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OBSERVATIONS ON INTERACTION BETWEEN SEABIRDS AND THE SPANISH SURFACE LONGLINE FISHERY TARGETING SWORDFISH IN THE ATLANTIC OCEAN DURING THE PERIOD 1993-2017

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SUMMARY

A total of 7.6 million hooks targeting swordfish using night setting surface longline style were scientifically observed during the 1993-2017 period in broad areas of the North and South Atlantic in relation to the interaction with seabirds. The areas observed correspond to those with greater historical fishing intensity by this fleet in the Atlantic. A total of 38 individual seabirds interacted with the total observed hooks during the 25-year period. 74% of the interactions occurred in a single trip made in 1995 under non-standard fishing operations in areas in which other vessels-trips-years had few or null interactions. 13% of the interactions occurred in a fishing prospecting survey carried out in southern areas where this fleet does not carry out regular fishing activity. The generally oceanic fishing areas, the type of nocturnal style, the low lighting during the set, together with the type of fishing practice regularly carried out by the vessels, were identified as probably being the main factors to explain the generally zero or low interaction with seabirds in most of the Atlantic fishing areas and trips observed.

RÉSUMÉ

On a scientifiquement observé la pose nocturne d'un total de 7,6 millions d'hameçons ciblant l'espadon dans les pêcheries palangrières de surface au cours de la période 1993-2017 dans de vastes zones de l'Atlantique Nord et Sud en relation avec l'interaction avec les oiseaux de mer. Les zones observées correspondent à celles où cette flottille exerce une intensité de pêche historique plus importante dans l'Atlantique. Au total, 38 oiseaux de mer individuels ont interagi avec la totalité des hameçons observés au cours de la période de 25 ans. 74% des interactions ont eu lieu lors d'une seule sortie effectuée en 1995 dans le cadre d'opérations de pêche non standard dans des zones où d'autres navires-sorties-années avaient peu ou pas d'interactions. 13% des interactions ont eu lieu lors d'une prospection de pêche réalisée dans les zones méridionales où cette flottille n'effectue pas d'activité de pêche régulière. Les zones de pêche généralement océaniques, le type de style nocturne, le faible éclairage pendant l'opération, ainsi que le mode de pêche régulièrement pratiqué par les navires, ont été identifiés comme étant probablement les principaux facteurs expliquant l'interaction généralement nulle ou faible avec les oiseaux de mer dans la plupart des zones de pêche de l'Atlantique et des sorties observées.

RESUMEN

Un total de 7,6 millones de anzuelos dirigidos al pez espada con palangre de superficie de lance nocturno fueron observados durante el periodo 1993-2017 en amplias áreas del Atlántico Norte y Sur en relación a las interacciones obtenidas con especies de aves marinas. El conjunto de áreas observadas representa aquellas con mayor intensidad de pesca ejercida históricamente por esta flota en el Atlántico. Un total de 38 individuos de aves marinas interactuaron con el total de esfuerzo observado durante todo el periodo de 25 años. El 74% de las interacciones ocurrieron en una única marea realizada en 1995 bajo condiciones no-estándar en áreas en las cuales otros buques-mareas-años tuvieron interacción escasa o nula. El 13% de las interacciones ocurrieron en una campaña de prospección pesquera desarrollada en áreas muy al Sur donde no suele realizar actividad pesquera regular esta flota. Las áreas de pesca generalmente oceánicas, el tipo de lance nocturno, la baja iluminación durante el lance, junto con el tipo de práctica de pesca realizada por los buques, fueron identificados como factores para explicar la generalmente nula o baja interacción ocurrida sobre aves marinas en la mayoría de las áreas de pesca Atlánticas y mareas observadas.

KEYWORDS

Seabirds, surface longline, interaction, Atlantic Ocean

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1. Introduction

International plans and guidelines on seabirds recommend the study of interactions between fisheries and seabird populations in order to promote effective actions to mitigate possible impacts in each fishing ground. ICCAT, like other tuna Regional Fisheries Management Organizations (tRFMOs) has been making resolutions and recommendations to assess these potential impacts on their tuna and tuna-like fisheries (see e.g. Anon. 2016, Lewison *et al*. 2005). These interactions, together with other sources of mortality, must be taken into account in any assessment of seabird populations (Croxall *et al.* 2012).

