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Endangered Species Act Recovery Status Review for the Oceanic Whitetip Shark (*Carcharhinus longimanus*)

2023

Executive Summary

This report was originally produced in response to a petition received from Defenders of Wildlife on September 21, 2015, to list the oceanic whitetip shark (*Carcharhinus longimanus*) as endangered or threatened under the Endangered Species Act (ESA). On January 18, 2016, the National Marine Fisheries Service (NMFS) published in the *Federal Register* a final rule to list the oceanic whitetip shark as threatened under the ESA (83 FR 4153). This document, the Recovery Status Review, contains a comprehensive collection of information for the oceanic whitetip shark, with updated information collected since 2018.

We intend for this Recovery Status Review to be a comprehensive living document that we update with significant new information as it becomes available. A Recovery Status Review does not result in a decision. Rather, it provides the best scientific and commercial data available to inform management and recovery actions for ESA listed species. It serves as the "Background" section of a recovery plan and provides information to help inform other ESA processes and activities such as Section 7 consultations, grant decisions, permits, conservation plans developed under Section 10 of the ESA, and 5-year reviews.

The oceanic whitetip shark is a circumglobal species of shark, found in tropical and subtropical seas worldwide. The oceanic whitetip shark is a truly pelagic species, generally remaining offshore in the open ocean, on the outer continental shelf, or around oceanic islands in water depths greater than 184 m, and occurring from the surface to at least 152 m depth. This species has a strong preference for the surface mixed layer in warm waters above 20°C and is therefore a surface-dwelling species. Oceanic whitetip sharks are highly mobile and can travel great distances in the open ocean environment, with excursion estimates of several thousand kilometers. The oceanic whitetip shark is a long-lived, slow-growing, and late-maturing species compared to teleosts, and has low-moderate productivity relative to other sharks.

While the oceanic whitetip shark is wide-ranging, its distribution and abundance throughout its range are not well known. Historical fisheries data and observations suggest that the species was once among the most common and ubiquitous shark species in tropical waters around the world. More recently, however, numerous lines of evidence from all three major ocean basins (Atlantic, Pacific, and Indian Oceans) suggest that the oceanic whitetip shark has experienced significant historical declines of varying magnitudes over the past several decades, with evidence that these declines are likely ongoing.

The most significant threat to the oceanic whitetip shark is overutilization of the species for commercial purposes. Because of the species' tropical distribution and tendency to remain in surface waters, the oceanic whitetip shark experiences frequent encounters and high mortality rates in commercial fisheries (e.g., pelagic longline, purse seine, and gillnet fisheries) throughout its range. The species' high-value fins also create an economic incentive for opportunistic retention and finning for the international shark fin trade. Although there is considerable uncertainty regarding the species' current abundance throughout its range, the best available information suggests significant population declines due to fisheries-related mortality throughout a large majority of its range (e.g., Eastern Pacific, Western and Central Pacific, Atlantic and Indian Oceans).

Recent evidence suggests that most populations are still declining due to continued fishing pressure and associated mortality. Efforts to address overutilization of the species through regulatory measures appear largely inadequate, with evidence of illegal retention and trade of oceanic whitetip fins despite prohibitions for the species in all Regional Fisheries Management Organizations (RFMOs) and its listing under the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) Appendix II. As such, we conclude that overutilization continues to be a threat to the oceanic whitetip shark through the foreseeable future (~30 years).

List of Acronyms

AFZ	Australian Fishing Zone
ASMFC	Atlantic States Marine Fisheries Commission
ATCA	Atlantic Tunas Convention Act
CCSB	Commercial Caribbean Small Boat
CI	Confidence interval
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMM	Conservation management measures
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CNMI	Commonwealth of the Northern Mariana Islands
CPC	Cooperating Non-Contracting Parties
CPUE	Catch per unit effort
CSTP	Cooperative Shark Tagging Program
CV	Coefficient of variation
EEZ	Exclusive Economic Zone
EFH	Essential fish habitat
EPO	Eastern Pacific Ocean
ERA	Ecological risk assessment
ESA	Endangered Species Act
ETBF	Eastern Tuna and Billfish fishery
EU	European Union
FAD	Fish aggregating device
FAO	Food and Agricultural Organization of the United Nations
FEP	Fishery Ecosystem Plan
FL	Fork length

