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Note

Plastic debris straps on threatened blue shark *Prionace glauca*

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ABSTRACT

Juveniles of blue shark *Prionace glauca* caught in pelagic longlines targeting tuna and swordfish in the Atlantic Ocean and the Mediterranean Sea were found entangled with plastic straps around their gill region. The plastic debris were identified as strapping bands and caused several degrees of injuries on the dorsal musculature and pectoral fins. They were also obstructing the gill slits probably causing breathing issues. These records were uploaded in the web site seawatchers.org, and highlight the potential of citizen science in revealing the occurrence of such problems which could help to measure the effects of plastic debris on marine life.

Plastic debris is increasing globally (Barnes et al., 2009) and they are considered an emerging problem that threatens marine life (Deudero and Alomar, 2015). Plastics are organic polymers whose characteristics: lightweight, tough, durable and inexpensive, make them suitable for the manufacture of a wide range of products (Laist, 1987). But precisely these same properties make them so dangerous to the marine environment. Jambeck et al. (2015) has estimated that 4.8 to 12.7 million metric tons of plastics entered the oceans in 2010, with a growing trend. Shipping, fishing and transport activities are the main sea-based sources reaching the open ocean (Derraik, 2002); while land-based sources such as tourism, adjacent industries or river inputs (Browne et al., 2010) are the origin of the plastics in coastal waters (Cliff et al., 2002). Marine organisms interact with plastics in several manners, but the main threats are the ingestion of plastic debris and the entanglement in discarded fishing gear, synthetic ropes and lines, or strapping bands (Laist, 1987) which can cause impacts of several degrees of gravity, sometimes being very harmful and even fatal. Although information on entanglement by plastic debris has been recorded in some shark species over the world (Laist, 1997), few data is available for the Mediterranean Sea. This lack of scientific information and the reduced ability of researchers to monitor all marine areas can be complemented by a volunteer monitoring also known as "citizen science".

Since 2012, within the context of a multidisciplinary web site "Sea Watchers" (http://www.seawatchers.org) coordinated by the Institute of Marine Sciences (ICM-CSIC) of Barcelona (Spain), citizens post their observations, usually sending digital images, which appear in a public map in the web site and are validated by a scientific team.

Here we document the first occurrence of a blue shark *Prionace glauca* (Linnaeus, 1758) entangled with a plastic debris ring in the Mediterranean Sea, and 5 other specimens from the Atlantic Ocean entangled with strapping bands. Additionally we also conducted a literature review to know the occurrence of the entanglement by plastic debris collars in other sharks, especially on threatened species (Table 1).

Prionace glauca is a pelagic and oceanic shark, although occasionally also occurs close inshore (Serena, 2005). It can be found worldwide in temperate and tropical waters from the sea surface down to 1160 m depth (Queiroz et al., 2012). It is relatively fast-growing; reaching a maximum size of 380 cm total length (TL). Males attain sexual maturity at 183 to 218 cm TL (4 to 6 years) and females are fully mature at 166 to 221 cm TL (5 to 7 years) (Pratt, 1979; Skomal and Natanson, 2003), producing litters of 35 pups of about 35–50 cm TL. *P. glauca* is taken in large numbers by commercial fisheries, mainly as bycatch of pelagic longlines targeting tuna or swordfish, but these catches are misreported. In the Atlantic Ocean a decline of 30% over the last 30 years placed the *P. glauca* as Near Threatened in the International Union for Conservation of Nature and Natural Resources' Red List of Threatened Species (Sims et al., 2015). The Mediterranean Sea population is considered to be a distinct one from the Atlantic population due to a very limited exchange of *P. glauca* individuals between these populations based on tags and satellite tracking studies (Kohler and Turner, 2008); and it is listed as Critically Endangered based on a past decline of up to 90% over three generations resulting from ongoing overfishing (Sims et al., 2015).

On 10 July 2016, a juvenile female of *P. glauca* with a yellow plastic collar surrounding its gill area (Fig. 1) was captured at 5:00 am by a commercial longline boat in the NW Mediterranean Sea (40° 56′ N-1° 12′ E). The plastic debris was identified as a polyolefin strapping band and removed from the shark. The ring encircled the gill region causing

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Table 1
Review of shark species injured by plastic debris worldwide (excluding fishing gear), with indication of IUCN conservation status (DD: Data Deficient, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered, CR: Critically Endangered), material type, location, number of sharks (n) and source of information.