Consequently, since the mid-1990s the tRFMOs responsible for the management of tuna and tuna-like species have undertaken measures to assess the potential interaction between these fisheries and the species of seabirds found in their respective areas of competence. The tRFMO scientific groups have also proposed initiatives and suggested guidelines for scientists to carry out research and present studies with a view to determining levels of interaction in the respective areas-fisheries targeting tuna and tuna-like species and recommending effective measures to minimize undesirable impacts where these may occur.

As well as the mandatory mechanisms established in the framework of the tRFMOs relative to species of seabirds, the respective ICCAT and CTOI scientific working groups have recently requested detailed studies of the interactions observed in restricted areas considered to be of special interest (Lat.≥25ºS) and the specific period requested. The information about different fleets analyzed according to these guidelines must be considered useful, complementing other information available from studies focusing on different locations or periods, according to the areas of activity of each fleet-gear-style. Recent work on scientific observations made in the Spanish longline surface fishery targeting swordfish in the Atlantic has provided a response to these specific requests and guidelines for the Atlantic and Indian Oceans (Fernández-Costa *et al.* 2016, Ramos-Cartelle *et al.* 2017).

Large numbers of studies have described some of the anthropogenic effects other than fishing on the mortality of seabirds. Macro and micro plastic materials are nowadays recognized as probably one of the main causes of international concern (Lebreton *et al.* 2018). Recent studies suggest that ocean plastic pollution is increasing at a faster rate and impacts ecosystems, health and economies, producing morbidity and mortality in seabirds and many other species such as fish, marine mammals, sea turtles, etc., including those effects produced by the direct intake of plastic materials or by intake through the trophic chain when ingesting their natural preys. The impact of chemical pollutants, such as spills of oil and its derivatives, has also been identified as one of the most visible causes of mortality among seabirds. However, relatively little attention has been paid to these last impacts, except those that have occurred as a consequence of visible ecological catastrophes produced by oil spills. The introduction of predators in the areas where seabirds nest, the impact of other different human activities on their natural habitats, such as urban development or increasing tourism in some ecologically sensitive areas and global warming-climate change have also been identified as factors contributing to mortality, the decline in some seabird populations and changes in migration pathways, nesting periods and the geographical distribution of these species. Some fishing operations, such as those carried out using trawling, driftnets, purse seine-FADs, longlines and many other gear types may in some cases also have unwanted interactions with some seabird species. However, the problem has been generalized on the general assumption that the overlap between the areas of distribution of the different seabird populations and the distribution of fishing activity using different types of gear necessarily implies an interaction between the two, leading to the death of seabirds.

Fishing can involve a wide range of practices with greater, lesser or null impact on the seabird populations present in a fishery area (Brothers *et al.* 1999). The level of interaction depends on a variety of elements linked to the behavior and distribution of the seabirds, the methods and equipment used to catch each target fish species and the fishing pattern followed, among other factors. In other cases, fishing activity may consolidate or increase the number of seabirds present in particular fishing areas (Furness 2003) and establish a link with the discards and waste produced in the course of regular 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 associated with high latitudes and the more productive cold water areas where much international fishing activity is assumed to take place. Although these generalizations are especially useful for certain species considered vulnerable, the information available (e.g. García-Barcelona *et al.* 2010[a,b,c], 2013; Báez *et al*. 2014, BirdLife International 2004, Valeiras and Camiñas 2003) suggests that these criteria must be qualified in the case of certain regions, coastal fishing areas and some seabird populations. Information about interactions with seabirds within coastal, artisanal or recreational fisheries is usually scarce in most sources of information found.

