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CONSERVATION OF WHALE SHARKS (*RHINCONDON TYPUS*) BYCAUGHT IN ICCAT: REVIEW OF BIOLOGY, INTERACTIONS WITH PURSE SEINE FISHERY AND BEST PRACTICES ON HANDLING AND RELEASE

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SUMMARY

This document reviews the biological knowledge and conservation status of whale sharks at both the global and regional levels. It also provides a detailed analysis of whale shark interactions with purse seine fisheries in the Atlantic Ocean. Although scientific data about this species is limited, the available information on whale shark life history characteristics and conservation status suggests that whale sharks in the Atlantic Ocean can be considered "a taxon of the greatest biological vulnerability and conservation concern for which there are very few data". Therefore, the application of precautionary management measures in ICCAT fisheries, such as a retention ban as required by Recommendation 23-12, is recommended to address this vulnerability. The document also reviews existing measures aimed at mitigating and minimizing the impacts of purse seine fisheries on whale sharks, including current practices for the safe handling and release of accidentally captured whale sharks, as per Recommendation 23-12.

RÉSUMÉ

Ce document passe en revue les connaissances biologiques et l'état de conservation des requins-baleines aux niveaux mondial et régional. Il fournit également une analyse détaillée des interactions entre les requins-baleines et les pêcheries de senneurs dans l'océan Atlantique. Bien que les données scientifiques soient limitées sur cette espèce, les informations disponibles sur les caractéristiques du cycle vital et l'état de conservation du requin-baleine suggèrent que le requin-baleine de l'océan Atlantique peut être considéré comme « un taxon présentant la plus grande vulnérabilité biologique et la plus grande préoccupation en matière de conservation, pour lequel il existe très peu de données ». Par conséquent, il est recommandé d'appliquer des mesures de gestion de précaution dans les pêcheries de l'ICCAT, telles que l'interdiction de rétention requise par la Rec. 23-12, pour faire face à cette vulnérabilité. Ce document examine aussi les mesures actuelles visant à atténuer et réduire les impacts des pêcheries de senneurs sur les requins-baleines, y compris les pratiques actuelles de manipulation et de remise à l'eau en toute sécurité des requins-baleines capturés accidentellement conformément à la Recommandation 23-12.

RESUMEN

Este documento examina los conocimientos biológicos y el estado de conservación del tiburón ballena tanto a escala mundial como regional. En él, también se ofrece un análisis detallado de las interacciones del tiburón ballena con la pesca de cerco en el océano Atlántico. Aunque los datos científicos sobre esta especie son limitados, la información disponible sobre las características del ciclo biológico y el estado de conservación del tiburón ballena sugiere que el tiburón ballena en el océano Atlántico puede considerarse "un taxón de máxima vulnerabilidad biológica y preocupación por su conservación del que existen muy pocos datos". Por lo tanto, se recomienda la aplicación de medidas de ordenación precautorias en las pesquerías de ICCAT, como la prohibición de retención, tal y como se establece en la Recomendación 23-12, con el fin de abordar la vulnerabilidad de la especie. El documento también revisa las medidas existentes destinadas a mitigar y minimizar el impacto de la pesca con redes de cerco en los tiburones ballena, incluidos los procedimientos actuales para la manipulación y liberación seguras de los tiburones ballena capturados accidentalmente, con arreglo a la Recomendación 23-12.

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KEYWORDS

Whale shark; Atlantic Ocean

1. Introduction

The whale shark (*Rhincondon typus)* is the only representative species of the family *Rhincodontidae* and its life history remains poorly understood. It is characterized by its large size, slow growth, late reproductive maturation, and extended longevity, which leads to an increased likelihood of population decline (Collman *et al*., 1997). Moreover, despite being a very charismatic species, detailed data on its biology and global distribution remains limited, most likely due to its sporadic and unpredictable encounters (Stevens, 2007; Rowat and Brooks, 2012). Sighting and abundance trend data suggest that the global whale shark population has been reduced by half over the past 50 years (Pierce and Norman 2016). This decline is primarily attributed to commercial fisheries targeting the species in the past, as well as bycatch in other net fisheries, ship strikes, and possibly other factors. This awareness of whale shark threats and decline has led to the implementation of various regulations to protect the species at national, regional, and international levels. The whale shark has been included in Appendix I of the CMS (Convention on the Conservation of Migratory Species of Wild Animals), since 2017, as well as in Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) since 2002.