FMA	Fisheries Management Area
FMP	Fishery management plan
FR	Federal Register
GL	Generation length
HMS	Highly migratory species
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IOTC	Indian Ocean Tuna Commission
IPCC	Intergovernmental Panel on Climate Change
IPOA	International Plan of Action
IUCN	International Union for the Conservation of Nature
IUU	Illegal, unreported, and unregulated
JARA	Just Another Red List Assessment
LVPA	Large Vessel Prohibited Area
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	Maximum sustainable yield
MT	Metric tons
MU	Management Unit
MUS	Management Unit Species
NE	Northeast
NEC	North Equatorial Countercurrent
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

NPFMC	North Pacific Fishery Management Council
NPOA	National Plan of Action
NW	Northwest
OSPESCA	Organization of the Fisheries and Aquaculture Section of the Central American Isthmus
PAT	Pop-up archival tag
PCB	Polychlorinated biphenyl
PCL	Pre-caudal length
PFMC	Pacific Fishery Management Council
PICT	Pacific Islands Countries and Territories
PIRO	Pacific Islands Regional Office
PLL	Pelagic longline
PSAT	Pop-up satellite tag
PSMA	Port State Measures Agreement
RFMO	Regional Fisheries Management Organization
RMI	Republic of the Marshall Islands
SAR	Special Administrative Region
SB	Spawning biomass
SBMSY	Spawning biomass at maximum sustainable yield
SCRS	Standing Committee on Research and Statistics
SEFSC	Southeast Fisheries Science Center
SICA	Central American Integration System
SPAW	Specially Protected Areas and Wildlife Protocol
SRFC	Sub-Regional Fisheries Council
SST	Sea surface temperature
SW	Southwest
TL	Total length

USD	United States dollar
VBGF	Von Bertalanffy growth function
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WPFMC	Western Pacific Fishery Management Council
WTBF	Western Tuna and Billfish fishery

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1. INTRODUCTION

1.1 Scope and Intent of the Present Document

On September 21, 2015, the National Marine Fisheries Service (NMFS) received a petition to list the oceanic whitetip shark as either threatened or endangered under the U.S. Endangered Species Act (ESA). Under the ESA, if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted, a status review shall be promptly commenced (16 U.S.C. 1533(b)(3)(A)). NMFS determined the petition presented substantial information for consideration and that a status review was warranted for the species (see following link for the Federal Register notice for the oceanic whitetip shark: https://federalregister.gov/a/2016-00384). The ESA stipulates that listing determinations should be based on the best scientific and commercial information available. NMFS appointed a biologist in the Office of Protected Resources Endangered Species Conservation Division to undertake the scientific review of the biology, population status and trends, threats, and future outlook for the species (Young *et al.* 2017). Using this scientific review, NMFS convened a team of biologists and shark experts to conduct an extinction risk analysis for the oceanic whitetip shark and make conclusions regarding the biological status of the species.

After reviewing the best scientific and commercial information available, including the status review report (Young et al. 2017), evaluating threats faced by the oceanic whitetip shark, and considering efforts being made to protect them, we determined that the oceanic whitetip shark is declining due to unsustainable fishing mortality and is likely to become endangered throughout its range in the foreseeable future (~30 years). On December 29, 2016, we proposed to list the oceanic whitetip shark as a threatened species throughout its range under the ESA (81 FR 96304), and solicited comments for 90 days from all interested parties. On January 30, 2018, after considering the best scientific and commercial data available, we finalized the proposed rule and listed the oceanic whitetip shark as a threatened species under the ESA (83 FR 4153). That final rule became effective on March 1, 2018.

In 2019, we held two 3-day workshops to gather information and perspectives on how to recover the oceanic whitetip shark. Over 40 experts from a range of relevant disciplines participated in the workshops. Information provided at those workshops was used to identify potential criteria and recovery actions and activities. Summary reports for these two workshops are available online: https://www.fisheries.noaa.gov/species/oceanic-whitetip-shark#conservation-management. We used the collective information from these workshops as the foundation for our three recovery planning documents: this Recovery Status Review, the Recovery Plan (NMFS 2023a), and the Recovery Implementation Strategy (NMFS 2023b).