Species	Family	IUCN status	Material type	Location	n	Source
Isurus oxyrinchus	Lamnidae	VU	Rubber automobile tire	Gulf of Mexico	1	Gudger and Hoffmann, 1931
Squalus acanthias	Squalidae	VU	Rubber band	Norwegian Sea	2	Hognestad, 1970
Squalus acanthias	Squalidae	VU	Rubber band	North Sea	1	Berland, 1971
Carcharhinus leucas	Carcharhinidae	NT	Plastic straps	Northwest Atlantic	1	Bird, 1978
Carcharhinus obscurus	Carcharhinidae	VU	Plastic straps	Northwest Atlantic	1	Bird, 1978
Galeocerdo cuvier	Carcharhinidae	NT	Plastic straps	Northwest Atlantic	1	Bird, 1978
Carcharhinus acronotus	Carcharhinidae	NT	Monofilament line	Northwest Atlantic	1	Schwartz, 1984
Mustelus lenticulatus	Triakidae	LC	Sausace tags	New Zealand Waters	1	Cawthorn, 1985
Rhizoprionodon lalandii	Carcharhinidae	DD	Plastic debris rings	Southwest Atlantic	3	Sazima et al., 2002
Carcharhinus brevipinna	Carcharhinidae	NT	Plastic straps	Southeast Atlantic	2	Cliff et al., 2002
Carcharhinus brachyurus	Carcharhinidae	NT	Plastic straps	Southeast Atlantic	4	Cliff et al., 2002
Carcharhinus leucas	Carcharhinidae	NT	Plastic straps	Southeast Atlantic	2	Cliff et al., 2002
Carcharhinus limbatus	Carcharhinidae	NT	Plastic straps	Southeast Atlantic	9	Cliff et al., 2002
Carcharhinus obscurus	Carcharhinidae	VU	Plastic straps	Southeast Atlantic	27	Cliff et al., 2002
Carcharhinus plumbeus	Carcharhinidae	VU	Plastic straps	Southeast Atlantic	2	Cliff et al., 2002
Galeocerdo cuvier	Carcharhinidae	NT	Plastic straps	Southeast Atlantic	2	Cliff et al., 2002
Carcharodon carcharias	Lamnidae	VU	Plastic straps	Southeast Atlantic	5	Cliff et al., 2002
Prionace glauca	Carcharhinidae	NT	Plastic straps	Southwest Atlantic	17	Santos, 2006
Prionace glauca	Carcharhinidae	NT	Plastic straps	Southwest Atlantic	2	Cardoso and Vooren, 2010
Isurus oxyrinchus	Lamnidae	VU	Rope	Northeast Pacific	1	Wegner and Cartamil, 2012
Carcharhinus galapagensis	Carcharhinidae	NT	Plastic cuff	North Pacific	1	http://seapics.com/feature-subject/conservation-issues/shark-finning-shark-fishing-pictures-004.html
Cetorhinus maximus	Cetorhinidae	VU	Plastic traps	North Sea	3	http://baskingsharkscotland.co.uk/basking-sharks-injured-by-marine-debris/
Carcharodon carcharias	Lamnidae	VU	Plastic traps	Indic Ocean	1	http://cms.ausgeo.bauer-media.net.au/news/2010/11/great-white-shark-freed-from-plastic-noose

damage to the tissue of this area and in the front part of the right pectoral fin. The fifth gill slit was obstructed by the plastic band which could cause breathing problems. The female of 49 cm fork length (FL) and 700 g total weight (TW) was released alive after removing the hook and the plastic ring.

The 5 specimens of *P. glauca* from the Atlantic Ocean were juveniles also captured by the pelagic longline fleet and kept onboard dead as part of the catch. All of them were found with white polyolefin packing straps, around their gills. The first specimen, a female of 114 cm FL and 6500 g gutted weight (GW) was caught on 15 January 2016 at 35° 11′ N-10° 46′ W. The plastic strap caused abrasions in the dorsal musculature where the knot of the strap carved an open wound. The second specimen was captured on 23 February 2016 at 36° 0′ N- 9° 14′ W. The plastic band caused severe erosion in the dorsal area between the pectoral fins (Fig. 1). The third specimen was caught on 16 March 2016 at 35° 56′ N-15° 51′ W. The strap caused damage in the front part of both pectoral fins and the knot in the strap injured the dorsal skin. On the left side of the gill region, the strap was obstructing the fourth and the fifth gill slits. There is no biological data (sex, length and weight) available for both previous sharks. The fourth specimen was also captured on 16 March 2016 but in a different position 35° 51′ N-15° 1′ W. It was a female with a plastic strap causing wounds on the back and pectoral fins. The fifth specimen (Fig. 1) was a female caught on 19 March 2016 at 36° 11′ N-9° 15′ W. The plastic ring settled into the groove between the pectoral fins and obstructed the fourth gill slit on both sides of the body applying pressure on the gill region possibly causing breathing problems.