Key current threats to whale sharks include ship strikes, incidental bycatches in tuna fisheries, and marine pollution. Targeted fishing for whale sharks is now uncommon or marginal (Dove, 2021). However, some specimens can be caught accidentally in large nets set for other species. Limited information is available on the level of whale shark bycatch in the gillnet fisheries, which mainly occur in the northern Indian and Pacific Oceans. However, some authors suggest that this fishery should also be treated as a major threat to whale sharks (Dove, 2021). In some instances, whale sharks swim along with tropical tuna schools and can become incidental bycatch of the purse seine fleet. However, several studies note that interactions between tropical purse seine fishing and whale sharks are sporadic, in addition to having an immediate mortality rate of less than 1% in the Atlantic Ocean (Capietto *et al*., 2014; Escalle *et al*., 2016; Escalle *et al*., 2018; Ruiz *et al*., 2017; Baez *et al*., 2019). In addition to fishing-induced mortality, other human activities, specifically ship collisions, may contribute to the decline of this species' population (Womersley *et al*., 202). Additional threats, including habitat degradation, climate change, and marine pollution, impact whale sharks at local or regional levels (Abreo *et al*., 2019; Yong *et al*., 2021; Reynolds *et al*., 2022; Villagómez-Vélez *et al*., 2024).

Several scientific studies presented to the SCRS show that some ICCAT fisheries, particularly the purse seine fishery, have implemented voluntarily best handling and release methods for whale sharks, before the implementation of any such Recommendation by the ICCAT. Evaluation of the effectiveness of these best release methods using satellite tag data to monitor their swimming behaviour after release, suggested that whale sharks have a very high probability of survival when released adequately. Although the sample size was limited, the results indicate a post release mortality rate following encirclement of large whale shark of 0% (Escalle *et al*., 2018).

In 2023, ICCAT adopted Recommendation 23-12 for the conservation of whale sharks caught in association with its fisheries, in line with measures adopted by other tuna Regional Fisheries Management Organizations (t-RFMOs) (IOTC Resolution 13/05, WCPFC CMM 2022-04, IATTC Resolution 19-06). Recommendation 23-12 prohibits fishing vessels from retaining on board, transhipping, or landing, in whole or in part, any specimen of whale shark, and setting a purse seine on a school of tuna associated with a whale shark if the animal is sighted before the commencement of the set. Additionally, the recommendation includes certain requirements for reporting interactions with whale sharks and implementing best handling and release practices.

Therefore, while all tuna RFMOs have comparable recommendations for the conservation of whale sharks, ICCAT is the only one that, on the one hand, establishes spatial distribution limits for the application of this recommendation (limiting it to the area between 40° N and 40° S), and on the other hand, subjects its entry into force upon the SCRS reaching a consensus on its conservation concern. Specifically, paragraph 8 of Recommendation 23-12 requests the SCRS "to review existing data and information relating to the life history and conservation status of whale sharks and confirm whether they meet the definition of being a taxon of the greatest biological vulnerability and conservation concern for which there are very few data". Should this be the case, the SCRS shall advise on the appropriateness of applying precautionary management measures in ICCAT fisheries, such as a retention ban. The SCRS may also identify options for future research and data collection, as well as advise on other mitigation measures for relevant ICCAT fisheries.

The recommendation also states in paragraph 11 that "Only if there is a consensus on the interpretation of the SCRS advice at the 2024 Annual Meeting of the Commission will this Recommendation enter into force as scheduled in paragraph 11"

Thus, this working document aims to (a) review the biology and conservation status of whale shark in the Atlantic Ocean; (b) provide a detailed characterization of the interactions with ICCAT fisheries and, where possible, assess to which extent such interactions may represent a conservation risk; and (c) review existing measures aimed at mitigating and minimizing the impacts of purse seine fisheries on whale sharks, including current best practices for handling and safely releasing whale sharks incidentally caught in purse seine fisheries, as required in Recommendation 23-12. This paper will contribute to ICCAT SCRS discussions to address Recommendation 23.12 requests as well as to ascertain if a whale shark could be considered "a taxon of the greatest biological vulnerability and conservation concern for which there are very few data".

