological findings, and the possible causes of death of cetaceans examined from Hong Kong waters, 1993–98.

Date (D/M/Y)	Code[a]	Length (cm)	Age[b]	Primary gross pathology	*Halocercus pingi*[c]	Diagnosed cause of death
Sousa chinensis						
25/5/93	4	150	1	Square cut in abdomen.		Fishery by-catch
27/1/94	2	144	<1	Cranial bruising.	+	Verminous pneumonia
12/6/94	3	181	#	Fins removed. Sediment in oesophagus.		Fishery by-catch
11/2/95	3	247	11	No lesions apparent.		Undetermined
2/4/95	3	234	14	Multiple lacerations. Skull fractures.		Boat strike
4/5/95	2	210	4	Deep, narrow, laceration through eye.		By-catch (stab wound)
28/5/95	4	205	6	Lacerations probably from fishing net.		Probable fishery by-catch
15/6/95	4	101.5	<1	Too decomposed for detailed examination.		Undetermined
2/9/95	4	189	2.5	Too decomposed for detailed examination.		Undetermined
10/9/95	4	254	#	Too decomposed for detailed examination.		Undetermined
24/5/96	4	101	<1	Too decomposed for detailed examination.		Undetermined
26/5/96	3	107	<1	Too decomposed for detailed examination.		Undetermined
31/5/96	2	207	5	Rope marks. Regurgitated stomach contents. Fluid in lungs.		Fishery by-catch
1/6/96	4	c.165	4	Too decomposed for detailed examination.		Undetermined
6/4/96	5	c.85	<1	Too decomposed for detailed examination.		Undetermined
6/6/96	4	223	#	Too decomposed for detailed examination.		Undetermined
9/8/96	4	107	<1	Fractured ribs. Too decomposed for further examination.		Undetermined
29/8/96	3	102	<1	No lesions apparent.		Undetermined
31/8/96	4	105	<1	Too decomposed for detailed examination.		Undetermined
10/2/97	4	207	9	Fractured skull. Long, shallow superficial laceration. Tumors.		Possible boat strike
28/3/97	3	—	#	Decapitated. Extremely congested blood vessels.		Boat strike
2/5/97	3	105	<1	No lesions apparent.		Undetermined
31/5/97	3	117	<1	Too decomposed for detailed examination.		Undetermined
31/5/97	2	235	11	Rope cuts on rostrum and dorsal fin. Foamy fluid in lungs.		Fishery by-catch
5/7/97	4	>85	<1	Too decomposed for detailed examination.		Undetermined
3/9/97	4	265	33	Too decomposed for detailed examination.		Undetermined
10/9/97	3	110	<1	No lesions apparent.		Undetermined
16/1/98	4	238	22	Too decomposed for detailed examination.		Undetermined
28 specimens		85–265	<1–33			
Neophocaena phocaenoides						
5/6/93	4	133	5	Too decomposed for detailed examination.	+	Undetermined
22/12/93	2	71	<1[d]	No lesions apparent.		Undetermined

TABLE 1. Continued.

Date (D/M/Y)	Code[a]	Length (cm)	Age[b]	Primary gross pathology	*Halocercus pingi*[c]	Diagnosed cause of death
15/3/95	2	104.5	0.3	Heavy lungworm infection. Pneumonia.	++	Verminous pneumonia
2/11/95	4	83	<1[d]	Heavy lungworm infection.	++	Probable verminous pneumonia
28/11/95	4	155	6	Too decomposed for detailed examination.		Undetermined
15/12/95	2	76	<1[d]	Diffuse pneumonia. Thymic involution. Moderate plasmacytosis and mild histiocytosis in lymph node.	++	Verminous pneumonia
25/12/95	2	143	2	Chronic cholitis and moderate gut-associated lymphoid hyperplasia. Multifocal plasmacytosis and lymphoid exhaustion.	+	Undetermined
8/1/96	3	138	3	Too decomposed for detailed examination.		Undetermined
11/1/96	2	168	10	No lesions apparent.		Undetermined
13/1/96	3	150	13	Too decomposed for detailed examination.		Undetermined
14/1/97	2	86	<0.1	Lungworm infection.	++	Probable verminous pneumonia
15/1/96	2	87	<1	Extensive bruising and hemorrhage at dorsal portion of head. Puncture wound at umbilicus. Macerated liver.	++	Boat strike
23/1/96	2	67	<1[d]	Fractured spine. Macerated lung and liver.		Boat strike
8/3/96	3	137	5	Open lesion in genital area. Uterus swollen & heavily infected with cysts. Stalked barnacles on flukes.	+	Uterine infection
9/3/96	3	94	<1	Too decomposed for detailed examination.		Undetermined
12/3/96	3	128	2	Too decomposed for detailed examination.		Undetermined
17/3/96	5	≫99	5	Too decomposed for detailed examination.		Undetermined
25/4/96	2	84	<1	Lungworm infection. Pneumonia.	++	Probable verminous pneumonia
1/6/96	4	c.170	18	Too decomposed for detailed examination.		Undetermined
27/6/96	4	c.150	#	Too decomposed for detailed examination.		Undetermined
23/7/96	3	144	#	Wound behind right eye.		Undetermined
7/9/96	4	c.137	6	Too decomposed for detailed examination.		Undetermined
22/1/97	3	157	12	Prolapsed uterus.		Prolapsed uterus
26/1/97	3	150	#	Prolapsed uterus.		Prolapsed uterus
12/4/97	2	≫130	11	Flukes and lower body missing. Large semi-circular dorsal wound. Rows of small superficial lacerations.		Shark attack
15/8/97	3	157	#	Too decomposed for detailed examination.		Undetermined
9/9/97	4	—	#	Multiple lacerations. Tail severed.		Possible boat strike
9/11/97	5	—	1	Too decomposed for detailed examination.		Undetermined
11/10/97	2	137	4	Net marks. Anoxia-induced changes in lung tissue.		Fishery by-catch
4/1/98	3	75	<1	No lesions apparent.		Undetermined

