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AN ALTERNATIVE HYPOTHESIS FOR THE RECONSTRUCTION OF TIME SERIES OF CATCHES FOR NORTH AND SOUTH ATLANTIC STOCKS OF SHORTFIN MAKO SHARK

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SUMMARY

The reconstruction of shark catch time series is particularly important for stock assessments, as the nominal catch data on sharks is usually very limited and a major source of uncertainty. This document provides an alternative hypothesis for the reconstruction of shark catches in the Atlantic (ICCAT fisheries) based on a method developed for the EUPOA-Sharks (EU Plan of Action for Sharks). The estimation method is based on ratios of sharks:main species catches, obtained from observer programs, literature revision and/or personnel communications. In this paper we present the average estimations by fleet/métier for the Atlantic (2000-2015) as well as time series for 1971-2015. A specific estimation for shortfin mako by stock is also presented. In this specific case, the main differences in the declared vs. estimated catches are more relevant in the earlier years of the series, which is consistent with more underreporting and lack of species specific information in the earlier years. These time series (North and South stocks) can be considered for use as alternative catch histories in the 2017 ICCAT SMA stock assessment.

RÉSUMÉ

La reconstruction de la série temporelle de capture de requins est particulièrement importante pour les évaluations de stocks, car les données de prise nominale sur les requins sont généralement très limitées et sont entachées d'incertitude. Le présent document fournit un postulat alternatif de reconstruction des prises de requins dans l'Atlantique (pêcheries relevant de l'ICCAT) sur la base d'une méthode mise au point pour le plan d'action de l'UE pour les requins. La méthode d'estimation reposait sur les ratios des requins:prises des espèces principales, obtenues à partir des programmes d'observateurs, révision de la littérature scientifique et/ou communications personnelles. Ce document présente les estimations moyennes par flottille/métier pour l'Atlantique (2000-2015) ainsi que pour les séries temporelles 1971-2015. Une estimation spécifique du requin-taupe bleu par stock est également présentée. Dans ce cas spécifique, les principales différences entre les prises déclarées et estimées sont plus pertinentes dans les premières années de la série, ce qui coïncide avec une sous-déclaration accrue et le manque d'informations spécifiques aux espèces des premières années. Ces séries temporelles (stocks du Nord et Sud) peuvent être considérées comme des historiques de prise alternative dans l'évaluation de l'ICCAT des stocks de requin-taupe bleu de 2017.

RESUMEN

La reconstrucción de series temporales de captura de tiburones es particularmente importante para las evaluaciones de stock, dado que los datos de captura nominal de tiburones son generalmente muy limitados y una fuente importante de incertidumbre. Este documento proporciona una hipótesis alternativa para la reconstrucción de las capturas de tiburones en el Atlántico (pesquerías de ICCAT) basada en un método desarrollado para el Plan de acción de la UE para los tiburones. El método de estimación se basó en ratios de tiburones: capturas de especies principales, obtenidas de programas de observadores, revisiones bibliográficas y/o comunicaciones personales. En este documento se presentan las estimaciones medias por flota/métier para el Atlántico (2000-2015), así como la serie temporal para 1971-2015. Se presenta también una estimación específica para el marrajo dientuso por stock. En este caso específico, las principales diferencias entre las capturas declaradas y las estimadas son más relevantes en los primeros años de la serie, lo que es coherente con una mayor

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infradeclaración y con la falta de información específica de cada especie en los primeros años. Estas series temporales (stocks del norte y del sur) pueden considerarse para su uso como historias de captura alternativas en la evaluación del stock de marrajo dientuso de ICCAT de 2017.

KEYWORDS

Catch reconstruction, catch history, data-limited stocks, nominal catches, shortfin mako shark, stock assessment

1. Introduction

The main purpose of the European Union Plan Of Action on Sharks (EUPOA-Sharks) is to contribute to the general objectives outlined in the FAO IPOA Sharks by ensuring the management of shark stocks fished by the EU fleet. The Plan of Action covers all fishery activities in relation to sharks, such as directed commercial, by-catch commercial, directed recreational, and by-catch recreational fishing. It covers fisheries within EU waters, and also fisheries by the EU fleet operating outside EU waters in the high seas managed by tuna-RFMOs. Thus, from a scientific point of view, the operational objectives of the EUPOA-Sharks aims to efficiently monitor and assess shark stocks on a species-specific level and develop harvesting strategies in accordance with the principles of biological sustainability and rational long term economic use.

In this context, the European Commission promoted an initial project with the main objective of obtaining scientific advice for implementing the EUPOA-Sharks (Murua *et al.*, 2013a, final report available online[2]). In 2016, the EU Commission (EASME - Executive Agency for Small and Medium-sized Enterprises, and DG-MARE - Directorate-General for Maritime Affairs and Fisheries) commissioned a new consortium of EU laboratories to continue research on the current status of development and provide advice to further advance the EUPOA-Sharks implementation (Coelho et al, 2017). One particular task of this new project (task 1) aims to update the state of knowledge and data compilation of the original EUPOA-Sharks study, including historical catch and effort, discards, length frequencies, biological information and fishery indicators.