2. Review of the distribution, biology, and conservation status of whale sharks

Overall, this species shows a distribution located between 30ºN and 35ºS, inhabiting all tropical and warm temperate seas, except the Mediterranean Sea, in both coastal and oceanic habitats (Compagno, 2001; Pierce & Norman, 2016) (**Figure 1**). Whale sharks occur mainly within a narrow sea surface temperature range of 26ºC and 30ºC (Sequeira *et al*., 2012), probably due to thermoregulatory requirements (Thums *et al*., 2013). Thus, this distribution could be limited by sea surface temperature (SST), as it has rarely been observed in waters with SSTs under 21°C.

While whale sharks are typically solitary mobile pelagic fish, they undertake long-distance migrations to coastal areas during specific seasons, forming large aggregations with a degree of site fidelity (Cagua *et al*., 2015; Robinson *et al*., 2017). In the Western Atlantic Ocean, these aggregations occur off the coasts of Belize, Honduras, Mexico, Brazil, and the United States (Macena and Hazin, 2016; McKinney *et al*., 2017). In the East Atlantic, as many planktivorous filter-feeding species, whale sharks appear at locations where seasonal production peaks (i.e. high chlorophyll-a concentrations) are known to take place, such as the coastal waters of west-central Africa (i.e. Angola, Congo, Equatorial Guinea, and Gabon EEZs) (Escalle *et al*., 2016; Báez *et al*., 2019). Moreover, these coastal feeding aggregation areas show a pronounced size- and sex-based segregation of sharks, being typically dominated by juvenile male sharks. Several species distribution models based on the presence and absence data from fishing observations in the Atlantic Ocean suggest several coastal regions and warm shallow currents, such as the Gulf Stream and the Canary and Benguela currents, as the most suitable areas for whale shark encounters (Báez *et al*. 2019).

In terms of the abundance of this species in these regions, the largest known aggregation sites for whale sharks, based on counts and model estimates, host hundreds to a few thousand individuals (Pierce & Norman, 2016). Whale sharks are characterized by their large size, and like many other shark species, it possesses inherent biological characteristics such as slow growth, late reproductive maturation, low reproductive potential, and extended longevity (Stevens, 2007). These attributes likely limit recruitment and make the species particularly vulnerable to exploitation. Additionally, these life-history characteristics may result in slow population recovery following population decline, making them particularly vulnerable to such events (Colman, 1997). Growing concerns about potential population decline driven by different anthropogenic activities have resulted in the inclusion of whale sharks in the IUCN Red List of Threatened Species, being globally catalogued as Endangered (Pierce & Norman, 2016) and largely depleted (Pierce, Grace & Araujo, 2021). There are two subpopulations used in the whale shark's current Red List assessment. These spatial units are based on genetic studies using both mitochondrial DNA and microsatellite analysis data (Castro *et al*., 2007; Vignaud *et al*., 2014), which suggest at least the existence of two populations that rarely mix between the Atlantic Ocean and Indo-Pacific Ocean. If mixing occurs between the Indian and Atlantic Oceans, it is not sufficient to counter genetic drift.

Based on count data, modeled population estimates, and habitat availability, 75% of the global whale shark population is inferred to occur in the Indo-Pacific, and 25% in the Atlantic (Pierce and Norman, 2016). A variety of datasets present declines of 40-92%, inferring an overall decline of 63% in the Indo-Pacific over the last 75 years (three generations), resulting in a subpopulation assessment of Endangered (UICN assessment criteria A2bd+4bd, which according to IUCN Red List criteria means a high risk of extinction in the wild in the near future, with a population reduction of at least 50% over the past and projected or suspected to be met in the future, due to a decline in the area of occupancy and/or quality of habitat, and potential levels of exploitation) (IUCN, 2012). In the Atlantic, the overall population decline is considered to be lower (≥30%), resulting in a subpopulation assessment of Vulnerable (UICN assessment criteria A2b+4b**)**. This is, it has experienced a significant population

decline in the past and it is expected to continue declining in the future due to habitat loss or degradation. Given the bulk of the global population occurs in the Indo-Pacific, the overall global decline is inferred to be ≥50%. Globally, the whale shark is therefore assessed as Endangered.

