Aquatic Mammals 2012, *38*(1), 86-91, DOI 10.1578/AM.38.1.2012.86

Short Note

Rake Marks on a Harbor Porpoise (*Phocoena phocoena*) Calf Suggestive of a Fatal Interaction with an Atlantic White-Sided Dolphin (*Lagenorhynchus acutus*)

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Ten species of odontocete have been recorded in the Estuary and Gulf of St. Lawrence (Canada). The harbor porpoise (*Phocoena phocoena*), the Atlantic white-sided dolphin (*Lagenorhynchus acutus*), the white-beaked dolphin (*L. albirostris*), and the long-finned pilot whale (*Globicephala melaena*) are the most abundant species of odontocete in the Gulf, whereas the harbor porpoise and the beluga whale (*Delphinapterus leucas*) are regarded as the predominant species of odontocete in the Estuary (Kingsley & Reeves, 1998). Sperm whales (*Physeter macrocephalus*) are occasionally reported in the Estuary and Gulf, while killer whales (*Orcinus orca*), northern bottlenose whales (*Hyperoodon ampullatus*), common dolphins (*Delphinus delphis*), and striped dolphins (*Stenella coeruleoalba*) are all considered rare visitors (Lesage et al., 2007; Quebec Marine Mammal Emergency Response Network, unpub. data).

The smallest of these species, the harbor porpoise, is listed as a protected species in Canada and is designated as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (2006). Based on genetic studies, it is believed that harbor porpoises inhabiting the Estuary and Gulf of St. Lawrence form a relatively isolated subpopulation from other Atlantic harbor porpoises (Evans et al., 2009). Incidental catches of harbor porpoise in fishing gear (bycatch) in the Estuary and Gulf of St. Lawrence are a significant cause of mortality and represent the most serious threat for these small cetaceans (Fontaine et al., 1994; Lesage et al., 2006). Little is known regarding other causes of mortality and population trends of harbor porpoises from the Estuary and Gulf of St. Lawrence. Harbor porpoises have been reported to be occasional victims of attacks from bottlenose dolphins (*Tursiops truncatus*) in Great Britain and California, and from Pacific white-sided dolphins (*L. obliquidens*) in Washington State (Ross & Wilson, 1996; Baird, 1998; Cotter et al., 2011). Such interspecific violent interactions have never been reported from the Estuary and Gulf of St. Lawrence.

The objective of this communication is to describe the *postmortem* findings on a harbor porpoise calf presenting lesions suggestive of interspecific violent interactions with Atlantic white-sided dolphins.

The carcass of a harbor porpoise calf was found stranded in December 2009 in Pointe-au-Père, Québec, Canada (48° 30' 51" N, 68° 27' 53" W) on the south shore of the St. Lawrence Estuary. The carcass was first reported to the Quebec Marine Mammal Emergency Response Network and then shipped fresh the following day by Fisheries and Oceans Canada to the Canadian Cooperative Wildlife Health Center – Quebec Regional Center, where a complete necropsy was performed according to a standard protocol (Geraci & Lounsbury, 2005). Age was estimated based on the formula of Gaskin & Blair (1977):

$$d = [b/(-0.84(b) + 156.15)]-1$$

for female harbor porpoises where b is body length and d is number of dentinal layers (1 GLG [growth layer group]/y). Sections of major organs and lesions were sampled, fixed in 10% buffered formalin, embedded in paraffin, sectioned at 5 µm, stained with hematoxylin-phloxine-saffron (Luna, 1968), and examined with light microscopy. Gram, Schiff Periodic Acid, and Zielh-Neelsen Acid fast stains were used on selected tissues (Luna, 1968). Liver, lung, and kidney, as well as aseptically collected swabs from the abnormal *panniculus* *adiposus* (blubber) and underlying muscles, were submitted for routine culture, which was done using Columbia agar +5% sheep red blood cells incubated for 48 h at 35° C with 20% O_2 and 5% CO_2. Following microscopic examination, frozen (-20° C) sections of affected skin and *panniculus adiposus* were thawed and submitted for anaerobic, fungal, and *Mycoplasma* spp. (35° C in a candle jar on Hayflick agar and Hayflick enrichment broth) cultures, as well as for the detection of *Mycoplasma* spp. by polymerase chain reaction (PCR) (Stradaioli et al., 1999; Waites & Taylor-Robinson, 1999).

