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Effects of hook and bait in a tropical northeast Atlantic pelagic longline fishery: Part II—Target, bycatch and discard fishes

Joana Fernandez-Carvalho[a,b], Rui Coelho[a,b,*], Miguel N. Santos[a], Sérgio Amorim[a]

[a] Instituto Português do Mar e da Atmosfera (IPMA I.P.), Avenida 5 de Outubro s/n, Olhão, 8700-305 Portugal
[b] Centro de Ciências do Mar (CCMAR), Universidade do Algarve, FCT Ed. 7, Campus de Gambelas, Faro, 8005-139 Portugal

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ABSTRACT

The incidental bycatch of sea turtle in tuna and swordfish fisheries is currently recognized as one of the major threats to the populations of these species. Therefore a number of mitigation measures have been tested, particularly for longline fisheries targeting swordfish. As mitigation measures may also affect the fish catches, it is important to quantify these impacts both at the ecological and socio-economic levels. Between August 2008 and December 2011, a total of 202 experimental pelagic longline sets were carried out in the Tropical Northeast Atlantic Ocean. The combination J-hook baited with squid (traditionally used by the fishery) was compared against two circle hooks (one non-offset and one with 10° offset) and mackerel bait. Catches per unit effort (CPUE) were calculated and compared between the different hook style and bait combinations for all target, bycatch and discarded fish species. In addition, a GLM (generalized linear model) was applied for swordfish *Xiphias gladius* and blue shark *Prionace glauca* (two main target species) and bigeye thresher *Alopias superciliosus* (most discarded species). The swordfish catches were negatively affected when changing from the traditional gear (J-style hooks baited with squid) to one of the experimental combinations, with the bait type having a stronger influence than the hook style on this reduction. However, the overall target species CPUE and the value of the retained catch (VPUE, value per unit of effort) were not significantly affected, due to an increase on the blue shark CPUE. Furthermore, the hook style and the bait type did not seem to influence the at-haulback mortality rates of most discarded species, which were highly species-specific. Given the apparent lack of impact on the overall value of the retained catch, the use of circle hooks baited with mackerel on this particular fishery and region would be highly beneficial for sea turtle conservation, without affecting the economic viability of the fishery.

1. Introduction

Over the last decades the unintentional capture of non-targeted species, known as "bycatch", has become a major issue in global fisheries management and conservation, with special concern for the accidental capture of vulnerable marine megafauna such as marine mammals, sea birds, sea turtles and sharks (Gilman et al., 2006, 2008; Lewison et al., 2004; Soykan et al., 2008). Although, pelagic longlines are considered more selective when compared to other fishing gears like trawls or gillnets (Gilman et al., 2006), there is considerable concern over the ecological effects of pelagic longline fishing, which extends throughout tropical and temperate regions of the world's oceans (Gilman et al., 2012; Lewison et al., 2004). Pelagic longlines consist of a series of baited hooks attached to a mainline that is suspended from floating buoys, that are deployed in daily operations to catch large tuna (*Thunnus* spp.) and billfishes (Istiophoridae and Xiphidae). Since the late 1990s there has been an increasing retention of sharks in pelagic longline fisheries, mostly due to changes on the markets and restrictions on the catches of traditional target species. Currently the industry is making use of a wider range of shark products, such as fins, meat, liver and skin. As a result, some changes on the traditional fishing gear configuration have been observed, namely the use of multifilament wire leaders. Such fishing gear configuration is used in particular areas and seasons where the abundance of sharks is high, such as in the tropical Northeastern Atlantic region.

In order to mitigate the incidental capture of sea turtles (and other vulnerable bycatch species) in fisheries, several measures have been proposed or implemented over the last years in different fleets worldwide. Some of the most common strategies to reduce

* Corresponding author at: Instituto Português do Mar e da Atmosfera (IPMA I.P.), Avenida 5 de Outubro s/n, 8700-305 Olhão, Portugal. Tel.: +351 289 700 520; fax: +351 289 700 535.
E-mail address: rpcoelho@ipma.pt (R. Coelho).

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this bycatch involve gear modifications such as changes in hook style and bait type, though time/area closures, limitation of fishing effort and fishery bans have been proposed as well. Particular attention has been given to the use of circle hooks, a hook with the point turned perpendicularly back towards the shank, as a means to reduce bycatch and mortality (see reviews by Read, 2007; Serafy et al., 2012; Wallace et al., 2010). However, several authors have mentioned that the efficiency of such gear modifications is not only taxon-specific, but also depends on the specificities of the fleets and fisheries (e.g. Gilman et al., 2008; Read, 2007), and as such thorough experimental studies should be developed and implemented to test the efficiency of such gear modifications in each particular fishery (Gilman et al., 2012).

The Portuguese pelagic longline fishery targeting swordfish in the Atlantic Ocean began in the 1970s, with only minor changes being incorporated in the last decade. Namely, in the late 1990s fisherman transitioned to the "modern gear" using mainlines and branchelines of monofilament, and lightsticks or flashlights while the gear is left fishing during the night (Watson and Kerstetter, 2006). Currently, "J-style hook baited with squid" is the more common combination used by the fishery, though when pelagic sharks are a major component of the catch multifilament wire leaders and mackerel bait might be used instead.

