DOI: 10.7589/2011-12-348 *Journal of Wildlife Diseases*, 48(4), 2012, pp. 1057–1062

Mortality Related to Spotted Ratfish (*Hydrolagus colliei*) in Pacific Harbor Seals (*Phoca vitulina*) in Washington State

Adrianne M. Akmajian,[1,4] Dyanna M. Lambourn,[1,5] Monique M. Lance,[1] Stephen Raverty,[2] and Joseph K. Gaydos[3] [1] Washington Department of Fish and Wildlife, Marine Mammal Investigations, 7801 Phillips Road SW, Lakewood, Washington 98498, USA; [2] Animal Health Centre, British Columbia Ministry of Agriculture and Food, 1767 Angus Campbell Road, Abbotsford, British Columbia V3G 2M3, Canada; [3] The SeaDoc Society, University of California–Davis Wildlife Health Center, Orcas Island Office, 942 Deer Harbor Road, Eastsound, Washington 98245, USA; [4] Makah Fisheries Management, PO Box 115, Neah Bay, Washington 98357, USA; [5] Corresponding author (email: Dyanna.Lambourn@dfw.wa.gov)

ABSTRACT: Tissue perforation and penetration by dorsal fin spines of spotted ratfish (*Hydrolagus colliei*) were responsible for the death of seven harbor seals (*Phoca vitulina*) in Washington State (USA) between 2006 and 2011. In six animals, necropsy revealed spines or spine parts that had perforated the esophagus or stomach and migrated into vital tissues, resulting in hemothorax, pneumothorax, pleuritis, and peritonitis. In a seventh case, a ratfish spine was recovered from the mouth of a harbor seal euthanized due to clinical symptoms of encephalitis. Gross examination revealed an abscess within the left cerebrum, which was attributed to direct extension of inflammatory infiltrate associated with the ratfish spine. Between 2009 and 2011, spotted ratfish spines were also recovered from the head or neck region of three Steller sea lions (*Eumetopias jubatus*) and one California sea lion (*Zalophus californianus*). Ratfish-related trauma appears to be a novel mortality factor for harbor seals in Washington State and could be related to increased ratfish abundance and a shifting prey base for harbor seals.

Key words: Harbor seal, *Hydrolagus colliei*, *Phoca vitulina*, predator-prey, spotted ratfish, Washington State.

Spotted ratfish (*Hydrolagus colliei*), which have a poisonous spine attached to their dorsal fin (Fig. 1), occur from southeast Alaska, USA, to Baja California, Mexico (Barnett et al., 2009). Between 2006 and 2011, spotted ratfish dorsal fin spines or spine parts were found embedded in or perforating vital tissues in seven harbor seals (*Phoca vitulina*) that were found stranded in Washington State, USA (Table 1). Additionally, three Steller sea lions (*Eumetopias jubatus*) and one California sea lion (*Zalophus californianus*) recovered during this period were identified with ratfish spines embedded in the head and esophagus (Table 1). All carcasses were necropsied to determine the cause of mortality, major tissues were collected and preserved in 10% neutral buffered formalin, and representative samples were frozen. Tissues from four harbor seals and two Steller sea lions in good postmortem condition were submitted to the Animal Health Center in Abbottsford, British Columbia, Canada, for histology and ancillary diagnostics (Table 1). To the best of our knowledge, mortality by ratfish spine injury has not been previously reported in harbor seals; however, spines from stingray species have caused esophageal and tissue perforation leading to mortality in several other marine mammal species (Obendorf and Presidente, 1978; Walsh et al., 1988; Duignan et al., 2000; McFee and Lipscomb, 2009).

Hemothorax, pneumothorax, and pyothorax due to ratfish spines penetrating the esophagus or lung were the most common lesions noted in harbor seals (Table 1). In five cases, dark-red fluid (WDFW0506-02, 2008-SJ004, WDFW2011-010) or opaque exudate (GI09-12, WDFW2010-029) was identified throughout the thoracic cavity (Table 1). In the case of an adult harbor seal with near-term fetus (WDFW2011-021), a ratfish spine was found free-floating in the abdominal cavity, having perforated the stomach and caused a septic peritonitis. One yearling harbor seal (WDFW2011-029) was found stranded on the Washington outer coast exhibiting neurologic symptoms, including body tremors and ataxia. The animal was euthanized, and gross

FIGURE 1. Spotted ratfish (*Hydrolagus colliei*) spine found penetrating the esophagus and lacerating the dorsal aorta of a harbor seal (*Phoca vitulina*) stranded in San Juan Islands, Washington State, USA. Scale bar is in centimeters.

necropsy revealed an abscess in the left cerebrum. A ratfish spine in the left jaw muscle had migrated from under the tongue to the base of the skull. It is suspected that perforation of the skull by the spine lead to infection and brain abscessation.

