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Short Note

Ingestion of Floating Net Debris in Sperm Whales and Larynx Strangulation with Gillnet Parts in Bottlenose Dolphins on the Coast of Tunisia

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Anthropogenic marine plastic pollution is impacting marine biota and ecosystems at many different levels (Ryan, 2016). Although debris can include plastic, glass, wood, rubber, metal, paper, and clothing, plastic is the most prevalent debris found in the marine environment (Cozar et al., 2014). Estimates report that plastic makes up 60 to 80% of all debris found in the oceans (Derraik, 2002).

Impacts are reported from a wide range of organisms, including microbiota, invertebrates, and vertebrates (Galloway et al., 2017; Law, 2017; Thiel et al., 2018). Floating plastic debris can be transported thousands of kilometers through ocean currents toward new habitats that had not been polluted previously (Kiessling et al., 2015). Two fundamental types of interaction occur between marine organisms and debris: (1) ingestion and (2) entanglement. Interactions with plastics by marine vertebrates are known since plastic has been found in the digestive tract of many taxa such as fish, turtles, birds, and marine mammals in which, due to the sheer size of some large cetaceans, very large volumes of plastic have been found during necropsies (Derraik, 2002). Entanglement of seabirds, turtles, sharks, and marine mammals in large litter (e.g., nets, ropes, etc.) has been documented since the early 1970s (Derraik, 2002). Lethal effects of entanglement include drowning, while sublethal ones involve skin lesions, compromised feeding, limited predator avoidance capabilities, and reduced reproductive capacity and growth that eventually lead to reduced fitness (Gregory, 1991; Laist, 1997; Katsanevakis, 2008). Available evidence suggests that debris ingestion may cause sublethal pathologies, such as ulcerations, perforations, and obstruction of the digestive tract followed by disrupted digestion, feelings of satiation, general debilitation, or starvation, potentially leading to death in the long term (Walker & Coe, 1990; Jacobsen et al., 2010; Brandão et al., 2011).

Interaction with fishing gear is an important factor in cetacean pathology (Gomerčić et al., 2009; Baulch & Perry, 2014; Unger et al., 2016; Fossi et al., 2018). Cetaceans have been documented to interact with fisheries by (1) feeding on the same target species or associated nontarget species of a fishery (Fertl & Leatherwood, 1997; Knowlton et al., 2016; Tellechea et al., 2017), (2) being attracted to fishing operation discards (Hamer et al., 2012), and/or (3) passively encountering fishing gear in the water column (Johnson et al., 2005; Tellechea et al., 2017). Incidental capture of a cetacean is the form of interaction most frequently reported by fisheries; for example, entrapment and entanglement in fishing nets usually have a high mortality rate and may impact the population dynamics of small or localized cetacean populations (Northridge, 1984; Northridge et al., 2011; Dewhurst-Richman et al., 2020). Although incidental captures usually result in the death of the animal concerned, there are also instances where cetaceans are injured or affected in some way during fishing operations so that their survival probability or reproductive potential is compromised (Northridge, 1984; Northridge et al., 2011; Dewhurst-Richman et al., 2020). Cetacean interaction with fishing gear can impact the entire body (e.g., death) or select anatomical systems such as the digestive tract, respiratory system, and musculoskeletal system. Ingestion of fishing gear (e.g., hooks and lures) can cause damage to the digestive and respiratory tracts leading to death (Gorzelany, 1998). Cetaceans may suffer from blockage of the alimentary tract due to ingested debris (Laist, 1987, 1997; Derraik, 2002; Levy et al., 2009; Alexiadou et al., 2019). Ingested debris in marine mammals has typically been detected via postmortem examination of harvested, bycaught, or stranded animals (Walker & Coe, 1990; Laist, 1997; Baird & Hooker, 2000; De Meirelles & Barros, 2007).

In toothed whales, the position of the larynx makes it vulnerable to ingested foreign bodies (e.g., fishing-net parts) during deglutition (Gomerčić et al., 2009). The larynx is elongated into a tubular extension, the laryngeal spout, that transverses the digestive tract into the nasal cavity where it remains in the erect position during deglutition. This position of the larynx provides a direct conduit for inspired air from the blowhole and nasal cavity to the larynx, trachea, and lungs, while food is swallowed through wide food channels lateral to the larynx (esophagus) (Reidenberg & Laitman, 1987). As larynx strangulation with gillnet parts has scarcely been reported previously as a cetacean pathology, our goal is to present findings and hypothesize on the pathogenesis of this cause of mortality.