1.2 Approach to the Recovery Status Review

This document is a Recovery Status Review for the oceanic whitetip shark. It contains information on the species' biology and status to inform ESA actions, and can be periodically updated as new information becomes available. This Recovery Status Review is the most comprehensive source for the oceanic whitetip shark's biological and status information needed for many ESA decisions (e.g., Section 7 consultations, grants, permits, conservation plans developed under Section 10, 5-year reviews, and recovery planning). In this Recovery Status Review, we compiled pertinent information from the original 2017 biological status review report (Young et al. 2017), additional biological and ecological information from the final listing rule (83 FR 4153), relevant publications since the oceanic whitetip shark was listed in early 2018, and information from the Recovery Outline (NMFS 2018). The intent of a Recovery Status Review is to provide a succinct yet comprehensive and regularly updated characterization of a species' status. Where there was new information available since the status review, we included that information and updated those portions of the status review. While the information in this document is not a full compilation of unabridged text from the other aforementioned sources, it is also more than a mere summary. However, original sources (e.g., the status review report, final listing rule, etc.) may contain more exhaustive descriptions or explanations and, like any reference cited, should be referred to for more contextual information, where appropriate or where noted. For example, the status review report (Young et al. 2017) contains much more detailed information from certain regions, including many individual publications regarding population trends from the Western and Central Pacific Ocean (WCPO); however, since the publication of the original status review, a comprehensive stock assessment was conducted that incorporated the same data as these other publications, and therefore replaces them in this document.

A Recovery Status Review does not result in any decisions. Rather, it provides the best scientific and commercial data available to inform management and recovery actions for ESA listed species.

2. LIFE HISTORY AND ECOLOGY

2.1 Taxonomy and Distinctive Characteristics

The oceanic whitetip shark is a large, pelagic apex predatory shark found in tropical and subtropical waters around the globe. This species belongs to the family Carcharhinidae and is classified as a requiem shark (Order Carcharhiniformes). The oceanic whitetip belongs to the genus *Carcharhinus*, which includes other pelagic species of sharks, such as the silky shark (*C. falciformis*) and dusky shark (*C. obscuras*), and is the only truly oceanic shark of its genus (Bonfil *et al.* 2008). Naturalist René-Primevère Lesson first described the oceanic whitetip shark in 1831 and named the shark *C. maou*. Felipe Poey later described it in 1861 as *Squalus longimanus.* The name *Pterolamiops longimanus* has also been used, but the current accepted name is *Carcharhinus longimanus*.

Compagno (1984) provides the following description of the oceanic whitetip shark: it has a stocky build with a large rounded first dorsal fin and very long and wide paddle-like pectoral fins. The first dorsal fin is very wide with a rounded tip, originating just in front of the rear tips of the pectoral fins. The second dorsal fin originates over or slightly in front of the base of the anal fin. The species also exhibits a distinct color pattern of mottled white tips on its front dorsal, caudal, and pectoral fins, with black tips on its anal fin and on the ventral surfaces of its pelvic fins. The head has a short and bluntly rounded nose and small circular eyes. The upper jaw contains broad, triangular, serrated teeth, while the teeth in the lower jaw are more pointed with serrations only near the tip. The color of the body varies depending upon geographic location, but is generally grayish bronze to brown, while the underside is whitish with a yellow tinge on some individuals (Compagno 1984). Oceanic whitetip sharks typically swim slowly at or near the surface; however, they are capable of making sudden dashes for short distances when disturbed (Compagno 1984).

