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Effects of hook and bait in a tropical northeast Atlantic pelagic longline fishery: Part I—Incidental sea turtle bycatch

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ABSTRACT

The interaction between tuna fisheries and sea turtles is commonly recognized as one of the major threats and causes for the decline of sea turtle populations. Within the tuna and swordfish fisheries, the incidental sea turtle bycatch is usually more frequent from longline fisheries targeting swordfish. Therefore it is important to test possible mitigation measures, particularly in areas where fishing activities and high abundance of these species overlaps, as is the case of the Tropical Northeast Atlantic Ocean. Between August 2008 and December 2011, a total of 202 experimental pelagic longline sets were carried out in that region (latitude: 11–22°N, longitude: 20–38°W). The aim was to test the effects of changing the traditional J-style hooks (10° offset) baited with squid used by the fishing industry, against two circle hooks (one non-offset and one with 10° offset) and mackerel bait. Four sea turtle species were captured, with the leatherback *Dermochelys coriacea* comprising most of the bycatches (BPUE, bycatch per unit of effort using the traditional configuration of 0.990 turtles/1000 hooks), followed by three hardshell species: the loggerhead *Caretta caretta* and the olive ridley *Lepidochelys olivacea* (BPUE = 0.165 turtles/1000 hooks), and the Kemp ridley *Lepidochelys kempii* (BPUE = 0.024 turtles/1000 hooks). In general, the sea turtle interactions in the fishery can be reduced by changing from the traditional gear to one of the experimental combinations. However, those reductions were species-specific, with the leatherback bycatches reduced only when changing from J-style to the non-offset circle hook, while for the hardshell turtles both the hook style (using a circle hook, with or without offset) and the bait (using mackerel) significantly reduced the incidental bycatches. Hooking location was also species-specific, with most hardshell specimens hooked by the mouth and esophagus, while leatherbacks were mostly hooked externally by the flippers. Most of the sea turtles were captured and released alive with the mortality rates independent of the hook style and bait type used. A reduction of 55% in leatherback incidental bycatches can be expected in this fishery by changing from J-style to circle hooks, whereas for the hardshell species a 50–59% reduction can be obtained by changing to circle hooks (respectively with and without offset), and a 55% reduction by using mackerel bait.

1. Introduction

The problem of fisheries bycatch, the unintended capture of non-target organisms during fishing operations, has become in recent years a major cause of concern for the management and conservation of marine resources (Hall et al., 2000; Soykan et al., 2008), as it affects virtually all fisheries and fleets at a global scale. Bycatch can be a major driver for marine species declines, particularly for vulnerable megafauna populations characterized for having long life-cycles and low productivity, as is the case of sea turtles, marine mammals, seabirds and most sharks (Lewison et al., 2004, 2013; Read, 2007; Dulvy et al., 2008; Wallace et al., 2010, 2013; Senko et al., 2014).

Within these groups, the incidental bycatch of sea turtles seems to be particularly problematic as six of the seven species living in today's world oceans are listed in one of the International Union for Conservation of Nature (IUCN) Red List threatened categories (IUCN, 2013). Specifically, three species are categorized as Critically Endangered (leatherback—*Dermochelys coriacea*, Kemp's ridley—*Lepidochelys kempii* and hawksbill—*Eretmochelys imbricata*), two species as Endangered (loggerhead—*Caretta caretta*

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and green turtle—*Chelonia mydas*), and one as Vulnerable (olive ridley—*Lepidochelys olivacea*). Furthermore, all sea turtle species are currently in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Appendices I and II of the Convention on Migratory Species (CMS).

Possible explanations for declines in sea turtle populations include direct turtle and egg harvest, egg predation, loss and degradation of nesting habitat, fisheries bycatch, pollution and large-scale changes in the oceanographic conditions and nutrient availability (Lewison and Crowder, 2007). However, it is recognized that fisheries bycatch is currently one of the major threats and causes of declines to those species (Hillestad et al., 1995; Lutcavage et al., 1996; Wallace et al., 2010, 2013). Sea turtles can be accidentally captured in a wide variety of fisheries and fishing gear, ranging from small scale to industrial fleets, including pelagic longlines, purse seines and driftnets in the pelagic environment (Gilman et al., 2006, 2007; Lewison and Crowder, 2007; Lewison et al., 2004), and trawls, gillnets and pound nets in more coastal waters (Álvarez de Quevedo et al., 2010; Casale, 2011; Gilman et al., 2010).

Several measures that can potentially mitigate the bycatch and mortality of sea turtles in commercial fisheries have been proposed and implemented. These include management measures such as time/area closures, fishery bans and limitation of fishing effort; and technical measures such as turtle excluding devices (for trawl fisheries), deterrents (sonic pingers, lights or chemical repellents for set and drift nets), and the use of circle hooks, sometimes in combinations with fish bait for longlines (FAO, 2009). Particularly for the longline fisheries, a number of research initiatives have been carried out using circle hooks, a hook with the point turned perpendicularly back toward the shank (Yokota et al., 2012), as those seem to be an efficient strategy to reduce sea turtle bycatch, particularly if associated with changes to fish bait (Watson et al., 2005; Read, 2007; Serafy et al., 2012; Wallace et al., 2010).