TABLE 1. Continued.

Date (D/M/Y)	Code[a]	Length (cm)	Age[b]	Primary gross pathology	*Halocercus pingi*[c]	Diagnosed cause of death
7/1/98	2	67	<1[d]	Net cuts on fins. Foamy fluid in trachea.	+	Probably fishery by-catch
6/3/98	4	158	4	Too decomposed for detailed examination.		Undetermined
32 specimens		67–170	<1–18			
Tursiops truncatus						
25/11/94	3	293	30+	Too decomposed for detailed examination.		Undetermined
4/12/94	3	244	6	Some inflammation of lymph tissue.		Undetermined
13/7/95	3	233.5	4–5	Cysts in stomach wall. Regurgitated stomach contents. Net mark lacerations in dermis. Focal lymph node necrosis and neutrophillia.		Fishery by-catch
2/5/97	4	294	#	Too decomposed for detailed examination.		Undetermined
4 specimens		233.5–294	4–30+			

[a] Code refers to decomposition code (Geraci and Lounsbury, 1983).

[b] Age is measured in growth layer groups (GLG's). One GLG is considered to be equal to one year of growth (Perrin and Myrick, 1980). The notation # means that no age data were available.

[c] + = moderate lungworm infection; ++ = heavy lungworm infection.

[d] Fetal folds and/or umbilical remnants still visible.

FIGURE 1. Evidence of vessel strikes on Hong Kong small cetaceans. (Top) An Indo-Pacific hump-backed dolphin (stranded 2/04/95) discovered at Chek Lap Kok, with lacerations consistent with cuts from a ship's propeller (Middle) A dead finless porpoise (stranded 15/01/96) with bruising and other pathology suggesting impact from a vessel's bow or keel (Scale bar = 0.1 m). (Bottom) A live hump-backed dolphin (NL71) with evidence of propeller cuts on the back and dorsal fin.

(stranded 2/04/95) had suffered a severe blow mid-laterally, to the right side of the skull, resulting in multiple fractures of both the upper and lower jaws and the right side of the cranium. Several long, diagonal, slashes consistent with propeller wounds from a large vessel were located laterally on the right side of the body (Fig. 1). From the position of the wounds and the underlying hemorrhage it was considered that the boat collision had not happened post-mortem and was undoubtedly the cause of death.

A second hump-backed dolphin (stranded 10/02/97) presented a long, straight, dorsal wound, which was apparently caused by a long, narrow, blunt object, possibly the keel of a boat. There was a major skull fracture with cranial fragments found deep within the brain tissue. The fracture was undoubtedly fatal. Internal organs were pale with hemorrhagic fluid found in the body cavity. The lungs were pale and emphysemic and the mesenteric lymph nodes were swollen and hemorrhagic. A chain of large nodular tumors were excised from the intestinal mesenteries. These tumors contained a yellow, slightly fibrous material. In addition, fresh rake marks were discovered on the tail stock of the animal.

The third dolphin (stranded 28/03/97) had been completely decapitated. The wound was not ragged, however, as would be expected if the head had been removed with a knife or similar implement. In addition, there was some fracturing of the post-cranial skeleton and extremely congested blood vessels were clearly visible in the flukes. The prognosis was that the animal had probably been decapitated by a vessel, possibly by one of the jetfoils which ply the waters between Hong Kong and Macau, adjacent to where the carcass was discovered. These vessels routinely travel at speeds of well over 40 km/hr.

Another hump-backed dolphin (stranded 27/01/94) was found to have bruising overlying the skull above the occipital region. This was possibly attributable to a traumatic injury, although there was no other observable gross pathology.

The first of the finless porpoises (stranded 15/01/96) displayed extensive bruising and subcutaneous hemorrhages on the dorsal portion of the head and thorax, extending from the level of the blowhole to the axilla of the left flipper and laterally to the mid-scapula region (Fig. 1). In addition, there was a discolored strip of blubber (measuring approximately 80 mm $\times$ 10 mm) level with the umbilicus extending dorso-laterally, with a small puncture wound, approximately 15 mm in diameter, extending into the peritoneum near the umbilicus. The underlying left lobe of the liver was macerated and the peritoneum contained sanguineous fluid (ca. 25–30 ml). The animal probably suffered a lateral blow, possibly as the result of an impact

from a boat. In addition, this animal had a heavy infection of nematodes (*Halocercus pingi*) with multiple abscesses in the caudal two-thirds of the lungs, with associated areas of atelectasis and emphysema (with nematodes extending into the airways, which contained a foamy exudate).