In the case of the different types of oceanic longlines (such as surface, mid-water, deep, demersal) there is a wide range of target fish species (from epipelagic to demersal) and fishing practices, ranging from cold to tropical regions, coastal to open seas, etc., and these can determine the likelihood of interaction with the different species of seabirds to be found in each fishing ground. The areas and periods in which fishing takes place have been described as one significant factor to explain the interaction of some of these activities with seabirds (BirdLife International 2004, Baker *et al*. 2007, Jiménez *et al*. 2010, Tuck *et al.* 2011, Yeh *et al*. 2012). However, the target species and the fishing strategy applied in each case could also have a significant influence on the probability of interaction, so that it may vary considerably depending on whether fishing is by day or by night, the type and size of bait used and other factors linked to fishing methods and technology and to environmental aspects. The choice of prey of the seabirds present in the fishing area and the specific mitigation measures applied, or those already implicit in each fishing technique, are elements to be taken into account in the wide range of situations described in the abundant literature available.

In this sense, the oceanic longlines used to target different tuna and tuna-like species are often mistakenly assumed to be similar, all being classified as *pelagic or drifting longlines* in most literature. It has been seen that the size and type of bait used on the hooks can sometimes lead to interaction, but it also depends on other variables such as time and location. Even with this general type of longline there is a wide range of styles with different potential impacts depending on each style, target species and fishing ground (see 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, Yeh *et al*. 2012). So, preventive measures when necessary should 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 the fishing activity (or the proximity of ocean islands in areas of possible overlap with these species) and the seabird populations present in each area can play a significant role in favoring a greater or lesser presence of seabirds in the selected fishing areas and the potential interaction of the fishing operations with them (Brothers *et al.* 1999). Longlines used for tuna and tuna-like species may be of different styles (e.g. surface, deep, mixed) with different technologies and main lines (e.g. monofilament, multifilament) and using different configurations (hooks, bait, leaders, weights, etc.) depending on the fleet, target species and area. 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.

This document summarizes information about the interaction with seabirds scientifically observed over a period of 25 years in the activity of the Spanish surface longline fishery targeting swordfish in the North and South Atlantic Ocean, using night setting style. This paper can be considered as a complementary overview of the information partially provided in previous annual reports or via other scientific papers according to specific guidelines established by the scientific working groups of ICCAT.

2. Material and methods

The data analyzed were recorded by scientific observers on board surface longline fishing vessels, targeting swordfish and using *night setting style*, over a period of 25 years (1993-2017). Historically, the practices of this fishing fleet targeting swordfish have been adapted to the vertical migration of this species (Abascal *et al.* 2010, 2015; Neilson *et al.* 2009), the swordfish being more accessible in surface layers at night. The vessels observed were mostly engaged in regular commercial fishing operations and in general did not change their fleet's standard practices during the trips observed. One trip made between 2007-2008 was engaged in an experimental-survey, looking for possible new, very southerly fishing areas and testing gear modifications for tuna species. In that particular trip, the fishing sets were in a previously defined southern fishing area 30º-45ºS, 0º-20ºE where commercial fishing activity targeting swordfish is not regularly carried out by this Spanish surface longline fleet. However, the observations obtained during this survey were also incorporated into this analysis.

All effort (hooks) set and haulback during the trips were observed and interactions (positive or null) recorded. Information recorded was compiled by year, month and area (5ºx5º squares). The 5ºx5º areas were named following the ICCAT criteria of four quadrants (1, 2, 3 and 4), latitude (2 digits) + longitude (3 digits). The name of each 5ºx5º area represents the nearest point to 0º Lat./0º Lon. Information by area, month and years combined was used to obtain an overall picture of the geographical and temporal coverage achieved during the period observed and analyzed. Rates of interaction were defined for each area based on the nominal effort observed (thousand hooks observed) and the number of seabird interactions recorded (positive or null) for the respective number of hooks. Task II-effort 5ºx5º data was also used for comparison with the areas of observations at sea and interactions with seabirds.

3. Results and discussion

A total of 7,636,138 hooks recorded in 138 5ºx5º areas in broad regions of the North and South Atlantic Ocean during the period 1993-2017 were analyzed. **Figure 1** shows a comparison between the nominal effort (thousand hooks) by area observed during the combined period and the number of positive interactions (number of seabird interactions) observed in each area. Zeros are omitted in the figure for those areas with null interactions. Additionally, the results obtained from the Global Procellariiform tracking workshop (BirdLife International 2004) are presented for comparison.

