Fisheries Research 199 (2018) 1–7

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Short Communication

Can ultraviolet illumination reduce sea turtle bycatch in Mediterranean set net fisheries?

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ARTICLE INFO

Handled by Dr. B Arara

Keywords:
Loggerhead turtle
BRD (Bycatch reduction device)
Visual deterrents
Passive nets
Small-Scale fisheries

ABSTRACT

Sea turtles suffer from the cumulative and synergistic effects of natural phenomena and human activities. Among the latter, incidental interaction with commercial fisheries is considered as the main threat to their conservation. Fixed nets are common gears traditionally used in Mediterranean small scale fisheries (SSF). The loggerhead turtle bycatch of fixed nets is estimated to be high and similar to that of trawl nets and longlines, but seems to be associated with higher mortality rates. Devices aiming at reducing sea turtle bycatch through gear modifications have largely been developed for large-scale commercial fisheries, *i.e.* longlines and trawls, but not for set nets. In the present study ultraviolet LED lamps, which have already proved to be effective visual deterrents along the Northern and Southern Pacific coasts, were mounted on fixed nets and assessed for their ability to reduce the loggerhead turtle bycatch in the Mediterranean set net fishery. No turtles were caught in the illuminated net, whereas 16 individuals were captured by the traditional net (mortality rate, 30%). There were no significant differences in the catch rates of target species. This is the first test of a BRD designed to reduce sea turtle bycatch in a Mediterranean set net fishery. A broad diffusion of these bycatch reducer devices (BRDs) would provide a significant contribution to the conservation of loggerhead turtles while enabling large-scale production and cost reduction. However, until this happens the cost of adopting this BRD cannot be afforded by the fishermen operating SSF.

1. Introduction

The loggerhead turtle (*Caretta caretta*) is the most abundant sea turtle species in the Mediterranean Sea (Casale and Tucker, 2015). It is a long-lived, slowly maturing species that nests mainly in the eastern part of the basin (Greece, Turkey, Cyprus, Libya, and southern Italy, Broderick et al., 2002; Margaritoulis et al., 2003; Mingozzi et al., 2007). *Caretta caretta* is included in the IUCN Red List of threatened species and assessed as “least concern”, downgraded from “endangered” (Casale and Tucker, 2015). Information on its ecology, biology, and behaviour, gained from a variety of sources including stranding data, tagging programs, and satellite telemetry studies (Maffucci et al., 2006), show that it occurs in the entire Mediterranean, with a preference for some areas (e.g. the Adriatic, the coastal waters of Tunisia, Libya, and Egypt, and south-east Turkey, Casale and Margaritoulis, 2010) that represent important foraging grounds. In the Mediterranean basin, sea turtles are subject to cumulative and synergistic effects of natural phenomena and human activities; the latter include the ingestion of marine litter, collisions with vessels, destruction of nesting beaches, as well as incidental interaction with commercial fisheries (bycatch), which is considered as the main threat to its conservation (Lucchetti et al., 2016a). Bycatch is the result of a combination of factors that are related both to the species life-cycle and to fisheries characteristics (Lucchetti and Sala, 2010). The technical and operating features of the different fishing gears, influence bycatch amount and composition; for instance, bottom trawl nets and set nets mainly affect turtles in the demersal phase of the life-cycle (Lucchetti et al., 2016a, 2016b), whereas drifting longlines mainly interact with turtles in the pelagic phase (Casale et al., 2007; Piovano et al., 2009).

