



Note

Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*)Jeff K. Jacobsen^{a,*}, Liam Massey^b, Frances Gulland^c^aHumboldt State University, Department of Biological Sciences, 1 Harpst St., Arcata, CA 95521, USA^bPacific Trawl and Supply Company, 4468 Myrtle Ave., Eureka, CA 95503, USA^cThe Marine Mammal Center, 2000 Bunker Road, Sausalito, CA 94965, USA

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ABSTRACT

In 2008 two male sperm whales (*Physeter macrocephalus*) stranded along the northern California coast with large amounts of fishing net scraps, rope, and other plastic debris in their stomachs. One animal had a ruptured stomach, the other was emaciated, and gastric impaction was suspected as the cause of both deaths. There were 134 different types of nets in these two animals, all made of floating material, varying in size from 10 cm² to about 16 m². The variability in size and age of the pieces suggests the material was ingested from the surface as debris rather than bitten off from active gear. These strandings demonstrate that ingestion of marine debris can be fatal to large whales, in addition to the well documented entanglements known to impact these species.

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Entanglement in marine debris is a well documented cause of marine mammal mortality: pinnipeds typically succumb to strangulation, sepsis or starvation following neck entanglement (Croxall et al., 1990; Boren et al., 2006; Dau et al., 2009), whereas cetaceans are more prone to injuries to caudal peduncles, pectoral flippers and mouths (Northridge, 1984; Neilson et al., 2008; Moore et al., 2009). Fatal sperm whale entanglements in gill nets were reported along the coast of Ecuador (Haase and Felix, 1994) and in the Mediterranean Sea (Pace et al., 2008). Ingestion of marine debris is a less well documented cause of marine mammal morbidity and mortality, although it is well recognized as a health problem in marine birds (Moser and Lee, 1992; Spear et al., 1995) and turtles (Tomás et al., 2002).

Ingested debris in marine mammals has typically been detected by post-mortem examination of harvested, by-caught or stranded animals. The impact of the debris on these animals' health is unclear because the debris is diverse and often in small amounts (Walker and Coe, 1990; Laist, 1997; Baird and Hooker, 2000; De Meirelles and De Rego Barros, 2007). Even small quantities can have large effects however, as observed in two pygmy sperm whales (*Kogia breviceps*) with stomachs occluded by pieces of plastic bags (Tarpley and Marwitz, 1993; Stamper et al., 2006), and three bottlenose dolphins (*Tursiops truncatus*) asphyxiated by laryngeal entrapment by ingested fishing lines (Gorzelay, 1998; Gomercic et al., 2009; Levy et al., 2009). Mate (1985) reported about one liter of tightly packed trawl net in one out of 38 sperm whale stomachs examined, although this was not likely the cause

of death for this individual in a mass stranding of 41 individuals. Here we document the mortality of two sperm whales associated with ingestion of large amounts of marine debris which, to the best of our knowledge, constitutes a previously undocumented cause of anthropogenic mortality in this species.

On February 1 2008, a male, 11.2 m long, sperm whale (HSUVM 2673) was found dead on a beach near Crescent City, northern California. The whale was slightly decomposed, did not appear emaciated, and there was no evidence of entanglement scars nor other injury. A small opening was made in the abdominal cavity and squid beaks were found on the exterior surfaces of the small intestines and loose within the peritoneal cavity. On February 4 2008 the entire abdominal cavity was opened and a large mass of compacted netting was observed protruding through a rupture in the third compartment of the stomach. The whale apparently had recently fed as there were about two liters of fresh squid beaks on the anterior surface of the netting. Large amounts of coagulated blood were observed in the netting and in the body cavity. Cause of death was presumed to be gastric rupture following impaction with debris. All of the pieces of netting and other debris were recovered, transported to the Humboldt State University Vertebrate Museum (HSUVM), and washed and dried. Each piece was labeled, weighed, mesh opening size was measured, and twine material, diameter, color, knot configuration, and fishery type were determined when possible. All of these criteria were used to categorize each piece of netting into a distinct type.

On March 15 2008, a second sperm whale, TMMC C251, was found dead on the beach at Tomales Point, Point Reyes National Seashore, California. It was a 15.6 m long male in poor nutritional condition (prominent transverse processes of the vertebrae, blubber thickness on the lateral aspect of the axillary girth was 15 cm

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Table 1

Composition of derelict floating debris found in two sperm whale stomachs stranded in northern California, 2008.

	HSUVM 2673	TMMC C251	Total
Number of net pieces	59	105	164
Number of net types	44	96	134
Dry weight of netting (kg)	22.16	57.14	79.30 (81%)
Dry weight of line pieces (kg)	1.47	15.41	16.88 (17%)
Dry weight of bags (kg)	0.57	1.08	1.65 (2%)
Total dry weight (kg)	24.20	73.63	97.83

thick) that was moderately decomposed. The left flipper had necrotic skin in the axilla and multiple linear scars along its leading edge and an indentation on the dorsal surface consistent with damage resulting from entanglement with a line. The blubber underlying the dorsal indentation and the necrotic axillary skin was deep purple, whereas muscle underlying the discolored blubber, although decomposing, appeared normal. The stomach of this whale was intact and contained a large amount of net, line, and plastic bags. This debris completely occluded the pylorus and impacted the third chamber of the stomach. The extent of impaction coupled with the emaciated body condition of this animal suggests starvation following gastric impaction was the cause of death in this animal, although decomposition precluded histological examination of other tissues. About 50% of this material was recovered and transported to HSUVM where it was washed, dried and evaluated as above.

