INTERACTION BETWEEN SEABIRDS AND SPANISH SURFACE LONGLINE TARGETING SWORDFISH IN THE INDIAN OCEAN (LAT ≥ 25º SOUTH) DURING THE PERIOD 2011-2015

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SUMMARY

A total of 310 fishing sets (361,608 hooks) targeting swordfish in the Indian Ocean (lat ≥ 25ºS) between 2011-2015 were analyzed. The areas included in the study are between 25º-36ºS and 34º-72ºE. However, the interaction with seabirds was restricted to areas between 31º-36ºS and 37º-48ºE during the January-April period. A total of 19 seabird individuals during the whole period 2011-2015, identified as belonging to seven species, interacted with the fishing operation (Diomedea exulans, Phoebetria fusca, Procellaria aequinoctialis, Thalassarche carteri, Thalassarche cauta, Thalassarche melanophris, Thalassarche salvini). Most interactions occurred in one year-months and in a single 5ºx5º square. Interactions observed in other areas were minor or regularly null. The overall rate of interaction estimated for areas lat ≥ 25ºS and species combined was estimated at 5.254E^{-05} seabird/hook. Night setting and low levels of lighting during setting operations as well as other fishing protocols applied by the vessels were identified as the most important factors to explain the regularly low or null interaction with seabirds.

Sightings of seabirds were also made during the trips studied, most of them occurring during daytime sailing. Procellaria aequinoctialis was identified as the most prevalent species in sightings. Other less prevalent species were identified as Phoebetria fusca, Thalassarche carteri, Diomedea exulans, Thalassarche cauta, Pterodroma macroptera, Thalassarche salvini and very sporadically Sulidae/Laridae, Oceanites spp. and Ardena pacifica.The paper also summarizes the mitigation regulations put in place at national level for reducing the incidental bycatch of seabirds in the longline fleet in the Indian Ocean.

KEYWORDS: *seabirds, interaction, surface longline, Indian Ocean*

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1. Introduction

The death of seabirds is caused by several natural factors and can also be produced by various anthropogenic effects including eating or being caught up in plastic and the impact of various chemical pollutants widely used nowadays. Major spills of oil and oil derivatives have been identified as one of the most visible causes of mortality among seabirds. The introduction of predators in the areas where they nest, the impact of other human activities on their natural habitats and climate change have also been postulated as some of the main factors contributing to the decline in some seabird populations.

Some fishing operations, such as those carried out with driftnets, trawls, purse seine, longlines and other gear may have unwanted effects in some cases and cause incidental deaths among some seabird species. This problem has been generalized on the assumption that the overlap between the areas of distribution of different seabird populations and the distribution of fishing activity using different types of gear necessarily implies a negative interaction between the two, leading to the death of birds (Wanless 2015). However, fishing can involve a wide range of practices with greater, lesser or zero impact on the seabird populations present in each fishery area (Brothers *et al.* 1999), the level of interaction depending on a variety of factors linked to the behavior and distribution of the birds, the methods and equipment used to catch each target fish species, the fishing pattern followed, etc. In other cases, fishing activity can consolidate or increase the number of seabirds present in a fishing area (Furness 2003) and establish a link with the discards and waste produced in the course of fishing activity (Santos *et al.* 2011, Valeiras 2003, Valeiras *et al.* 2009). It has often been pointed out that the greatest interaction with seabirds is regularly associated with high latitudes and the most productive cold water areas, where much international fishing activity takes place. Although this generalization is useful, especially for certain species considered vulnerable, the information available (e.g. García-Barcelona *et al.* 2010[a,b,c], 2013; Baez *et al*. 2014, Valeiras and Camiñas 2003) suggests that it must be qualified in the case of certain geographical areas and species.

