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

Salgado*[1], A., Grande[1], M., Cuevas[1], N., Murua[1], J., Arrizabalaga[1], H., Santiago[1], J., Murua[2], H., Alzorriz[3], N., Herrera[4], M., Juan Jorda[5], M.J., Ruiz[1], J.

1 AZTI, Marine Research, Basque Research and Technology Alliance (BRTA), Basque Country, Spain (* Corresponding author asalgado@azti.es)
2 International Seafood Sustainability Foundation (ISSF), Pittsburgh, (USA)
3 Asociación Nacional de Armadores de Buques Atuneros Congeladores (ANABAC), Bermeo (Spain)
4 Organización Productores Asociados Grandes Atuneros Congeladores (OPAGAC), Madrid (Spain)
5 Instituto Español de Oceanografía (IEO-CSIC), Madrid (Spain)

This document reviews current knowledge on the biology, distribution and conservation status of whale sharks (*Rhincodon typus*) at global and regional levels. It also provides a detailed analysis of whale shark interactions with purse seine fisheries in the Indian Ocean. Although scientific data about whale sharks remains limited, the available information on their life history characteristics and conservation status suggests that whale sharks in the Indian Ocean is "a taxon of the greatest biological vulnerability and conservation concern for which there are very few data". Therefore, we suggest the SC recommended, as stated in Resolution 25-08, the application precautionary management measures including a retention ban for this species for IOTC fisheries 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.

1. Introduction

The whale shark (*Rhincodon 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, 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, marine pollution, 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. Regional Fishery Management Organizations (RFMO) have adopted bans on the retention of whale sharks. In addition, the intentional setting of purse seine on a school of tuna associated with a whale shark (e.g., if the animal is sighted prior to the commencement of the set) is prohibited in all tuna RFMOs (ICCAT Rec 23-12, WCPFC CMM 2022-04, IATTC Resolution C-19-06 and IOTC Res 13/05). However, regarding the retention ban for all gears, it is not yet applied in either the IOTC or the IATTC.

Whale sharks are vulnerable to a diverse range of direct and indirect human activities, many of which are still understudied. Fisheries have historically been the main threat. Prior to the 1980s, whale sharks were rarely fished, however, increasing demand for their meat and fins in the 1990s, lead to targeted fisheries, or at least valuable bycatch (Pravin, 2000). These practices have led to several region-specific regulations to minimize and limit impacts. Targeted fishing for whale sharks is now uncommon or marginal (Dove and Pierce 2021; Nijman, 2023). In addition to fishing-induced mortality, other threats contributing to the decline of this species population include ship collisions (Womersley *et al*., 2022), habitat degradation, climate change, natural predation, and marine pollution (Abreo *et al*., 2019; Yong *et al*., 2021; Reynolds *et al*., 2022; Pancaldi *et al*., 2024; Villagómez-Vélez *et al*., 2024).

In tuna fisheries, whale shark specimens can be caught accidentally, particularly those using purse-seine nets or drifting gillnets, entangled in longlines, and occasionally in other coastal net fisheries. Limited information is available on the level of bycatch interactions with longlines. Similarly limited information is available on the level of bycatch interactions with gillnet fisheries, which mainly occur in the northern Indian and Pacific Oceans. However, some authors suggest that gillnet fisheries should also be considered as a major threat to whale sharks (Dove and Pierce 2021). Whale sharks interactions with tropical tuna purse-seine fisheries are sporadic. In some cases, whale sharks swim along with tropical tuna schools and can become incidental bycatch of the purse seine fleet. These interactions have an immediate mortality rate of less than 1% in the Atlantic Ocean and less than 3% in the Indian Ocean (Capietto *et al*., 2014; Escalle *et al*., 2016; Escalle *et al*., 2018; Ruiz *et al*., 2018; Baez *et al*., 2019). In the Indian Ocean, most of the purse seine fleets[1] have been implementing voluntary best handling and release practices for whale sharks for more than a decade, and this has contributed to the high probability of survival when whale sharks are released properly. An evaluation of the effectiveness of these best release methods, using satellite tag data to monitor post-release swimming behavior, suggested a post-release mortality rate following the encirclement of large whale shark of 0%, though sample sizes are limited (Escalle *et al*., 2018).

[1] https://opagac.org/wp-content/uploads/2024/11/BBPP-OPAGAC-2024.pdf

In 2025, the IOTC adopted Resolution 25/08 on the conservation of sharks caught in association with fisheries under its mandate, providing a broader and more detailed framework than Resolution 13/05. Resolution 25/08 prohibits the intentionally setting a purse seine net around a whale shark if it is sighted prior to the set, and prohibits the retention, transshipment, storage, and landing of whale sharks for all gears. This resolution also includes the whale shark in the list of fully protected species, along with thresher sharks and oceanic whitetip sharks. Importantly, the scope of Resolution 25/08 extends beyond purse seine fisheries to include other gear types, and it introduces more comprehensive reporting requirements for whale shark interactions than Resolution 13/05. It also expands the requirements to safely release the animal, following best practice guidelines to be developed by the Scientific Committee by 31 December 2025.

However, the resolution (paragraph 45) specifies that "*this Resolution shall enter into force for whale sharks on 1 July 2026, only if the IOTC Scientific Committee explicitly and unambiguously recommends a retention ban for whale sharks*." And the Resolution requests that (Paragraph 43) "*The IOTC Scientific Committee shall, at its annual Session in 2025, 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 IOTC Scientific Committee shall advise the Commission on the appropriateness of applying precautionary management measures in IOTC fisheries, including a retention ban*."