The reconstruction of catch histories is particularly important for the stock assessments of data-limited stock, as most by-catch species (including sharks). In 2011, the ICCAT Sharks Working Group (WG) discussed needs related with this, including preparing recommendations for continuing work on the estimation of catch series using tuna:shark ratios or other alternative methods (Anon, 2011). In 2012, and related with the previous shortfin mako (SMA) stock assessment, the ICCAT Sharks WG noted that due to the reporting problems of shark species especially prior to 1997, there were difficulties in obtaining reliable estimates of catches by species (Anon, 2012). Since the 2008 stock assessment, several approaches have been conducted including the use of a ratio of shark catch to tuna catch and the use of shark fin trade information (Anon, 2012). The Sharks WG considered critical the proper reporting of Task I for sharks by species and recommended conducting further analysis to obtain reliable estimates of shark catches by species for the entire time series (Anon, 2012).

Due to the uncertainty in the estimates of the historic catches of sharks there is an urgent need to further progress research and hypothesis for obtaining alternative catch histories that can then be used as alternative scenarios in stock assessments. Therefore, and considering that the ICCAT SCRS is carrying a stock assessment of shortfin mako shark in 2017, the main goal of this paper is to provide alternative time series of catch histories for both the North and South Atlantic stocks of SMA, that can be considered in the stock assessments.

2. Materials and methods

A revision on the available catch and effort data for oceanic sharks and rays was carried out, as defined in the scope of the EUPOA-Sharks study in the various tuna-RFMOs and from other relevant sources: Overall, this revision included the Atlantic, Indian and Pacific Oceans, as well as the Mediterranean Sea (see Murua *et al.*, 2013a, 2013b for general methodological aspects).

For updating the EUPOA-Sharks study results, the data was processed in a 3 step approach:

[2] https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/scientific-advice-sharks_en.pdf

1) Data gaps: summaries on what countries report data to the tuna-RFMO on shark catches (i.e., summary information presenting if the data is available or not by country);

2) tuna-RFMO official catch data for major fleets and countries catching sharks based on current data available in the tuna-RFMOs: this includes the catches of sharks and/or the target species, which may be indicative of global shark catch;

3) Estimation of “possible” catch shark by major fleets and countries which are estimated to be catching sharks based on the ratio of shark catch/by-catch over the main target species. The ratios were estimated through observer programmes data, literature revision and/or personal communications (as applied in Murua *et al.*, 2013a).

The 2 first steps of the process are revisions based on the currently available information. For the estimation of the potential catches that is presented in the 3rd step, the datasets available in the tuna-RFMOs were analyzed in order to identify fleets/métiers susceptible to generate catches of sharks.

As reported by Murua *et al.* (2013a, 2013b) the basic assumption of the method is that the target species quantities declared by flag/fleet to the tuna-RFMOs are correct, and that it is reliable to use these estimates to compute the potential shark catches knowing each fleet specific métier (target species and gear characteristics) and the corresponding catch ratio (shark:target species). With this information and assumptions, the biomass of sharks caught by each fleet/métier can then be estimated.

Based on the original nominal catch databases from the tuna-RFMOs, which typically include tuna and shark catch information by year, species, area, gear, country, flag and fleet, we then estimated the “potential” shark catches by major fleets involved in fisheries capturing sharks. For the global averages the data used are the reported nominal catches by species for the period 2000-2015, while for the time series specific data by year was used.

The final tables and estimations are the result of the following steps:

1 - Ratio references by métier: preparation of reference ratios of shark by-catch/catch over target species catch by métier. This information is based on literature available, expert knowledge and unpublished observer data (see Murua *et al.*, 2013a).

1.1 - A list of métiers (combination of gear and target species group) is identified and for each of these métier the following is defined:

1.1.1 - A ratio of shark (all species combined) catch to target species group (in weight);

1.1.2- Shark species composition in proportion (sum = 1): For this specific sub-task the original EUPOA project focused on 18 major pelagic sharks species or groups of species

2 - Preparation of data.

2.1 - Data task I (total nominal catches by flag and year) from each tuna-RFMO was compiled by fishery, i.e., a combination of flag, fleet and gear for the period 2000-2015 (16 years),

2.2 - Mean nominal catches were calculated for target species groups (main shark species, major tuna including billfishes but excluding swordfish, other sharks, other species, small tunas, swordfish). Two types of means were then calculated:

2.2.1 - Simple mean using all 16 years including zeros (0s). This means that if a country makes no declaration one year, this will be used as a 0 catch to calculate the mean. With this scenario it is assumed that each 0 or blank (no declaration) in the data corresponds to a year without catch (real zero). This method provides the update of the "Low Estimate" scenario as was done in the EUPOA study;

2.2.2 - For positive years only, in this case assuming that most zero declarations do not correspond to zero catches, but to missing data (e.g., lack of data submission). In this scenario, the mean is estimated by considering only years with positive shark catches. This method provides the update of the "High estimate" scenario, as was done in the EUPOA study;

2.2.3. The number of positive years is compiled and compared to analyze the effect of these two different assumptions in the final results.

3 Estimation of "potential" shark catches by métier.

3.1 - Based on the ratio by métier (step 1) and target species average nominal catch declared (step 2), the potential catch of the sharks by species are then estimated:

3.1.1 - Shark species catch = Target species * Ratioshark species/target species

3.2. The results are summarized and ranked by:
 3.2.1 - Shark species mostly impacted;
 3.2.2 - Métiers with most impact in shark catches (overall);
 3.2.3 - Métiers with most impact in shark catches (species-specific).