The majority of debris in each whale consisted of scraps of netting (81% dry weight), pieces of line (17%) and pieces of bags, made mostly of plastic (2%) (Table 1). Fifty-nine pieces of netting were collected from whale 2673, and 105 pieces from whale C251, although a few of these pieces may have been torn from others during extraction. The pieces ranged in size from 10 cm² to about 16 m². All of the pieces had at least one cut edge, most had ragged holes torn in them, some had hand stitching, all suggesting that these scraps had been discarded during net repairs. Five pieces were new, and most likely had never been used for fishing. There were 134 different types of netting (Table 1), with only six types observed in both animals. The types ranged from small (1 cm) to large (9 cm) mesh size constructed of thin and thick (0.7–4.2 mm) twine, and included bait nets, gill nets, and shrimp and fish trawl nets. All netting was made of floating polyethylene except for two pieces made of nylon. The majority were constructed of twisted cord and tied, with only nine of the woven “Ultra Cross” type. Twisted cord is used mostly by Asian fishers in the Western Pacific, whereas braided cord is used in US and Canadian waters. The orientation of the knots relative to the direction the net collapses indicates whether or not the netting had been dimension stretched after it was woven, a practice that became standard among US and Canadian net manufacturers starting around 1985. It is possible that Asian manufacturers still produce netting that is not dimension stretched. Knot orientation could be determined for 114 of the 134 types of netting, and slightly more than half (53%) had not been dimension stretched. Some of these net scraps may therefore have been at sea for at least 20 years. Polyethylene netting was first used in the North Pacific in the 1970s and was aboard most fishing vessels by 1980. This type of hazard therefore is recent.

The remaining debris included pieces of line of a variety of lengths and diameters, all of it made of floating polyethylene except for a few pieces of nylon line tied to floating net or line. There also was a variety of plastic garbage bag scraps and one large (0.9 kg) bag woven of narrow plastic strips in C251.

The sources of the derelict debris observed in these whales' stomachs cannot be determined, as the feeding sites for these

individual animals and the sources of the nets are unknown. The wide variety of floating net and line types, coupled with the assumed age of the debris, indicates that these whales ingested the debris at or near the surface rather than during depredation interactions with a specific fishery, extracting fish from gill nets for example. The debris likely accumulated over many years, possibly in the North Pacific gyre that would carry Asian netting into eastern Pacific waters. Sperm whales are widely distributed across the entire North Pacific and into the southern Bering Sea, but the majority are thought to be south of 40° N in winter (Rice, 1989). Pichel et al. (2007) demonstrated that the greatest concentration of debris in the North Pacific Subtropical Convergence Zone occurs during the winter at about 30° N. Sperm whales are thought to ingest their prey whole via suction (Caldwell et al., 1966; Heyning and Mead, 1996). Perhaps a piece of netting, after years floating at the surface, becomes compacted with accumulated organic material so that it mimics a food source for opportunistic scavenging. These two strandings illustrate that discarded nets can have severe impacts on marine mammal health, and highlight the need for preventing the deposition of debris into the marine environment.

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References

- Baird, R., Hooker, S.K., 2000. Ingestion of plastic and unusual prey by a juvenile harbour porpoise. *Marine Pollution Bulletin* 40, 719–720.
- Boren, L.J., Morrissey, M., Muller, C.G., Gemmill, N.J., 2006. Entanglement of New Zealand fur seals in man-made debris at Kaikoura, New Zealand. *Marine Pollution Bulletin* 52, 442–446.
- Caldwell, D.K., Caldwell, M.C., Rice, D.W., 1966. Behavior of the sperm whale, *Physeter catodon* L. In: Norris, K.S. (Ed.), *Whales, Dolphins and Porpoises*. University of California Press, Berkeley, CA, pp. 677–717.
- Croxall, J.P., Rodwell, S., Boyd, L., 1990. Entanglement in man-made debris of Antarctic fur seals at Bird Island, South Georgia. *Marine Mammal Science* 6, 221–233.
- Dau, B.K., Gilardi, K.V.K., Gulland, F.M., Higgins, A., Holcomb, J.B., St. Leger, J., Ziccardi, M.H., 2009. Fishing gear-related injury in California marine wildlife. *Journal of Wildlife Diseases* 45 (2), 355–362.
- De Meirelles, A.C.O., De Rego Barros, H.M.D., 2007. Plastic debris ingested by a rough-toothed dolphin, *Steno bredanensis*, stranded alive in northeastern Brazil. *Biotemas* 20, 127–131.
- Gomercic, M.D., Galov, A., Gomercic, T., Skrtic, D., Curkovic, S., Lucic, H., Vukovic, S., Arbanasic, H., Gomercic, H., 2009. Bottlenose dolphin (*Tursiops truncatus*) depredation resulting in larynx strangulation with gill-net parts. *Marine Mammal Science* 25 (2), 392–401.
- Goetzlany, J.F., 1998. Unusual deaths of two free-ranging Atlantic bottlenose dolphins (*Tursiops truncatus*) related to ingestion of recreational fishing gear. *Marine Mammal Science* 14 (3), 614–617.
- Haase, B., Felix, F., 1994. A note on the incidental mortality of sperm whales (*Physeter macrocephalus*) in Ecuador. Report to the International Whaling Commission 15, 481–483.
- Heyning, J.E., Mead, J.G., 1996. Suction feeding in beaked whales: morphological and observational evidence. *Contributions in Science, Natural History Museum of Los Angeles County* 464, 1–12.
- Laist, D.W., 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: Coe, J.M., Rogers, D.B. (Eds.), *Marine Debris: Sources, Impacts and Solutions*. Springer Verlag, New York, NY, pp. 99–140.
- Levy, A.M., Brenner, O., Scheinin, A., Morick, D., Ratner, E., Goffman, O., Kerem, D., 2009. Laryngeal snaring by ingested fishing net in a common bottlenose dolphin (*Tursiops truncatus*) off the Israeli shoreline. *Journal of Wildlife Diseases* 45 (3), 834–838.

