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STANDARDIZED YIELDS OF THE WHITE MARLIN (*KAJIKIA ALBIDA*) AND THE ROUNDSCALE SPEARFISH (*TETRAPTURUS GEORGII*) CAUGHT AS BYCATCH OF THE SPANISH SURFACE LONGLINE FISHERY TARGETING SWORDFISH (*XIPHIAS GLADIUS*) IN THE ATLANTIC OCEAN

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SUMMARY

Standardized yields of Kajikia albida *and* Tetrapturus georgii *were obtained from 27,481 recorded trips (887.86 x10*^{6} *hooks) by the surface longline fleet targeting swordfish in the fishing areas of the Atlantic during the period 1988-2017. The observations represent about 95% of the total fishing effort of this fleet during the combined period. Roughly 4.64% of the trips recorded showed a positive catch of these species. Because of their low prevalence in this fishery, the standardized yields were calculated using a Generalized Linear Mixed Model, assuming a delta-lognormal error distribution. An overall flat trend was predicted for the whole period considered, with some annual fluctuations. The very low values predicted for the last three years were caused by the implementation of drastic domestic regulations. Some other considerations are also discussed, such as a high inter-annual variability, considered biologically unlikely, and uncertainty in the data, possibly caused by factors such as dead discards, live releases, species misidentification and current regulations.*

RÉSUMÉ

La standardisation de la production de Kajikia albida *et de* Tetrapturus georgii *a été calculée à partir de 27.481 sorties enregistrées (887,86 x 10*^{6} *hameçons) par la flottille palangrière de surface ciblant l'espadon dans les zones de pêche de l'Atlantique pendant la période 1988-2017. Les observations représentent environ 95% de l'effort de pêche total de cette flottille au cours de la période combinée. Environ 4,64% des sorties enregistrées présentaient une capture positive de ces espèces. En raison de leur faible prévalence dans cette pêcherie, la standardisation des productions a été réalisée au moyen d'un modèle mixte linéaire généralisé postulant une distribution d'erreur delta-lognormale. Une tendance généralement aplanie était prévue pour l'ensemble de la période considérée, avec quelques fluctuations annuelles. Les très faibles valeurs prévues pour les trois dernières années ont été causées par la mise en œuvre de réglementations nationales drastiques. D'autres facteurs sont également pris en compte, tels qu'une variabilité interannuelle élevée, considérée comme étant biologiquement improbable, et une incertitude dans les données, probablement causée par des facteurs tels que les rejets morts, les remises à l'eau de spécimens vivants, l'identification erronée des espèces et les réglementations en vigueur.*

RESUMEN

Rendimientos estandarizados de Kajikia albida *y* Tetrapturus georgii *fueron obtenidas a partir de 27.481 registros de mareas (887,86 x10*^{6} *anzuelos) de palangreros de superficie dirigidos al pez espada en áreas del Atlántico durante el periodo 1988-2017. Estas observaciones representan el 9 5% del total del esfuerzo de pesca de esta flota durante dicho periodo. Aproximadamente el 4,64 % de las mareas registradas tuvieron captura positiva de estas especies. Debido a la baja prevalencia de estas especies en esta pesquería, los rendimientos estandarizados fueron estimados usando un modelo mixto lineal generalizado, asumiendo una distribución de error "delta-lognormal". Una tendencia generalmente plana fue estimada para todo el periodo considerado, con algunas fluctuaciones anuales. Los muy bajos valores predichos para los tres últimos años fueron producto de la implementación de drásticas regulaciones internas. También son discutidas algunas consideraciones como la alta variabilidad interanual, considerada biológicamente inverosímil, así como la incertidumbre en los datos debida a posibles factores como los descartes muertos, las liberaciones vivas, la mala identificación de especies y las regulaciones vigentes.*

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KEYWORDS

White Marlin, Catch Rates, Abundance, GLM

1. Introduction

The white marlin species *Kajikia albida/Tetrapturus albidus* (WHM) is a bony fish targeted by recreational fleets in many coastal countries and around oceanic islands with warm sea waters. This species is an important attraction for tourism activity related to big-game fishing and high-end charter cruises. The species may also be captured by small-scale coastal fleets using driftnets and artisanal gears, so that this and other species of istiophorids can provide an important source of food for people living near the coast in many countries. The fishing areas where the tuna and tuna-like fisheries operate overlap in some cases with areas where some common istiophorids may be found, because of their biological characteristics (García de los Salmones *et al*. 1989, González and Gaertner 1992, Dickson 1995, Goodyear 2002). The white marlin can thus appear as a target species in some fisheries, but also as a bycatch species in other fisheries such as deep and surface longliners (Anon. 2005), in purse seine fleets targeting tropical tuna (Anon. 2013, Delgado de Molina *et al*. 2001, Gaertner *et al*. 2003) and in other fishing gears.

Catches and landings of WHM by all fleets have probably not been well documented historically. There are estimates for some of the main ocean-going fleets but there are still important gaps in information on many others, such as artisanal, coastal and sports fisheries, which probably account for a significant proportion of catches and mortality of all fish belonging to the species. Catches reported as WHM have fallen significantly since the years 2000-2002, especially for the main Atlantic longline fleets, where a reduction in fishing effort was also observed. However, there does not seem to have been a fall in catches equivalent to the reduction in nominal effort (Anon. 2013).