The second porpoise (stranded 23/01/96) was a young animal, still displaying obvious fetal folds. Externally, a deep crease was visible extending dorso-ventrally on the right side of the body. Below this crease there was extensive hemorrhaging, ribs 6 to 10 were fractured and the vertebral column was severed between vertebrae T8 and T9. Underlying this trauma, the internal organs were macerated and the caudal third of the right lung and the posterior tip of the left lung had been severed. Copious amounts of sanguineous fluid were present in the body cavity.

The third porpoise (stranded 9/09/97) was extremely decomposed and was discovered near a major ferry terminal, bearing straight lacerations suggestive of propeller wounds, and a severed tail stock. However, these may have been caused post-mortem.

FIGURE 2. Evidence of fishery by-catch. (Top) A hump-backed dolphin (stranded 31/05/96) with net cuts on the rostrum (Scale bar = 1 cm). (Middle) Healed net or rope scars at the bases of the flippers of the same animal (Scale bar = 5 cm). (Bottom) A live hump-backed dolphin at sea, with a portion of net wrapped around the head.

Fishery by-catch

Eight of the examined cetaceans displayed wounds consistent with, or suggestive of fisheries by-catch, according to the criteria outlined by Kuiken (1996). One hump-backed dolphin (stranded 25/05/93), was found with a 30 cm × 30 cm opening cut into the abdomen. Pieces of fishing net were found entangled in the mesenteries. The dorsal fin and flippers of a second dolphin (stranded 12/06/94) had been cleanly sliced off. Moreover, the distal end of the esophagus contained sand and sediment, but there was little in the cranial part. The animal may have swallowed matter from the seabed prior to death, which would explain this ingested sediment. A further, decomposed, dolphin carcass (stranded 28/05/95), was discovered with monofilament netting wrapped around the flukes and tail stock and was, therefore, considered a possible by-catch.

There were two fresh stranded hump-backed dolphins that also presented gross pathology consistent with fisheries by-catch (stranding dates 31/05/96 and 31/05/97). There were straight lacerations on the flippers, rostrums, and dorsal fins of both animals (Fig. 2), which were indicative of net marks (Kuiken, 1996). In the first of these animals, impressions that resembled rope marks were also visible on the flukes and tail stock. The animal also possessed

healed rope scars around the bases of its flippers, suggestive of a previous non-fatal encounter with a net (Fig. 2). There was edema of the pericardium, with approximately 10 ml of fluid in the pericardial sac. Foamy fluid was found in the thoracic cavity, as well as in the lungs. This pathology was consistent with accidental by-catch (Kuiken, 1996). The more recent animal had quantities of foamy, blood-tinged exudate in the lungs, a symptom associated with by-catch induced hypoxia.

A finless porpoise caught in a pair trawl net (date: 11/10/97) displayed, not surprisingly, net-induced lacerations and lung pathology consistent with by-catch induced anoxia (Kuiken, 1996). Another finless porpoise, a neonate of 67 cm total length (stranded 7/01/98), had foamy fluid in the lungs and apparent cuts from a thin-stranded net on the flukes.

One bottlenose dolphin stranded in Hong Kong (on 13/07/95) appeared to have been by-caught. The animal was found in Aberdeen Harbour, close to the Aberdeen wholesale fish market. Obvious 'criss-cross' wounds were visible on the tail stock, suggestive of net marks. Semi-digested stomach contents were found within the trachea, suggesting that the animal had regurgitated and aspirated stomach contents prior to death. On further examination, several cysts were discovered within the stomach wall, and the sphincter connecting the first and second stomach chambers appeared swollen and rigid. The volume of stomach contents was low (<75 cm^3) and the second stomach chamber was empty.

Histopathology

Tissues from four hump-backed dolphins, three finless porpoises, and two bottlenose dolphins were examined histologically. Foci of suppurative and necrotizing pneumonia were noted in lung samples from a hump-backed dolphin (stranded 27/01/94). One of these foci was associated with a nematode mass (*Halocercus pingi*). Moreover, some pinpoint hemorrhages were detected in the lung tissue. Eosinophils and macrophages were noted in surrounding air spaces, with occasional multinucleate cells. These macrophages were foamy and some contained eosinophillic granules in the cytoplasm. The lesions and cells detected could be attributable to the parasitic infection and verminous pneumonia was diagnosed to be the ultimate cause of death. In addition, there was hemorrhaging into the omentum around the spleen. The spleen itself contained well-developed follicles, but a high percentage of lymphocytes in these follicles had fragmented nuclei, suggesting cell death. The adrenal glands were hemorrhagic and the animal's mesenteric lymph nodes were enlarged. Good follicular development was noted in the lymph nodes, although there was some loss of cells within the germinal centers of the follicles. Cells in the germinal centers contained eosinophilic bodies and mitotic activity in these follicles was high. Within the medullary sinuses, there were numerous macrophages, with some containing a brown pigment (possibly hemosiderin). There also were some large cells resembling megakaryocytes, possible evidence of extra-medullary hematapoensis.