In the case of the different types of longline (surface, mid-water, deep, bottom) there is a wide variety of target species and fishing practices - ranging from demersal to pelagic species and from cold to tropical regions - and this diversity can determine the greater or lesser interaction with the different species of seabirds to be found in each fishing ground. The area and season in which fishing takes place have been described as significant factors to explain the interaction of some of this activity with seabirds (e.g. BirdLife International 2004, Baker *et al*. 2007, Jiménez *et al*. 2010, Tuck *et al.* 2011, Yeh *et al*. 2012, Petersen *et al*. 2008). However, the target species and the fishing strategy applied in each case also have a significant influence on interaction, so that it may vary considerably between vessels in a fleet and between fleets, depending on whether fishing is by day or by night, the type and size of the bait used, the depth at which hooks are set, the branchline length and other factors linked to the fishing method used, as well as on environmental factors and the behavior of seabirds in their interaction with baited hooks (Brothers *et al.* 2010). The choice of prey of the birds present in the fishing area and the specific mitigation measures implemented, or those implicit in each fishing technique, are also elements to be taken into account in the wide range of situations described in the literature.

Longlines used for targeting tuna and/or tuna-like species are often mistakenly assumed to be similar, all being regularly classified as *pelagic longlines* or *drifting longlines*. It has been seen that the species-size and bait used on the hooks during setting can sometimes lead to interaction, but it also depends on variables of time and location. Even with this type of longline there is a wide range of impacts depending on each type of longline and fishing ground (Anderson *et al.* 2011, García-Barcelona *et al.* 2010[a,b,c], 2013; Inoue *et al*. 2012[a,b], Jiménez *et al.* 2011, Mejuto *et al*. 2008, Ramos-Cartelle *et al*. in press, Yeh *et al*. 2012), so that preventive measures, when they are necessary, must be adapted to each situation if they are to be effective (Gilman *et al.* 2005). The type/style of longline, the target species, the distance from the coast of fishing activity (or the proximity of ocean islands in areas of possible overlap with these species) and the bird populations present in each area can play a significant role in favoring a greater or lesser presence of birds and interaction with them (Brothers *et al.* 1999). The same type of longline used at similar latitudes can have very different impacts depending on whether fishing activity targets one species or another, whether fishing is high sea or coastal, and whether it is carried out by day or by night with a view to adapting it to the behavior and availability of the respective target fish species, among other factors regularly considered in RFMO resolutions and recommendations. Longlines used for tuna and tuna-like species may be of different types (e.g. surface, mixed, deep) and styles (e.g. monofilament, multifilament), while various technologies, fishing patterns and configurations may be applied, depending on the target species. However, from the point of view of their potential impact on seabirds, and irrespective of the technique used for each type of longline, at least two major categories should be considered: those set at night and those set during the day.

Recent studies of the Atlantic Spanish longline fleet targeting swordfish revealed null interaction with seabirds in broad oceanic areas observed in the North and South Atlantic (e.g. Mejuto *et al*. 2008, Ramos-Cartelle *et al*. in press). However, positive interactions with seabirds have been reported in some areas of the Mediterranean Sea (García-Barcelona *et al.* 2010[a,b,c]). These results suggest that the interaction with sea birds in the Spanish surface longline fishery targeting swordfish in broad oceanic areas of the Atlantic is regularly low or null, and affects very restricted fishing areas of the Mediterranean.

Independently of the wide range of factors affecting the interaction between seabirds and fishing and the greater or lesser impact in each fishing ground, numerous international agreements have been signed to study these potential problems and propose effective measures to mitigate them. Several RFMOs have been taking measures to assess this impact on the fisheries for which they are responsible (Lewison *et al*. 2005) because this factor, together with others, must be considered in any assessment of mortality rates among these bird populations (Croxall *et al.* 2012). RFMOs and some national authorities in their domestic frame have implemented specific recommendations to assess, prevent or minimize the possible impact of fishing operations on seabirds.

This document describes the interaction with seabirds observed during the activity of the Spanish surface longline fishery targeting swordfish in the Indian Ocean (lat ≥ 25º S) following the scientific recommendations of the IOTC-WPEB. A summary of the mitigation measures to deal with the problem of seabirds implemented by Spain in the surface longline fishery in the Indian Ocean is also provided.

