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Evidence of loggerhead sea turtle (*Caretta caretta*, Linnaeus, 1758) injuries caused by Rapido (beam) trawling in the Mediterranean

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The loggerhead turtle (*Caretta caretta*, Linnaeus, 1758) is the most abundant sea turtle species in the Mediterranean Sea, where commercial fishing appears to be the main driver of mortality. The North Adriatic Sea (central Mediterranean) is a major feeding habitat for turtles in the demersal stage. Its shallow and flat seabed is ideal for bottom-towed gears, making interactions with sea turtles and incidental catches unavoidable. We provide evidence of the impact of Rapido trawls (a type of beam trawl) on sea turtles through the analysis of the distinctive injuries sustained by four turtles.

Key words: Caretta caretta; Loggerhead turtle; Sea turtle-fisheries interaction, Rapido trawl, Sea turtle injuries, Mediterranean Sea.

The loggerhead turtle (*Caretta caretta*, Linnaeus, 1758) is the most abundant sea turtle species in the Mediterranean Sea (Casale & Margaritoulis, 2010; Lucchetti and Sala, 2010; Lucchetti et al., 2017) and a priority species listed in Appendix II/IV of the Habitats Directive, the cornerstone of Europe Union's nature conservation policy ("least concern" status; Casale, 2015). The main threats to marine turtle populations in the Mediterranean Sea are related to human activities such as incidental capture by fishing gears, degradation of habitats (mainly of nesting beaches), and marine litter (Margaritoulis et al., 2003). Incidental capture (or bycatch) is probably the most significant danger to sea turtles as well as to several other species worldwide. According to recent data, more than 50,000 turtle capture events are estimated to take place in Italian waters each year; of these, 10,000 are believed to result in death, sketching a more alarming scenario than expected based on earlier estimates (Lucchetti et al., 2017). The most harmful fishing gears are towed gears; in particular, a turtle bycatch hotspot has been identified in the Adriatic Sea (central Mediterranean Sea; Lucchetti & Sala, 2010; Lucchetti et al., 2016a). The shallow seabed and the rich benthic communities characterising this semi-enclosed basin provide a major feeding habitat for loggerhead sea turtles in the demersal stage, especially the populations nesting in Greece (Lazar et al., 2004; Zbinden et al., 2008).

The turtle rescue centres (MTRCs) operating in the Adriatic periodically collect stranded turtles exhibiting distinctive, regularly spaced carapace injuries that are commonly attributed to vessel propellers. In this study we propose a different explanation and provide evidence that at least some of them are caused by fishing gears such as Rapido trawls.

The Rapido trawl is a type of beam trawl (Fig. 1). It is mainly used in the Adriatic Sea to target flatfish (*Solea* spp., *Platichthys flesus*, *Psetta maxima*, *Scophthalmus rhombus*) in muddy inshore areas and, rarely, pectinids (*Pecten jacobaeus*) in sandy offshore grounds in the northern area of the basin. The modern Rapido gear resembles a toothed beam trawl. It consists of a box dredge (about 4 m wide, 120 kg in weight) rigged with

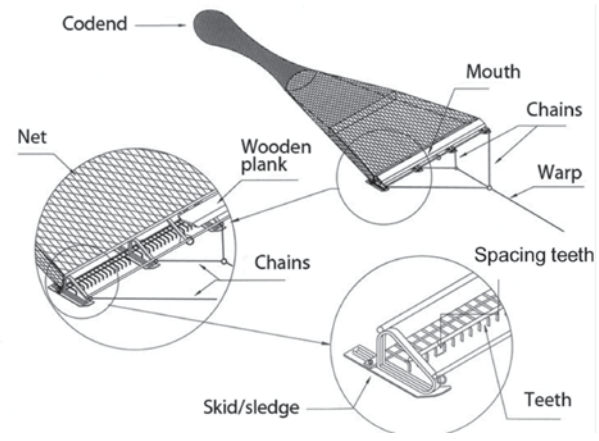

Figure 1. Rapido trawl: technical design and detail of tooth spacing.

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teeth (13-15 cm long) along the lower leading edge, and fitted with a codend to collect the catch (Giovanardi et al., 1998). The gear is towed at high speed (7-8 knots); a spoiler prevents it from rising off the bottom (Pranovi et al., 2000). A commercial vessel typically tows four sets of gears simultaneously. The Rapido trawls used in Adriatic fisheries share the same key characteristics, i.e. tooth spacing, gear dimension, and net length (Fig. 1).

Of the four injured specimens of *C. caretta* described in this study, two were retrieved by the local MTRCs – Fondazione Cetacea (Riccione, North Adriatic Sea) and Legambiente (Manfredonia, South Adriatic Sea) and two by a research institute, the National Research Council (CNR) of Ancona (Central Adriatic Sea) in winter 2016-2017. Whereas three were stranded, the fourth was incidentally caught by a Rapido trawler. Two died at the MTRC from deep bowel perforations a few days after being rescued.