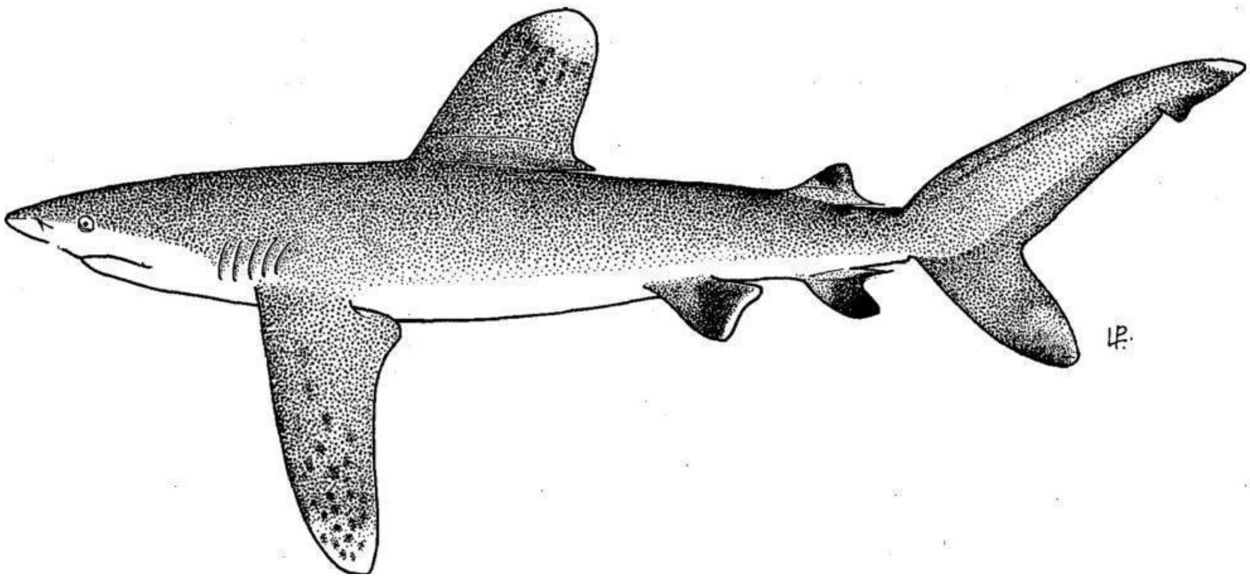

Figure 1 Oceanic whitetip shark. Source: Compagno 1984.

2.2 Distribution and Habitat Use

The oceanic whitetip shark is globally distributed in epipelagic tropical and subtropical waters between 30º North and 35º South latitudes (Rigby *et al.* 2019; Young and Carlson 2020). In the Western Atlantic, oceanic whitetip sharks occur from Maine to Argentina, including the Caribbean and Gulf of Mexico. In the Central and Eastern Atlantic, the species occurs from Madeira, Portugal south to the Gulf of Guinea, and possibly in the Mediterranean Sea. In the western Indian Ocean, the species occurs in waters of South Africa, Madagascar, Mozambique, Mauritius, Seychelles, India, and within the Red Sea. Oceanic whitetip sharks also occur throughout the Western and Central Pacific, including China, Taiwan, the Philippines, New Caledonia, Australia (southern Australian coast), Hawaiian Islands south to Samoa Islands, Tahiti and Tuamotu Archipelago and west to Galapagos Islands. Finally, in the eastern Pacific, the species occurs from southern California to Peru, including the Gulf of California and Clipperton Island (Compagno 1984; Ebert *et al.* 2013).