Table 1 shows the number of hooks observed as well as details of interactions with seabirds by year and month for those 5ºx5º areas where at least one seabird interacted with the longline fleet during the whole 1993-2017 period observed. Other areas also observed with null interactions throughout the period are omitted from this table. **Table 2** summarizes the number of hooks observed, the number of interactions and rates of interaction of seabirds per thousand hooks, for years and months combined, in each 5ºx5º square where positive interaction occurred during the period observed. Only in eight of the one hundred and thirty-eight 5ºx5º areas observed did positive interactions occur. Two of the squares with positive interactions were in the southern area of the experimental survey-trip looking for new fishing areas/season/species and they showed the highest rates of interaction observed **(Table 2 and Figure 2)**. The number of positive interactions observed by year is also provided (**Table 3**). Years with null interactions are omitted from this table.

No interaction with seabirds was observed in areas of the North Atlantic during the period analyzed. Although the number of hooks observed in the North Atlantic was relatively smaller because of the home-based approach of this fleet and the fact that scientific information was based predominantly on data collected during landing, no interaction with seabirds was observed at any time during the period observed or during electronic and conventional tagging surveys carried out by scientific staff. Of the total of 38 interactions observed in the Atlantic during the 25-year period analyzed, 36 (95%) occurred at latitudes ≥25ºS. A total of 28 interactions (74%) corresponded to a single vessel-trip-year observed between August and October 1995 in areas falling within the squares at 25º-30ºS/35º-45ºW. However, interaction recorded by other vessels-trips in previous and later years and in the same areas and months was rare or null. The scientific observer points out that during the trip where there was a high degree of interaction certain factors affected regular operations on the ship, including very adverse weather conditions which led to changes in normal fishing practice and timetables, an exceptional number of seabirds following the ship and problems with the bait, which easily became detached from the hooks, making it necessary at times to employ a different type of bait from that normally used. All these circumstances suggest that the high figures recorded in 1995 for that particular vessel and trip were the result of these exceptional factors. Of the total of 38 interactions observed during the period analyzed, the 5 (13%) corresponding to the highest rates of interaction were observed in two southern squares where an experimental-survey trip for new fishing areas/season/species was being carried out. However, the areas prospected had not been regular fishing areas for this fleet and did not become such areas after the survey.

Procellariiformes was the order of seabirds that had most encounters with the trips observed. The distribution of these seabirds is related to the stages in its breeding cycle. The seasonal breeding stages of the main seabird species incidentally captured in some observed longline fishing fleet data are described in various ACAP reports (ACAP 2012 [a,b,c]). **Figure 3** shows the geographical distribution of the annual average fishing effort (task II-effort) and the observed seabird interaction rate in the Spanish longline fleet during the breeding (October-April) and non-breeding (May-September) seasons (Jimenez *et al.* 2017).

The locations observed during the 25-year period represent areas in which this fleet has traditionally fished, with the addition of information regarding some other rare areas only observed during a survey. The observations available for the twenty-five year period analyzed allow us to conclude that interaction with seabirds in this fleet was generally very rare or null in most of the areas-periods observed in the North and South Atlantic where the fleet is targeting swordfish. However, exceptions were found in one trip in 1995 and another in a survey prospecting-trip in 2008 done in very southerly areas which are not regularly fishing this fleet.

There may be a slight overlap between the areas preferred by swordfish and those chosen by certain seabirds such as Procellariiformes, so that the highest rates of interaction with these species of seabirds could occur further to the South than the areas where swordfish are predominantly distributed and fished, or in fisheries closer to the coast or in those fisheries targeting other species and/or using other type of setting styles.

The results obtained recommend that analyzes to assess overall interaction rates be carried out fleet specific. When information from several different fleets is combined, the analyses should be focused on at least considering fleet specific factor and details about each fleet and circumstances associated with the data. As indicated above, oceanic longlines used for targeting different tuna and tuna-like species are very often mistakenly assumed to be similar. However, fishing areas (i.e. ranges of lat-long) and target species, gear characteristics, gear styles, fishing protocols and many other factors are very different among different longlines. For this reason, the results obtained in a fleet should not be assumed as representative of other longline fleets. Records from different fleets should not be combined in a simple way without considering the peculiarities of each fleet-gear-style.