Thus, this working document aims to (a) review existing data and information related to the biology, life history, and conservation status of whale shark in the Indian Ocean; (b) provide a detailed characterization of the interactions with IOTC purse seine fisheries, 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 Resolution 25/08.

This paper will contribute to the IOTC Scientific Committee's discussions by evaluating whether whale sharks should be considered a species of particular biological vulnerability and conservation concern, given the limited data currently available.

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

This species is distributed between 30ºN and 35ºS, inhabiting all tropical and warm temperate seas, except the Mediterranean Sea, in both coastal and oceanic habitats (**Figure 1**) (Compagno, 2001; Pierce and Norman, 2016). 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*., 2012). Thus, its 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; Macena and Hazin 2016; McKinney *et al.,* 2017; Robinson *et al*., 2017). As many planktivorous filter-feeding species, whale sharks appear at locations where seasonal production peaks (i.e., high chlorophyll-a concentrations). In the Indian Ocean, aggregations have been documented in coastal waters of Mozambique, Seychelles, Maldives, Djibouti, Tanzania, Saudi Arabia, Qatar, India, Indonesia and Western Australia. These areas are typically associated with high productivity and favorable oceanographic conditions.

Data from the purse-seine fleet indicate high density of whale shark-associated sets in the Mozambique Channel (Sequeira *et al.,* 2012). Complementing these fishery-based observations, a regional survey across 11 Indian Ocean coastal states revealed that whale sharks are generally seen on a regular basis during specific periods, with only a few areas reporting occasional sightings year-round (Rowat, 2007). Satellite tagging studies have further highlighted the influence of oceanographic conditions and sea surface temperature on whale shark movements (Arrowsmith *et al.,* 2021) and emphasized the importance of productive coastal waters for juvenile individuals (Rohner *et al.,* 2018). These aggregations areas often show demographic patterns, with juvenile males being the dominant group, similar to pattern observed in other ocean basins (Prebble *et al.*, 2018)

In terms of the global abundance of this species, the largest known aggregation sites for whale sharks, based on counts and model estimates, host hundreds to a few thousand individuals (Pierce & Norman, 2016). Areas where 500 or more individuals have been documented through either counts or model estimates include the Arabian Gulf and Gulf of Oman (Robinson *et al*., 2016), Ningaloo Reef in Western Australia (Meekan *et al.,* 2006), Darwin Island in the Galapagos (Acuña-Marrero *et al.,* 2014), Quintana Roo in Mexico (De la Parra Venegas *et al*., 2011, Ramírez-Macías *et al*., 2012), Inhambane province in Mozambique (Auditore, 2022), the Philippines (Schleimer *et al.,* 2015), and around Mahe in the Seychelles (Rowat *et al*., 2009, 2011; Brooks *et al*., 2010). Additionally, fisheries data indicates that the Gujarat coast of India (Akhilesh *et al*., 2012), Taiwan (Hsu *et al.,* 2012), and southern China (Li *et al*., 2012) also had large numbers of whale sharks in the vicinity, at least prior to the initiation of targeted fisheries in those countries, with estimated catches of up to 1,000 individuals per year (Li *et al.,* 2012).

Whale sharks are characterized by their large size, and like many other shark species, they possess inherent biological characteristics such as slow growth, late reproductive maturation, low reproductive potential, and extended longevity (Stevens, 2007). These life-history characteristics make the species particularly vulnerable to exploitation and may result in slow population recovery and low resilience (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 and Norman, 2016).

There are two subpopulations used in the whale shark's current Red List assessment-Atlantic and Indo-Pacific. 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). In the Indo-Pacific, a variety of datasets present declines of 40-92%, inferring an overall decline of 63% over the last 75 years (i.e., three generations), resulting in a subpopulation assessment of Endangered). In the Atlantic, the overall population decline is considered to be lower (≥30%), resulting in a subpopulation assessment of Vulnerable. Given the bulk of the global population occurring in the Indo-Pacific, the overall global decline is inferred to be ≥50%. Globally, the whale shark is therefore assessed as Endangered (IUCN, 2012).

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 and Stewart 2001, Ramírez-Macías *et al*., 2012) but are 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 placental viviparous. The largest size class of embryos, 58–64 cm total length (TL), appeared close to fully developed (Joung *et al*., 1996). The smallest free-swimming neonate found in the wild was 46 cm TL (Aca and Schmidt, 2011). Size at birth is therefore presumed to be around this range (Aca and Schmidt, 2011).

3. Whale shark interactions with the purse seine fishery in the IOTC 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. Tuna schools can aggregate under the whale shark, which potentially acts as a living Fish Aggregating Device (FAD), in specific oceanic regions (i.e., areas of high plankton productivity) (Escalle *et al.,* 2018). While on certain occasions

the setting of the net around these animals can be intentional, in others, however, when mixed among large tuna schools, whale sharks can remain out of sight and be inadvertently caught. Note that unlike marine mammals, like whales, that need to surface to breathe air, whale sharks are elasmobranchs and remain continuously below the water surface. Although it's common for the larger incidentally captured specimens to be released alive (Escalle *et al.*, 2018; Ruiz *et al.*, 2018), such encounters should be monitored, especially considering that it is a species particularly vulnerable. 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. Additionally, socio-economic considerations should be taken into account, such as the importance of catches of target species, which may influence fishing effort and spatial distribution. A previous study identified specific periods and regions, particularly the Mozambique Channel during the inter south-west monsoon period (April-May), and to a lesser extent, a 10° square area east of the Seychelles during the north-east monsoon and inter north-east monsoon periods. (Capietto *et al.*, 2014).