- Mate, B.R., 1985. Incidents of marine mammal encounters with debris and active fishing gear. In: Shomura, R.S., Yoshida, H.O. (Eds.), Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26–29 November 1984, Honolulu, Hawaii. NOAA Technical Memorandum NMFS-SWFC-54. NOAA, Silver Spring, MD, pp. 453–457.
- Moore, E., Lyday, S., Roletto, J., Little, K., Parrish, J.K., Nevins, H., Harvey, J., Mortenon, J., Greig, D., Piazza, M., Hermance, A., Lee, D., Adams, D., Allen, S., Kell, S., 2009. Entanglements of marine mammals and seabirds in central California and the north-west coast of the United States 2001–2005. *Marine Pollution Bulletin* 58, 1045–1051.
- Moser, M.L., Lee, D.S., 1992. A fourteen-year survey of plastic ingestion by western North Atlantic seabirds. *Colonial Waterbirds* 15, 83–94.
- Neilson, J.L., Straley, J.M., Gabrielle, C.M., Hills, S., 2008. Non-lethal entanglement of humpback whales (*Megaptera novaeangliae*) in fishing gear in northern Southeast Alaska. *Journal of Biogeography* 36, 452–464.
- Northridge, S.P., 1984. World review of interactions between marine mammals and fisheries. *FAO Fisheries Report* 251, 1–190.
- Pace, D.S., Miragliuolo, A., Mussi, B., 2008. Behavior of a social unit of sperm whales (*Physeter macrocephalus*) entangled in a drift net off Capo Palinuro (southern Tyrrhenian Sea, Italy). *Journal of Cetacean Research and Management* 10 (2), 131–135.
- Pichel, W.G., Churnside, J.H., Veenstra, T.S., Foley, D.G., Friedman, K.S., Brainard, R.E., Micoll, J.B., Zheng, Q., Clemente-Colòn, P., 2007. Marine debris collects within the North Pacific Subtropical Convergence Zone. *Marine Pollution Bulletin* 54, 1207–1211.
- Rice, D.W., 1989. Sperm whale *Physeter macrocephalus*, Linnaeus 1758. In: Ridgway, S.H., Harrison, R.J. (Eds.), *Handbook of Marine Mammals*, vol. 4. Academic Press, London, pp. 177–233.
- Spear, L.B., Ainley, D.G., Ribic, C.A., 1995. Incidence of plastic in seabirds from the tropical Pacific, 1984–1991: relation with distribution of species, sex, age, season, year and body weight. *Marine Environmental Research* 40 (2), 123–146.
- Stamper, M.A., Whitaker, B.R., Schofield, T.D., 2006. Case study: morbidity in a pygmy sperm whale *Kogia breviceps* due to ocean-borne plastic. *Marine Mammal Science* 22, 719–722.
- Tarpley, R.J., Marwitz, S., 1993. Plastic debris ingestion by cetaceans along the Texas coast: two case reports. *Aquatic Mammals* 19 (2), 93–98.
- Tomás, J., Guitart, R., Mateo, R., Raga, J.A., 2002. Marine debris ingestion in loggerhead sea turtles, *Caretta caretta*, from the Western Mediterranean. *Marine Pollution Bulletin* 44, 211–216.
- Walker, W.A., Coe, J.M., 1990. Survey of marine debris ingestion by odontocete cetaceans. In: Shomura, R.S., Godfrey, M.L. (Eds.), Proceedings of the Second International Conference on Marine Debris, 2–7 April 1989, Honolulu, Hawaii. NOAA Technical Memorandum NMFS-SWFSC-154. NOAA, Silver Spring, MD, pp. 747–774.