Age and growth data on whale sharks are sparse. Stranded sharks in South Africa (Wintner, 2000) and fishery catches in Taiwan (Hsu *et al*., 2014), respectively, were sampled for growth estimates, being limited by small sample sizes of predominantly juvenile sharks. The growth band deposition is likely to be biannual and, based on this, Hsu *et al*. (2014) estimated male sharks begin maturing at 17 years and females at 19–22 years in the Indo-Pacific. However, it should be noted that biannual band deposition has been demonstrated in very few other shark species, while other orectolobiform species showed aperiodic band pair formation (Huveneers *et al*., 2013).

Whale shark reproductive ecology is also poorly known. Pregnant female sharks are seasonally found in the Eastern Pacific, particularly off Darwin Island in the Galapagos Archipelago (Acuña-Marrero *et al*., 2014) and the Gulf of California (Eckert & Stewart 2001, Ramírez-Macías *et al*., 2012), but rarely sighted outside this region. An exception is St. Helena Island in the mid-Atlantic, where pregnant female sharks are routinely observed on a seasonal basis (Perry *et al*., 2020). The single pregnant female that was physically examined had 304 pups in various stages of development, the largest litter size reported from any shark species (Joung *et al*., 1996, Schmidt *et al*., 2010). This discovery established that whale sharks are a placental viviparous. The largest size class of embryos, 58–64 cm TL, appeared close to fully developed (Joung *et al*., 1996). The smallest free-swimming neonate found in the wild was 46 cm TL (Aca & Schmidt, 2011). Size at birth is therefore presumed to be around this range (Aca &Schmidt, 2011).

3. Whale shark interactions with the purse seine fishery in the ICCAT Convention area

Whale sharks can co-occur with tuna schools (or at least found in the same area), which could be an indicator of tuna presence. Thus, on certain occasions, the setting of the net around these animals can be intentional. On other occasions, however, when mixed in between large tuna schools, whale sharks can remain out of sight and be inadvertently caught inside purse seine nets. Although it's common for the larger incidentally captured specimens to escape from the purse seine or be released alive (Escalle *et al*., 2018; Ruiz *et al*., 2017), such encounters should be monitored, especially considering that this a species particularly vulnerable to exploitation. Therefore, to reduce these interactions, it is essential to identify if there are high-risk areas/periods, as well as the fishing and environmental conditions that could increase the likelihood of interaction. Previous studies pointed to seasonal and yearly variability in the distribution of fishing activities and interactions of whale sharks in the Atlantic Ocean, with key aggregation areas along the coast of Gabon from April to September (Capietto *et al*., 2014; Escalle *et al*., 2016; Ruiz *et al*., 2017). Hence, understanding the details of these interactions is vital to assess ways to minimize them.

When a fishing set is conducted with a whale shark nearby, these animals can, or cannot, end up inside the purse seine net. This study only considers interactions as those fishing sets in which whale sharks remain inside the purse seine gear. This update has been conducted based on the analysis of at-sea observations aboard the Spanish, Curacao, Cape Vert, Panama, Belize, and Guatemala purse seine fleets from 2015 to 2022, indicating the degree of interactions (i.e. interactions per 1,000 fishing sets) with whale sharks, as well as their spatial distribution.

The observers' consolidated final database encompasses a total of 31,091 monitored fishing sets, with an average of 3,886 fishing sets sampled annually, representing around 25-30% of the total purse seine production in the tropical Atlantic Ocean. A total of 137 interactions with whale sharks were recorded over the 8-year period (**Table 1**), of which 73 (53%) were observed in the second quarter, 45 (33%) in the third quarter, 13 (9 %) in the four quarter, and 6 (4 %) in the first quarter (**Table 1**). **Table 2** presents the quarterly ratio of interactions with whale sharks relative to the number of fishing sets, calculated as the number of interactions per 1,000 fishing sets. We observe that quarters 2 and 3 display the highest rates, particularly during 2016-2017. When analysing data per year, significant differences emerge, but with a constant downward trend of interactions since 2016.