The stranded harbor porpoise was a female weighing 24.3 kg and measuring 111 cm from the tip of the rostrum to the tail notch. The animal was assessed to be in good body condition, and the preservation of the carcass was determined to be good—carcass code 2 (Geraci & Lounsbury, 2005). The estimated number of dentinal layers (d = 0.764425) indicated that this female harbor porpoise was in its first year of life. Over 300 superficial cutaneous lacerations were present on the flanks, belly, fluke, dorsal fin, and flippers of the animal (Figure 1). The depth and length of most of these 1-mm wide lacerations ranged from 1 to 2 mm and from 0.1 to 10 cm, respectively. These lesions, mainly involving the epidermis, were organized in parallel groups of three to 15 regularly spaced lacerations. Three of the lacerations on the right flank communicated with small cavities, 1 mm in diameter, occurring at the epidermis–dermis interface. The subjacent *panniculus adiposus* contained dissected areas of edema, hemorrhage, and necrosis radiating from the dermal cavities and infiltrating

Figure 1. Harbor porpoise calf; numerous rake marks are present on the ventral abdomen (Bar = 5 cm).

Figure 3. Carcass of the harbor porpoise calf (right side) with skin and blubber resected showing multifocal to coalescing areas of necrosis and hemorrhage (Bar = 5 cm).

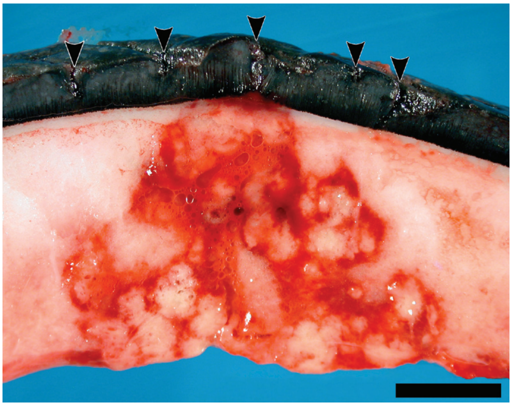

Figure 2. Transverse section of the epidermis and dermis of the harbor porpoise; transepidermal lacerations (arrow heads), one of which is associated with radiating areas of hemorrhage and necrosis extending into the subjacent panniculus (Bar = 1 cm).

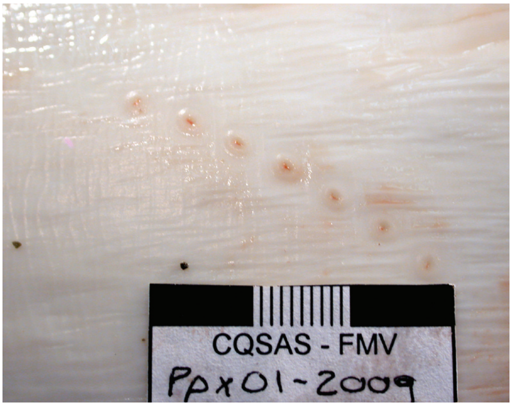

Figure 4. Skin of the harbor porpoise calf; teeth impressions without raking used to measure intertooth distances (Label = 3 cm).

the muscular layers below (Figure 2). Multifocal to coalescing areas of necrosis covered approximately 60% of the interface between the blubber and the muscles on the right flank (Figure 3). These areas of necrosis were surrounded by multiple hemorrhages. A wound, present on the dorsal aspect of the left flipper, reached the hypodermis and was associated with a 4 cm² hemorrhagic area of the subcutaneous tissues. One of the abdominal wounds consisted of seven aligned and regularly spaced punctures (mean spacing ± standard deviation: 5.8 ± 0.3 mm; Figure 4). The trachea and bronchi were filled with abundant white foam, and the gastro-intestinal tract was empty. No other significant lesions were visible upon macroscopic examination.