An examination of the liver, kidney, lung and some lymph nodes of a second hump-backed dolphin (stranded 4/05/95) revealed a slight increase in periportal fibrous tissue, and in some portal zones there was a subacute inflammatory response. In the liver, mild biliary stasis was present with lakes of bile between some hepatocytes. Sectioned lymph nodes were congested peripherally with the possibility of some hemorrhaging. Moreover, there were some megakaryocytes in the medulla, but there was no evidence of lymphoid depletion. This animal was thought to have been killed by a Hong Kong fisherman (see above); therefore, the pathological findings were probably not related to the cause of death.

Later in the same month, the lung, liver, kidney and gonadal tissues of a male

hump-backed dolphin (stranded 28/05/95) were examined, revealing some golden-brown pigment in the hepatocytes and renal tubular epithelium (this was not iron-based). In the testes, spermatogenesis was occurring, but few spermatids were present. The tissues of this animal were too badly decomposed to yield any further information. For the fourth hump-backed dolphin (stranded 15/06/95), lung, liver, and kidney tissues were examined, but the only detectable pathology was the presence of some cholestasis in the liver.

To date, histopathological samples have been examined from three finless porpoises. The histological results from one of these specimens is presented in detail in Parsons et al. (1999). In this study, a neonate porpoise (stranded 15/12/95), displayed lesions associated with verminous (*Halocercus pingi*) bronchopneumonia, with moderate multifocal plasmacytosis and mild multifocal histiocytosis in lymph node tissue, as well as thymic lymphoid hypoplasia.

A second neonate porpoise (stranded 15/03/95) also was examined. From this specimen, samples were collected from the lung, liver, kidney, pancreas, duodenum, testis, and lymph nodes. The latter were large, with a well-developed paracortical area and no evidence of lymphoid depletion. There was mild fat necrosis around the pancreas, but no inflammation within the organ itself; therefore, these lesions were not considered to be significant as the cause of death, but they are of interest. Within the lungs, several lesions were detected. There was evidence of severe verminous pneumonia, with granulomatous foci containing parasites (*H. pingi*). There were many macrophages in the surrounding alveoli and verminous pneumonia was probably the ultimate cause of death.

A third porpoise (stranded 25/12/95), displayed chronic, multifocal colitis. There was moderate hyperplasia of gut-associated lymphoid tissue, with lymphocyte extension and infiltration into the submucosa and along the lamina propria. The lymphoid changes had resulted in glandular disruption and displacement. A sectioned lymph node displayed reactive changes, including plasmacytosis and enlarged and increased numbers of germinal follicles. These germinal follicles exhibited lymphoid depletion, presumably the result of chronic disease. The lungs of the animal contained the nematode *H. pingi*. No lesions were detected in pancreas, spleen, kidney, or stomach tissues. In summary, the pathological changes could have been the result of a chronic parasitic infection and/or inflammatory bowel disease.

Although, as can be seen from the above, finless porpoises frequently possess widespread infections of the lungworm *Halocercus pingi* (Table 1), this nematode was only found in one hump-backed dolphin (Table 1). In both the finless porpoises and the hump-backed dolphins the nematodes were typically found within lesions and abscesses or granulomata accompanied by a either a foamy or catarrhal exudate in the airways and suppurative and/or necrotizing pneumonia.

In addition to the two resident species, histopathology samples were taken from two bottlenose dolphins. The lymph nodes of the first animal (stranded 4/12/94) were slightly enlarged and erosions were detected in the mucosa and the cranial portion of the duodenum, but no other pathology was apparent. The testes were undergoing active spermatogenesis. One sample of lymphoid tissue from the second bottlenose dolphin (stranded 13/07/95) showed an increased number of neutrophils within the sinuses and there appeared to be some foci of necrosis and inflammation of lymphoid tissue, possibly from an acute infection. No other lesions were discernible.

Bacteriology

Bacterial samples were taken and cultured from three hump-backed dolphins, four finless porpoises and two bottlenose

TABLE 2. Summary of bacteria cultured from cetaceans examined from Hong Kong waters.

Cetacean	Bacteria	Tissue infected
Sousa chinensis	*Clostridium* sp.[ab]	Lung, liver, lymph nodes
	Edwardsiella tarda[c]	Lung, liver, lymph nodes, spleen
	Streptococcus faecium[ab]	Lung, liver, lymph nodes
	Vibrio alginolyticus[d]	Lung, liver
	Vibrio cholera[ab]	Lung, liver, lymph nodes
	Vibrio damsela[b]	Lung, liver, lymph nodes
	Fecal coliforms[ab]	Lung, liver, lymph nodes
	G− rods[b]	Lung
	G+ rods[b]	Lung
	G+ cocci[b]	Lung
Neophocaena phocaenoides	*Citrobacter freundii*[ah]	Heart blood, lung
	Escherichia coli[aei]	Lung, colon
	Klebsiella oxytoca[ah]	Heart blood
	Listonella damsela[fh]	Heart blood, lung, liver
	Proteus mirabilis[ai]	Lung
	Schewanella putrifaciens[efi]	Lung, ileum
	Vibrio alginolyticus[efhi]	Heart blood, lung, liver, colon
	Vibrio parahaemolyticus[e]	Lung, 2nd stomach, ileum, colon
	Vibrio vulnificus[eg]	Lung, 2nd stomach, pericardial and peritoneal fluid
Tursiops truncatus	*Edwardsiella tarda*[j]	Lymph node
	Proteus mirabilis[ak]	Lung, liver

[a] Sewage-borne bacteria (Olivieri, 1982).