2. Material and methods

The data analyzed come from scientific observers on board surface longline fishing vessels targeting swordfish and using a night setting strategy. Historically, the practices of all fishing fleets targeting swordfish with longlines have been adapted to the vertical migration and availability of this species (Abascal *et al.* 2010, 2015; Neilson *et al.* 2009), the swordfish being regularly more accessible in surface layers at night. The vessels observed were engaged in commercial fishing with the American style (monofilament) surface longline and did not change the fleet's standard practices.

The records selected for this analysis – as recommended by the IOTC-WPEB – comprise observations at sea from areas restricted to latitudes ≥ 25º S obtained during the period 2011-2015. The months during which the observations at sea were made were also considered from the point of view of their possible influence on interaction. The bait used during the trips was squid or a combination of squid and mackerel. All the sets and hauls (all the hooks) were observed, so that any interaction with seabirds during the trips was recorded. Additionally, when possible, observers with knowledge of seabirds carried out the taxonomic identification of the species sighted in the trip areas. A revision of the national regulations put in place since 2002 as well as the IOTC resolutions on seabirds implemented after 2006 is provided.

3. Results and discussion

3.1 Interaction rates

The data used for this analysis were obtained by scientific observers in the period 2011-2015 from a total of 310 commercial fishing sets (361,608 hooks observed) in latitudes ≥ 25ºS (Tables 1 and 2). The fishing areas in the study were between 25º-36ºS and 34º-72ºE. However, interaction with sea birds only occurred in areas between 31º-36ºS and 37º-48ºE.

A total of 19 sea birds, identified as belonging to 7 species, interacted with fishing activity during the sets in question. The species identified were: *Phoebetria fusca, Diomedea exulans, Thalassarche carteri, Thalassarche cauta, Procellaria aequinoctialis, Thalassarche melanophri* and *Thalassarche salvini* (Table 3).

Observations in latitudes ≥ 25ºS were made in the months January - July and November - December. However, interaction with seabirds only occurred in the period January - April, March being the month in which most cases were observed (Table 4). The absence of sightings in August, September and October made it impossible to evaluate potential interaction in these months.

Table 5 shows the number of seabird interactions by year and years combined, and by species and species combined, in areas at latitude ≥ 25ºS. In the sets observed in 2011 and 2012 there was no interaction with seabirds. In 2013 the species that interacted with fishing gear were: 4 *Diomedea exulans*, 3 *Phoebetria fusca*, 3 *Thalassarche carteri*, 2 *Thalassarche cauta* and 1 *Thalassarche salvini*. In 2014 interaction only occurred with 2 individuals of species recorded as *Thalassarche melanophris* and *Procelaria aequinoctialis* and in 2015 there was interaction with 4 members of the species *Phoebetria fusca*. Of the total of 19 interactions recorded in the whole period analyzed, 10 (52.63%) occurred in grid reference 30035ºSE, 8 in 2013 and 2 in 2014 (Figure 1).

Table 6 summarizes interaction rates per year and for combined years, and for each species and combined species. The overall interaction rate for all areas at latitude ≥ 25ºS and for all species combined was $5.254E^{-05}$ birds per hook.

The results obtained during the period analyzed suggest that interaction with seabirds occurs in particular areas during certain months. There were no interactions north of 31ºS. Consequently, potential interaction should not be generalized to all the areas in the Indian Ocean where this fleet fishes. These results are consistent with the absence of interaction detected with this type of fishing in large areas of the North and South Atlantic (Mejuto *et al*. 2008, Ramos-Cartelle *et al*. in press). In the case of the Indian Ocean, the greater proximity of fishing activity to certain coastal areas may mean that in certain areas at certain times there is a greater likelihood of interaction. However, the fact that most cases are linked to a single trip suggests that these interactions may be sporadic and caused by poor implementation of the mitigation procedures generally applied.