When a fishing set is conducted with a whale shark nearby, these animals can, or cannot, be encircled by the purse seine net. This study only considers interactions as those fishing sets in which whale sharks were caught by the purse seine gear. This update was conducted using at-sea observations aboard the Spanish, Seychellois, Mauritian, Tanzanian, and Kenyan purse seine vessels operating in the Indian Ocean from 2017 to 2024, indicating the degree of interactions (i.e., interactions per 1,000 fishing sets) with whale sharks, as well as their spatial distribution.

Between 2017 and 2024, the observers' consolidated final database encompasses a total of 24,403 monitored fishing sets, with an average of 3,050 fishing sets sampled annually (**Figure 2**), representing around 25-30% of the total purse seine effort in the tropical Indian Ocean. A total of 66 whale shark interactions were recorded over the past 8 years (**Table 1 and Figure 2**), with 10.6 % occurring in the first quarter, 22.7 % in the second, 28.8% in the third and 37.9% in the last quarter. Interannual comparison reveals a marked rise in interactions in recent years, with 2024 alone accounting for 56% of the total encirclements. **Table 2** presents the quarterly ratio of whale shark interactions relative to fishing effort, expressed as the number of interactions per 1,000 fishing sets. Notably, the highest interaction rates were observed in the second quarters of 2019 and 2020, as well as in the third and fourth quarters of 2024. When examining the data by year, significant differences become apparent. It is important to note, however, that these interactions are also influenced by the fishing agreements available in each country. Despite this, the observed patterns suggest a possible shift in the seasonal or annual presence of whale sharks within the study area, potentially driven by environmental or ecological factors. Furthermore, out of the total whale shark interactions, 68% (45 individuals) have occurred within international waters. Seventeen (26%) interactions have been recorded in the Exclusive Economic Zone (EEZ) of Seychelles. Additionally, 2 interactions were recorded in the waters of Madagascar, one in Tanzania, and another in Mayotte. The area between 5º-10ºS and 60º-70ºE had the highest whale shark interaction ratio relative to the number of fishing sets conducted (**Figure 3**).

4. Review of best release practices of whale shark

When interactions with whale sharks occur, it's crucial to mitigate their effects. Preferably, whale sharks should be released from the purse seine net before fully closing the purse line. As a last choice, when the animal is encircled in the net, appropriate release techniques should be applied. 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 total length), which might be unable to escape by itself over the net's cork line, it could be released carefully using the brail to lift it out of the water and deposit it outside the purse seine net.

Whenever possible, whale shark release should be prioritized and completed before brailing. 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 facilitate the release it (**Figure 5**), as otherwise maneuvering 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 maneuver 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 jumped inside the net to help whale shark release by manually pushing the cork line down (**Figure 8**). This practice is highly discouraged due to crew safety issues, 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 of the net using the skiff or lifting them out with the crane in the case of small individuals. Such methods are considered poor practices that can injure whale sharks and are discouraged by regulations in all tuna RFMOs (IATTC Rec. C-19-06; WCPFC CMM-22-04; IOTC Res. 25/08; ICCAT Rec 23-12).

Many of the purse seine fleets operating in IOTC (i.e., Europe, Seychelles, Mauritius, Tanzania or Kenya) were voluntarily applying whale shark safe-handling and release best practices before Resolution 25-08 was established (Grande *et al.*, 2019). Best practices guidelines for purse seiners were updated in 2024 (Murua *et al.,* 2023[2]), which could be considered when developing the safe handling and releasing best practice guidelines at IOTC as requested by Res. 25/08. 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 also suggests that immediate post-release mortality is very low provided that best handling and release practices are applied.

5. Conclusions and Recommendations

This document provides an overview of the biological knowledge of the whale shark and its conservation status at a global level, and specifically within the IOTC area of competence. It seeks to provide information and facilitate discussion at the SC to provide management recommendations as requested by Res. 25-08.

Although Resolution 25-08 does not specify latitudinal limits for whale sharks, it applies to all IOTC-managed fisheries. Therefore, it is recommended that the resolution be implemented across the entire known distribution of the species in the Indian Ocean, including tropical and subtropical areas where interactions with purse-seine and gillnet fisheries have been documented (Capietto *et al.,* 2014; Moazzam and Nawaz, 2014).

As for its conservation status, the latest IUCN assessment classifies the Indo-Pacific subpopulation of the whale shark as *Endangered*. This subpopulation represents approximately 75% of the global whale shark population, with an overall population decline of 63% over the past 75 years (three generations). Given the species´ life history characteristics and conservation status, whale sharks in the Indian Ocean can be considered as a species of greatest biological vulnerability and conservation concern. Therefore, it is recommended that precautionary management mitigation measures, such as a retention ban established in Resolution 25-08 should be implemented across all IOTC fisheries to address its vulnerability.

Electronic tagging data and observer data, although limited in sample size, have demonstrated the effectiveness of best handling and release practices on purse seiners

[2] https://www.azti.es/wp-content/uploads/2024/02/AZTI_Guia_BBPP_low.pdf

results in almost zero post-release mortality rate. Therefore, it is also highly recommended that Resolution 25-08 requires the application of safe-handling and release best practices for whale sharks. Similarly, it is advisable to implement safe-handling and release best practices for all fisheries, such as those developed by Razzaque *et al*. (2020) for gillnet fisheries.

Finally, it is recommended that, in addition to continuing research on the biology of this iconic species, efforts be made to assess the overall impact of IOTC fisheries, including all fleets, particularly gillnet fisheries, on whale sharks.