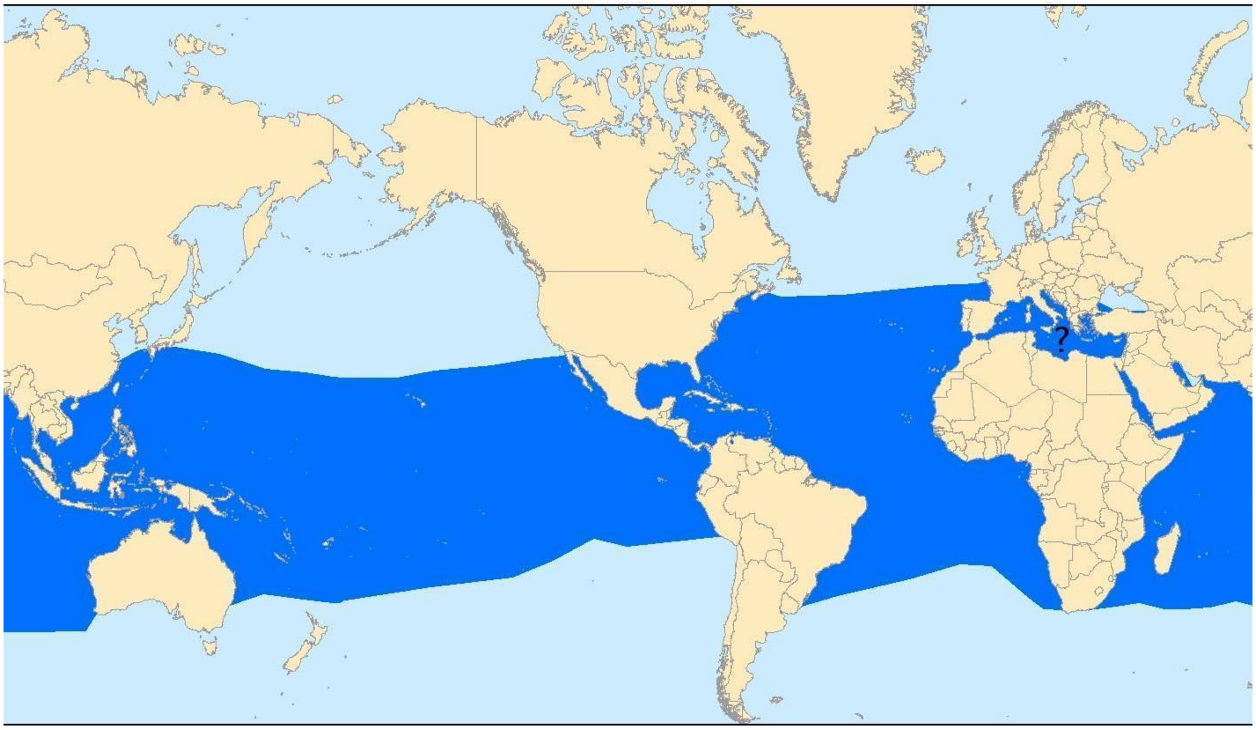

Figure 2. Geographic distribution of oceanic whitetip shark. Source: Young and Carlson 2020.

The oceanic whitetip shark was characterized historically as one of the most abundant oceanic sharks (Mather and Day 1954; Backus *et al.* 1956; Compagno 1984); it is usually found offshore in the open ocean, on the outer continental shelf, or around oceanic islands in deep water greater than 184 m, and occurs from the surface to at least 152 m depth. This species has a clear preference for open ocean waters between 10˚N and 10˚S, but can be found in decreasing numbers out to latitudes of 30˚N and 35˚S, with abundance decreasing with greater proximity to continental shelves (Backus *et al.* 1956; Strasburg 1958; Compagno 1984; Bonfil *et al.* 2008). Although the oceanic whitetip shark occurs in waters between 15ºC and 28ºC, this species exhibits a strong preference for the surface mixed layer in warm waters above 20°C (Bonfil *et al.* 2008). It is, however, capable of tolerating colder waters down to 7.75°C for short durations, as shown by brief, deep dives into the mesopelagic zone below the thermocline (>200 m) (Howey-Jordan *et al.* 2013; Howey *et al.* 2016). This indicates that the oceanic whitetip shark may commonly explore extreme environments (e.g., deep depths, low temperatures) as a potential foraging strategy. However, exposures to these cold temperatures are not sustained (Musyl *et al.* 2011; Tolotti *et al.* 2015a) and there is some evidence to suggest the species tends to withdraw from waters below 15ºC (e.g., the Gulf of Mexico in winter; Compagno (1984)). The thermal preferences of oceanic whitetip sharks in conjunction with their reported range within 30° N and S suggest possible thermal barriers to inter-ocean basin movements around the southern tips of Africa and South America (Bonfil *et al.* 2008; Musyl *et al.* 2011; Howey-Jordan *et al.* 2013; Gaither *et al.* 2015). Andrzejaczek *et al.* (2018) modeled the effects of sea surface temperature on oceanic whitetip shark movements and found they generally oscillated throughout the upper 200 m of the water column. However, in summer they reduced the amount of time spent in the upper 50 m, and in winter oscillations decreased in amplitude and cycle length and sharks frequently occupied the upper 50 m.

Information regarding movement patterns or possible migration paths for oceanic whitetip sharks is limited. In the Pacific, Musyl *et al.* (2011) used pop-up satellite tags (PSATs) to describe the behavior of several shark species, including the oceanic whitetip, which showed a complex movement pattern generally restricted to tropical waters of the central Pacific north of the North Equatorial Countercurrent (NEC) near the original tagging location (Musyl *et al*. 2011; see Figure 3 below). Results showed that oceanic whitetip sharks remained in the near-surface mixed layer within 2°C of the sea surface temperature (SST; >25°C) over 95% of the time. Maximum time at liberty was 243 days, but the largest linear movement was 2,314 nmi (4,285 km) in 95 days (Musyl *et al.* 2011).