Date of stranding of sampled animal: [b] 27/01/94; [c] 31/05/96; [d] 28/03/97; [e] 15/12/95; [f] 25/12/95; [g] 15/01/96; [h]12/04/97; [i] 13/08/97; [j]25/11/94; [k]4/12/94.

dolphins. The bacteria species identified from these cultures are listed in Table 2.

DISCUSSION

Shark attack

Predatory sharks appear to migrate seasonally into eastern Hong Kong waters, notably around Sai Kung, during the summer months, where they have been deemed to be responsible for several attacks on human swimmers (Morton, 1994). There are several species of large, predatory sharks whose theoretical range would include Hong Kong. They are, predominantly, the great white shark (*Carcharodon carcharias*), the bull (or Zambezi) shark (*Carcharinus leucas*) and the tiger shark (*Galeocerdo cuvieri*).

Tiger sharks are a potential predator of hump-backed dolphins in Moreton Bay, Australia (Corkeron, 1990) and bull sharks are a likely candidate for the source of many shark attacks on hump-backed dolphins in South Africa (Cockcroft, 1991). Both tiger and bull sharks (and related species) have been recorded from Hong Kong and, although great white sharks have not, as yet, been recorded from these waters, their presence would not be surprising. From the shape and depth of the tooth incisions, the shark that attacked the porpoise reported here, had wide, thin, triangular-shaped teeth and was, therefore, probably a large carcharinid such as *C. carcharias.* White sharks have been known to feed on finless porpoise in Japanese waters (Kasuya, 1999).

Carcinomas

One necropsied hump-backed dolphin (stranded 10/02/97) was found to have a tumor, which was associated with the intestinal tract. Due to the rarity of tumors reported in cetaceans, this case is worth further discussion. Beluga whales (*Delphinapterus leucas*) in the St. Lawrence estuary have been reported to have a high prevalence of adenocarcinomas of the gas-

trointestinal tract, which has been suggested to be the result of ingesting contaminated sediments while feeding on demersal prey species (Martineau et al., 1999). Hump-backed dolphins in Hong Kong are also known to consume demersal prey species (Parsons, 1997a; Jefferson, 2000), which are not only contaminated by carcinogenic contaminants, but also inhabit contaminated seabed sediments (Parsons, 1998a). The consumption of contaminated seabed sediment and prey species may, therefore, have been a contributing factor to the tumor described in the necropsied hump-backed dolphin. The prevalence of tumors and contaminant-associated pathologies in the intestinal tracts of Hong Kong's cetaceans warrants further investigation.

Boat strikes

Hong Kong is one of the busiest ports in the world. In 1994, over 432,481 oceanic and river-going vessels traveled through Hong Kong's waters (Howlett, 1996). The area of greatest hump-backed dolphin abundance also contains the Urmston Road shipping channel and approximately 30 high-speed and hydrofoil ferries pass through this area daily (Leatherwood and Jefferson, 1997). In addition to these, up to 200 vessels may be present in the area between Chek Lap Kok, Castle Peak and Sha Chau, the area of greatest hump-backed dolphin density (Jefferson, 2000). Also, a major ferry lane between Hong Kong and Macau runs through important finless porpoise habitat south of Lantau Island (Jefferson and Braulik, 1999). Therefore, it is not surprising that boats collide with local cetaceans. Several (6 of 174) live dolphins (Jefferson, 2000) bear scars apparently caused by propellers (Fig. 1), in addition to the cases documented in this paper.

Mortality as the result of collisions with shipping is a significant cause of mortality to several populations of cetaceans, notably North Atlantic right whales (*Eubalaena glacialis*) (Kraus, 1990; Kenney, 1993) and as noted in this study, it is also an issue in Hong Kong. Unfortunately, the volume of shipping traffic in Hong Kong will increase in the next few years, as there are plans for a new river trade terminal, container terminal, and a new shipping channel in waters inhabited by dolphins and porpoises.

Fishery by-catch

Eight specimens, when examined for gross pathology, exhibited lesions associated with fishery by-catch. In addition, researchers received a photograph of, but did not manage to recover, a hump-backed dolphin (reported 11/02/95) wrapped in a thick-stranded net, possibly a trawl net. Fishermen also may have been involved in the death of another hump-backed dolphin (stranded 4/05/95), a young animal with a relatively clean stab wound to its left eye. Fluid also was present within the lungs and air passages, but no obvious net marks were observed. Subsequent information obtained by AFD field officers suggested that the carcass had been dumped from a fishing vessel near Lantau Island.

In addition to the above, there also is evidence of non-fatal net entanglement in Hong Kong hump-backed dolphins, as several live dolphins display net scars (6 of 174; Jefferson, 2000), and in one case, an animal was seen still enshrouded by netting (Fig. 2). Fishing effort within Hong Kong's inshore waters is considerable. According to the AFD's 1994 fishing vessel census, the Hong Kong fishing fleet numbers more than 4,800 vessels, consisting of pair trawlers, stern and shrimp trawlers, longliners, gillnetters and purse-seiners. Inshore fisheries net over 24,000 tons of fish annually within an area of only 1,827 km^2. There is, therefore, a high density of fishing gear, within which cetaceans could become entangled. The situation may be exacerbated by the fact that local hump-backed dolphins are frequently observed following fishing trawlers, presumably catching fish stirred up by the nets (Parsons, 1998c; Jefferson, 2000).