Additionally to the overall averages over the last 16 years (2000-2016), time series were also created for some species complexes, species or stocks. In this paper we provide the results specific to the shortfin mako shark for the North and South Atlantic stocks, to be considered as sensitivity scenarios in the 2017 SMA stock assessments.

3. Results and Discussion

3.1. Estimates of overall shark catches in the Atlantic

Given the continued lack of sufficient quantitative information for stock assessment purposes, there is still an interest in using alternative methods for reconstructing alternative catch histories, especially for the main shark species. The original outputs of the EUPOA-Shark project were presented to the ICCAT SCRS in the 2013 Species Groups meetings (Murua *et al.*, 2013b), showing the overall estimated shark species catches for the period 2000-2010. However, at that time it was not possible to estimate the potential shark catches by year, and therefore the results could not be used in the stock assessments. Now, based on the same method but adding the stratification by year, it was possible to further develop the method and provide results in terms of time series that can be considered in future stock assessments.

Based on the information provided in Task I, the major fisheries (country/fleet/gear) targeting tunas, swordfish and sharks in the Atlantic Ocean were identified. According to the aggregated total catch available in the ICCAT database for the Atlantic during the last 16 years (2000-2015), the largest shark catches (all species combined) have been declared by EU.España, followed by EU.Portugal, EU.France, Japan and Brazil. The list of flags that account for 99% of the catches are shown in **Table 1**. **Figure 2** presents the total sharks reported landing (major sharks and other species) for the aggregate period 2000-2015.

The estimated "potential" shark catches vary between around 100,000 to 150,000 t, depending on considering the High and Low estimation scenarios (see methods for the description on those estimates). This contrasts to the currently reported shark catches of around 80,000 t presently declared to ICCAT for the Atlantic Ocean (**Figure 2** and **Figure 3**). Among the different métiers identified, longlines targeting sharks (LL-shark) is the most impacting with the majority of the total estimated studied shark species catches (**Figure 4** and **Figure 5**). This is followed by general longlines and other/unknown gears.

In terms of species, the shark with more estimated catches is blue shark with the majority of the catches, followed by shortfin mako. Those two species are mainly impacted by longline fisheries (LL-Sharks and LL-general). Other species with some relevance are hammerheads and general Carcharhinidae sharks that are mainly impacted by gillnets (**Figure 6** and **Figure 7**).

In terms of fleets and métiers, in the Atlantic Ocean the impact on pelagic sharks is highly concentrated in just a few fisheries (**Figure 8** and **Figure 9**). The EU longline fleets, particularly Spain followed by Portugal, are responsible for the majority of the catches, and the main captured species are blue shark and shortfin mako. Other important fleets and métiers that contribute to the overall shark catches are longlines from Brazil, Taiwan, Japan, Namibia and Senegal (**Figures 8** and **Figure 9**).

One important note on these results is that these fleets/métiers were identified on the basis of tuna and tuna like reported catches to ICCAT. Such data is based on the national reports from the national fisheries agencies, and can have significant limitations due to data collection, reporting efficiency and problems related with species identification. As such, the presented estimates are affected by possible under- or non-reporting of the main targeted tuna and tuna like species by each country.

In terms of time series, and as an extension to the EUPOA-Sharks project method, it was now possible to carry out an estimate of the time series of overall catches. The estimates start in 1971, as that is the starting year of many stock assessment models for sharks, before the expansion of oceanic fisheries in the 1970's. The time series for the EUPOA shark species and for all sharks is shown in **Figure 10**.

3.2. Times series for shortfin mako shark catches by stock

With the extension of the estimation method, it is now also possible to reconstruct alternative catches for specific species delimited by stock, which can be directly included in the stock assessment models. **Figure 11** and **Table 2** provide the alternative reconstructed catches for shortfin mako for both the North and South Atlantic stocks using the EUPOA-Sharks method.

This particular series is of special interest, as the shortfin mako is currently being assessed by the ICCAT Sharks WG (assessment taking place in June 2017), and this reconstructed series can be used as a sensitivity scenario to the nominal catches reported to ICCAT (Anon, 2017). For this specific case of the shortfin mako, the main differences in the declared *vs.* estimated catches are in the earlier years of the time series, which seems to be consistent with the fact that underreporting and lack of species specific information was likely more problematic in the past (**Figure 11**). It is also consistent with the previous note from the ICCAT Sharks WG that the historical time series of catches were particularly problematic and uncertain prior to 1997, due to reporting problems and lack of species-specific identification (Anon, 2012).

4. Acknowledgments

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Table 1. Sharks (all species) total reported catches by fleet from 2000 to 2015. Only fleets until cumulative catches of 99% are shown (source: ICCAT Task 1 database).