Sightings were also considered during some trips observed and in some cases these were very abundant (see details e.g. Ramos-Cartelle *et al.* 2017). Most sightings took place in the middle of the day or during navigation, but on some occasions when setting or hauling were taking place, although generally no interactions occurred. The sightings varied greatly from one area to another. Most scientific observers attributed the lack or scarcity of positive interactions to various main factors and the routine regularly followed: (a) The lack of some seabird species in most important ocean areas where this fleet regularly fishes swordfish in the Atlantic Ocean. (b) Setting is generally started with very little daylight, mainly at dusk or when night has fallen. (c) In general, there is no waste that might attract seabirds and deck lighting is limited to what is strictly necessary for the safety of the vessel and the crew members. (d) The speed during setting procedures with the line setter, which is designed to pull monofilament longlines from the spool at a rate greater than or equal to the speed of the vessel and allows the main and branch lines carrying the hooks and bait to sink more rapidly, as well as the bait types regularly used.

The *night setting style* was historically implemented by this fleet targeting swordfish. However, since 2002, in response to domestic Order APA/1127/2002, more precautionary mitigation measures have been implemented, which were applicable to all surface longline fishing vessels flying the Spanish flag and targeting swordfish in waters South of 30º S, irrespective of the ocean and area in which they carried out their activity. Additionally, in the case of ICCAT, new actions based on Rec. 07-07 and Rec. 11-09 have been put in place since 2008. More recently, via domestic Order AAA/658/2014[2] (later updated in Order APM/1057/2017), the National Fishing Authority has established more precautionary actions which are stricter than those specified in Rec. 07-07 and Rec. 11-09 and are applicable to the whole Spanish surface longline fleet, irrespective of the area or ocean in which each specific boat is authorized to fish.

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[2] Order AAA/658/2014 of 22 April. Ministry of Agriculture, Food and the Environment. Official State Gazette no. 102, 28 April 2014.

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Table 1. Number of hooks observed and number of interactions with seabirds by year and month, in those 5ºx5º squares (Quad.+Area) where at least one seabird was interacted during the whole observed period (1993-2017). Areas with null interaction are omitted.

Quad	*Area*	*Year*	*Month*	*Hooks*	*Seabirds interacted*
2	15010	2003	10	27840	
			11	47896	1 *Larus sp.* + 1 *Morus bassanus*
		2003	12	3840	
2	30000	2008	01	5344	2 *Thalassarche spp.*
2	35000	2008	01	4460	3 *Thalassarche spp.*
3	25035	1993	10	6300	
		1995	10	10680	
		1996	11	2760	
		1997	03	23500	
			04	10320	
			03	10680	
		2001	04	1120	
		2004	09	14400	
		2005	04	14918	
		2017	07	4505	1 *Ardenna gravis*
			11	1923	
3	25040	1993	10	17684	
			11	12000	
			12	20380	
		1994	09	21260	
			10	25618	
		1995	08	62600	3 *Thalassarche chlororhinchos* + 1 *Thalassarche melanophris*
			09	37492	3 *Procellaria aequinoctialis* + 3 *Thalassarche chlororhinchos* + 1 *Diomedea exulans*
			10	30600	1 *Procellaria aequinoctialis* + 1 *Thalassarche chlororhinchos*
		2004	08	18720	
			09	23040	
			10	17280	1 Diomedeidae
		2005	04	4729	
			05	65860	
		2017	07	5684	
			09	1956	
3	30030	1994	09	7000	
			10	31844	
		1995	10	2400	1 *Thalassarche chlororhinchos* + 2 *Thalassarche melanophris*
		1996	11	2880	
		1997	03	2520	
		2001	04	2520	
		2005	02	2548	
		2017	09	6925	
			10	12190	1 *Thalassarche melanophris*
3	30035	1993	11	6816	
		1994	09	4600	
		1995	09	9600	1 *Thalassarche chlororhinchos*
			10	2200	1 *Thalassarche chlororhinchos* + 1 *Thalassarche melanophris*
		1997	03	7920	
		2005	02	2548	
			04	12737	
		2017	09	11715	
3	30045	1993	10	2200	
			12	10080	
		1994	10	2400	
			11	4400	
		1995	09	2200	1 *Thalassarche chlororhinchos* + 1 *Thalassarche melanophris*
			10	7560	1 *Thalassarche chlororhinchos* + 2 *Thalassarche melanophris* + 4 *Procellaria aequinoctialis*
		1996	11	2760	
		2004	08	2880	
			10	5760	
			11	2880	
		2005	02	2093	
			05	5093	
			06	7274	
		2017	08	3679	