In this short note, we present details on the mortality of four bottlenose dolphins (*Tursiops truncatus*) by larynx strangulation and the mortality of two sperm whales (*Physeter macrocephalus*) via acute stomach ulcers due to ingestion of gillnet parts found stranded along the coast of Tunisia, Gulf of Gabes, in the Mediterranean Sea.

We investigated marine mammal strandings on the coast of Tunisia for over 2 years (Figure 1). Carcasses of four bottlenose dolphins and two sperm whales were found on the beach from March 2018 to March 2020 and were subsequently examined (for geographic details, see Figure 1 & Table 1). Postmortem examinations included determination of species, sex, weight, external measurements, and a pathoanatomical dissection according to a standard protocol (based on Kuiken & García Hartmann, 1991).

In animals with signs of strangulation, such as a fishing-net part hanging from the mouth or gillnet parts forming an interweaved cord encircling the dorso-lateral wall of the larynx, the areas were specifically examined macroscopically, photographed, and both the larynx and pharynx were dissected during necropsy (Figure 2). The skin and superficial muscles of the head and mandible were removed with a knife after which the mandible was disarticulated on both sides. Subsequently, the mouth and pharynx were examined, and the larynx was dissected and sagittally sectioned. The larynx samples were stored permanently in 4% formalin at the Ecole Nationale De Médecine Vétérinaire. The necropsy protocols of Pugliares et al. (2007) were followed for the necropsy of the six animals examined. Data on ingestion of plastic debris and gillnets were obtained for each specimen.

Bottlenose Dolphin Carcasses

In all four bottlenose dolphins, the larynx was strangled with gillnet filaments (Table 1; Figure 2). Each dolphin also had gillnet parts in their forestomach.

There were no external lacerations, net marks, or subcutaneous hemorrhages on the skin of any of the four bottlenose dolphins. The dolphins were also neither gravid nor lactating. The main abnormal finding was the presence of stranded-cord, nylon, and gillnet filaments wrapped around the larynx of each dolphin (see example in Figure 2), just caudal to the aryepiglottic tube. The net filaments cut into the soft tissue and were located within a deep groove flanked by exuberant and irregular soft tissue proliferation. The epiglottis and plica aryepiglottica were rounded and appeared swollen. The netting material extended down into the esophageal lumen and inside the forestomach. Inside each forestomach, there was a mass composed of netting filaments. The fundic and pyloric (second and third) gastric chambers and the intestines were empty and contained slimy, yellowish-green mucus. Due to the advanced state of decomposition, we were only able to observe a partial strangulation of the larynx in the four dolphins, which surely caused suffocation. The larynx was in an identical state in each of the four dolphins, partially or almost completely strangled by the cords and filaments of the nets. When partially unraveled, the net mass in the dolphins was found to be composed of sections of different types of gillnet with mesh sizes from 5 to 15 cm. The type of gillnet material in all four dolphins was double/multiple-stranded, and it was made of nylon monofilament line.

Sperm Whale Carcasses

The first sperm whale was found dead on the beach (Table 1). The whale was slightly decomposed, it did not appear emaciated, and there was no evidence of entanglement scars or other injury. Due to the state of interior decomposition, it was not possible to observe lesions in the tissues. 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. Then, the entire abdominal cavity was opened, and a large mass of compacted nylon and plastic netting (about 3 kg) was observed protruding through a rupture in the first compartment of the stomach. The whale apparently had recently fed as there were several (about 2 kg) 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. The cause of death was presumed to be gastric rupture following impaction with net debris.