Parasitology

Infections of the nematode *Halocercus pingi* were present in the lung tissue of one hump-backed dolphin and 10 finless porpoises (Table 1). Of the latter, infection was severe in six cases (Table 1). Verminous pneumonia resulting from these infections was deemed to the most likely cause of death in the above hump-backed dolphin and five of the finless porpoises, due to the severity of the cases (Table 1). The presence of *H. pingi* in neonatal finless porpoises suggests that the nematode may be transferred pre-partum (Parsons et al., 1999). Moreover, finless porpoises have been demonstrated to possess high body burdens of immune-suppressing contaminants which may increase the susceptibility of this species to parasitic infection (Parsons and Chan, 1998). Parasite-induced mortality and morbidity and the factors which may exacerbate infection, particularly in neonatal animals, merit further investigation.

Bacteriology

Bacterial infections are a leading cause of death in marine mammals (Howard et al., 1983). Many bacterial infections are, however, secondary to conditions resulting from viral and parasitic infections, or trauma (Haebler and Moeller, 1993). In the animals sampled, at least two died as the result of fisheries by-catch and the bacteria discovered were not the ultimate cause of death, but rather incidental infections. However, the bacteria may have led to the debilitation of the animals and reduced their ability to avoid entanglement in fishing gear.

Most of the bacterial species cultured from Hong Kong cetacean strandings (Table 2) have been described in cetacean populations from other regions of the world, notably the predominance of *Vibrio* spp. (Buck et al., 1991). *Vibrio* spp. have been reported to be the cause of mortality and morbidity in several species of dolphin (Tangredi and Medway, 1980; Schroeder et al., 1985; Fujioka et al., 1988), although *Vibrio* spp. also have been cultured from both seawater and apparently healthy animals (Buck and Spotte, 1986). Thus, the presence of these bacteria do not necessarily imply a pathogenic infection.

Hong Kong's small cetaceans live in heavily polluted waters. Over 12,000 sewage outfalls drain into the area of highest hump-backed dolphin abundance. Over 2 million tons of largely untreated sewage water are pumped into Hong Kong's 1,827 km^2 of territorial waters daily, and currently only 25% of this sewage is treated (Environmental Protection Department, 1996). This sewage water contains the fecal waste from over 750,000 pigs, 7.5 million poultry, and 6.1 million people (Morton, 1989; Chan and Yung, 1995).

Several of the species of bacteria cultured can be carried in sewage wastes, such as *Escherichia coli, Streptococcus faecium,* and *Vibrio cholera.* Therefore, sewage may be the source of these infections. Sewage-borne bacteria could be transferred to marine mammals through the ingestion of contaminated fish (Smith and Boyt, 1990) and water, or through wounds (Buck and Shepard, 1987). To give an example of the degree of bacterial contamination in the waters inhabited by Hong Kong's small cetaceans, fecal coliform concentrations in the waters to the north of Lantau Island can exceed 21,000 coliforms/100 ml (Parsons, 1997b). Because of this, it should be borne in mind that some of the bacteria cultured may not be indicative of infection, but rather of seawater contamination.

High levels of organochlorine pollutants have been found in the tissues of Hong Kong's cetaceans (Parsons and Chan, 1998; Jefferson, 2000), and as this class of chemical can cause immunosuppression, with an increased vulnerability to bacterial infections (Smith et al., 1978; Thomas and Hinsdill, 1978), the degree of bacterial contamination in Hong Kong waters is a cause for concern.

CONCLUSIONS

Cetacean mortalities in Hong Kong as the result of human activities have been recorded since the beginning of official records (Parsons et al., 1995). During the current study, at least 32% of necropsied hump-backed dolphins, 15% of finless porpoises, and 25% of bottlenose dolphins appear to have died as the result of human activities. Of the necropsied hump-backed dolphins, 11% died as the result of boat collisions ($n = 3$) and 21% as the result of fishery by-catch ($n = 6$). For finless porpoise mortalities, 9% ($n = 3$) were attributed to boat collisions and 6% ($n = 2$) to fishery by-catch. One of the bottlenose dolphin mortalities (25%) was attributed to fishery by-catch.

The number of hump-backed dolphins that occur in Hong Kong is not large (approximately 88–145; Jefferson, 2000), although other animals from the same population inhabit adjacent areas of the Pearl River Estuary (the best estimate of the total population size is around 1,000 animals; Jefferson, 2000). The size of the finless porpoise population is unknown, but appears to number at least 150 animals (Jefferson and Braulik, 1999), and there is no information on bottlenose dolphin population size. The number of deaths attributable to human activities may be significant, when considering the probable size of the local resident populations. Moreover, high concentrations of anthropogenic toxic pollutants have been detected in the tissues of both species of resident cetaceans (Parsons, 1998a; Parsons and Chan, 1998; Jefferson, 2000). The combination of these factors has led to concerns about the long-term viability of Hong Kong's local small cetacean populations (Parsons, 1997a, b; Jefferson and Braulik, 1999; Jefferson, 2000).