Flag	Total catch (t)	%	Cum %
EU.España	568,084	46.2	46.2
EU.Portugal	157,843	12.8	59.1
EU.France	87,411	7.1	66.2
Japan	65,847	5.4	71.5
Brazil	56,158	4.6	76.1
Senegal	43,351	3.5	79.6
Namibia	43,307	3.5	83.2
Maroc	37,216	3.0	86.2
Chinese Taipei	28,974	2.4	88.6
Guyana	16,715	1.4	89.9
EU.United Kingdom	15,246	1.2	91.2
U.S.A.	13,605	1.1	92.3
Trinidad and Tobago	10,642	0.9	93.1
Canada	10,397	0.8	94.0
Uruguay	7,972	0.6	94.6
Argentina	7,624	0.6	95.2
Norway	7,052	0.6	95.8
Belize	6,944	0.6	96.4
South Africa	5,461	0.4	96.8
China PR	5,240	0.4	97.3
Panama	4,553	0.4	97.6
Ghana	3,931	0.3	97.9
Turkey	3,387	0.3	98.2
St. Vincent and Grenadines	2,905	0.2	98.5
EU.Ireland	2,551	0.2	98.7
S. Tomé e Príncipe	2,405	0.2	98.9
Venezuela	2,158	0.2	99.0

Table 2. Reported *vs.* estimated shortfin mako shark (SMA) catches, between 1971 and 2015, for the North and South Atlantic stocks.

Year	Reported North	Estimated North	Reported South	Estimated South
1971	112.00	2357.80	88.00	1347.93
1972	115.00	2218.99	53.00	1503.08
1973	61.00	2114.19	202.00	1432.83
1974	307.00	2259.54	39.00	1191.04
1975	344.00	1742.71	45.00	1081.93
1976	84.00	1907.04	8.00	1179.30
1977	236.00	2066.53	229.00	1419.50
1978	153.00	2168.45	146.00	1150.02
1979	45.00	2146.76	268.00	1123.13
1980	246.00	1720.46	228.00	1371.22
1981	771.96	2286.07	227.48	1185.36
1982	928.18	2579.61	780.97	1622.08
1983	569.29	2293.28	405.34	1043.11
1984	1112.49	2854.37	680.50	1155.82
1985	3142.71	4828.80	660.51	1547.21
1986	1483.48	3514.50	470.68	1423.84
1987	768.03	2211.56	262.21	1463.95
1988	1016.63	2716.43	547.70	1490.37
1989	1019.04	2705.62	636.95	1441.89
1990	785.97	2702.32	564.19	1555.97
1991	802.59	2747.08	519.49	1557.14
1992	957.38	2820.83	480.30	1565.68
1993	2194.26	3421.09	763.47	1668.46
1994	1594.11	3494.56	1542.00	2079.15
1995	3137.58	4759.08	1914.39	2007.99
1996	2052.51	3246.96	927.41	1934.70
1997	3579.77	5121.49	2159.69	2555.21
1998	3855.44	4967.50	1788.15	2357.93
1999	2791.21	5071.03	1485.40	2351.70
2000	2597.28	5278.08	2540.45	2830.88
2001	2682.10	5109.43	2043.57	2748.71
2002	3415.82	3979.28	1949.28	2555.37
2003	3923.06	4208.96	3770.47	2923.63
2004	5180.01	4246.85	2407.51	2783.33
2005	3479.06	4809.91	3116.05	2994.68
2006	3377.60	4569.01	2934.46	2833.08
2007	4083.19	4371.84	2808.77	3568.37
2008	3565.53	4578.82	1880.19	2966.14
2009	4115.55	4998.23	2028.67	3133.16
2010	4167.66	5162.28	2489.82	3393.73
2011	3770.65	5059.37	3250.54	3892.52
2012	4478.35	4994.73	2859.47	2986.34
2013	3645.78	4903.96	1894.05	2434.23
2014	2975.00	4526.83	3322.35	2805.90
2015	3269.17	4255.89	2573.53	2548.28

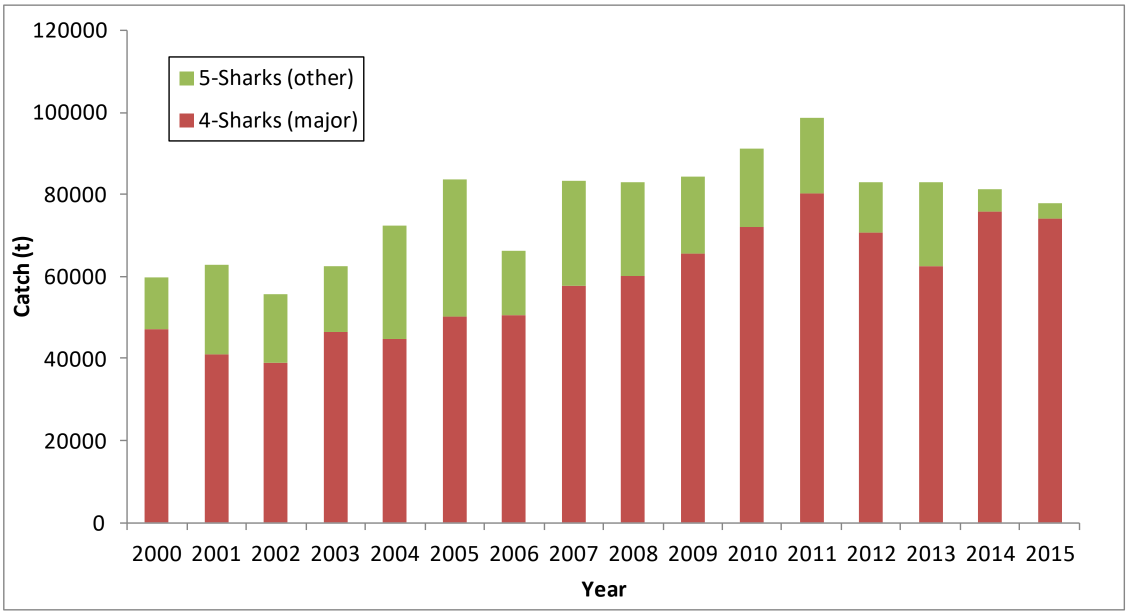

Figure 1. Reported landings of sharks (t) between 2000 and 2015 in the Atlantic (ICCAT) for major sharks (BSH, SMA and POR) and other shark species.