6. Acknowledgments

The authors thank the ANABAC and OPAGAC purse seine industry companies for providing their observer data for the analysis.

References

Abreo N.A., Blatchley D., Superio M.D. (2019). Stranded whale shark (*Rhincodon typus*) reveals vulnerability of filter-feeding elasmobranchs to marine litter in the Philippines, Marine Pollution Bulletin, Volume 141, Pages 79-83, ISSN 0025-326X, https://doi.org/10.1016/j.marpolbul.2019.02.030

Aca E.Q. and Schmidt J.V. (2011). Revised size limit for viability in the wild: Neonatal and young of the year whale sharks identified in the Philippines. Asia Life Sciences 20: 361-367

Acuña-Marrero D., Jiménez J., Smith F., Doherty P.F., Jr., Hearn A., Green J.R., Parades-Jarrin J. and Salinas-de-Leon P. (2014). Whale shark (*Rhincodon typus*) seasonal presence, residence time and habitat use at Darwin Island, Galapagos Marine Reserve. PLoS ONE 9: e102060

Akhilesh, K.V., Shanis, C.P.R., White, W.T., Manjebrayakath, H., Bineesh, K.K., Ganga, U., Abdussamad, E.M., Gopalakrishnan, A. and Pillai, N.G.K. (2012). Landings of whale sharks *Rhincodon typus* Smith, 1828 in Indian waters since protection in 2001 through the Indian Wildlife (Protection) Act, 1972. *Environmental Biology of Fishes* 96: 713-722.

Arrowsmith, L. M., Paidi, C. K., Bloch, F. H., John, S., Choudhury, B. C., Kaul, R., ... & Meekan, M. G. (2021). First insights into the horizontal movements of whale sharks (*Rhincodon typus*) in the northern Arabian Sea. *Frontiers in Marine Science*, *8*, 682730.

Auditore, L.M. (2022). Sexual segregation and abundance trend of whale sharks in southern Mozambique

Báez J.C., Barbosa A.M., Pascual P., Ramos M.L., Abascal F. (2019). Ensemble modeling of the potential distribution of the whale shark in the Atlantic Ocean. Ecol Evol. 2020; 10: 175-184. https://doi.org/10.1002/ece3.5884

Brooks, K., Rowat, D., Pierce, S.J., Jouannet, D. and Vely, M. (2010). Seeing spots: photo-identification as a regional tool for whale shark identification. *Western Indian Ocean Journal of Marine Science* 2: 185-194.

Cagua E.F., Cochran J. E., Rohner C.A., Prebble C.E., Sinclair-Taylor T.H., Pierce S.J., Berumen M.L. (2015). Acoustic telemetry reveals cryptic residency of whale sharks. Biology Letters, 11 (4), 20150092. https ://doi.org/10.1098/rsbl.2015.0092

Capietto A., Escalle L., Chavance P., Dubroca L., Delgado de Molina A., Murua H., Floch L., Damiano A., Rowat D., Merigot B. (2014). Mortality of marine megafauna induced by fisheries: insights from the whale shark, the world's largest fish. Biol. Conserv. 174, 147e151

Castro A.L.F., Stewart B.S., Wilson S.G., Hueter R.E., Meekan M.G., Motta P.J., Bowen B.W. and KARL, S.A. (2007). Population genetic structure of Earth's largest fish, the whale shark (*Rhincodon typus*). Molecular Ecology, 16: 5183-5192. https://doi.org/10.1111/j.1365-294X.2007.03597.x

Colman, J.G. (1997). A review of the biology and ecology of the whale shark. Journal of Fish Biology, vol. 51: 1219 – 1234

Compagno L.J.V. (2001). Sharks of the World: An annotated and illustrated catalogue of shark species know to date. FAO species catalogue for fishery purposes No. 1 (Vol. 2). Rome, Italy: FAO

De la Parra Venegas, R., Hueter, R., González Cano, J., Tyminski, J., Gregorio Remolina, J., Maslanka, M., Ormos, A., Weigt, L., Carlson, B. and Dove, A. (2011). An unprecedented aggregation of whale sharks, *Rhincodon typus*, in Mexican coastal waters of the Caribbean Sea. *PloS One* 6: e18994.

Dove A.D.M., Pierce S.J. (Eds.). (2021). *Whale Sharks: Biology, Ecology, and Conservation (1st ed.)*. CRC Press. https://doi.org/10.1201/b22502

Eckert S.A. and Stewart B.S. (2001). Telemetry and satellite tracking of whale sharks, *Rhincodon typus*, in the Sea of Cortez, Mexico, and the north Pacific Ocean. Environmental Biology of Fishes 60: 299-308

Escalle L., Pennino M.G., Gaertner D., Chavance P., Delgado de Molina A., Demarcq H., Merigot B. (2016). Environmental factors and megafauna spatio-temporal co-occurrence

with purse-seine fisheries. Fisheries Oceanography, 25, 433–447. https://doi.org/10.1111/fog.12163

Escalle L., Amandé J., Filmalter J., Forget F., Gaertner D., Dagorn L., Mérigo T. (2018). Update on post-release survival of tagged whale shark encircled by tuna purse-seiner. Collect. Vol. Sci. Pap. ICCAT, 74, pp. 3671-3678

Escalle L., Gaertner D., Chavance P., Murua H., Simier M., Pascual-Alayón P.J., Ménard F., Ruiz J., Abascal F., Mérigot B. (2018). Catch and bycatch captured by tropical tuna purse-seine fishery in whale and whale shark associated sets: comparison with free school and FAD sets. Biodiversity and Conservation (2019) 28:467–499. https://doi.org/10.1007/s10531-018-1672-1

Grande M., Murua J., Ruiz J. *et al., (*2019). Bycatch mitigation actions on tropical tuna purse seiners: best practices program and bycatch releasing tools. In: IATTC - 9th Meeting of the Working Group on Bycatch. San Diego, California

Hsu, H.H., Joung, S.J. and Liu, K. (2012). Fisheries, management and conservation of the whale shark *Rhincodon typus* in Taiwan. *Journal of Fish Biology* 80: 1595-1607.