The cause of mortality of the California and Steller sea lions was presumed to be unrelated to the finding of ratfish spines (Table 1). The ratfish spine found in one adult Steller sea lion (2010-SJ006) was located adjacent to the esophagus, cranial to the diaphragm, and was encapsulated with only minor hemorrhage in surrounding tissue. A ratfish spine impaled in the lip of a Steller sea lion pup (WDFW2010-022) could have resulted in difficulty with prehension and mastication, contributing to the poor nutritional state of the animal at necropsy. Ratfish spines were also found embedded in the soft palate and cheek muscle of the California sea lion and third Steller sea lion but could not be associated with mortality due to carcass decomposition.

Tissue perforation by stingray spines reported in other marine mammal species has resulted in pathologies similar to those described here. In an Australian fur seal (*Arctocephalus pusilus*), the barbed spine of a stingray perforated the esophagus and migrated into the tricuspid valve of the heart, causing a pericarditis (Obendorf and Presidente, 1978). Mortality of several bottlenose dolphins (*Tursiops truncatus*) stranded in South Carolina and Florida, USA, was also attributed to tissue perforation by stingray spines (Walsh et al., 1988; McFee and Lipscomb, 2009). Similar to the yearling harbor seal with abscessed cerebrum (WDFW2011-029), stingray spines have been found to be associated with abscesses in the head and neck region of leopard seals (*Hydrurga leptonyx*) and oral abscesses of northern elephant seal (*Mirounga angustirostris*) yearlings (Obendorf and Presidente, 1978). A stingray spine that migrated from the esophagus into the hypaxial muscle of a killer whale (*Orcinus orca*) was found enclosed in fibrous tissue (Duignan et al., 2000). This same biologic response to encapsulate penetrating foreign objects likely occurred in the Steller sea lion that had a walled-off ratfish spine (2010-SJ006).

Although spotted ratfish have rarely been reported in the diet of marine mammals, they have been documented in the diet of northern elephant seals within the California Current (Antonelis and Fiscus, 1980; Condit and Le Boeuf, 1984). Parts from ratfish have also been identified in the stomachs of northern fur seals (*Callorhinus ursinus*) and Steller sea lions from the British Columbia coast (Spalding, 1963). Ratfish have also been

TABLE 1. Necropsy findings of pinnipeds stranded in Washington State, USA, found with spotted ratfish (*Hydrolagus colliei*) spines.

Species and identification no.	Age class	Sex[a]	Carcass condition	Stranding date	Gross necropsy findings	Histology performed?	Cause of death
Phoca vitulina (WDFW0506-02)	Adult	M	Moderate decomposition	22 May 2006	Dorsal spine penetrating right caudal lung	N	Pleural perforation and hemothorax
Phoca vitulina (2008-SJ004)	Adult	F	Fresh	11 May 2008	Dorsal spine penetrating esophagus	Y	Hemothorax, pleuritis
Eumetopias jubatus (WDFW2009-039)	Adult	F	Moderate decomposition	7 June 2009	Dorsal spine in left masseter muscle; bullet in perimandibular tissue	N	Undetermined due to carcass condition
Phoca vitulina (GI09-12)	Adult	M	Fresh	15 July 2009	Dorsal spine penetrating right caudal lung	N	Pyothorax and pneumothorax
Phoca vitulina (WDFW2010-029)	Adult	M	Fresh	10 February 2010	Dorsal spine penetrating left caudal lung	N	Pyothorax, pleuritis
Zalophus californianus (WDFW2010-049)	Adult	M	Moderate decomposition	24 March 2010	Dorsal spine in right masseter muscle	N	Undetermined due to carcass condition
Eumetopias jubatus (2010-SJ006)	Adult	M	Fresh	8 April 2010	Dorsal spine encapsulated in tissue adjacent to esophagus	Y	Blunt trauma, presumed killer whale attack
Phoca vitulina (WDFW2011-010)	Adult	M	Fresh	11 February 2011	Dorsal spine in right lung	Y	Hemothorax, pleuritis
Phoca vitulina (WDFW2011-021)	Adult	F	Moderately fresh	26 April 2011	Dorsal spine free floating in abdomen	Y	Gastric perforation and peritonitis
Eumetopias jubatus (WDFW2011-022)	Pup	M	Moderately fresh	30 April 2011	Dorsal spine embedded in lip	Y	Malnutrition
Phoca vitulina (WDFW2011-029)	Yearling	F	Fresh	30 May 2011	Dorsal spine in left masseter muscle, brain abscess	Y	Euthanized, bacterial and protozoal encephalitis

[a] M = male, F = female.