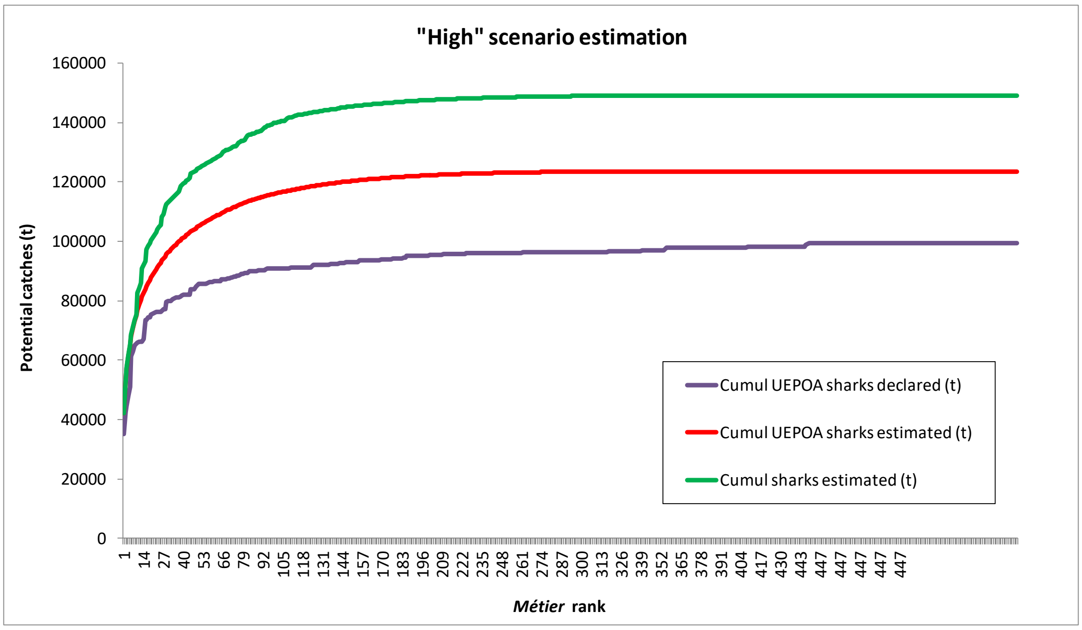

Figure 2. Cumulative catches (t) of reported catches and estimated "potential" reconstructed catches for the "High" estimation scenario, ranked by métier. "Cumul EUPOA sharks" refer to the 18 species originally in the EUPOA project and "Cumul sharks" refer to all shark species combined.

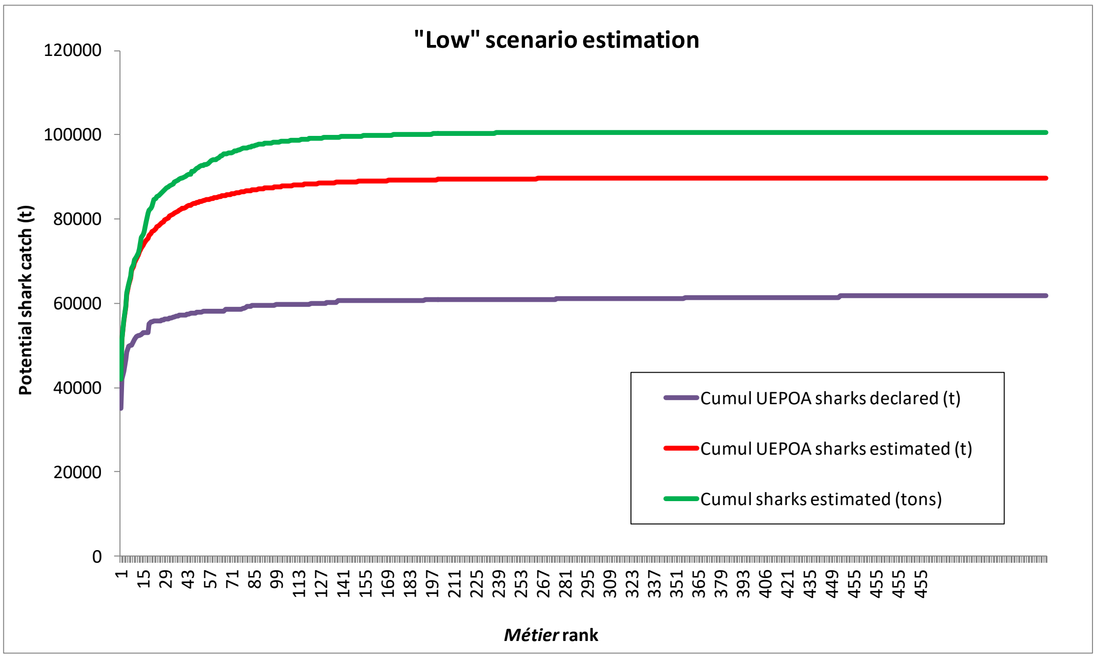

Figure 3. Cumulative catches (t) of reported catches and estimated "potential" reconstructed catches for the "Low" estimation scenario, ranked by métier. "Cumul EUPOA sharks" refer to the 18 species originally in the EUPOA project and "Cumul sharks" refer to all shark species combined.