Drifting longlines and bottom trawls are believed to involve the greatest risk for sea turtles in the Mediterranean Sea. Therefore, most studies of sea turtle bycatch in the Mediterranean have been conducted in large-scale commercial fisheries, which use longlines and trawls, and rarely in set net fisheries. Evaluating the overall impact of small-scale fisheries (SSF) is rather complicated, due mainly to the large number of vessels operating along the Mediterranean coasts and the high heterogeneity in fishing gears used and metier practiced (Lazar and Tvrtkovic, 2003). Small-scale fisheries fleet accounts for about 79% of the EU fishing fleet in the Mediterranean (more than 30,000 vessels, Lucchetti, 2012; STECF, 2016). Passive nets (gillnets, trammel nets, combined

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https://doi.org/10.1016/j.fishres.2017.11.012
Received 24 May 2017; Received in revised form 9 November 2017; Accepted 11 November 2017

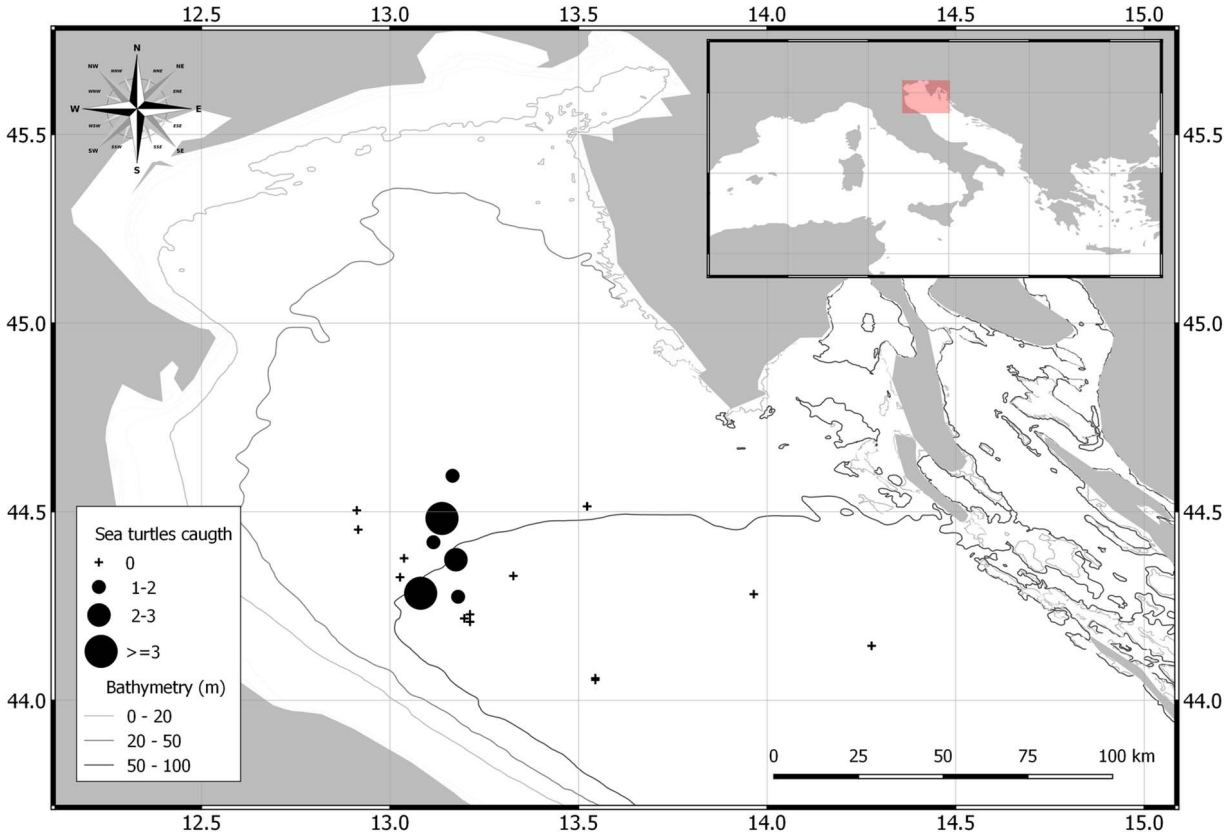

Fig. 1. Map of the study area and of the sea trials carried out in the Mediterranean Sea (Northern Adriatic Sea) indicating bycatch events and the number of turtle specimens caught.

nets, and small driftnets) are among the principal gears used by SSF to target a variety of demersal, benthic, and pelagic species in the Mediterranean (Lucchetti et al., 2015).