Table 2. Observed seabird interaction rate (number per thousand hooks) and 5ºx5º squares (Quad.+Area) with positive interaction, during the combined 1993-2017 period. Only areas with positive interaction are included.

Quad.	*Area*	*Hooks*	*No. seabirds*	*Rate*
2	15010	79576	2	0.0251
2	30000	5344	2	0.3743
2	35000	4460	3	0.6726
3	25035	101106	1	0.0099
3	25040	364903	14	0.0384
3	30030	70827	4	0.0565
3	30035	58136	3	0.0516
3	30045	61259	9	0.1469

Table 3. Number of seabird interactions observed by year during the 1993-2017 period. Only years with positive interaction are included. (1) All interactions in a single trip. (2) All interactions in a survey-trip.

Year	*No. seabird interactions*
1995	28(1)
2003	2
2008	5(2)
2017	2

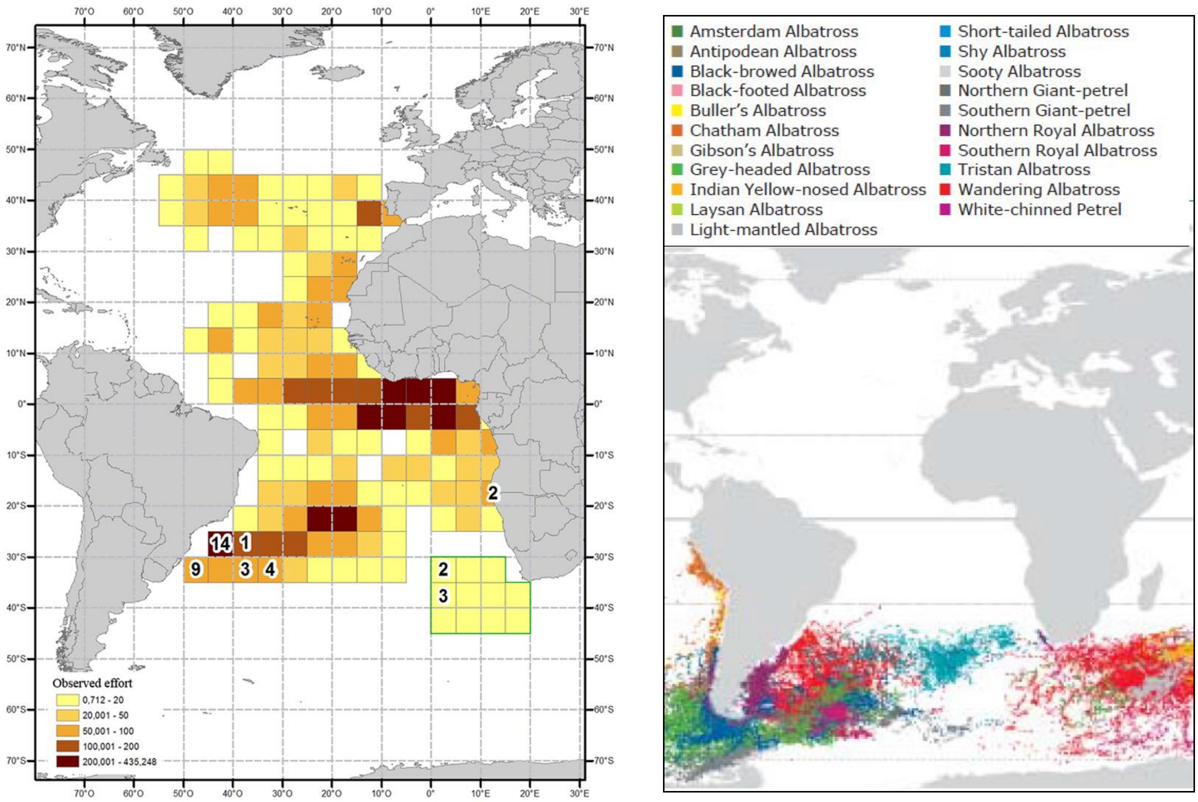

Figure 1. Left panel: 5ºx5º areas, nominal observed effort in thousands of hooks (combined 1993-2017). Numbers in each square identify the total number of seabird interactions. Numbers in squares with null interaction are omitted. The green outline indicates the experimental fishing areas of the survey-trip also included. Right panel: Satellite/platform terminal transmitter (PTT) tracking locations submitted to the Global Procellariiform Tracking Database (BirdLife International 2004).