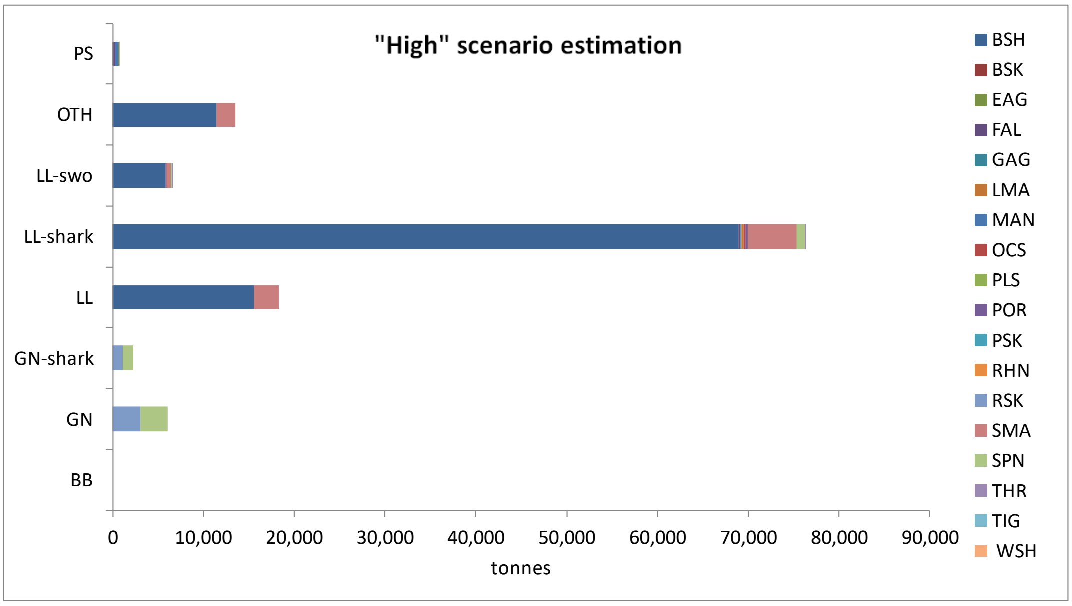

Figure 4. Estimated Catch (tonnes) by métier and by species in the Atlantic Ocean, for the "High" scenario estimation.

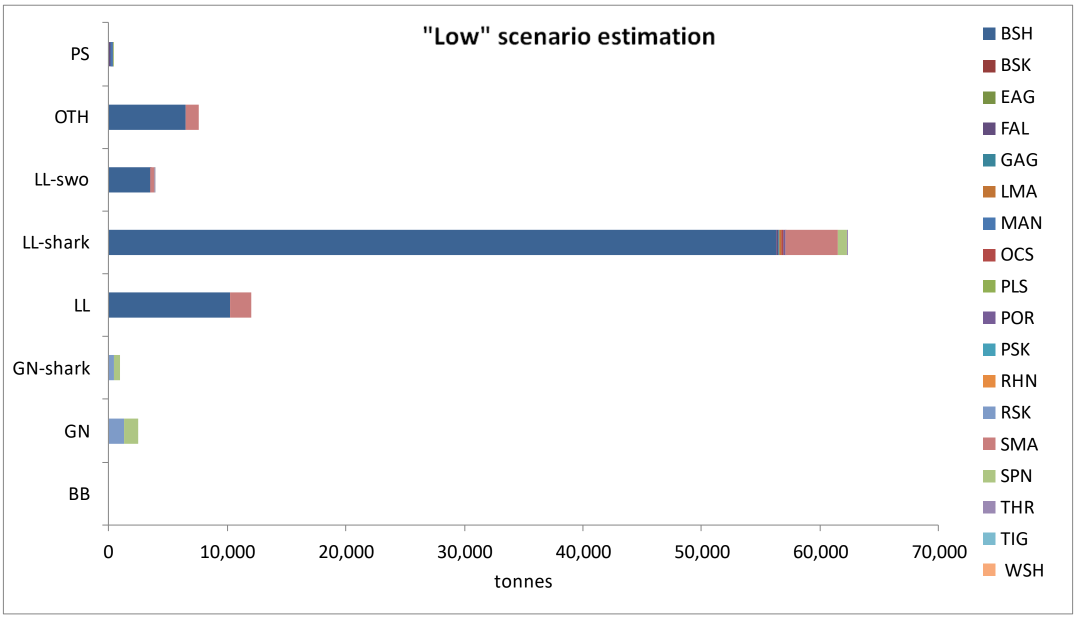

Figure 5. Estimated Catch (tonnes) by métier and by species in the Atlantic Ocean, for the "Low" scenario estimation.