Previous studies of this fleet have made scientific estimates of catches and landings and have also provided biological details of the species (García-Cortés *et al*. 2010, 2012, 2019-SCRS/2019/047; Mejuto *et al.* 2000, 2002, 2006, 2007). For the first time standardized CPUE indices were also developed for this species, which appears sporadically in this fishery as low prevalence bycatch (Ortiz de Urbina *et al.* 2013). Nevertheless, because of confusion between *Kajikia albida* (WHM) and *Tetrapturus georgii* (RSP) in the Spanish fleet up to 2008 and given that historically catches of both species were not reported separately to ICCAT by most fleets, there is a risk that trends for these two species may be masked. For this reason, this study follows the SCRS recommendation that the two species should be combined for analysis.

Based on results and conclusions achieved in previous studies (Ortiz de Urbina *et al.* 2013), this document analyses the scientific records by trip gathered for 1988-2017 in order to obtain standardized yield for both species combined in the Atlantic Ocean, where the Spanish surface longline fleet has traditionally operated. Some possible sources of uncertainty are also considered and discussed, which could affect the different fleets that operate in the Atlantic.

2. Materials and methods

The traditional surface longline gear of the Spanish fleet targeting swordfish in the Atlantic remained relatively constant over several decades of the past century in terms of general structure and configuration. However, around the year 2000 the monofilament or so-called “American style” gear was suddenly and widely introduced in most fishing areas and boats. The two longline styles were considered and categorized in this analysis. Night setting was used for both styles of longline (Mejuto and De la Serna 2000, Mejuto *et al*. 2003, 2005, 2011).

Up to 2008 no distinction was made between catches of white marlin (*Kajikia albida*-WHM) and roundscale spearfish (*Tetrapturus georgii*-RSP), so that identification and reporting were subject to confusion. In accordance with SCRS recommendations, records for the two species (WHM+RSP) were therefore considered jointly for this study.

Landing data considered in the present paper as catch of WHM+RSP, and the nominal fishing effort per trip were recorded during the period 1988-2017 from research activity. Nine geographical regions were defined (**Figure 1**). Yearly quarters were defined as follows: Q1 = January, February, March; Q2 = April, May, June; Q3 = July, August, September; Q4 = October, November and December. The 'gear' factor took two types of longline style (traditional and 'American style') into account.

The standardization of yields in number of fish landed per million hooks (CPUE) for the Atlantic Ocean was carried out using a Generalized Linear Mixed Model (MIXED procedure, SAS 9.4) assuming a delta-lognormal model error distribution. Under this model, both the catch rates of positive records and the proportion of positive records were fitted separately (Lo *et al.* 1992, Ortiz and Arocha 2004). The proportion of positive components serves to model the probability of capturing these species (at least one fish) in a trip. The factors tentatively considered were year, region, quarter, gear and their interactions. The final models were selected based on the analysis of deviance, including the main factors and factor-interactions that reduce overall deviance ≥ 5% of the null model and provide a solution. Since the objective is to provide a relative annual index of abundance, the interactions that involve the year factor could not be included as a fixed interaction in the model. However, year interactions may be considered as random interactions (Maunder and Punt 2004) where the estimated variance due to interaction is incorporated into the annual trend along with its estimated standard error. The final models were:

> Model positive catch rates = year + quarter + region + gear + quarter*gear + quarter*region and random interactions year*quarter + year*region, assuming a lognormal error distribution.
>
> Model proportion of positives = year + quarter + region + gear and random interaction year*quarter, assuming a binomial error distribution.

3. Results and discussion

The analysis covered a total of 27,481 trips (887.86 x10^6 hooks analysed) made in the swordfish fishing grounds of this fleet in the Atlantic Ocean as a whole for the period 1988-2017 (**Figure 1**). This effort represented around 95% of the total fishing effort of this fleet during the combined period. Only in 4.64% of the trips (1,275 trips, corresponding to 30.60 x10^6 hooks) was a positive catch of white marlin or roundscale spearfish recorded. Data analysed confirm the overall low prevalence of these species in the Spanish longline fishery in the whole Atlantic Ocean fishing areas. The low number of positive trips obtained should be considered informative in the context of all fishing areas and seasons regularly covered by this fleet targeting swordfish in North and South Atlantic zones during this long time period, while information from observers analysed and discussed in other contributions (e.g. Ortiz de Urbina *et al.* 2013, García-Cortés *et al.* 2012, 2019-SCRS/2019/047) represents only minor coverage, but mainly from specific areas-zones where the presence of billfish species is more likely, providing in this last case different but useful complementary information for some other subjects such as biological data.

The analysis of deviance (**Table 1**) highlights the main factors and factor-interactions that reduce the overall deviance (≥ 5%) of the null models, in both the positive only observations model and the proportion of positive model components. The year factor and its interactions explained most of the variations observed in positive catch rates (82.1%) and in the proportion of positive catches (81.9%). However, it does not seem biologically plausible in this long-lived and highly migratory species that natural inter-annual variability should carry so much more weight than other factors such as region or season. The low prevalence of these two species in this fishery, possible environmental variations between years and/or access to certain areas with more or less local occurrence/availability of these species in specific years, and other factors such as misidentification or incomplete records over the years, etc., are elements that could affect the inter-annual variability recorded which probably should not be assumed as an indicator of "relative abundance" each year. However, the usefulness of this indicator may be the interpretation of the overall general trend in the period analysed, although with the reservations discussed below. Similar uncertainty may affect the analysis of other fleets and types of gears with a smaller coverage and where the prevalence of these species as bycatch is usually low, although such details are rarely described or considered.