Out of the total whale shark interactions, 69% (95 individuals) have occurred within the Exclusive Economic Zone (EEZ) of Gabon, and an additional 9% (12 individuals) have occurred north of the EEZ of Angola. Additionally, 2 interactions have been recorded in the waters of Equatorial Guinea, Mauritania, and Sao Tome and Principe, and 1 in Liberia and Ghana. The remaining 22 interactions have taken place in international waters. Similarly, the Gabon EEZ and the northern part of Angola have the highest whale shark capture ratio relative to the number of fishing sets conducted, both for the overall series (**Figure 2**) and for each year (**Figure 3**). It is important to point out that these areas have some of the highest tuna catches in the Atlantic Ocean. Some of the 5*5-degree rectangles

represented in **Figures 2** and **3** with lower numbers of fishing sets may present relatively high capture ratios if there has been a specific interaction (e.g., the western part of Mauritania, where a single whale shark interaction occurred).

4. Review of best release practices of whale shark

In cases where interactions do occur, it's crucial to mitigate their effects, preferably by removing whale sharks from the purse seine net before fully closing the purse line, and as a last choice, only when the animal is trapped in the net, applying appropriate release techniques. Over the years, fishers have developed different techniques to release whale sharks, which often depend on the size of the individual and its position inside the net.

The most frequently used release techniques rely on the ability of the animal to find its way out of the net by facilitating an escape route (**Figure 4**). It is highly recommended to always leave whale sharks in the water and avoid bringing them on deck. However, if a whale shark caught is a juvenile of small size (i.e. 2-3 m fork length), it may be released carefully using the brail to lift it out of the water and deposit it outside the purse seine net.

When possible, prioritize releasing the whale sharks before brailing is advisable. If the whale shark is inside the net with its head pointed towards the stern of the boat, the crew, always taking the necessary safety measures, can make a cut in the net in front of the shark's mouth to release it (**Figure 5**), as otherwise manoeuvring the animal around inside the bunt to face towards the bow can be difficult. Another method employed to release whale sharks facing sternward is to pass a rope placed under the animal and attached to the float line which can help to roll the whale shark out of the net (**Figure 6**).

If the head of the whale shark is pointing towards the bow of the vessel, fishers can manoeuvre the winch and the capstan to bring the whale shark close to the hull. The cork line of the net should be loosened so that the individual can put its head over the cork line, moving it below the sea surface with its weight, and slowly pass the whole body over to roll it outside the bunt (**Figure 7**). The net must always be pulled in a direction from the animal's tail toward its head, attempting to help the whale shark move toward the slacked cork line. On occasions, fishers have been known to jump inside the net to try to help whale shark releases by manually pushing the cork line down (**Figure 8**). This practice is highly discouraged due to the dangerousness of the manoeuvre for the crew, as fishers could accidentally become trapped between the whale shark and the net. Instead, in some fleets, tools such as long weighted poles are employed to assist with lowering the cork line.

Fishers should avoid tying a rope to the caudal peduncle of the animal and towing it out using the skiff or lifting them out with the crane if it is a small individual. Such methods are considered poor practices that can injure whale sharks and are discouraged by regulations in all tuna RFMOs (Rec. C-19-06; CMM-22-04; Res. 15/03; Rec 23-12).

Many of the purse seine fleets operating in ICCAT (European, Panama, Guatemala, Belize, Curacao, or Cape Verde) have been voluntarily applying best whale shark release practices before Recommendation 23-12 was established (Grade *et al*, 2019). The studies conducted with electronic tagging indicate that when these best practices of safe release are applied, post-release mortality of whale sharks is practically non-existent (Escalle *et al*, 2018). However, this conclusion should be taken with caution, given that the number of tagged specimens to date is limited. Therefore, a greater number of electronic tags on whale sharks would be advisable. Observer data, on the other hand, also suggest that immediate post-release mortality is very low if best handling practices are applied.

5. Conclusions and Recommendations

This document aims to first present an overview of the biological knowledge of the whale shark and its conservation status at a global level, and specifically within the ICCAT area of competence. It seeks to provide information and facilitate discussion at the SCRS to provide management recommendation as requested by Rec. 23-12.