Data for Task II-effort in the combined period 2011-2014 indicate that the nominal effort for the whole of this fleet in the Indian Ocean was approximately 20.8 million hooks (average 5.2 million hooks/yr), of which 19.5 million (93.7%) were used in latitudes ≥ 25ºS (average 4.9 million hooks/yr). However, only 2.83 million hooks (11.2% of the total) were recorded in the areas-months in which interaction with seabirds was likely, according to this study. Based on these figures and the interaction rates obtained for combined species in the years analyzed, we could conclude that, in the case of this fishing technique, targeting this species and using night setting, overall interaction with seabirds in areas at latitude ≥ 25ºS generally appears very moderate or non-existent and is probably restricted to specific areas and periods.

3.2. Sightings

Although the interaction between fishing operations and seabirds was generally low, it is useful to consider the sightings recorded during the trips observed. The scientific observers took sightings of seabirds whenever possible, during sailing, setting and hauling, to identify the species present in fishing areas and relate them to possible interaction occurring during sets.

In three of the trips observed there were sightings of birds during all the sets. In two of these trips there was no interaction with seabirds even though on 43% of days when fishing took place individuals of the species *Procellaria aequinoctialis* (58 birds altogether) were sighted and on 16% of fishing days there were sightings of *Pterodroma macroptera* (18 birds in all). Two other species were seen more sporadically, one probably of the *Sulidae* or *Laridae* family and the other an *Oceanites spp*. During the trip when interaction with birds occurred the most frequent sightings were also of *Procellaria aequinoctialis,* a total of 586 birds being sighted on 72% of the days on which fishing took place, although there was no interaction with fishing activity. Other species observed were identified as *Thalassarche cauta,* a total of 53 individuals being sighted on 19% of fishing days, two birds being caught; *Phoebetria fusca* with 48 individuals sighted on 20% of fishing days and 3 birds caught; *Thalassarche carteri* with 37 individuals sighted on 27% of fishing days and 3 birds caught, one being caught in a set in which the species was not sighted; *Diomedea exulans* with 27 individuals sighted on 20% of fishing days and 4 birds caught. The following species were sighted very sporadically: *Pterodroma macroptera* (9 individuals), *Thalassarche salvini*, 1 individual being sighted in a set and 1 bird being caught in a set in which the species was not sighted, *Ardenna pacifica* (1 individual), *Puffunis carniceps* (1 individual) and *Puffinus gravis* (1 individual). In some cases it was difficult to distinguish the species *Thalassarche carteri, Thalassarche cauta* and *Thalassarche salvini,* as they were flying at some distance from the vessel.

3.3 Mitigation measures

The mitigation measures most often used by vessels during trips were the following: line shooting device (implemented in all boats), night setting with minimal deck lighting (implemented in all boats), weighted branch lines (implemented in all boats), offal discharge control on the opposite side to the haul with coordination between offal discharges and hauling operations (implemented in all boats), blue-dyed squid bait (in some boats) and bait previously thawed to sink faster (in some boats).

Although the rate of interaction with seabirds in this fleet seems low or non-existent in most areas and at most times - also indicated in previous records for the Spanish surface longline fleet targeting swordfish in the Indian Ocean[2]- it is desirable to improve the training of some crews to increase the efficiency of mitigation measures in those sets carried out in areas and at times when interaction with seabirds is likely. In this connection, recent national regulations have introduced additional precautionary measures, irrespective of the area or ocean in which the vessel is working.

In addition to Spanish and EU legislation applicable to the whole Spanish longline fishing fleet, which limits capacity and access to certain stocks and areas, with the use of VMS and other systems to track fishing activity, the Administración Nacional Pesquera of Spain (ANP) has

[2] See IOTC national annual reports, section on seabirds.

established measures to reduce incidental seabird mortality in surface longline fisheries via the Official State Gazette[3] and also within the framework of the mandatory Temporary Fishing Permit (PTP). These PTPs are individual permits granted annually to each vessel included in the census of those authorized to engage in fishing. The permit establishes conditions which are specifically applicable to each vessel, such as the areas in which it is authorized to fish, the mitigation measures required in each region, fish species allowed and prohibited, minimum sizes and other conditions affecting the vessel's activity. These guidelines include specific measures to avoid possible interaction with seabirds, based on the current recommendations of each RFO, but also on current domestic regulations, which are frequently more restrictive.