Higher or lower rates of capture for these two low-prevalence species as bycatch in longline fisheries targeting tuna and tuna-like species could be due above all to random elements related to their local availability, not necessarily linked to fishing strategy, annual abundance of the stock or to factors normally considered in these type of analyses applied to the main or targeted species. Moreover, the low prevalence of these species in this gear makes it necessary on occasion to approach analysis pragmatically, especially when assuming broad geographical strata. Although it is desirable to use the finest stratification possible (Anon. 2013), it is not always viable to obtain solutions for species of this kind.

Figure 2 shows the residual pattern of log-transformed catch rates, the normal probability, *qq*-plots and residuals by year of the positive catches. **Figure 3** and **Table 2** show the standardized CPUE obtained for the series analysed. The standardized CPUEs obtained probably do not represent annual stock abundances but suggest a relatively flat trend throughout the period analysed. However, for the interpretation of this trend our subsequent comments should be considered.

The document Ortiz de Urbina *et al.* (2013) and others dealing with the same fishery (see previous references) probably represented advances in the study of WHM or the two species taken together. The WHM-2012 assessment group (Anon. 2013) made a number of observations focusing on several of the documents presented. The authors of the present study are aware of the difficulties normally experienced by national scientists when carrying out studies of low prevalence bycatch species, allowing for possible sources of uncertainty affecting the data over time for these species in the different fleets analysed. Records of catches/landings of WHM and RSP can be affected by various sources of uncertainty, regarding both annual estimates for Tasks I and II and also the calculation of standardized yields for each fleet. They include:

(a) The effect of regulatory measures implemented domestically or by ICCAT. (b) Catches of these species by coastal, artisanal, sports or recreational fisheries are not reported or only partially reported. (c) Catches by ocean-going fishing vessels may be unreported or only partially reported when these species are a low prevalence bycatch considered of less commercial importance than other more prevalent species. (d) Poor classification of these fish, which may be included under the general heading of “other fish”. (e) Taxonomic misidentification of the species, so that they are recorded as other type-species of billfish. (f) Catches of these species may be recorded under the general heading of unidentified “istiophoridae” (BILunk), which includes various genera/species. (g) Voluntary or accidental discards of dead fish, eaten by sharks, false killer whale, etc. which are often not correctly recorded. (h) Releases of live fish (including tagged and released fish).

It is probably optimistic, and perhaps pragmatic, to assume that the systems implemented and the data used by scientists can take into account all possible sources of uncertainty and faithfully record all possible components of the catch when we are dealing with a low prevalence bycatch species, unless the systems involve a firm conviction of their usefulness and there is a profound awareness in the respective fleets of “collaborative science” with fishermen (Jiménez-Esquivel *et al.* 2018), providing tools to help fishermen – in collaboration with scientists and managers – generate trusted, credible and relevant data which has the best chance of being applied as evidence in stock assessments and fisheries management (Mackinson *et al.* 2017).

In this sense, consideration must also be given to the difficulties normally introduced by the regulations on catch limits of low prevalence bycatch species which are often misidentified in many commercial, artisanal and sports fisheries, and the effects of cases where the taxonomic identification of species is difficult for crews and even for scientists (Anon. 2013, García-Cortés *et al.* 2019-SCRS/2019/047). These elements of uncertainty not only affect studies of standardized CPUE, whether such uncertainty is recognized or disregarded for various reasons, but can also affect the estimates of Tasks I and II used in assessments.

Badly designed regulatory measures can have undesirable effects on the reliability of scientific data and/or generate true or apparent *cross-taxa* conflicts (Gilman *et al.* 2019), including in some cases species bias in calculations of CPUE and Tasks I and II. An example of uncertainty probably caused by regulatory measures in the case of WHM is suggested by the SCRS, which points out that the drop in landings reported by some CPCs could be virtual matter and/or that some WHM landings could have been recorded and/or submitted as combined istiophorids (BILunk). In the latter case, if the BILunk component were not allowed for and only WHM records were considered, not only the indicator assumed for relative abundance but also the Task I and II estimates used for assessment would be significantly underestimated, unless corrective action were previously taken.

Regulatory measures introduced since 2000 [Rec. 2000-13] including annual landing limits and other measures, and other recommendations implemented subsequently [e.g. Recs. 2011-07, 2012-04, Rec. 2015-05] have probably had effects on data from some fleets (see Anon. 2013). Certain drastic domestic regulations are also likely to have contributed to inaccuracy in the quality and representativeness of the data recorded for these species. Independently of the studies carried out, as suggested by Anon. (2013), one would expect the CPUE indicators obtained in some fleets to show bias after the introduction of regulations imposing area-time restrictions, limits on catches-landings, dead discards and/or live releases.