Firstly, the recommendation sets the latitudes 40º N and 40º S as the species' limits, while the literature establishes a somewhat narrower limit, specifically between 30º N and 35º S. Thus, the recommendation covers the whole distribution of the species.

As for its conservation status, the latest IUCN assessment evaluates it as a vulnerable species in the Atlantic Ocean, with its overall population decline considered to be ≥30% over the last 75 years (three generations). Therefore, the available information on whale shark life history characteristics, conservation status, and paucity of scientific data on whale sharks indicate that whale sharks in the Atlantic Ocean can be considered "a taxon of the greatest biological vulnerability and conservation concern for which there are very few data". Therefore, precautionary management mitigation measures in ICCAT fisheries, such as a retention ban, as required in Recommendation 23-12 could be recommended to address its vulnerability.

Electronic tagging data and observer data have demonstrated the effectiveness of best handling and release practices, achieving an almost zero post-release mortality rate. Therefore, it is also highly recommended that the recommendation 23-12 requires the application of best practices for safe handling and release of whale sharks. However, additional research is needed to better understand the sources of whale shark mortality in the Atlantic Ocean, including the overall levels of mortality induced by purse seine and, most importantly, other fishing gears, for which there is no information available on interactions.

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Table 1. Observed number of whale shark interactions with tropical tuna purse seiners in the Atlantic Ocean by year and quarter during the period 2015-2022.

Año	*Q1*	*Q2*	*Q3*	*Q4*
2015	0	5	10	2
2016	4	17	12	1
2017	0	22	4	0
2018	2	2	13	7
2019	0	13	3	0
2020	0	7	3	2
2021	0	3	0	1
2022	0	4	0	0

Table 2. Observed whale shark interaction ratio with tropical tuna purse seiners in the Atlantic Ocean, calculated as the number of interactions per 1,000 fishing sets, by year and quarter (Q) for the period 2015-2022. The colour scale, ranging from blue (low) to red (high), represents the degree of interaction. Blank cells indicate quarters without whale shark captures.

Year	*Q1*	*Q2*	*Q3*	*Q4*
2015	0	6	12	3
2016	4	19	12	1
2017	0	17	4	0
2018	2	2	11	6
2019	0	12	4	0
2020	0	7	4	2
2021	0	3	0	1
2022	0	5	0	0

Figure 1. Resident Whale Shark distribution map (from IUCN Shark Specialist Group 2016).