Hsu, H.H., Joung, S.J., Hueter, R.E. and Liu, K.M. (2014). Age and growth of the whale shark (*Rhincodon typus*) in the north-western Pacific. *Marine and Freshwater Research* 65: 1145-1154.

Huveneers C., Stead J., Bennett M.B., Lee K.A. and Harcourt R.G. (2013). Age and growth determination of three sympatric wobbegong sharks: How reliable is growth band periodicity in Orectolobidae? Fisheries Research 147: 413-425

IUCN. (2012). IUCN Red List Categories and Criteria: Version 3.1. Second edition. Gland, Switzerland and Cambridge, UK: IUCN. iv + 32pp

Joung S.J., Chen C.T., Clark E., Uchida S. and Huang W.Y.P. (1996). The whale shark, *Rhincodon typus*, is a livebearer: 300 embryos found in one ''megamamma'' supreme. Environmental Biology of Fishes 46: 219-223

Li, W., Wang, Y. and Norman, B. (2012). A preliminary survey of whale shark *Rhincodon typus* catch and trade in China: an emerging crisis. *Journal of Fish Biology* 80: 1608-1618.

Macena B.C.L., Hazin F.H.V. (2016). Whale Shark (*Rhincodon typus*) Seasonal Occurrence, Abundance and Demographic Structure in the MidEquatorial Atlantic Ocean. PLoS ONE 11(10): e0164440. Doi:10.1371/journal.pone.0164440

McKinney J.A., Hoffmayer E.R., Holmberg J., Graham R.T., Driggers W.B. III, de la Parra-Venegas R., *et al*. (2017). Long-term assessment of whale shark population demography and connectivity using photo-identification in the Western Atlantic Ocean. PloS ONE 12(8): e0180495.

Meekan, M.G., Bradshaw, C.J.A., Press, M., Mclean, C., Richards, A., Quasnichka, S. and Taylor, J.G. (2006). Population size and structure of whale sharks *Rhincodon typus* at Ningaloo Reef, Western Australia. *Marine Ecology Progress Series* 319: 275-285

Moazzam, M., & Nawaz, R. (2014). By-catch of tuna gillnet fisheries of Pakistan: A serious threat to non-target, endangered and threatened species. *J Mar Biol Ass India*, *56*(1), 85-90.

Nijman, V. (2023). Illegal trade in protected species: the case of artisanal whale shark meat fisheries in Java, Indonesia. *Animals, 13*(16), 2656

Pancaldi F., Ayres K.A., Gallagher A.J., Moskito J., Williamson K.C., Higuera Rivas J.E. (2024). Killer whales (*Orcinus orca*) hunt, kill and consume the largest fish on Earth, the whale shark (*Rhincodon typus)*. Frontiers in Marine Science, Sec Discoveries, Volume 11 - 2024

Perry C.T., Clingham E., Webb D.H., de la Parra R., Pierce S.J., Beard A., Henry L., Taylor B., Andrews K., Hobbs R., Araujo G. and Dove A.D.M. (2020). St. Helena: An Important Reproductive Habitat for Whale Sharks (*Rhincodon typus*) in the Central South Atlantic. Front. Mar. Sci. 7:576343. doi: 10.3389/fmars.2020.576343

Pierce S.J., Norman B. (2016). *Rhincodon typus*. The IUCN Red List of Threatened Species 2016:e.T19488A2365291.http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T19488A2365291.en

Pierce S. J., Grace M. K., Araujo G. (2021). *Rhincodon typus* (Green status assessment). In: *The IUCN red list of threatened species 2021* (Accessed 22 February 2022)

Pravin P. (2000). Whale shark in the Indian coast-Need for conservation. Current science, 79(3). 310-315

Prebble, C. E., Rohner, C. A., Pierce, S. J., Robinson, D. P., Jaidah, M. Y., Bach, S. S., & Trueman, C. N. (2018). Limited latitudinal ranging of juvenile whale sharks in the Western Indian Ocean suggests the existence of regional management units. *Marine Ecology Progress Series*, *601*, 167-183.

Ramírez-Macías D., Vázquez-Haikin A. and Vázquez-Juárez R. (2012). Whale shark *Rhincodon typus* populations along the west coast of the Gulf of California and implications for management. Endangered Species Research 18: 115-128

Razzaque, S. A., Khan, M. M., Shahid, U., Nieduzak, M., Khan, B., Cornish, A., ... & Chirinda, G. (2020). Safe handling & release for gillnet fisheries for whale shark, manta & devil rays and sea turtles. *IOTC-16th Working Party on Ecosys-tems and Bycatch. IOTC-2020-WPEB16-26_Rev1, Online. https://www. bmis-bycatch. org/system/files/zotero_attachments/library_1/9WDALSML*.

Reynolds, S. D., Norman, B. M., Franklin, C. E., Bach, S. S., Comezzi, F. G., Diamant, S., ... & Dwyer, R. G. (2022). Regional variation in anthropogenic threats to Indian Ocean whale sharks. *Global Ecology and Conservation*, *33*, e01961.