Microscopically, the epidermal lacerations were characterized by epidermal clefts, at times extending into the dermis. The adjacent epidermis contained disorganized epithelial cells often showing signs of ballooning degeneration. Some of these clefts were partially filled with aggregates of degenerate inflammatory cells embedded in fibrin. The subjacent dermis was multifocally infiltrated by a large quantity of inflammatory cells, mainly composed of degenerate neutrophils, and displayed congested blood vessels. No sign of fibrosis was observed. The *panniculus adiposus* was multifocally dissected by large coalescing areas of interstitial hemorrhages and marked perivascular infiltration by variable proportions of macrophages and neutrophils. These areas of blubber often contained adipocytes with discontinued cellular walls coalescing into irregularly shaped cavities. Discrete areas of fat saponification and thrombotic blood vessels were occasionally present. The adipocytes of the surrounding blubber were separated by an edematous fluid containing numerous inflammatory cells. Superficial musculature of the affected regions was multifocally edematous and infiltrated by numerous macrophages and neutrophils occasionally centered on fragmented myocytes having coagulated sarcoplasms. Aggregates of bacterial colonies (Gram positive cocci) were occasionally observed in the affected skin, blubber, and muscle. Necrosis of the intestinal crypts was observed in one of the intestinal sections examined. This lesion was characterized by a moderate distention of the crypts on the affected section associated with necrotic epithelial cells and the presence of cellular debris in the lumen of the abnormal crypts. The cellular integrity of the associated intestinal villosities could not be determined due to the presence of significant *postmortem* changes. No etiologic agent could be identified in the affected tissues by light microscopy. No other significant histological lesions were present in the examined organs. No microorganisms could be isolated or identified from the *panniculus adiposus* and underlying muscles by aerobic, anaerobic, fungal, and mycoplasmal cultures or by PCR for *Mycoplasma* spp. Rare colonies of *Escherichia coli* and nonfermenting Gram negative bacilli were cultured from the kidney and the lungs, respectively, but were considered to be contaminants. A bacterial culture of the liver did not lead to any growth.

Based on these findings, the cause of death of this porpoise was attributed to an extensive fibrinonecrotic granulomatous panniculitis and myositis associated with multiple linear and punctiform cutaneous lacerations. Focal lesions of necrotic enteritis of undetermined etiology were also present. The significance of these intestinal lesions is unknown, but they might have contributed to the demise of this animal. Even if we were unable to isolate a causative agent in the pannicular and muscular lesions, the histological appearance of these pathological changes and the presence of intralesional Gram positive cocci are highly suggestive of a bacterial infection. The failure to culture the bacteria may be attributed to the lack of bacteria in the samples submitted, to the effect of freezing or exposure to oxygen on the viability of the bacterial strains present, or to the presence of a bacterial species that does not grow on the media used. The obvious anatomic relationship between the dissecting and extensive inflammatory reaction and the transepidermal lacerations strongly suggests that these cutaneous wounds were the source of this bacterial infection. The regularly spaced, parallel lacerations observed on the skin of this porpoise are characteristic of rake marks produced when an odontocete slides its teeth across a cutaneous surface (Ross & Wilson, 1996). This mortality was, therefore, likely a consequence of an attack by one or a group of toothed whales. The presence of an intense inflammatory reaction directed toward the bacteria, which probably originated either from the oral cavity of the attacker or from the cutaneous surface, indicate that this porpoise did not succumb immediately following the attack.

Based on its length, this calf was estimated to be less than 1 y of age (Gaskin & Blair, 1977). Given that harbor porpoises in the Northwest Atlantic give birth around the month of May and that their lactation lasts 8 to 12 mo, we assume that this calf, which died in December, was still nursing and fully dependant on its mother (Palka et al., 1996). The absence of milk in the stomach of this calf indicates that it had not recently nursed. This suggests that it was either too weak to do so or it had become separated from its mother. Due to the optimal body condition of this carcass and the absence of scarring tissue, we believe that this mortality was relatively acute and either consecutive to sepsis or inanition-associated dehydration.

In order to determine which species of odontocete could have been responsible for this attack, the

Table 1. Mean inter-tooth distance and 95% confidence interval (CI) for small odontocetes known to frequent the Estuary and Gulf of St. Lawrence; data obtained from the literature or from archived jaws.

Species	Mean (CI) inter-tooth distance (mm)	
	Measurement on jaws[a]	Data from Ross & Wilson (1996)
Harbor porpoise (*Phocoena phocoena*)	3.48 (2.58-4.38)	3.61 (3.36-3.87)
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	5.12 (3.16-7.08)	
White-beaked dolphin (*L. albirostris*)		6.87 (6.26-7.48)
Striped dolphin (*Stenella coeruleoalba*)	4.94 (3.57-6.31)	5.34
	4.74 (3.54-5.94)	
Common dolphin (*Delphinus delphis*)		4.71 (4.46-4.95)

[a] Each line are measurements taken from one adult animal.

distances between seven regularly spaced puncture wounds present on the affected porpoise (Figure 4) were measured. These values were then compared with data acquired from the literature and obtained from measurements done on archived jaws of one harbor porpoise, one Atlantic white-sided dolphin, and two striped dolphins from the St. Lawrence Estuary (Table 1). The average distance between teeth marks on the porpoise carcass was 5.8 mm, with a standard deviation (SD) of 0.3 mm. This distance is included in the 95% confidence intervals (CI) of the individuals of only two species of odontocete found in this region: (1) the Atlantic white-sided dolphin and (2) the striped dolphin (Table 1).