Although information about set nets-turtle interactions is scarce and spatio-temporarily scattered, in the Mediterranean region it has been estimated that bycatch is responsible for more than 23,000 incidental catches and 14,000 deaths per year (Casale et al., 2005; Casale, 2011). Recorded capture events concern exclusively loggerhead turtles. Bycatch due to interaction with passive nets is reported as highest in the southern and eastern Mediterranean, along the coast of Egypt (Nada and Casale, 2011), France (Laurent, 1991), and Greece (Casale, 2011), with hotspots in Cyprus (Godley et al., 1998), Tunisia (Echwikhi et al., 2010a), and Turkey (Godley et al., 1998). However, bycatch also seems to be high in other areas, such as Croatia (Lazar et al., 2004a), Syria (Godley et al., 1998), and to a less extent in Italy (Casale, 2011). Indeed, according to Lucchetti et al. (2017a,b) the impact of passive nets along the Italian coast may be underestimated, and could be greater than the one related to bottom trawling and long-lining. Both juvenile and adult life stages of loggerhead turtle are affected, as confirmed by biometric data indicating that the size of the turtles caught ranges from 21 to 80 cm carapace length (Casale et al., 2005; Echwikhi et al., 2010b; Lucchetti et al., 2017b).

Over the past 10 years, a number of technical devices directed at mitigating the fishing impact on sea turtles have been tested in the Mediterranean Sea. Experiments with bycatch reducer devices (BRDs), aimed at making traditional gears more selective or less dangerous for sea turtles while limiting the loss of commercial species, have been conducted mainly in two fisheries, drifting longlining and bottom trawling. Technical modifications in longlines (e.g. hook shape and size, bait type and setting position) to reduce both turtle bycatch and direct mortality have yielded inconsistent results (Echwikhi et al., 2010a; Lucchetti and Sala, 2010; Piovano et al., 2009, 2010; Piovano et al., 2012a, 2012b). On the other hand, as regards the turtle excluder devices (TEDs) developed for bottom trawling (Atabey and Taskavak, 2001; Sala et al., 2011), promising results have recently been obtained using a flexible grid (FLEXGRID, Lucchetti et al., 2016b) developed in the context of the TartaLife Project (www.tartalife.eu); this device proved to be sturdier and easier to handle and ensured greater catch retention compared with the previous devices.

Conversely, the development of BRD for set nets has been lagging behind (Melvin et al., 1999; Gilman et al., 2006). One approach to develop effective BRD for these fisheries is to consider the biological aspects that lead sea turtles to interact with the fishing gear. Understanding turtles' behaviour, particularly their physiology (auditory, chemosensory, and visual abilities, Southwood et al., 2008; Jordan et al., 2013), is crucial to minimize fisheries interactions. Anatomical, physiological, and behavioural studies of their reactions to acoustic stimuli (Southwood et al., 2008; Fritsches and Warrant, 2013) suggest that acoustic deterrents such as the pingers used to protect dolphins (Nestler et al., 1992; Dawson et al., 1998; Cox et al., 2004) are not effective, because the sound intensity required to exert the desired effect is so high that it may also affect the behaviour of other species. Sea turtles rely extensively on visual cues, particularly when foraging (Swimmer et al., 2005), due to their well-developed visual system provided with a wide spectral range (Mäthger et al., 2007; Southwood et al., 2008). This characteristic has prompted the development of visual deterrents such as LED lamps and light sticks to be attached to gillnet float lines (Wang et al., 2010, 2013; Ortiz et al., 2016). Over the past few years, an appreciable decrease in turtle bycatch rates (ranging from 39.7% to 63.9%) and preservation of target species catch rates have been obtained along the Northern and Southern Pacific coasts by illuminating gillnets with green light (Wang et al., 2010; Ortiz et al., 2016) or UV light (Wang et al., 2013).

The present study is a preliminary assessment of the efficacy of UV-LED lamps in a Mediterranean set net fishery and aims to (*i*) find their most suitable rigging to the floatline, (*ii*) assess the effectiveness of net