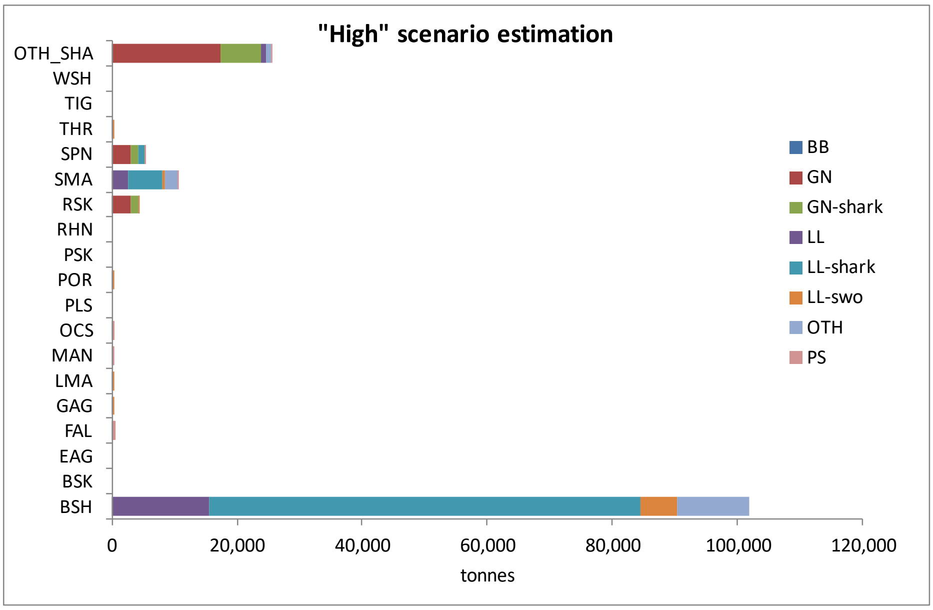

Figure 6. Estimated catch (tonnes) of the EUPOA shark species by métier in the Atlantic Ocean, for the "high" estimation scenario.

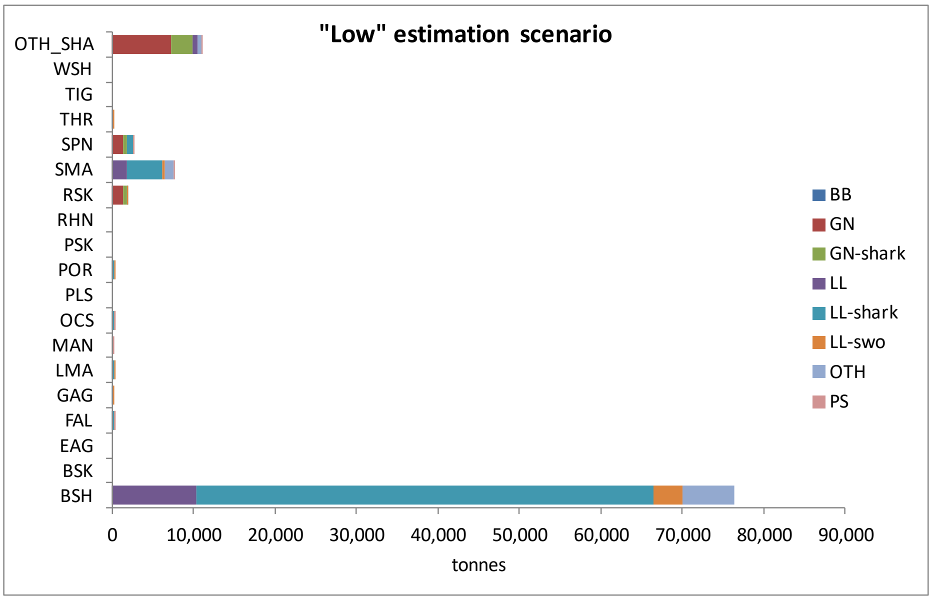

Figure 7. Estimated catch (tonnes) of the EUPOA shark species by métier in the Atlantic Ocean, for the "low" estimation scenario.

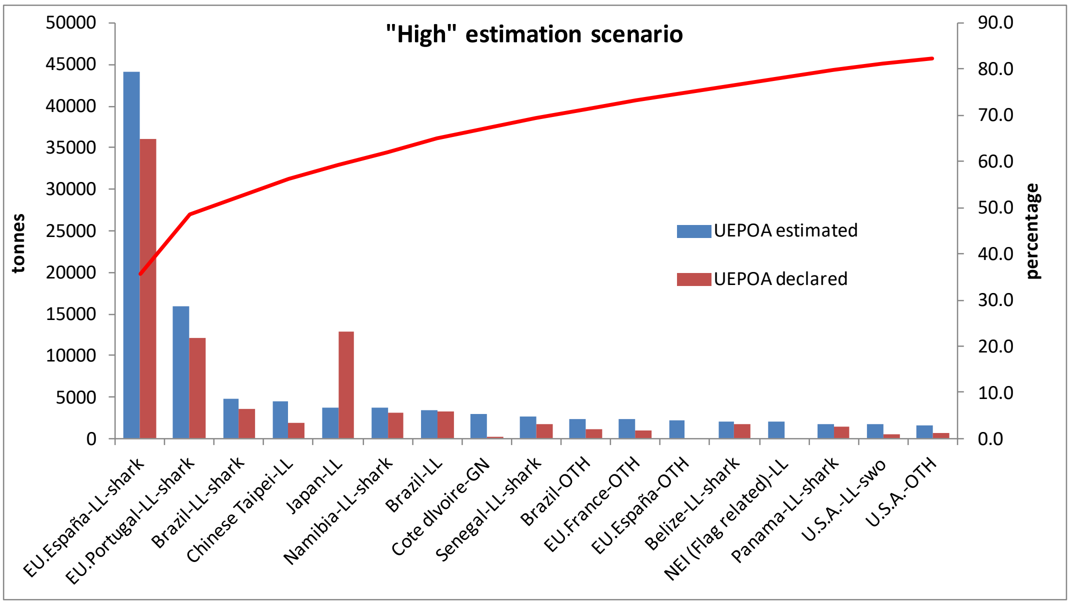

Figure 8.Main fisheries (flag and métier) responsible for catching pelagic sharks species in the Atlantic Ocean (EUPOA shark species), under the "high" estimation scenario.