However, some conflicting results in the past have shown that the efficiency of such strategies seems to be taxa-, fleet- and region-specific, and as such it has been recommended that thorough scientific experiments should be conducted and implemented before the application of such gear modifications (Read, 2007). In the Atlantic Ocean, some previous studies have looked into the effects of changing hook styles and bait types but most were carried out in the northwest Atlantic (Foster et al., 2012; Watson et al., 2005), and to a less extent in the equatorial region (Pacheco et al., 2011; Santos et al., 2012) and the South Atlantic (Domingo et al., 2012; Pinedo and Polacheck, 2004; Sales et al., 2010; Santos et al., 2013). However, no studies have been reported for the tropical northeastern Atlantic, an area that seems to be particularly important for sea turtle populations, including the vulnerable leatherbacks and loggerheads (Abella, 2012; Tomás et al., 2010). Although the eastern Atlantic concentrations of leatherback sea turtles are less studied and known than those in the western Atlantic, there are evidences of nesting concentrations of this vulnerable species that extend from Mauritania in the north to Angola in the south (Weir et al., 2007). Moreover, these nesting concentrations of leatherbacks, especially off Gabon, may in fact be one of the largest in the world (Fossette et al., 2008; Fretey et al., 2007). With regards to the loggerheads, the nesting population in the Cape Verde Archipelago is considered the 2nd most abundant in the Atlantic and one of the largest in the world, after the nesting populations in Florida and Oman (Abella, 2012; Marco et al., 2012).

Recognizing the specificities of testing fishing gear modifications in terms of taxa, fleets and regions, and the lack of information for the European pelagic longline fishery, a Research Project was designed (*SELECT-PAL—Redução das capturas acessórias na pescaria de palangre de superfície*) under the auspices of the Portuguese Fisheries Authority. The aims of the project were to test the efficiency and viability of using different hook styles and bait type combinations along the different areas of operation of the fishery in the Atlantic Ocean. The first results were already reported for the Equatorial area (Santos et al., 2012) and the South Atlantic (Santos et al., 2013), and in this paper we report the result for the tropical northeast Atlantic. In this paper the objectives were therefore to test the efficiency of changing the traditional gear configuration of J-style hooks baited with squid to alternative circle hooks and mackerel bait, analyzing the data in terms of bycatch rates, hooking location, catch sizes and mortality rates of sea turtles. A second paper (Fernandez-Carvalho et al., this issue) used the same experimental design but focuses on the targeted, bycatch and discarded fishes.

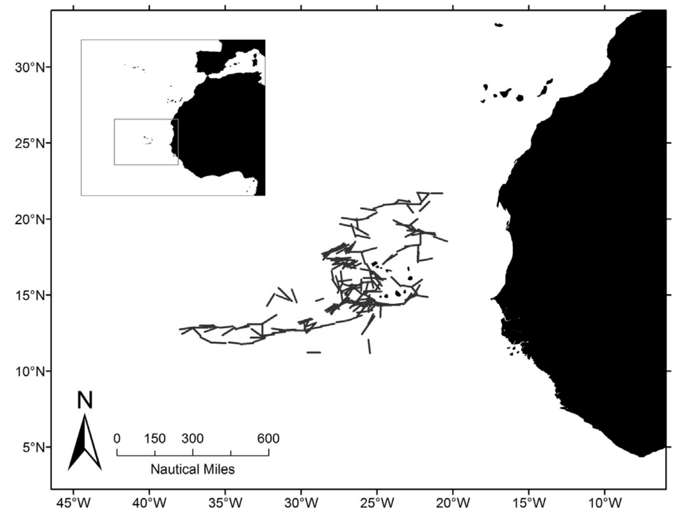

Fig. 1. Location of the experimental pelagic longline sets carried out during this study in the tropical northeast Atlantic.

2. Materials and methods

2.1. Experimental design and data collection

A total of 202 experimental longline fishing sets, corresponding to 254,520 deployed hooks (42,420 with each hook/bait combination), were carried out in the tropical northeast Atlantic (latitude: 11–22°N, longitude: 20–38°W), between August 2008 and December 2011 (Fig. 1). The experimental fishing was carried out by a contracted commercial Portuguese longline vessel following the general practices of the European longline fleet in this area. Therefore, most of the fishing experiments occurred between October and January, as this is the period when the longline fleet is most active in the area. Gear deployment started at around 17:00 h and haulback the next day from about 06:00 h, with the gear fishing mostly at depths between 20 and 50 m. The fishing gear consisted of a standard monofilament polyamide mainline of 3.6 mm diameter (~55 nm long), with five branch lines between floats. Each branch line had two sections connected by a 5 cm swivel (60 g): the first section of approximately 11 m long, consisting of two monofilaments portions of 9 m long (ø 2.5 mm) and 2.2 m (ø 2.2 mm), connected by a swivel (8 cm and 80 g); the second section, corresponding to the terminal tackle, consisting of a 0.75 m long multifilament wire leader (ø 1.4 mm) with a hook. A battery-powered flashlight (green light) was attached to each leader.

Three different stainless steel hook styles (produced by WON YANG) were used in each longline set. The control of the experiment corresponded to the traditional 10° offset J-style hook typically used on the fleet (EC-9/0-R), and the treatments corresponded to: G style hook, a non-offset circle hook (H17/0-M-S); and Gt style hook,

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