Often bycatch mitigation studies have focused on the ability of particular measures to reduce mortality of the species of concern, such as marine turtles accidentally caught by pelagic longlines (Cambiè et al., 2012; Santos et al., 2012, 2013; Stokes et al., 2012). However, a more holistic approach is emerging with the broadening of studies to include the effects of such mitigation measures on the catches of target and non-target species, and on the economical aspects of the fisheries (Coelho et al., 2012b; Curran and Bigelow, 2011; Foster et al., 2012; Graves et al., 2012). To the author's best knowledge, the present study is the first carried in the tropical north-eastern Atlantic area, which in recent years became a major fishing ground for the European pelagic longline fleets (i.e. Spanish and Portuguese). The study was designed to test the influence of different hook styles and bait type combinations on the catches of target and non-target fish species in the Portuguese pelagic longline fishery operating in the tropical north-eastern Atlantic. It complements a previous paper that used the same experimental design and the same geographical region but was focused on the sea turtles. Specifically, the effects of two circle hooks were compared to the traditional J-style hook, and the effect of using mackerel was compared to using the traditional squid. The study reports the catch composition, and addresses the issues of catch rates and hooking mortality on target, non-target and fish discards from this fishery. Moreover, it includes analyses of the financial impact (value per unit of effort) for the different hook style and bait type combinations tested.

2. Materials and methods

2.1. Experimental design and data collection

A total of 202 experimental longline sets (254,520 hooks in total, corresponding to 42,420 of each hook/bait combination) were carried out between August 2008 and December 2011, by a commercial Portuguese longline vessel hired to carry out the study. All sets were deployed along the Tropical northeastern Atlantic Ocean, between latitudes 11°N and 22°N and longitudes 20°W and 38°W (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, with most of the experimental fishing taking place between October and January as this is the period when the longline fleet is most active in the

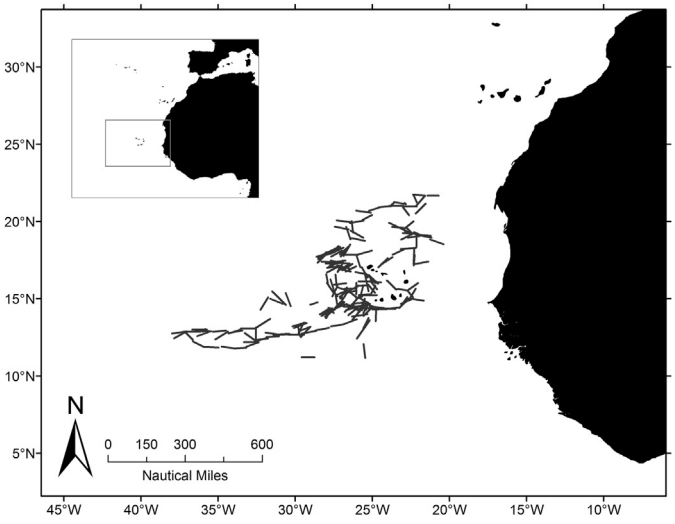

Fig. 1. Location of the experimental pelagic longline sets carried out during this study in the tropical northeast Atlantic.

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.

The experimental component consisted on testing two bait types and three different stainless steel hook styles (manufacturer: WON YANG, Korea) in each longline set. The control was the traditional 10° offset J-style hook baited with squid used by the fishery (Model EC-9/0-R), and the treatments were two circle hooks: G hook (a non-offset circle hook Model H17/0-M-S) and Gt hook (a 10° offset circle hook Model H17/0-M-R). The characteristics of the different hooks are provided in detail in Fig. 2. Hook styles were alternated section by section (each containing between 70 and 80 hooks) of the longline, and with the style of the first section in the water changing every set and following a fixed scheme (i.e., J:G:Gt:J:G:Gt, and so on). Two different bait types were used, mackerel (*Scomber* spp.) and squid (*Illex* spp.), with only one bait type used in each set to avoid possible interaction effects, as suggested by Watson et al. (2005). Whole baits with standardized sizes were used in all longline sets (squid 27.8 ± 0.97 cm and mackerel 35.1 ± 1.19 cm).

All operational and biological data were collected by onboard fishery observers. For each set, information on location, date, and number of hooks of each style and bait type used was recorded. In addition, for every fish captured, the species, sizes to the nearest lower cm (LJFL, lower jaw fork length for the billfishes and FL, fork length for the other fishes), hook style and bait type used for capture, condition at-haulback (alive/dead), specimen's fate (retained/discarded) and its condition if discarded (alive/dead) was recorded.

Three categories were established for the captured fish species: target, bycatch and discards. In the study area the fleet is currently using mainly multifilament wire leaders, and therefore we considered that the main target species were swordfish (*Xiphias gladius*), blue shark (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*),