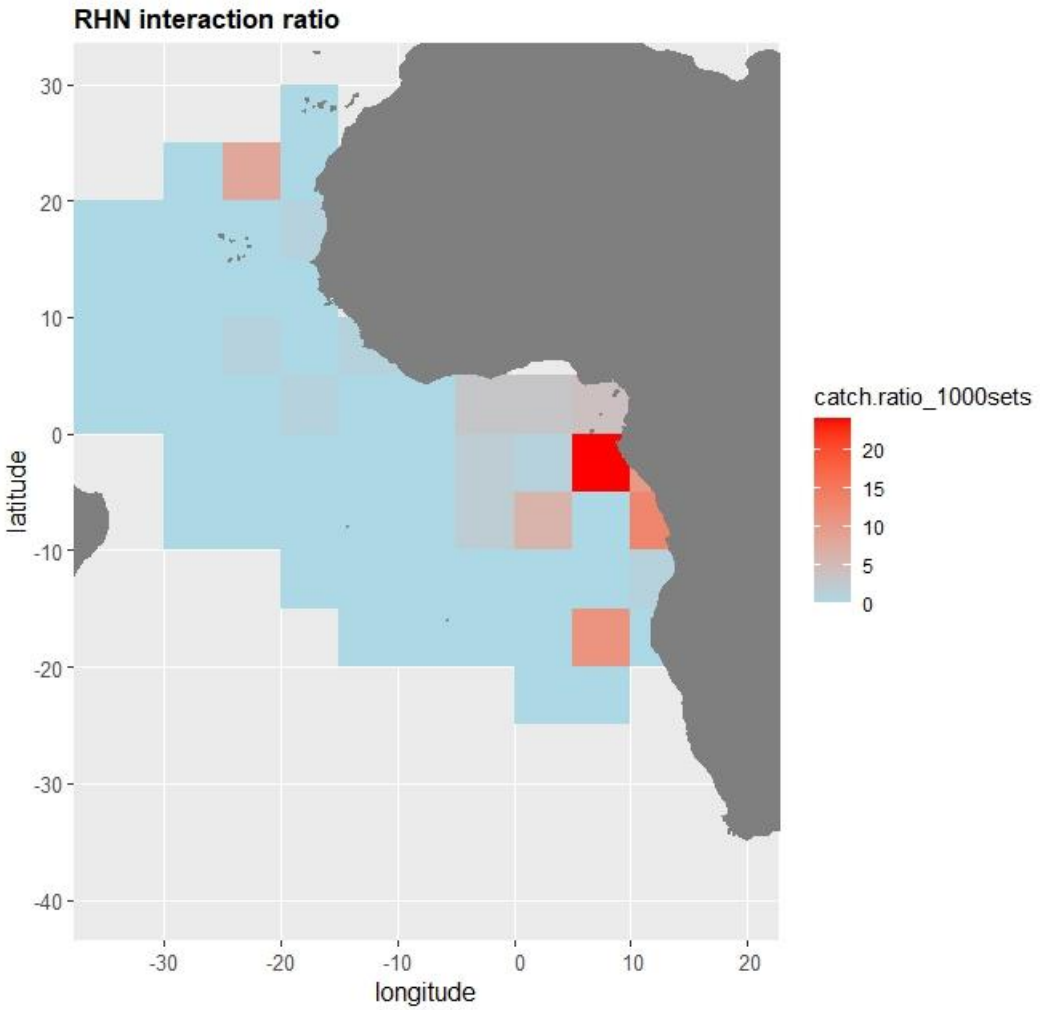

Figure 2. Global ratio of the Spanish and associated fleet interactions with whale sharks during the period 2015-2022. The ratio has been calculated as the number of interactions per 1000 fishing sets in a 5x5 degree grid.