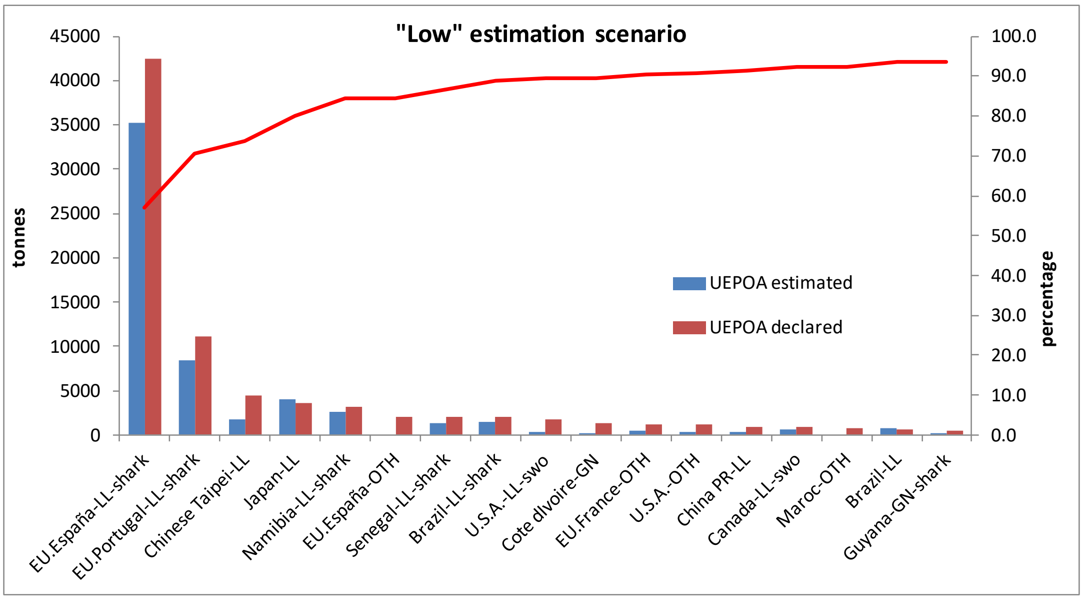

Figure 9. Main fisheries (flag and métier) responsible for catching pelagic sharks species in the Atlantic Ocean (EUPOA shark species), under the "low" estimation scenario.

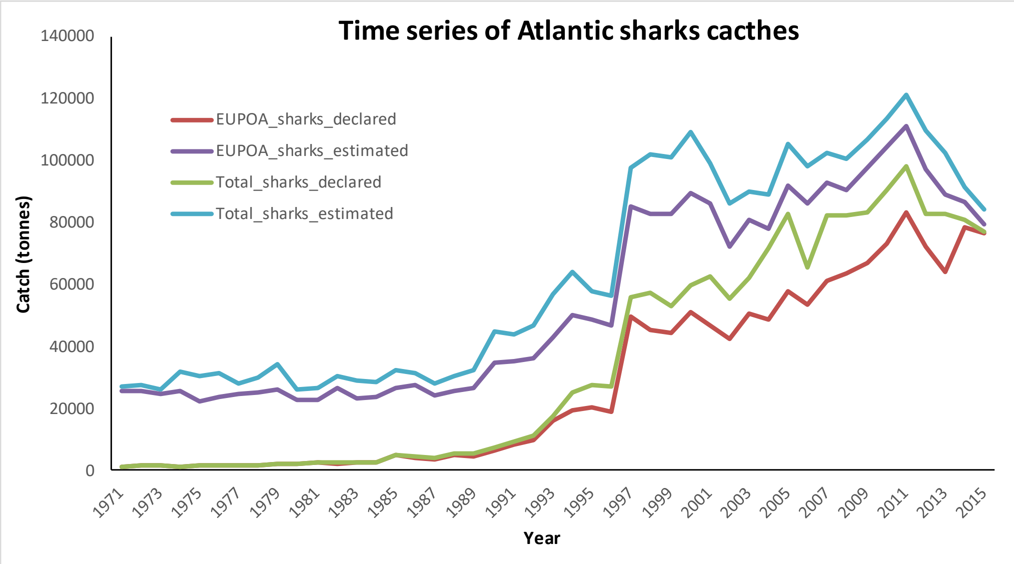

Figure 10. Time series of declared and estimated shark catches, between 1971 and 2015, for the Atlantic Ocean.

Figure 11. Time series of reported and estimated shortfin mako shark (SMA) catches, between 1971 and 2015, for the North and South Atlantic stocks.