Before IOTC Resolution 06/04 on reducing incidental bycatch of seabirds in longline fisheries came into force, the Spanish ANP had been implementing precautionary measures to reduce the likelihood of such interactions since 2002. In response to domestic Order APA/1127/2002, mitigation measures on reducing incidental seabird bycatch were introduced, which were applicable to all surface longline fishing vessels flying the Spanish flag and targeting swordfish and similar species in waters south of 30ºS, irrespective of the ocean in which they carried out their activity. Later, in the case of IOTC, some measures based on Resolution 06/04, Resolution 08/03, Resolution 10/06 and Resolution 12/06 had been specifically put in place and also incorporated by the ANP in domestic Orders. More recently, via domestic Order AAA/658/2014[4], the ANP has established more precautionary measures which are stricter than those specified in IOTC and other RFMO resolutions and recommendations, and they are applicable to all Spanish surface longline vessels irrespective of the area or ocean in which they are authorized to fish.

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Table 1. Number of sets and nominal effort (hooks) observed by year, total and in latitudes ≥ 25ºS of the Indian Ocean.

Year	Nº Sets	Nº Hooks	Nº sets ≥ 25ºS	Nº hooks ≥ 25ºS
2011	56	63139	52	58670
2012	7	7451	7	7451
2013	153	180921	153	180921
2014	60	70749	58	68833
2015	40	45733	40	45733
Total	316	367993	310	361608

Table 2. Nominal effort (hooks) observed by year and month in the Indian Ocean at latitude ≥ 25ºS.

Year/Month	1	2	3	4	5	6	7	8	9	10	11	12
2011							8520				27800	22350
2012												7451
2013	31291	28969	34483	46480	36467	3231						
2014			3888	20164	28965	15816						
2015			16577	29156								
Total	31291	28969	54948	95800	65432	19047	8520	0	0	0	27800	29801

Table 3. Species identified in interactions during sets observed, number of interactions per species and codes used in this document.

Species reported	Spec. Code	# Interactions
Phoebetria fusca	PFO	7
Diomedea exulans	DEO	4
Thalassarche carteri	DCA	3
Thalassarche cauta	DSO	2
Procellaria aequinoctialis	PAO	1
Thalassarche melanophris	DMO	1
Thalassarche salvini	THS	1

Table 4: Number and percentage of seabird interactions observed by month at latitudes ≥ 25ºS.

Month	Nº of seabirds	%
1	2	10.53
2	2	10.53
3	11	57.89
4	4	21.05
5	0	0.00
6	0	0.00
7	0	0.00
8	n.a.	n.a.
9	n.a.	n.a.
10	n.a.	n.a.
11	0	0.00
12	0	0.00
Total	19	100

Table 5. Number of seabird interactions by year and years combined (species combined and by species) in areas at latitude ≥ 25ºS (see codes of species in table 3).

	Number of seabirds with interactions							
Year/Species	Nº seabirds	DCA	DEO	DMO	DSO	PAO	PFO	THS
2011	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0
2013	13	3	4	0	2	0	3	1
2014	2	0	0	1	0	1	0	0
2015	4	0	0	0	0	0	4	0
Total	19	3	4	1	2	1	7	1

Table 6. Interaction rate of seabird per hook, by year and years combined (species combined and by species) in areas at latitude ≥ 25ºS (see codes of species in table 3).