As pointed out above, based on the results of previous studies of this fleet, this document uses scientific records of landings per trip obtained over thirty years, a period during which various events some of them already commented on could have affected data for these two species (García-Cortés *et al*. 2012) and probably other fleets as well (Anon. 2013). However, if we were to consider the results available for the Spanish surface longline fleet based on data provided by scientific observers (e.g. García-Cortés *et al*. 2019-SCRS/2019/047) and assume that some of these results were representative of the general behaviour of this fleet, it would not seem that dead discards or the release of live fish had a significant effect on uncertainty regarding long-term CPUE after 1999. Nevertheless, even if we accept this strong premise, dead discards and/or live releases could have had an impact before 1999 and possibly in some later years, such as 2005-2006 or 2009-2010 and, to a lesser extent, 2018 (a year not considered in this document). In the years indicated, levels of dead discards seem to have been relatively high on those vessels with observers on board, especially before 1999 (García-Cortés *et al*. 2019-SCRS/2019/047). However, it would be a strong assumption to conclude that the behaviour observed in some vessels can be generalized for the whole fleet, especially for temperate north Atlantic areas where high fishing activity is carried out by the home-based fleet in which discards are highly unlikely and the occurrence of the two species analysed is very low. For the years indicated above and especially before 1999, the standardized yields values obtained in this document could have been underestimated because discards and other uses were not considered.

Another possible source of uncertainty pointed out by the SCRS is the recording and reporting of catches of WHM and RSP within the BILunk group, which combines various types of istiophoridae. In the fleet analysed in this document, an increase in the BILunk category was seen between 1992 and 2000, after which the trend was relatively flat until 2017 (**Figure 4**). For the purposes of scientifically estimating annual Task I, as reported to ICCAT by EU-Spain, the BILunk group has been reclassified and the components reported separately by species based on verified scientific records. However, this breakdown cannot be applied to all observations for the purposes of calculating standardized CPUE, assuming common ratios between species for all observations. The authors are thus aware that, as in other fleets described (Anon. 2013), the standardized annual CPUE indicators presented here could be underestimated for the period 1992-1998 because of possible discards that are not considered and may also be underestimated for 2000-2017 as a proportion of the catches for both species could be catalogued as BILunk causing probably the virtual fall of positive WHM and RSP records observed after 2007. For the whole Atlantic fishing zones combined it has been estimated that around 25% of individuals in this BILunk group could belong to the species WHM and RSP, although with substantial differences between zones (García-Cortés *et al*. 2019-SCRS/2019/047).

Drastic restrictions on catches and null quotas implemented domestically in years 2015, 2016 and 2017[2] suggest that standardized yields obtained for the last three years of the period analysed in this document should be discounted as representative of regular catch rates and abundance levels and should, therefore, not be used for models tested with a view to assessing stocks.

4. Addendum

The present paper was submitted in time to the 2019 ICCAT white marlin stock assessment meeting (Miami, USA 10-14 June 2019) (Anon. 2019). The working group's comments include the following points:

(1) "*It was noted that an earlier version of the Spanish LL index was submitted within the timeframe for inclusion in the stock assessment, however the earlier version differed significantly from the index presented in this paper, and both differed from the previous version of the index presented in 2012 (Figure 2.2.1)*".

The preliminary standardized CPUE series sent to ICCAT in March-2019, *within the timeframe for inclusion in the stock assessment*, could not include such detailed analysis as that incorporated in the present paper. Due to the very early date of the preparatory meeting, and the early deadline established for submitting additional data even before the preparatory data report was available, it was not possible at that time to submit final results that would be fully satisfactory for the authors, as indicated by describing it as "*in progress*". Some refinements of the raw data, such as being able to have the complete series for effort duly verified and in the correct units (hooks), or the inclusion of some factors that the authors considered potentially relevant (e.g. the longline style), could only be incorporated in the final analyses, together with appropriate models and a discussion. This explains some of the differences between the preliminary and final results for standardized CPUE values estimated for some years in the series. However, the general relative trends in the preliminary results and those

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[2] Regulations EU 2015/1281, 2016/470, 2017/643

finally provided in the present paper do not differ so much from each other as they do from the figure (Figure 2.2.1) referred to in that paragraph of the WG report. "*The Group confirmed that this information is potentially useful because of the spatial and temporal extent of the data and that the analysis and diagnosis were appropriate given the small proportion of positive trips in the data set*". However, this series was not incorporated into the assessment except for "*sensitivity analysis*", a decision the authors do not discuss, although, from a scientific point of view, perhaps it should be justified and compared in terms of qualitative, quantitative and credibility criteria in relation to the other indices which were finally incorporated into the base-case analyses. The comment above gives the impression that it is unprofitable to improve analyses for future studies because such improvement could be considered a minor priority or even a demerit.

(2) “*The Group was concerned, however, that SCRS/2019/047 reported much higher proportion of positive sets for those sets monitored by scientific observers than the percentage of positive sets for trips reported in SCRS/2019/046*”.

This matter was extensively covered in the discussion of the two papers cited. A similar comment was made in the report on the previous assessment, although this issue had also been explained in scientific papers submitted at that time. This year, in order to avoid any misinterpretation, the authors explained this fact again in greater detail (see paragraph 1 of our discussion in the present paper), as well as in the complementary paper (see paragraph 17 of the discussion in García-Cortés *et al.* 2019-SCRS/2019/047). The authors reiterate once again the inconvenience of making such a comparison between the different information provided in both papers.

(3) “*Additionally, there was a concern that Task 1 reports from the Spanish longline for that same fishery in 2015-2017 had large catches in comparison to previous years, even though SCRS/2019/046 reports very low CPUE at landing for that same period*”.