Robinson, D. P., Jaidah, M. Y., Bach, S., Lee, K., Jabado, R. W., Rohner, C. A., March A., Caprodossi S., Henderson A.C, Mair J.M., Ormond R., Pierce, S. J. (2016). Population structure, abundance and movement of whale sharks in the Arabian Gulf and the Gulf of Oman. *PLoS one*, *11*(6), e0158593.

Robinson D.P., Jaidah M.Y., Bach S.S., Rohner C.A., Jabado R.W., Ormond R. & Pierce S.J. (2017). Some like it hot: Repeat migration and residency of whale sharks within an extreme natural environment. *PLoS ONE*, *12*(9), e0185360. https://doi.org/10.1371/journal.pone.0185360

Rohner, C. A., Richardson, A. J., Jaine, F. R., Bennett, M. B., Weeks, S. J., Cliff, G., ... & Pierce, S. J. (2018). Satellite tagging highlights the importance of productive Mozambican coastal waters to the ecology and conservation of whale sharks. *PeerJ*, *6*, e4161.

Rowat, D. (2007). Occurrence of whale shark (Rhincodon typus) in the Indian Ocean: A case for regional conservation. *Fisheries Research*, *84*(1), 96-101.

Rowat, D., Speed, C.W., Meekan, M.G., Gore, M.A. and Bradshaw, C.J.A. (2009). Population abundance and apparent survival of the vulnerable whale shark *Rhincodon typus* in the Seychelles aggregation. *Oryx* 43: 591-598.

Rowat, D., Brooks, K., March, A., McCarten, C., Jouannet, D., Riley, L., Jeffreys, G., Perri, M., Vely, M. and Pardigon, B. (2011). Long-term membership of whale sharks (*Rhincodon typus*) in coastal aggregations in Seychelles and Djibouti. *Marine and Freshwater Research* 62: 621-627.

Rowat D, Brooks K.S. (2012). A review of the biology, fisheries and conservation of the whale shark *Rhincodon typus*. J Fish Biol. Apr;80(5):1019-56. doi: 10.1111/j.1095-8649.2012.03252.x. Erratum in: J Fish Biol. 2013 May;82(5):1769. PMID: 22497372

Ruiz J., Abascal F.J., Bach P., Báez J.C., Cauquil P., Grande M., Krug I., Lucas J., Murua H., Ramos M.L., Sabarros P.S. (2018). Bycatch of the European, and associated flag, purse-seine tuna fishery in the Indian Ocean for the period 2008-2017. WD-IOTC-2018-WPEB14-15.

Sequeira A., Mellin C., Rowat D., Meekan M.G., & Bradshaw C.J. (2012). Ocean-scale prediction of whale shark distribution. Diversity and Distributions, 18, 504–518. https://doi.org/10.1111/j.1472-4642.2011.00853.x

Schleimer, A., Araujo, G., Penketh, L., Heath, A., McCoy, E., Labaja, J., Lucey, A. and Ponzo, A. (2015). Learning from a provisioning site: code of conduct compliance and behaviour of whale sharks in Oslob, Cebu, Philippines. *PeerJ* 3: e1452.

Schmidt J.V., Chen C.C., Sheikh S.I., Meekan M.G., Norman B.M. and Joung S.J. (2010). Paternity analysis in a litter of whale shark embryos. Endangered Species Research 12: 117-124

Stevens J.D. (2007). Whale shark (*Rhincodon typus*) biology and ecology: A review of the primary literature, Fisheries Research, Volume 84, Issue 1. Pages 4-9, ISSN 0165-7836

Thums M., Meekan M., Stevens J., Wilson S., Polovina J. (2012). Evidence for behavioural thermoregulation by the world's largest fish. Journal of the Royal Society Interface, 10, doi:10.1098/rsif.2012.0477

Vignaud T.M., Maynard J.A., Leblois R., Meekan M.G., Vázquez-Juárez R., Ramírez-Macías D., Pierce S.J., Rowat D., Berumen M.L., Beeravolu C., Baksay S. and Planes S. (2014). Genetic structure of populations of whale sharks among ocean basins and evidence for their historic rise and recent decline. Mol Ecol, 23: 2590-2601. https://doi.org/10.1111/mec.12754

Villagómez-Vélez S.I., Noreña-Barroso E., Galván-Magaña F., González-Armas R., Rodríguez-Fuentes G., Marmolejo-Rodríguez A.J. (2023). Persistent Organic Pollutants in Whale Shark (*Rhincodon typus*) Skin Biopsies from Bahía de Los Ángeles, Mexico. Bull Environ Contam Toxicol. Dec 23;112(1):18. doi: 10.1007/s00128-023-03841-2. PMID: 38141110; PMCID: PMC10748776

Wintner, S.P. (2000). Preliminary study of vertebral growth rings in the whale shark, *Rhincodon typus*, from the east coast of South Africa. *Environmental Biology of Fishes* 59: 441-451.

Womersley F., Humphries N., Queiroz N., Vedor M., da Costa I., Furtado M., Tyminski J., Abrantes K., Araujo G., Bach S., Barnett A., Berumen M., Lion S., Braun C., Clingham E., Cochran J., & de la Parra R., Diamant S., Dove A. and Sims D. (2022). Global collision-risk hotspots of marine traffic and the world's largest fish, the whale shark. Proceedings of the National Academy of Sciences. 119. 10.1073/pnas.2117440119

Yong M.M.H., Leistenschneider C., Miranda J.A. *et al*. (2021).Microplastics in fecal samples of whale sharks (*Rhincodon typus*) and from surface water in the Philippines. Micropl.&Nanopl. 1, 17. https://doi.org/10.1186/s43591-021-00017-9

Table 1. Number of whale shark encirclement with tropical tuna purse seiners in the Indian Ocean by year and quarter during the period 2017-2024.