	Interaction rate per hook							
Year/Species	Total	DCA	DEO	DMO	DSO	PAO	PFO	THS
2011	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0
2013	$7.185E^{-05}$	$1.658E^{-05}$	$2.211E^{-05}$	0	$1.105E^{-05}$	0	$1.658E^{-05}$	$5.527E^{-06}$
2014	$2.906E^{-05}$	0	0	$1.453E^{-05}$	0	$1.453E^{-05}$	0	0
2015	$8.746E^{-05}$	0	0	0	0	0	$8.746E^{-05}$	0
Total	$5.254E^{-05}$	$8.296E^{-06}$	$1.106E^{-05}$	$2.765E^{-06}$	$5.531E^{-06}$	$2.765E^{-06}$	$1.936E^{-05}$	$2.765E^{-06}$

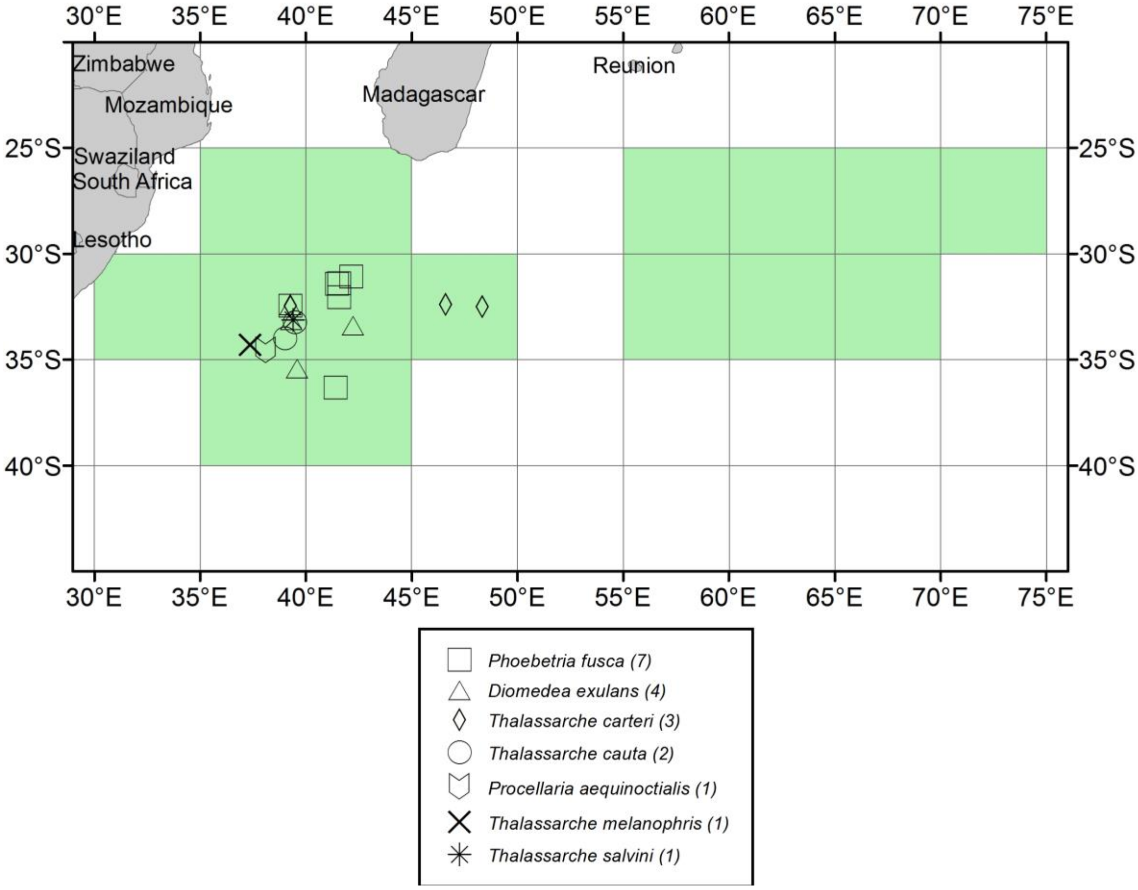

Figure 1. Map of incidence of seabirds, by species. The green squares represent the areas observed.