This issue had already been explained in the present paper when dealing with the BILunk or BILunc groups (see the penultimate paragraph of the discussion in the present paper). The authors pointed out that the BILunk group has already been broken down by species and reported to ICCAT with the estimated annual T1 breakdown by species. However, it was not considered appropriate to apply this breakdown to each observation for the purposes of standardized CPUE analyses, as indicated in the discussion and related figures of this paper.

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References

Anonymous. 2005. Informe bienal 2004-2005. SCRS. Comisión Internacional para la Conservación del Atún Atlántico. 1^{a} parte (2004) Vol. 2: 230 pp.

Anonymous 2013. Report of the white marlin stock assessment meeting (Madrid, Spain, may 21-25, 2012). Collect. Vol. Sci. Pap. ICCAT, 69(3):1085-1183.

Anonymous 2019. Report of the 2019 ICCAT white marlin stock assessment meeting (Miami, USA 10-14 June 2019). Collect. Vol. Sci. Pap. ICCAT, 76(in press): 51pp.

Delgado de Molina, A., J. Ariz, J.C. Santana, P. Pallares and V. Nordstrom. 2001. Estimación de la importancia de las capturas fortuitas de peces de pico de las familias Istiophoridae y Xiphiidae realizadas por la flota de cerco en el océano Atlántico intertropical. Collect. Vol. Sci. Pap. ICCAT, 53:298-306.

Dickson, S.A. 1995. Unique adaptations of metabolic biochemistry of tunas and billfishes for life in the pelagic environment. Environ. Biol. Fish. 42: 65-97.

Gaertner, D., R. Pianet, J. Ariz, A. Delgado de Molina and P. Pallarés. 2003. Estimates of incidental catches of billfishes taken by the European purse seine fishery in the Atlantic Ocean (1991-2000). Collect. Vol. Sci. Pap. ICCAT, 55(2): 502-510.

García de los Salmones, R., O. Infante and J. Alió. 1989. Reproducción y alimentación de los peces de pico, Istiophorus albicans, Tetrapturus albidus y Makaira nigricans, en la costa central de Venezuela. Collect. Vol. Sci. Pap. ICCAT, 30: 436-439.

Gilman, E., M. Chaloupka, L. Dagorn, M. Hall, A. Hobday, M. Musyl, T. Pitcher and F. Pisson. 2019. Robbing Peter to pay Paul: replacing unintended cross-taxa conflicts with international tradeoffs by moving from piecemeal to integrated fisheries bycatch management. Rev. Fish. Biol. Fisheries: 31pp.

González, L.W. and D. Gaertner. 1992. Análisis preliminar de las campañas de pesca exploratoria de pez espada en la ZEE de Venezuela. Collect. Vol. Sci. Pap. ICCAT, 39(3): 643-655.

García-Cortés, B., J. Fernández, A. Ramos-Cartelle and J. Mejuto. 2010. Prevalence of Istiophorids (fam. Istiophoridae) on the basis of observations of the Spanish surface longline fleet targeting swordfish (Xiphias gladius) in the Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 65(5): 1797-1823.

García-Cortés, B., Ramos-Cartelle, A. and Mejuto J. 2012. Observations of the white marlin (Tetrapturus albidus) carried out on board of the Spanish surface longline fleet targeting swordfish from 1993-2010. Collect. Vol. Sci. Pap. ICCAT, 68(4):1432-1445.

García-Cortés, B., Ramos-Cartelle, A., Fernández-Costa, J. and Mejuto J. 2019. Update of scientific observations of white marlin (Kajikia albida) in the Spanish surface longline fishing fleet targeting swordfish in the Atlantic in the period 1993-2018. Collect. Vol. Sci. Pap. ICCAT, 76 ICCAT.SCRS/2019/047.

Goodyear, C.P. 2002. Spatio-temporal distribution of longline CPUE and sea surface temperature for Atlantic marlins. Collect. Vol. Sci. Pap. ICCAT, 54(3): 834-845.

Jiménez-Esquivel, V., C. López-Sagástegui, J.J. Cota-Nieto and I. Mascareñas-Osorio. 2018. Northwest Coastal Communities in Mexico Doing Science. Relaciones. Estudios de Historia y Sociedad, Vol. 39(153): https://www.redalyc.org/jatsRepo/137/13756646006/html/index.html.

Lo, N.C., L.D. Jacobson and J.L. Squire. 1992. Indices of relative abundance from fish spotter data base on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

Mackinson, S., S. Mangi, S. Hetherington, T. Catchpole and J. Masters. 2017. Guidelines for Industry-Science Data Collection: Step-by-step guidance to gathering useful and useable scientific information. Fishing into the Future report to Seafish: 65p. http://www.verdeprofundo.net/wp-content/uploads/2017/07/Data-Protocols-Guidance.pdf

Maunder, M.N. and A.E. Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fish. Res. 70: 141-159.

Mejuto, J. and De la Serna. J.M. 2000. Standardized catch rates by age and biomass for the North Atlantic swordfish (Xiphias gladius) from the Spanish longline fleet for the period 1983-1995. Collect. Vol. Sci. Pap. ICCAT 51(5): 1387-1410

Mejuto, J., B. García-Cortés and J.M. de la Serna. 2000. Estimaciones científicas preliminares de desembarcos de peces de pico capturados en el O. Atlántico y Mar Mediterráneo por la flota española de palangre de superficie de pez espada, durante el período 1988-1998. Collect. Vol. Sci. Pap. ICCAT, 51(3): 976-980.