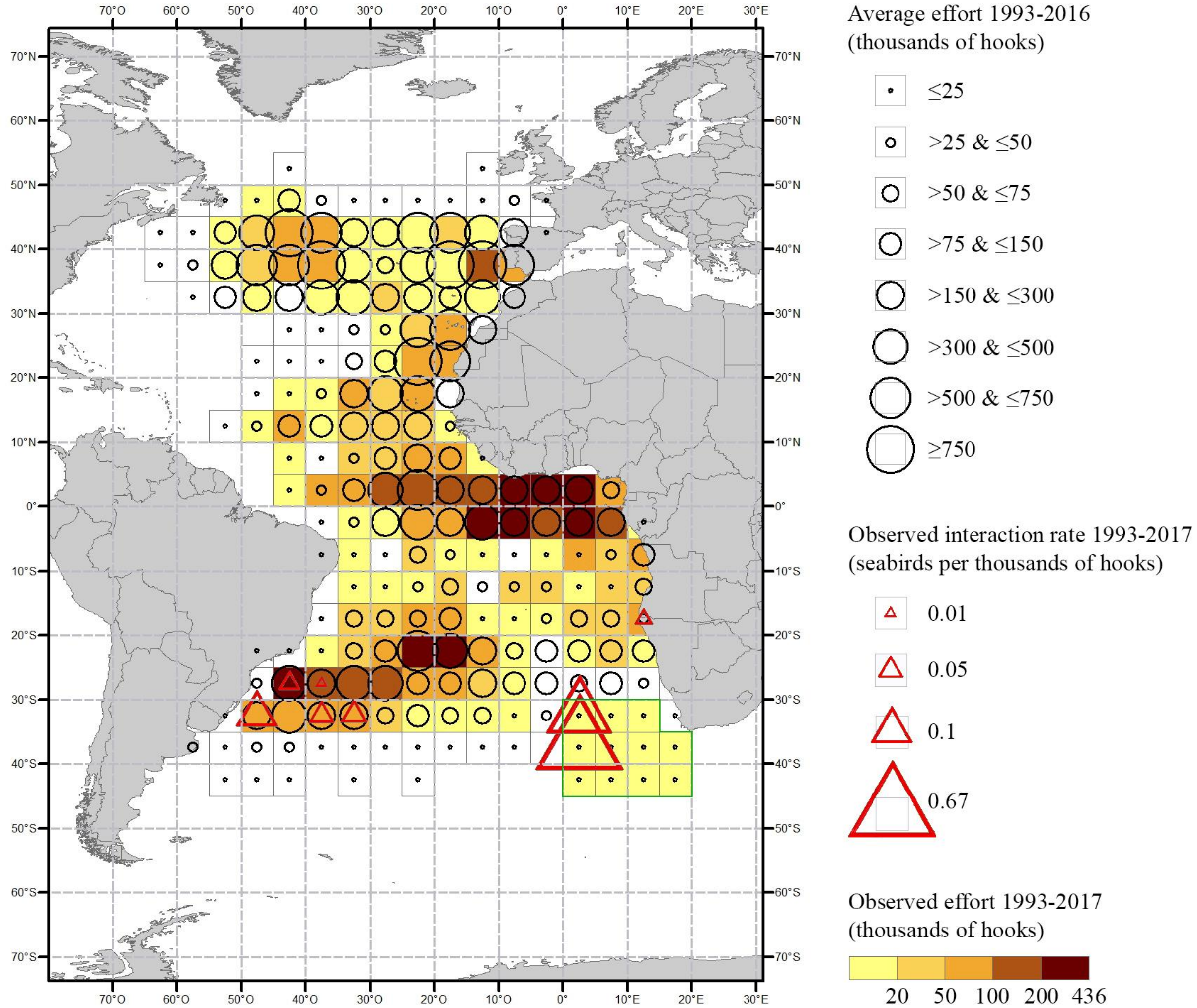

Figure 2. Circle scale represents the average-annual 5ºx5º area nominal effort (Task II-effort) in thousands of hooks of the Spanish surface longline fleet targeting swordfish during the combined period 1993-2016 (data for 2017 are not yet processed). Red triangles indicate the observed seabird interaction rate (number of seabirds per thousand hooks observed) in the combined period 1993-2017. The yellow-brown color scale represents the nominal scientifically observed effort in thousands of hooks (combined period 1993-2017) for each 