The second sperm whale was also found dead on the beach (Table 1). There was no evidence of entanglement scars or other external injury. The stomach of this whale was intact and contained a large amount of nylon net, line, and plastic bags. This debris completely occluded the pylorus and impacted the third chamber of the stomach. The

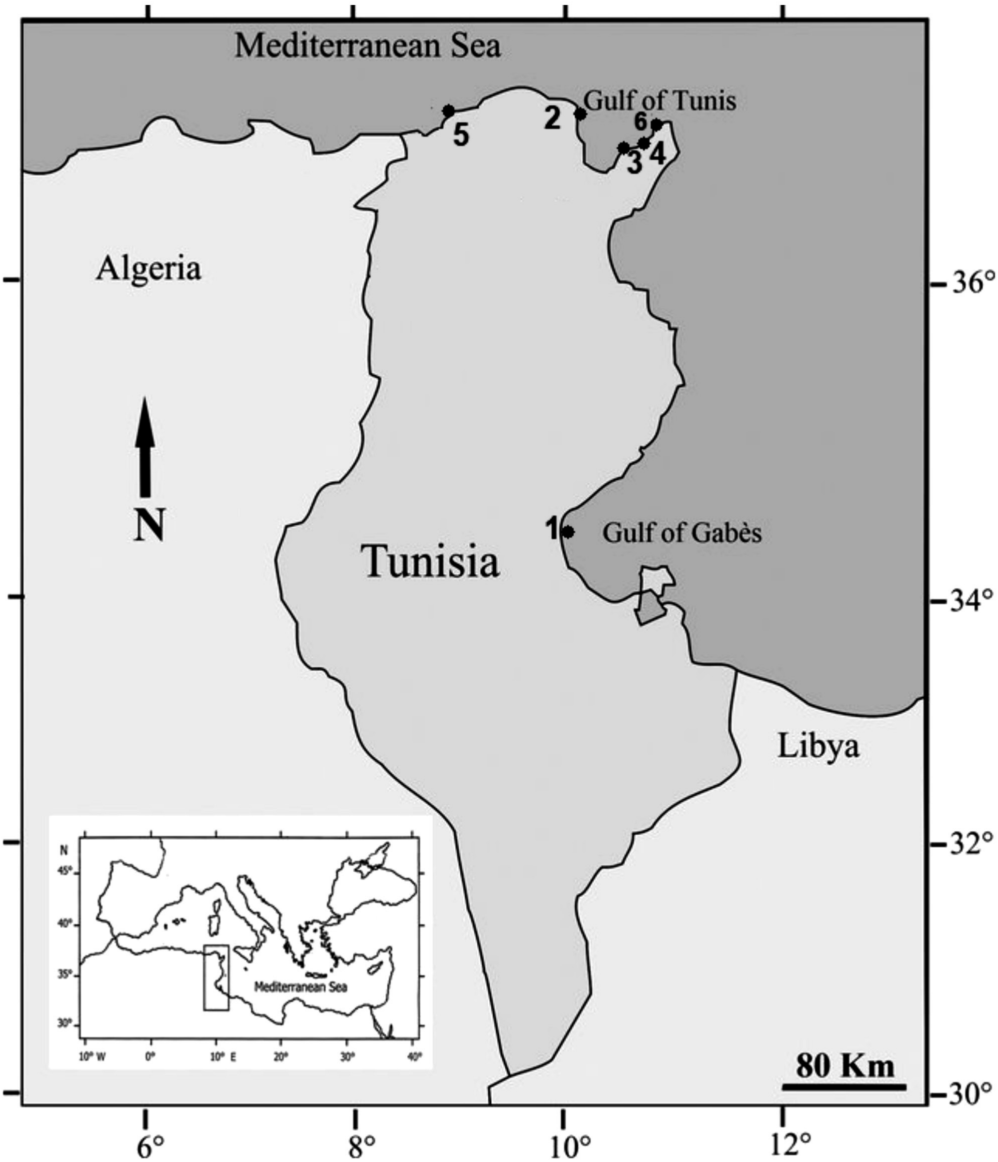

Figure 1. Map of the Tunisia coast showing the position of stranded species examined in this study. See Table 1 for information on each specimen.

extent of impaction coupled with the emaciated body condition of this animal suggests that starvation following gastric impaction was the cause of death, although decomposition precluded histological examination of other tissues. For both sperm whales, the nets were mainly composed of nylon.

Some species of cetacean forage at depths where direct observations of their feeding habits are basically impossible. Stomach content analysis of stranded cetaceans is a method that has been well established for studying debris ingestion (Baulch & Perry, 2014; Stelfox & Hudgins, 2015; Fossi et al., 2018; Kühn & Franeker, 2020). Ideally, the whole gastrointestinal tract of a stranded cetacean should be examined since smaller pieces of debris (i.e., microplastics) can pass from the stomach to the intestines (Walker & Coe, 1989; Panti et al., 2019).