Although our knowledge of other causes of mortality and morbidity in these animals is still rudimentary, we do possess enough information to state that at least fisheries and boat traffic appear to be having an effect on Hong Kong's cetaceans. Therefore, as work continues on other causes of death, we recommend the implementation of additional mitigation measures to reduce mortality from these factors and help conserve Hong Kong's resident species.

ACKNOWLEDGMENTS

We wish to thank G. Bossart, J. M. Groff, and L. Simms for conducting the histopathological analyses, R. Overstreet for the identification of the collected parasites, R. Yuen for the bacteriological culturing and R. Kinoshita, I. Beasley, M. Torey, G. Yang, L. Porter, D. Choi, Y. K. Chan, C. C. Lay and several others for their assistance with the performance or the logistics of the necropsies. This project was funded by the Agriculture and Fisheries Department of the Hong Kong SAR Government and was supported by Ocean Park, Hong Kong. This paper was kindly reviewed by J. Baker, S. Clark, B. Curry, P. Jepson, R. Kinoshita, D. Pence, L. Simms and two anonymous reviewers.

LITERATURE CITED

BUCK, J. D., AND S. SPOTTE. 1986. The occurrence of potentially pathogenic *Vibrios* in marine mammals. Marine Mammal Science 2: 319–324.

———, AND L. L. SHEPARD. 1987. Clostridium perfringens as the cause of death of a captive Atlantic bottlenosed dolphin (*Tursiops truncatus*). Journal of Wildlife Diseases 23: 488–490.

———, N. A. OVERSTROM, G. W. PATTON, H. F. ANDERSON, AND J. F. GORZELANY. 1991. Bacteria associated with stranded cetaceans from the northeast USA and southwest Florida Gulf coasts. Diseases of Aquatic Organisms 10: 147–152.

CHAN, K. K., AND Y. K. YUNG. 1995. Marine water quality in Hong Kong for 1994. Hong Kong Government Printer, Hong Kong, 121 pp.

COCKCROFT, V. G. 1991. Incidence of shark bites on Indian Ocean humpbacked dolphins *Sousa plumbea* off Natal, South Africa. *In* Cetaceans and cetacean research in the Indian Ocean sanctuary, S. Leatherwood and G. P. Donovan (eds.). United Nations Environment Program Marine Mammal Technical Report No. 3. United Nations Environment Program, Nairobi, Kenya, pp. 271–276.

CORKERON, P. J. 1990. Aspects of the behavioral ecology of inshore dolphins *Tursiops truncatus* and *Sousa chinensis* in Moreton Bay, Australia. *In* The bottlenose dolphin, S. Leatherwood and R. R. Reeves (eds.). Academic Press, San Diego, California, pp. 285–293.

ENVIRONMENTAL PROTECTION DEPARTMENT. 1996.

Environment Hong Kong 1996. Hong Kong Government Printer, Hong Kong, 225 pp.

FUJIOKA, R. S., S. B. GRECO, M. B. CATES, AND J. P. SCHROEDER. 1988. *Vibrio damsela* from wounds in bottlenose dolphins *Tursiops truncatus*. Diseases of Aquatic Organisms 4: 1–8.

GERACI, J. R., AND V. J. LOUNSBURY. 1993. Marine mammals ashore: A field guide for strandings. Texas A&M Sea Grant Publications, Galveston, Texas, 305 pp.

HAEBLER, R., AND R. B. MOELLER. 1993. Pathobiology of selected marine mammal diseases. *In* Pathobiology of marine and estuarine organisms, J. A. Couch and J. W. Fourine (eds.). CRC Press, Baton Roca, Florida, pp. 217–244.

HOHN, A. A., AND C. LOCKYER. 1995. Protocol for obtaining age estimates from harbour porpoise teeth. Reports of the International Whaling Commission (Special Issue) 16: 494–496.

HOWARD, E. B., J. O. BRITT, G. K. MATSUMOTO, R. ITAHARA, AND C. N. NAGANO. 1983. Bacterial diseases. *In* Pathobiology of marine mammal diseases. Vol. 1, E. B. Howard (ed.). CRC Press, Baton Roca, Florida, pp. 70–117.

HOWLETT, R. 1996. Hong Kong 1996. Hong Kong Government Printer, Hong Kong, 494 pp.

JEFFERSON, T. A. 2000. Population biology of the Indo-Pacific hump-backed dolphin in Hong Kong waters. Wildlife Monographs: In press.

———, AND G. T. BRAULIK. 1999. Preliminary report on the ecology of the finless porpoise in Hong Kong waters. IBI Reports 9: 41–54.

———, A. C. MYRICK, AND S. J. CHIVERS. 1994. Small cetacean dissection and sampling: A field guide. National Oceanic and Atmospheric Administration Technical Memorandum NMFS SWFSC 198. NMFS, La Jolla, California, 54 pp.

KASUYA, T. 1999. Finless porpoise *Neophocaena phocaenoides* (G. Cuvier, 1829). *In* Handbook of marine mammals, Volume 6: The second book of dolphins and the porpoises, S. H. Ridgway and R. Harrison (eds.). Academic Press, San Diego, California, pp. 411–442.