5ºx5º area. The green outline indicates the experimental fishing areas of the survey-trip also included in these analyses.

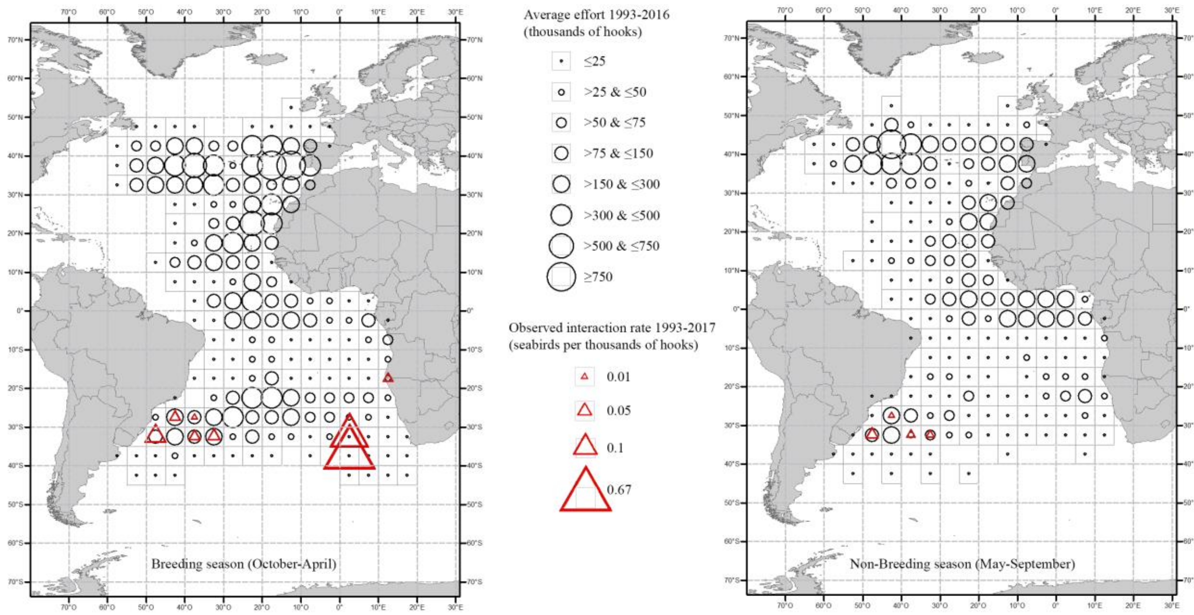

Figure 3. Comparison between *breeding* and *non-breeding* seasons (Jimenez *et al*. 2017) for 5ºx5º areas: average nominal effort (Task II-effort) in thousand hooks of the Spanish surface longline fleet targeting swordfish during the combined period 1993-2016 (data for 2017 are not yet processed) and the observed seabird interaction rate (number of seabirds/thousand hooks) in the combined period 1993-2017.