Table 1. Data for each stranded specimen on the coast of Tunisia; the number of each animal is correlated to the map in Figure 1.

Species	Sex	Position	Total length (m)	Weight (kg)	Larynx strangulation	Net in stomach
1 *Tursiops truncatus*	Male	34N21'75, 10E05'19	3.10	254	Yes	Yes
2 *T. truncatus*	Female	37N25'72, 09E90'94	2.12	190	Yes	Yes
3 *T. truncatus*	Female	36N88'44, 10E71'46	3.50	263	Yes	Yes
4 *T. truncatus*	Female	36N88'44, 10E71'46	3.05	222	Yes	Yes
5 *Physeter macrocephalus*	Female	37N06'46, 08E95'36	5.60	1,256	No	Yes
6 *P. macrocephalus*	Male	36N88'44, 10E71'46	7.00	2,000	No	Yes

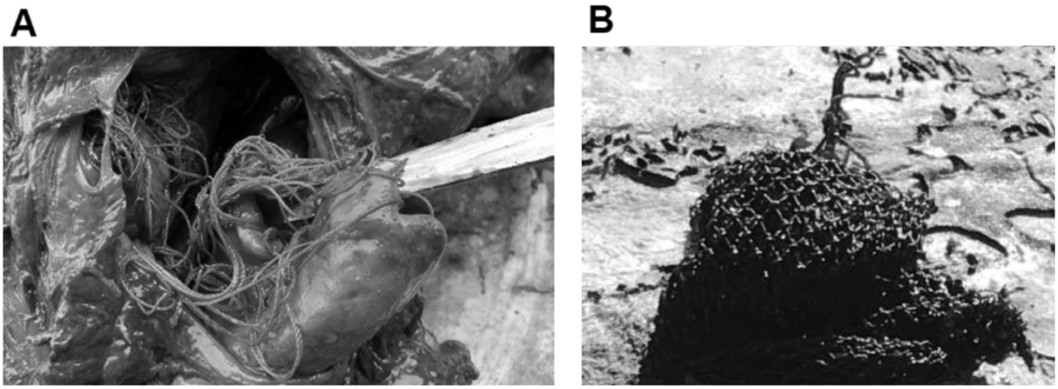

Figure 2. (A) Gillnet part causing larynx strangulation and protruding from the mouth of a bottlenose dolphin (*Tursiops truncatus*); and (B) part of a gillnet obtained from a sperm whale (*Physeter macrocephalus*) stomach.

It is probable that larynx strangulation may have occurred when a dolphin tore off a part of a gillnet while feeding on fish entangled in it, though it may be more frequent for gillnet part(s) to be swallowed together with prey without any larynx strangulation. This is supported by findings of dolphins with gillnet parts in their forestomachs but without larynx strangulation (Gomerčić et al., 2009). However, torn gillnet parts might only partly pass into the esophagus during prey swallowing while the rest of the parts hang through the pharynx into the oral cavity and out of the mouth. Such gillnet parts cannot be further sucked into the oral cavity and swallowed completely. A partially swallowed gillnet part could trigger automatic muscle reaction and regurgitation or a dolphin could also try to get rid of the material by voluntarily regurgitating (Yeater, 2005). This muscular action brings the swallowed part of the gillnet out of the esophagus and into the pharynx. These subsequent events are probably crucial for strangulation to occur as we saw in the bottlenose dolphin cases.

Sperm whales are thought to ingest their prey whole via suction (Caldwell et al., 1966; Heyning, 1996). Perhaps a piece of netting, after years of floating at the surface or at depth, becomes compacted with accumulated organic material so that it mimics a food source for opportunistic scavenging by a sperm whale. These two sperm whale strandings illustrate that discarded nets can have severe impacts on marine mammal health and highlight the necessity of preventing debris from entering into the marine environment (Jacobsen et al., 2010).

The sources of derelict debris observed in these sperm whales' stomachs cannot be determined as feeding sites for these individual animals and sources of the net materials are unknown. The wide variety of floating net and line types found in their stomachs, 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—for example, by extracting fish from gillnets.

These bottlenose dolphin and sperm whale strandings illustrate again that discarded nets can have severe impacts on marine mammal health. They highlight once more the need for preventing the deposit of anthropogenic debris into the marine environment, and they reveal for the first time that this problem exists along the coast of Tunisia.

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