KENNEY, R. D. 1993. Right whale mortality-a correction and an update. Marine Mammal Science 9: 445–446.

KRAUS, S. D. 1990. Rates and potential causes of mortality in North Atlantic right whale (*Eubalaena glacialis*). Marine Mammal Science 6: 278–291.

KUIKEN, T. (ed.). 1996. Proceedings of the 2nd ECS workshop on cetacean pathology. Diagnosis of by-catch in cetaceans. European Cetacean Society, Saskatoon, Saskatchewan, Canada, 43pp.

LEATHERWOOD, S., AND T. A. JEFFERSON. 1997. Dolphins and development in Hong Kong: A case study in conflict. IBI Reports 7: 57–69.

MARTINEAU, D., S. LAIR, S. DEGUISE, AND P. BELAND. 1999. Cancer in cetaceans, a potential biomarker of environmental contamination. Reports of the International Whaling Commission (Special Issue) 17: In Press.

MORTON, B. 1989. Pollution of the coastal waters of Hong Kong. Marine Pollution Bulletin 20: 310–318.

———. 1994. Shark! Marine Pollution Bulletin 28: 62–63.

MYRICK, A. C., A. A. HOHN, P. A. SLOAN, M. KIMURA, AND D. D. STANLEY. 1983. Estimating age of spotted and spinner dolphins (*Stenella attenuata* and *Stenella longirostris*) from teeth. National Oceanic and Atmospheric Administration Technical Memorandum NMFS 30, NFMS, La Jolla, California, 17 pp.

OLIVIERI, V. P. 1982. Bacterial indicators of pollution. *In* Bacterial indicators of pollution, W. O. Pipes (ed.). CRC Press, Baton Roca, Florida. pp. 21–41.

PARSONS, E. C. M. 1997a. Hong Kong's cetaceans: The biology, ecology and behaviour of *Sousa chinensis* and *Neophocaena phocaenoides*. Ph.D. Thesis, University of Hong Kong, Hong Kong, 257 pp.

———. 1997b. Sewage pollution in Hong Kong: Implications for the health and conservation of local cetaceans. Final report to Friends of the Earth, Wan Chai, Hong Kong, 42 pp.

———. 1998a. Trace metal pollution in Hong Kong: Implications for the health of Hong Kong's Indo-Pacific hump-backed dolphins (*Sousa chinensis*). Science of the Total Environment 214: 175–184.

———. 1998b. Strandings of small cetaceans in Hong Kong's territorial waters. Journal of the Marine Biological Association of the United Kingdom 78: 1039–1042.

———. 1998c. The behaviour of Hong Kong's resident cetaceans: The Indo-Pacific hump-backed dolphin and the finless porpoise. Aquatic Mammals 24: 91–110.

———, M. L. FELLEY, AND L. J. PORTER. 1995. An annotated checklist of cetaceans recorded from Hong Kong's territorial waters. Asian Marine Biology 12: 79–100.

———, AND H. M. CHAN. 1998. Organochlorines in Indo-Pacific hump-backed dolphins (*Sousa chinensis*) and finless porpoises (*Neophocaena phocaenoides*) from Hong Kong. *In* The marine biology of the South China Sea 3, B. Morton (ed.). Hong Kong University Press, Hong Kong, pp. 423–437.

———, G. F. BOSSART, AND R. E. KINOSHITA. 1999. Postmortem findings in a finless porpoise (*Neophocaena phocaenoides*) calf stranded in Hong Kong. The Veterinary Record 144: 75–76.

PERRIN, W. E., AND A. C. MYRICK (EDS.). 1980. Age determination of toothed whales and sirenians. Reports of the International Whaling Commission (Special Issue 3), International Whaling Commission, Cambridge, UK, 229 pp.

ROMER, J. D. 1958. Cetaceans recorded from within

or near Hong Kong territorial waters. Hong Kong University Fisheries Journal 2: 127–129.

SCHROEDER, J. P., J. G. WALLACE, M. B. CATES, S. B. GRECO, AND P. W. B. MOORE. 1985. An infection by *Vibrio alginolyticus* in an Atlantic bottlenose dolphin in an open ocean pen. Journal of Wildlife Diseases 21: 437–438.

SMITH, A. W., AND P. M. BOYT. 1990. Caliciviruses of ocean origin: A review. Journal of Zoo and Wildlife Medicine 21: 3–23.

SMITH, S. H., V. M. SANDERS, B. A. BARRETT, J. F. BORZELLERA, AND A. E. MUNSON. 1978. Immunotoxicological evaluation on mice exposed to polychlorinated biphenyls. Toxicolology and Applied Pharmacology 45: 330.

TANGREDI, B. P., AND W. MEDWAY. 1980. Post-mortem isolation of *Vibrio alginolyticus* from an Atlantic white-sided dolphin (*Lagenorhynchus acutus*). Journal of Wildlife Diseases 16: 329–331.

THOMAS, P. T., AND R. D. HINSDILL. 1978. Effect of polychlorinated biphenyls on the immune responses of rhesus monkeys and mice. Toxicolology and Applied Pharmacology 44: 41–51.

Received for publication 15 September 1998.