Año	Q1	Q2	Q3	Q4
2017	2	0	1	0
2018	1	1	0	0
2019	0	7	0	3
2020	1	2	0	0
2021	0	0	1	0
2022	3	2	5	0
2023	0	0	0	0
2024	0	3	12	22

Table 2. Observed whale shark interaction ratio with tropical tuna purse seiners in the Indian Ocean, calculated as the number of encirclements per 1,000 fishing sets, by year and quarter (Q) for the period 2017-2024. The colour scale, ranging from blue (low) to red (high), represents the degree of interactions. Blank cells indicate quarters without whale shark captures.

Year	Q1	Q2	Q3	Q4
2017	2	0	2	0
2018	1	2	0	0
2019	0	11	0	5
2020	1	8	0	0
2021	0	0	1	0
2022	4	2	5	0
2023	0	0	0	0
2024	0	2	9	16

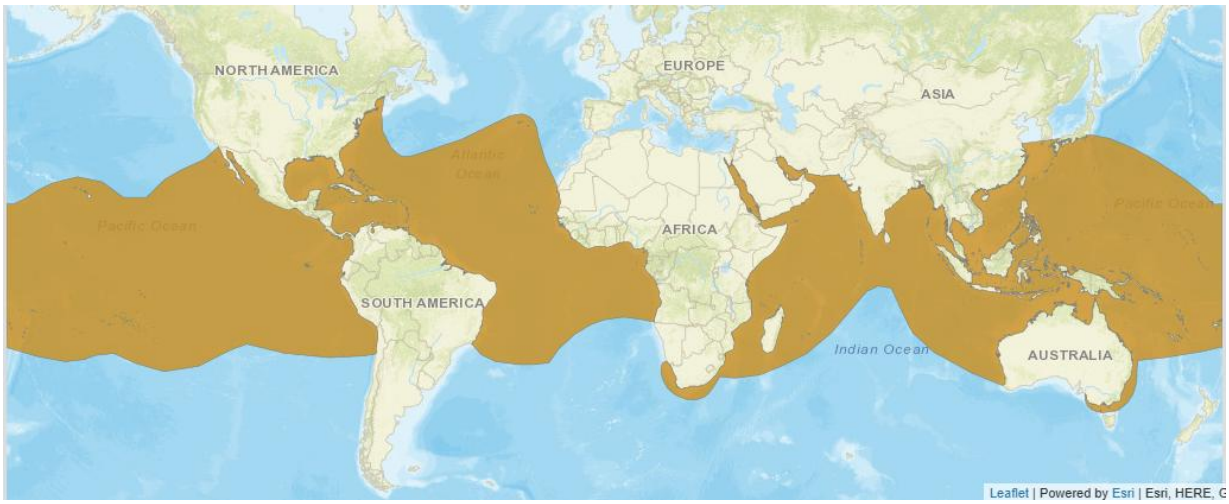

Figure 1. Extant Whale Shark distribution map (from IUCN Shark Specialist Group 2016).

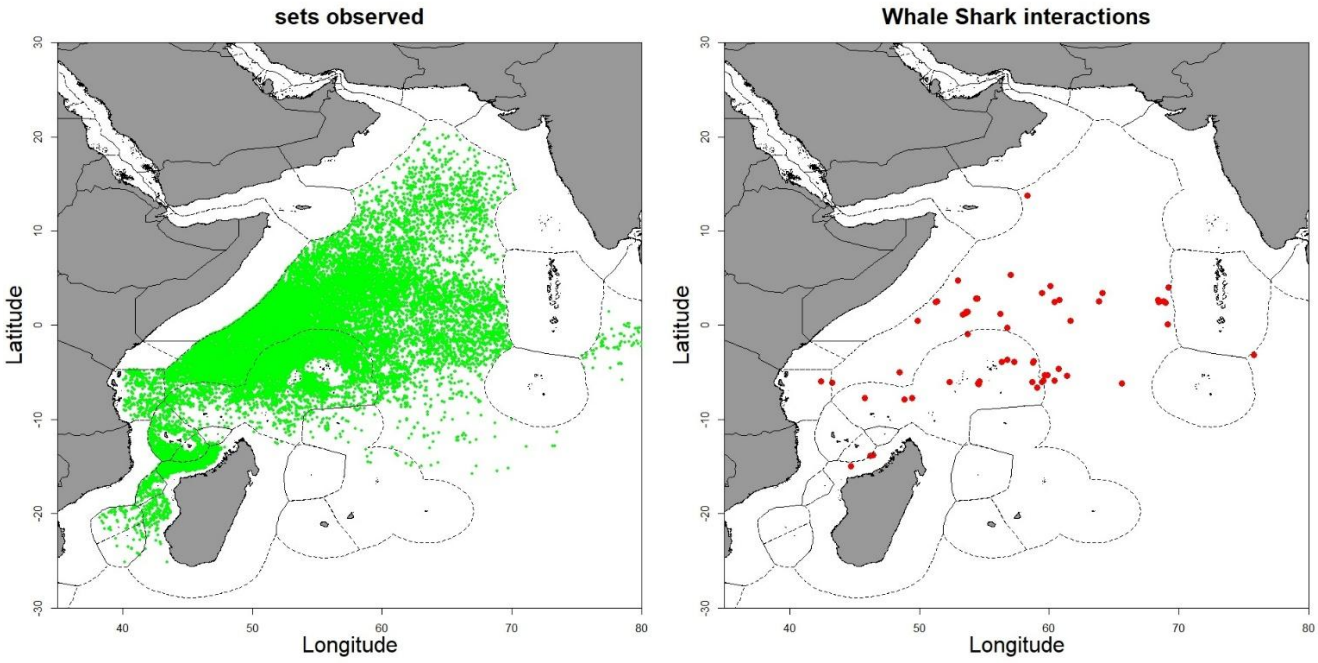

Figure 2. Sets observed in purse seiners during 2017-2024 (left). Interactions with sets involving RHN during 2017-2024 (right).