Mejuto, J., B. García-Cortés and J.M. de la Serna. 2002. Preliminary scientific estimations of Billfish (Family Istiophoridae) landed by the Spanish surface longline fleet targeting swordfish in the Atlantic Ocean and Mediterranean Sea: years 1999-2000. Collect.Vol. Sci. Pap. ICCAT, 54(3):826-833.

Mejuto, J., García-Cortés, B. and De la Serna, J.M. 2003. An overview of the activity of the Spanish surface longline fleet targeting swordfish (Xiphias dladius) during 2000, with special reference to the Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 55: 1485-1494.

Mejuto, J., García-Cortés, B., De la Serna, J.M. and Ramos-Cartelle A. 2005. An overview of the activity of the Spanish surface longline fleet targeting swordfish (Xiphias gladius) during the year 2002, with special reference to the Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 58(4):1495-1500 (2005).

Mejuto, J., B. García-Cortés, J.M. de la Serna and A. Ramos-Cartelle. 2006. Scientific estimations of bycatch landed by the Spanish surface longline fleet targeting swordfish (*Xiphias gladius)* in the Atlantic Ocean: 2000-2004 period. Collect. Vol. Sci. Pap. ICCAT, 59(3): 1014-1024.

Mejuto, J., B. García-Cortés and A. Ramos-Cartelle. 2007. Preliminary approach to evaluate the importance of discards and other uses of Billfish in the Spanish surface longline fishery carried out in different oceans between 1993-2005. Collect. Vol. Sci. Pap. ICCAT, 60(5): 1547-1554.

Mejuto, J., Ortiz de Urbina, J., Ramos.Cartelle, A. and García-Cortés, B. 2011. Equivalence in efficiency per hook between the traditional multifilament and monofilament surface longline styles used by the Spanish fleet targeting swordfish (Xiphias gladius) in the South East Pacific. Collect. Vol. Sci. Pap. ICCAT, 33(4): 1541-1553.

Ortiz, M. and F. Arocha. 2004. Alternative error distribution models for standardization of catch rates of non target species from a pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery. Fisheries Research 70: 275-297.

Ortiz de Urbina, J.M., B. García-Cortés, A. Ramos-Cartelle and J. Mejuto. 2013. Application of zero-inflated models to the catch rates of white marlin (*Tetrapturus albidus*) based on data from the Spanish surface longline fishery targeting swordfish in the Atlantic Ocean. Collect. Vol. Sci. Pap. ICCAT, 69(3): 1195-1212.

Table 1. Deviance table analyses of the factors tested, for positive catch rates and for proportion of positives, respectively. Highlighted are the factors with ≥ 5% deviance explained.

Model factors positive catch rates values	*d.f.*	*Residual deviance*	*Change in deviance*	*% of total deviance*	*p*
Null	_	2458.8147			
Year	29	1999.2088	459.6059	40.5%	< 0.001
Year Quarter	3	1755.6892	243.5196	21.5%	< 0.001
Year Quarter Region	8	1570.9575	184.7317	16.3%	< 0.001
Year Quarter Region Gear	1	1570.8009	0.1566	0.0%	0.6923063
Year Quarter Region Gear Year*Gear	9	1559.3944	11.4065	1.0%	0.2488708
Year Quarter Region Gear Region*Gear	6	1531.9232	38.8777	3.4%	< 0.001
Year Quarter Region Gear Quarter*Gear	3	1510.5759	60.2250	5.3%	< 0.001
Year Quarter Region Gear Quarter*Region	21	1483.0116	87.7893	7.7%	< 0.001
Year Quarter Region Gear Year*Region	81	1356.5519	214.2490	18.9%	< 0.001
Year Quarter Region Gear Year*Quarter	73	1324.2592	246.5417	21.7%	< 0.001

Model factors proportion positives	*d.f.*	*Residual deviance*	*Change in deviance*	*% of total deviance*	*p*
Null	_	2918.5706			
Year	29	2319.1827	599.3879	31.2%	< 0.001
Year Quarter	3	1971.2646	347.9181	18.1%	< 0.001
Year Quarter Region	8	1621.5065	349.7581	18.2%	< 0.001
Year Quarter Region Gear	1	1581.6321	39.8744	2.1%	< 0.001
Year Quarter Region Gear Quarter*Gear	3	1564.5140	17.1181	0.9%	< 0.001
Year Quarter Region Gear Year*Gear	22	1504.2661	77.3660	4.0%	< 0.001
Year Quarter Region Gear Region*Gear	8	1480.7487	100.8834	5.2%	< 0.001
Year Quarter Region Gear Quarter*Region	24	1416.7437	164.8884	8.6%	< 0.001
Year Quarter Region Gear Year*Quarter	87	1268.6472	312.9849	16.3%	< 0.001
Year Quarter Region Gear Year*Region	215	996.4091	585.2230	30.4%	< 0.001

Table 2. Number of trips (Nobs), probability of positive catch (Obppos), observed mean CPUE in number of WHM+RSP / 10^6 hooks (Obcpue), estimated standardized CPUE (STDCPUE), 95% confidence intervals (LCI, UCI) by year.