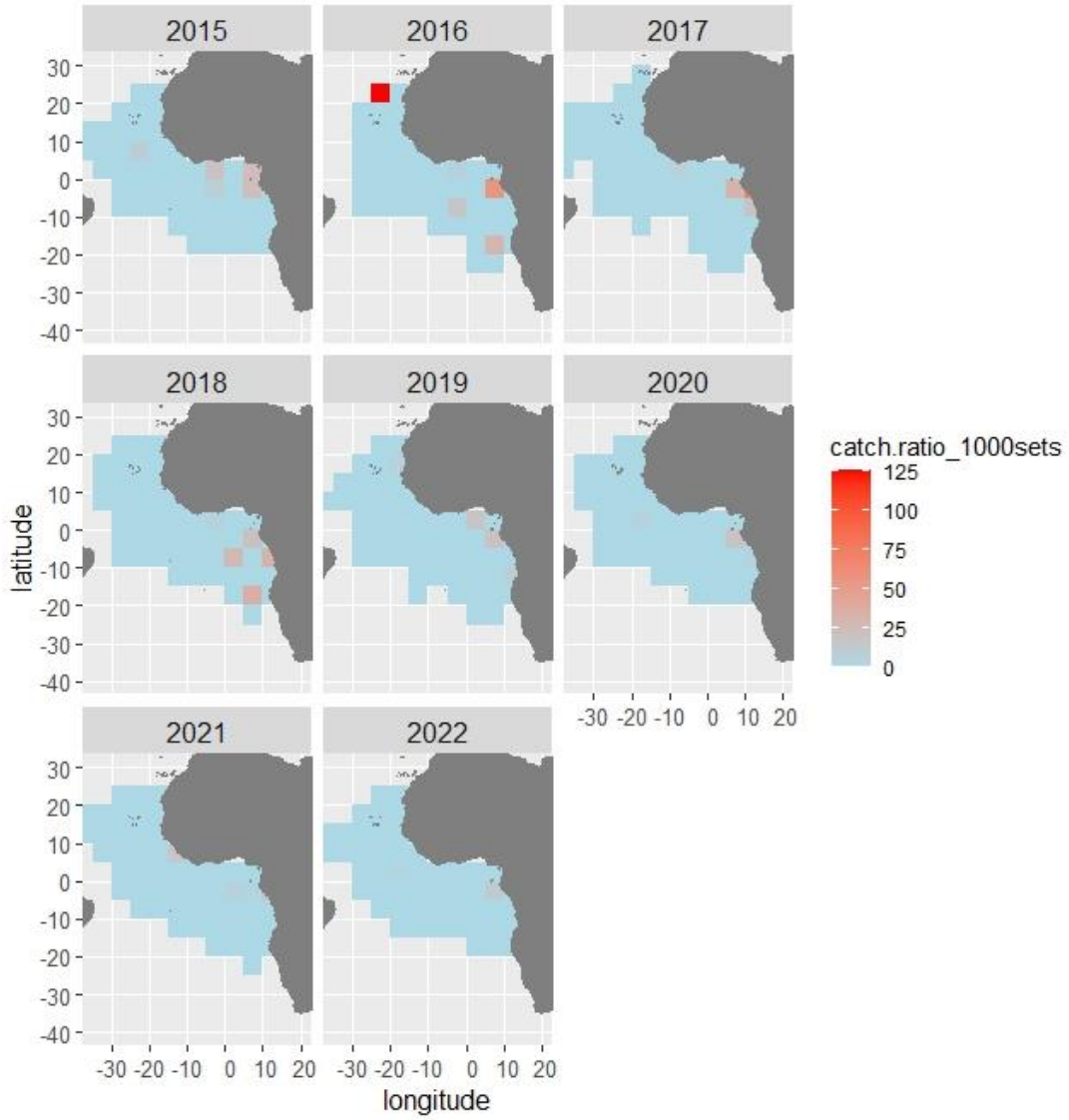

Figure 3. Annual ratio of Spanish and associated fleet interactions with whale sharks during the period 2015-2022. The ratio has been calculated as the number of interactions per 1000 fishing sets in a 5x5 degree grid.

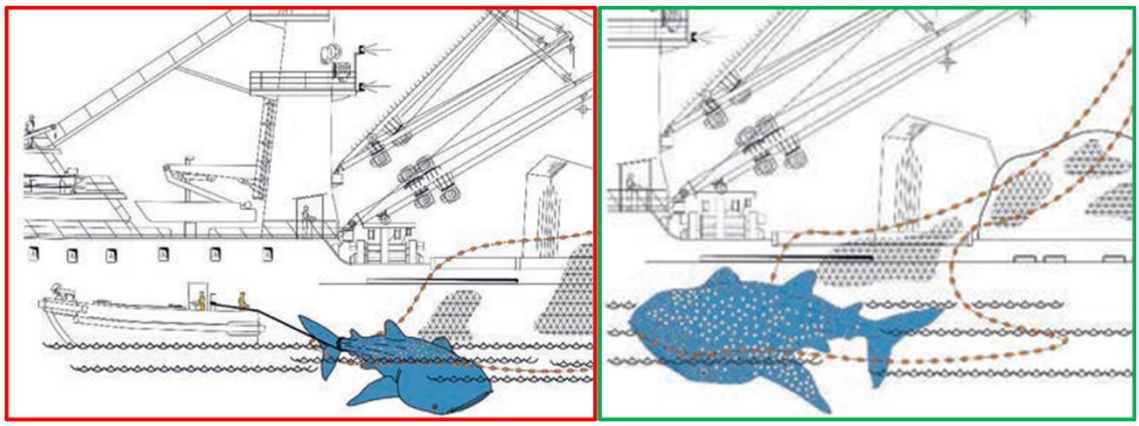

Figure 4. Releasing the whale shark by lowering the cork line of the net (right) and poor practice by pulling the whale shark by its tail (left).

Figure 5. Whale shark facing sternward escaping after fishers cut a hole in the net.

Figure 6. Fishers passing a rope under the whale shark to roll it out when facing sternward.

Figure 7. Whale shark facing towards the bow of the boat escaping after being rolled over the bunt.

Figure 8. Dangerous practice of fishers trying to assist from the water lowering the cork line.