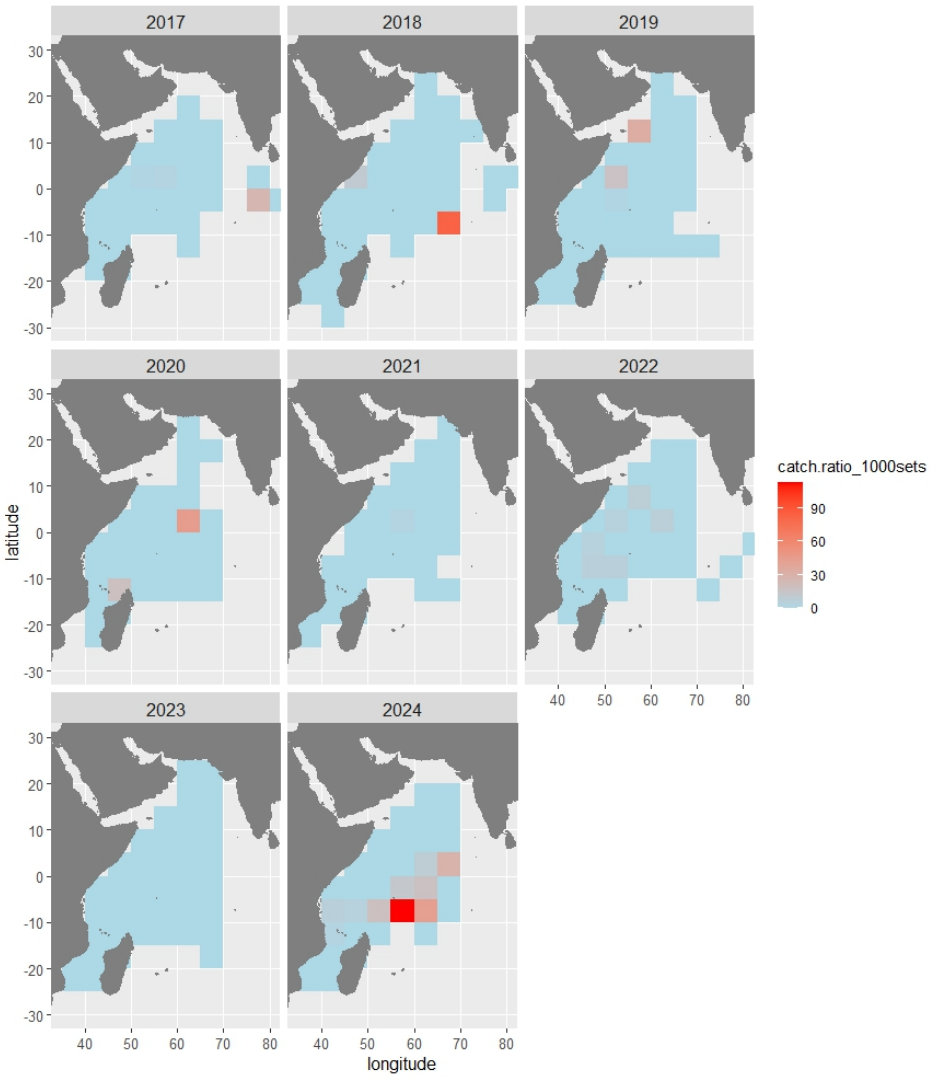

Figure 3. Annual ratio of tropical tuna purse seiners interactions with whale shark during the period 2017-2024. The ratio has been calculated as the number of interactions per 1000 fishing sets in a 5x5 degree grid.

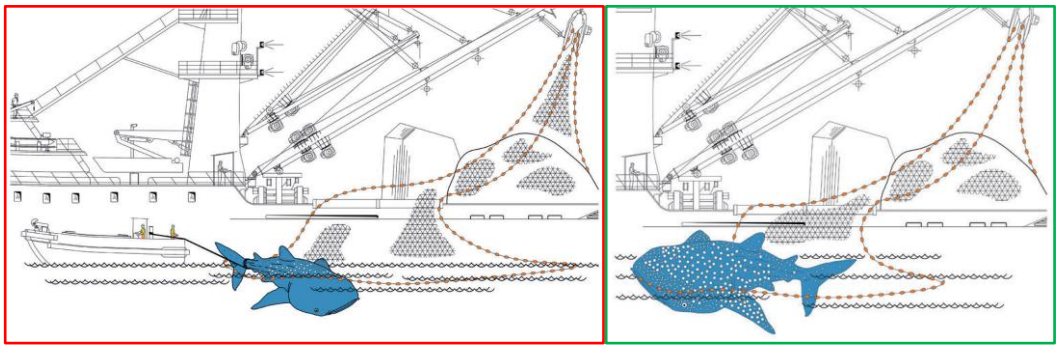

Figure 4. Releasing the whale shark by lowering the cork line of the net (right) and poor practice by pulling the whale shark by its tail (left).

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

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

Figure 7. Whale shark facing towards the bow of the boat escaping after being rolled over the hunt. Photo by AZTI

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