Year	*Nobs*	*Obppos*	*Obcpue*	*STDCPUE*	*LCI*	*UCI*
1988	567	0.095	53.024	1.5162	0.5713	4.0238
1989	646	0.050	42.546	1.4836	0.4977	4.4228
1990	847	0.027	16.351	0.4957	0.1528	1.6084
1991	890	0.060	13.677	0.7593	0.2929	1.9680
1992	886	0.038	70.304	0.4252	0.1492	1.2120
1993	1158	0.038	4.178	0.2523	0.0913	0.6968
1994	1150	0.052	4.700	0.3022	0.1161	0.7864
1995	1374	0.055	15.337	0.5378	0.2199	1.3155
1996	1584	0.086	56.618	1.8561	0.7990	4.3119
1997	1759	0.106	61.434	1.1813	0.5211	2.6781
1998	1543	0.091	106.326	1.8143	0.7586	4.3390
1999	1127	0.046	12.504	0.5754	0.2246	1.4743
2000	897	0.027	16.477	0.6118	0.1994	1.8770
2001	1083	0.048	21.157	1.7113	0.6613	4.4286
2002	1083	0.006	0.787	0.0816	0.0154	0.4331
2003	836	0.037	13.806	1.1661	0.4050	3.3576
2004	807	0.051	25.281	1.6744	0.6133	4.5710
2005	678	0.069	15.428	1.4546	0.5435	3.8932
2006	631	0.057	9.882	1.3965	0.5079	3.8398
2007	580	0.072	10.218	1.4331	0.5209	3.9428
2008	633	0.028	7.846	1.1718	0.3465	3.9635
2009	711	0.013	1.154	0.1431	0.0312	0.6572
2010	708	0.020	5.398	0.5561	0.1513	2.0437
2011	751	0.007	0.965	0.1015	0.0171	0.6015
2012	704	0.020	11.599	0.9962	0.2643	3.7557
2013	638	0.025	52.012	3.7916	1.1011	13.0566
2014	771	0.017	18.077	1.8638	0.4716	7.3665
2015	864	0.006	1.482	0.2072	0.0360	1.1938
2016	816	0.007	1.927	0.2249	0.0407	1.2418
2017	759	0.008	3.292	0.2150	0.0397	1.1650

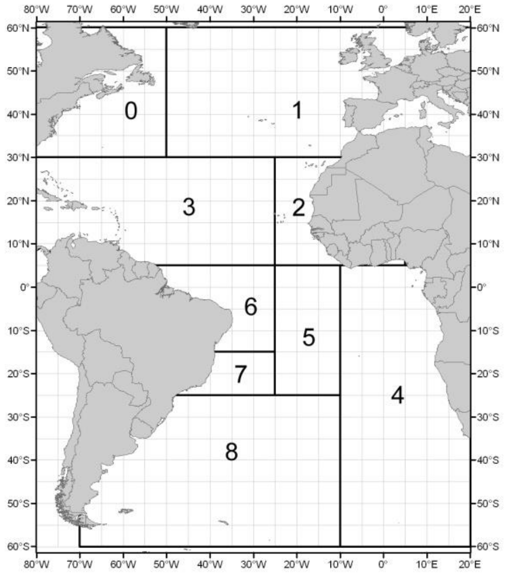

Figure 1. Stratification of geographical regions used for the GLM analysis of WHM+RSP in the Atlantic Ocean (figure from García-Cortés *et al*. - SCRS/2019/047).