There are few sightings of striped dolphins in the Gulf of St. Lawrence, with only two reported strandings in the Estuary (Lesage et al., 2007; Quebec Marine Mammal Emergency Response Network, unpub. data); thus, it seems less likely that this species would have been responsible for the lesions observed on this calf. In contrast, the Atlantic white-sided dolphin is one of the most abundant odontocete species in this area; the population in 1995 in the Gulf of St. Lawrence was estimated at over 12,000 individuals (Kingsley & Reeves, 1998), and this species commonly strands in the Estuary (Quebec Marine Mammal Emergency Response Network, unpub. data). In addition, striped dolphins are reported in warmer waters (12 to 22° C) than Atlantic white-sided dolphins (5 to 16° C) (Doksæter et al., 2008). As the surface water temperature on 7 December 2009 near Pointe-au-Père was close to 0° C (St. Lawrence Global Observatory, 2011), striped dolphins had a lower probability than Atlantic white-sided dolphins to be present in the area. Therefore, we are confident that this harbor porpoise calf was the victim of a fatal attack with one or a group of Atlantic white-sided dolphins.

Since the usual diet of Atlantic white-sided dolphins consists of small- to medium-sized fish and cephalopods (Craddock et al., 2009), the nature of this attack was not predatory. Nonpredatory interspecific violent interactions directed towards other odontocetes have been occasionally reported in bottlenose dolphins, Pacific white-sided dolphins, Atlantic spotted dolphins (*Stenella frontalis*), spinner dolphins (*S. longirostris*), and Risso's dolphins (*Grampus griseus*) (Shane, 1995; Ross & Wilson, 1996; Baird, 1998; Frantzis & Herzing, 2002; Herzing et al., 2003; Psarakos et al., 2003; Bearzi, 2005; Barnett et al., 2009). To our knowledge, this type of violent interaction between Atlantic white-sided dolphins and a harbor porpoise has not been reported previously. Violent interactions between bottlenose dolphins and harbor porpoises have been particularly well-described in Great Britain where lesions, such as extensive bruising, fractures of the ribs, and lacerations of internal organs, suggested violent blunt trauma (Ross & Wilson, 1996; Jepson & Baker, 1998). In the present case, interactions were probably not as violent since no sign of blunt trauma was present. The lesions reported herein were of similar magnitude to what has been previously described in a case in which a group of Pacific white-sided dolphins were involved in dragging an isolated harbor porpoise calf (Baird, 1998). Several hypotheses have been proposed to explain interspecific violent behaviors in odontocetes. Competition for food resources has been proposed to explain fatal attacks by bottlenose dolphins on harbor porpoises as these two species show a partial diet overlap, at least in the Northeastern Atlantic (Spitz et al., 2006). Indirect evidence of intraspecific infanticide has also been documented among bottlenose dolphins. These infanticides have been suggested to be driven by reproductive motivation since females deprived of their calves will cycle anew and, therefore, could be mated (Patterson et al., 1998; Kaplan et al., 2009). Since the calves of harbor porpoises and bottlenose dolphins are similar in size, attacks against harbor porpoises were hypothesized to be an expression of this infanticidal behavior (Patterson et al., 1998). Well-documented attacks in California involved mainly male bottlenose dolphins at the height of the breeding season, which further supports this hypothesis. The seasonality of the violent interactions also suggests that high testosterone levels in male dolphins may increase aggressive behavior (Cotter et al., 2011). Other proposed hypotheses include defensive aggression, playful behavior, practice-fighting, sexual frustration, and aberrant behavior from an isolated individual (Ross & Wilson, 1996; Cotter et al., 2011).

With no evidence of blunt trauma in the present case, the hypothesis that this harbor porpoise calf was intentionally killed is not supported. It is more likely that this event was the result of some playful or aberrant behavior. The significance of such interactions for the harbor porpoise population in the Estuary and Gulf of St. Lawrence is unknown, but effects are likely limited provided that this type of interaction is occasional.

Acknowledgments

We are grateful to the Quebec Marine Mammal Emergency Response Network for having reported this stranded animal. We are also thankful to Edisleidy Rodriguez Batista from the microbiology lab of the Service de Diagnostic de la Faculté de Médecine Vétérinaire.

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