Sharks are usually considered keystone species in marine environments and the loss of these predators from our oceans would have unpredictable consequences (Barría et al., 2015, Sibersma, 2015, Baum and Worm, 2009). The literature review conducted showed a total of 16 species entanglement around their gill region; the 88% of these species are threatened or near threatened. Although the number of sharks that become entangled and die undetected could be much greater than those reported since they will invariably die at sea and very likely be rapidly consumed (Butterworth et al., 2012). Carcharhinidae, as *Prionace glauca*, are the most affected by plastic straps (Laist, 1997) (Table 1) since this family are the most abundant shark groups in coastal areas globally and usually reproduce in shallow waters (Compagno, 1984). The tendency of sharks to investigate objects is the most likely reason for them to become entangled. This attraction can be increased if the bands were associated with a source of food, such as bait or discards from fishing vessels (Cliff et al., 2002).

The problem of plastic waste is very complex. There have been some attempts to address the increasing problem of marine pollution of the world's oceans through international legislation, such as the establishment of the 1972 Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter, although the most important one is probably the 1978 Protocol to the International Convention for the Prevention of Pollution from Ships (MARPOL) (Lentz, 1987). Legislation at the national level also plays an important role. Government laws should promote the prevention of marine waste and its proper management through reuse, recycling, other forms of recovery (including energy) and disposal. The development and use of biodegradable and photodegradable plastics could be one more way to mitigate the problem (Gorman, 1993). A combination of legislation and the enhancement of ecological consciousness through education are likely to be the best way to solve such environmental issues (Derraik, 2002). Promoting public awareness of such phenomenon though citizen science could help to measure the effects of plastic debris on marine life and encourage an environmental culture which makes this kind of accident could be reduced in the near future.

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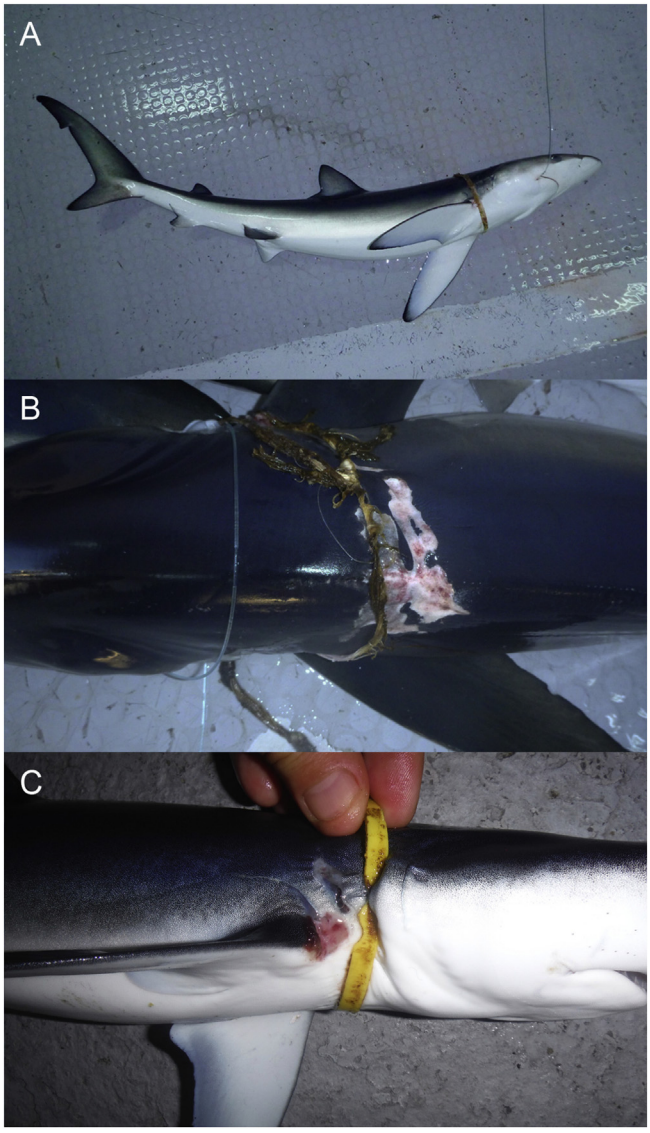

Fig. 1. Blue shark *Prionace glauca* entangled with strapping bands. (A) General view of the fifth specimen. (B) Dorsal view of the second specimen showing the severe erosion caused by a plastic band. (C) Lateral view of the head of the Mediterranean specimen showing damage on the gill region and the pectoral fin by a plastic debris collar.

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