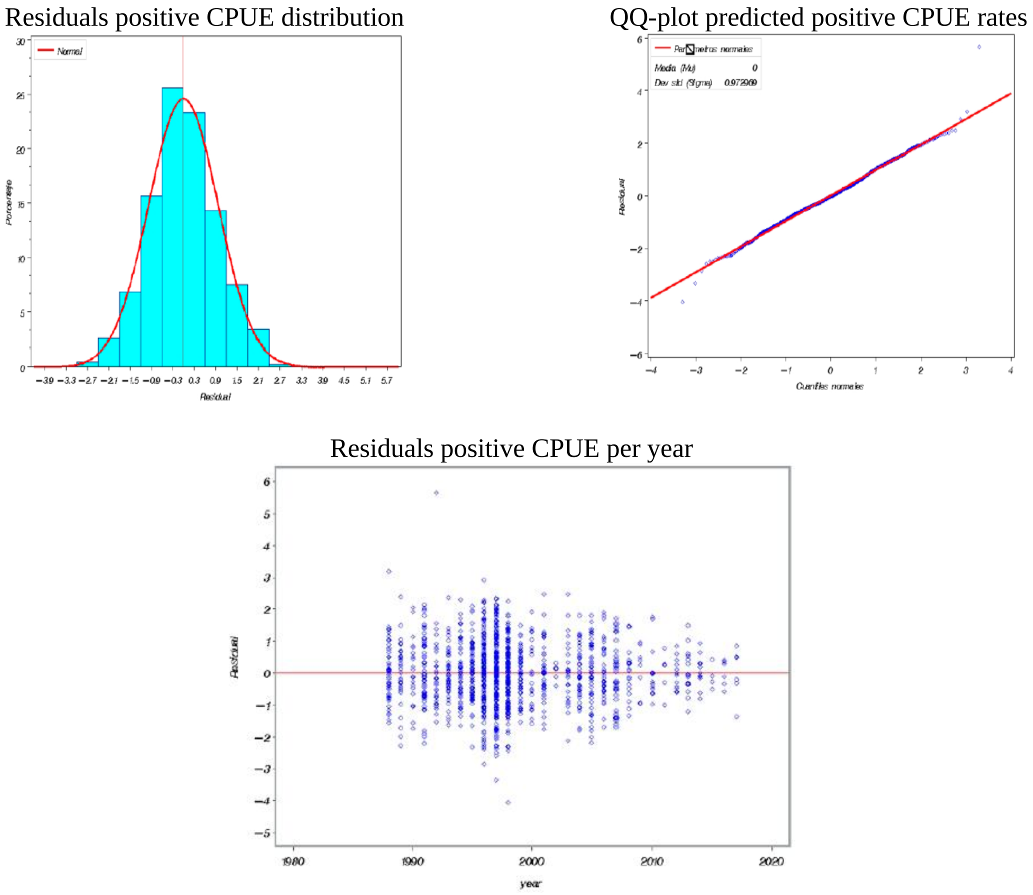

Figure 2. Distribution of the standardized residual of WHM+RSP CPUE, normal probability *qq*-plots and residuals of positive CPUE by year.

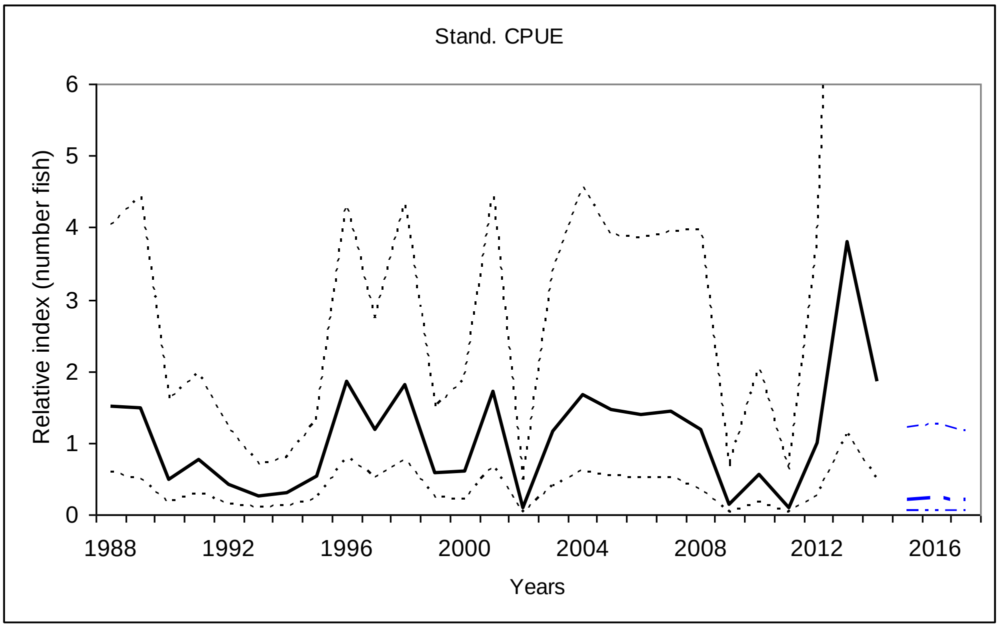

Figure 3. Estimated standardized CPUE in number of WHM+RSP and their corresponding 95% confidence intervals during the period 1988-2017 (the last three years of the period analysed should be discounted as representing regular catch rates)

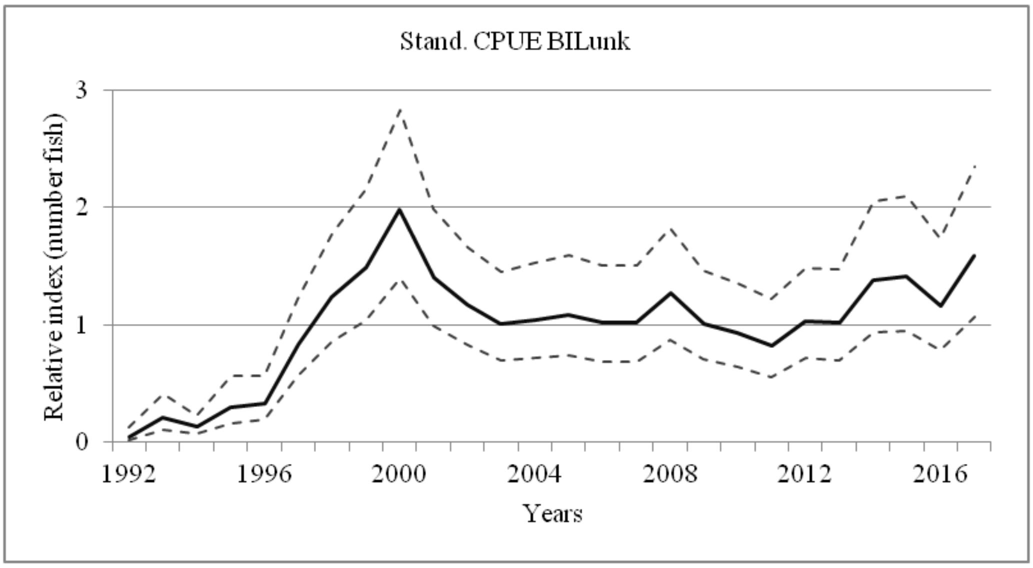

Figure 4. Estimated standardized CPUE in number of misidentified billfish species (BILunk) and their corresponding 95% confidence intervals during the period 1988-2017 (there were no BILunk records during the 1988-1991 period).