The four specimens were measured (Table 1). All were sub-adults with a curved carapace length of 42 to 60 cm. All bore from two to four regularly spaced wounds on the carapace (Fig. 2). The space between wound pairs was measured. To establish whether the injuries could have been caused by a Rapido trawl, the space between the rake teeth was measured in four Rapido trawls randomly selected from different fishing vessels. All measurements were performed with both a calliper and a tape measure. To minimise errors, each measurement was also recorded with a photograph. Photographs were processed with ImageJ software (Rasband, 2010) to measure the distance between two consecutive wounds and two consecutive rake teeth.

Descriptive statistics (mean and standard deviation) were computed. Data analysis with one-way analysis of variance (ANOVA) showed that there was no significant difference in wound spacing among the four turtles ($p = 0.598$), in rake tooth spacing among the four trawls ($p = 0.142$), or between wound spacing (80.39 ± 6.26 mm) and tooth spacing (79.92 ± 5.71 mm) ($p = 0.848$). The fact that the individual incidentally caught by the trawler presented the same wounds as the other three (Fig. 2) reinforced the hypothesis that all four specimens had been injured by a Rapido rake.

Information on sea turtle bycatch by Rapido trawls is still scarce and unreliable (Lucchetti et al., 2017). However, considering that around 70 vessels operate in the central-northern Adriatic Sea for a total of 130 fishing days per year, and that a Rapido trawler can explore a wide area (ca. 224,000 m^2 per hour) in a single fishing day, interactions with sea turtles are highly likely, especially in winter, when turtles forage near the coast in the same grounds exploited by trawlers (Lucchetti et al., 2016b). As shown by our data, the high towing speed of this gear can injure sea turtles severely and even cause their death.

Interactions between sea turtles and towed gears similar to the Rapido trawl are a major conservation issue in some fisheries, such as the sea scallop dredge in the US, where bycatch is well documented. Although some bycatch-reducing devices have already been tested and adopted (i.e. in US; Haas et al., 2008), the size and

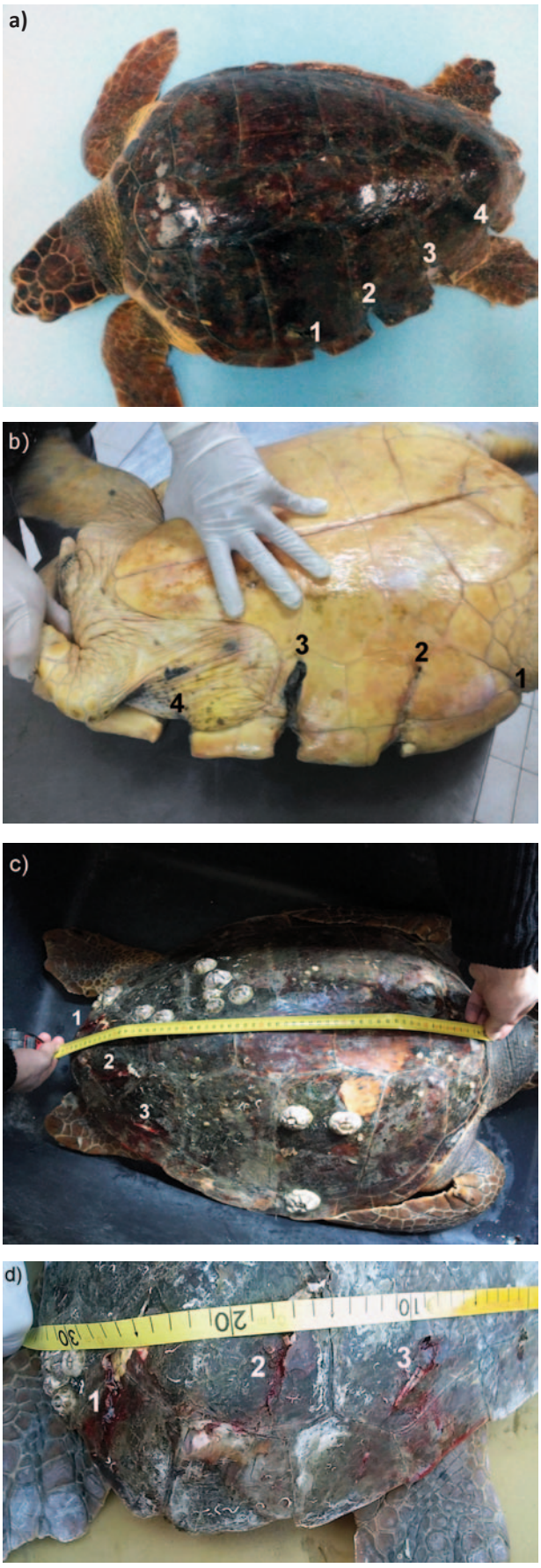

Figure 2. (Top) One of the three stranded sea turtles presenting regularly spaced wounds: **a)** dorsal view, **b)** ventral view. (Bottom) Sea turtle incidentally caught by a Rapido trawler and detail of wounds: **c)** dorsal view, **d)** close up view of the three wounds.

configuration of Rapido trawls (especially its teeth and limited height) and the non-sedentary nature of target species hamper their use in this fishery. Given that the Rapido trawl is banned in the rest of the Mediterranean, management measures, at least spatial and temporal closed areas, should be adopted also in Italy.

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