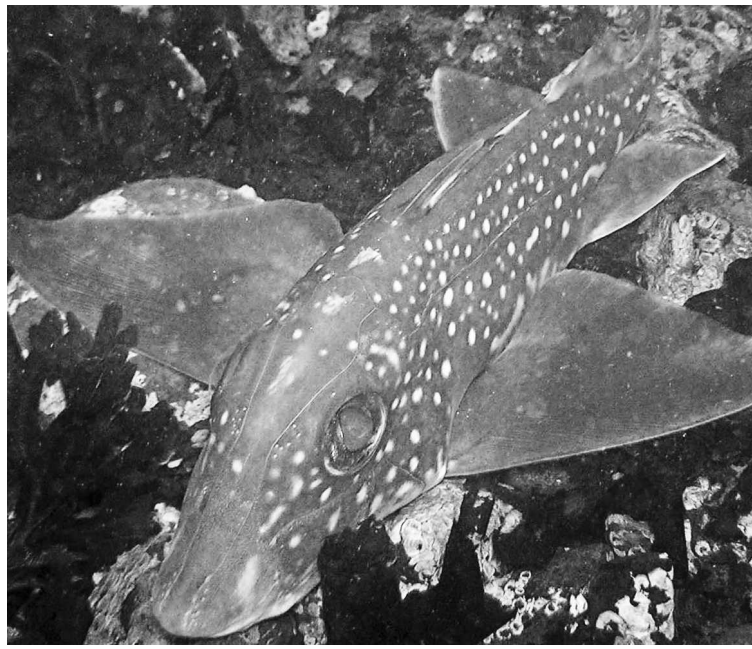

FIGURE 2. Spotted ratfish (*Hydrolagus colliei*). Photograph by Nick Brown. The caudal-facing dorsal spine held opposed to the body in this image is capable of being erected cranially and dorsally to sit perpendicular to the length of the body.

noted in the stomach of a single California sea lion from California (summary by Spalding, 1963) and a single harbor seal from the Nisqually River in South Puget Sound, Washington State (Scheffer and Sperry, 1931).

Spotted ratfish are the most abundant groundfish in Puget Sound and transboundary waters of Washington and British Columbia (Palsson et al., 1997, 2003). In trawl surveys of central Puget Sound, spotted ratfish were dominant between 80 to 160 m, but were also collected in shallower (40 m) waters (Reum, 2006). On the Washington coast, spotted ratfish were among the 20 most abundant groundfish caught between 55 and 550 m (Keller et al., 2008). Despite being one of the most common species found in bottom trawls from this region, with the exception of one report documenting a ratfish in the stomach of an adult female harbor seal (Scheffer and Sperry, 1931), spotted ratfish have not been identified in the food habits of Washington State harbor seals (Lance and Jeffries, 2007; Scordino, 2010).

The majority of animals collected in this study were found with no food items in the stomach; however, five of seven harbor seals were found in good to excellent nutritional condition as determined by sternal blubber depth (2.6–4 cm in adults and 1.7 cm in one yearling), making it unlikely that consumption of ratfish was due to desperation feeding. Histopathology of the yearling harbor seal (WDFW2011-029) revealed a severe meningoencephalitis; the contribution of this inflammation to alterations in behavior and possible effects on prey selection are unknown. A single fish bone was found in the stomach of the harbor seal with near-term fetus (WDFW2011-021). One adult harbor seal (WDFW2010-029), with only 0.8-cm sternal blubber depth, had up to 18 otoliths, multiple cephalopod beaks, and other fish parts. All sea lion stomachs were found empty.

We were unable to determine the significance of ratfish-related trauma as a

mortality factor for harbor seals in Washington State. Necropsies of stranded harbor seals and other pinnipeds began in Washington State in the late 1970s contingent on available funds and research interest. Since 2001, funding from the John H. Prescott Marine Mammal Rescue Assistance Grant Program has allowed for increased, systematic necropsy effort throughout the state. Ratfish-related mortality, however, was not noted prior to 2006. Harbor seals and Steller and California sea lions are generalist predators and commonly switch prey species based on seasonal and local abundance (Weise and Harvey, 2008; Sigler et al., 2009; Scordino, 2010). In 2011 alone, four animals were collected with ratfish spines, both from inland and coastal waters (Fig. 2); however, it is not known whether ratfish as a harbor seal prey item is increasing or is affected by availability of other prey species. It is possible that the relatively high bioavailability of ratfish in Washington waters, as noted by Palsson et al. (1997), has led to more harbor seals testing them as viable prey. To the best of our knowledge, this is the first report of spotted ratfish–related mortality in marine mammals.

This project was funded by the John H. Prescott Marine Mammal Rescue Assistance Grant Program, Washington Department of Fish and Wildlife, and the National Marine Mammal Laboratory. Special thanks go to stranding network volunteers who helped collect samples, especially Amy Traxler and the San Juan County Marine Mammal Stranding Network, and staff and volunteers from Washington Department of Fish and Wildlife Marine Mammal Investigations and Cascadia Research Collective, particularly Jessie Huggins, Josh Oliver, Bethany Diehl, and Ericka Hundrup. Photographs are published with permission by Joe Gaydos and Nick Brown. Samples were collected under the Marine Mammal Stranding Agreement held by the San Juan County Marine Mammal Stranding Network, the 109h Authority held by the Washington Department of Fish and Wildlife, and permits from the National Marine Fisheries Service (Scientific Research Permits 782-1446 and 782-1702).

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Submitted for publication 6 December 2011.
Accepted 11 April 2012.