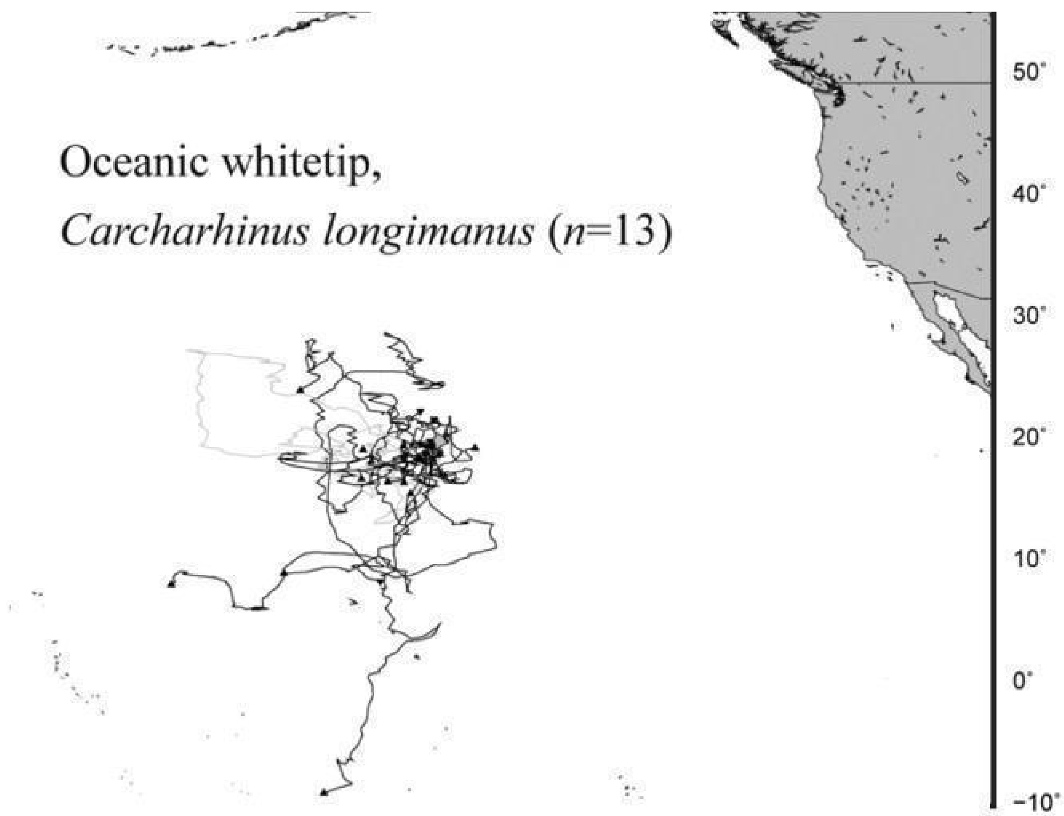

Figure 3. Most probable tracks for oceanic whitetip sharks tagged with PSATs and released in the central Pacific Ocean estimated from the raw geolocations using the Kalman filter-sea surface temperature state-space model (Source: see Appendix 1 in Musyl et al. 2011).

In the Atlantic Ocean, participants in the NMFS Cooperative Shark Tagging Program (CSTP) tagged 645 oceanic whitetip sharks between 1962 and 2015, but only 8 were recaptured. Maximum time at liberty was 3.3 years, maximum distance traveled was 1,225 nmi (2,270 km), and maximum estimated speed was 17 nmi/day (32 km/day; Kohler and Turner (2018); NMFS unpublished data). These data show movements by juveniles from a variety of locations, including from the northeastern Gulf of Mexico to the East Coast of Florida, from the Mid-Atlantic Bight to southern Cuba, from the Lesser Antilles west into the central Caribbean Sea, from east to west along the equatorial Atlantic, and from off southern Brazil in a northeasterly direction (Kohler *et al.* 1998; Bonfil *et al.* 2008; see Figure 4 below). An immature female was also tagged in the waters between Cuba and Haiti and was recaptured the next day within 6 nmi (11 km) of the tagging location (NMFS unpublished data; see Figure 4 below). Additionally, an adult of unknown sex was tagged and recaptured three years apart in the vicinity of Cat Island, Bahamas (NMFS unpublished data; see Figure 4 below).

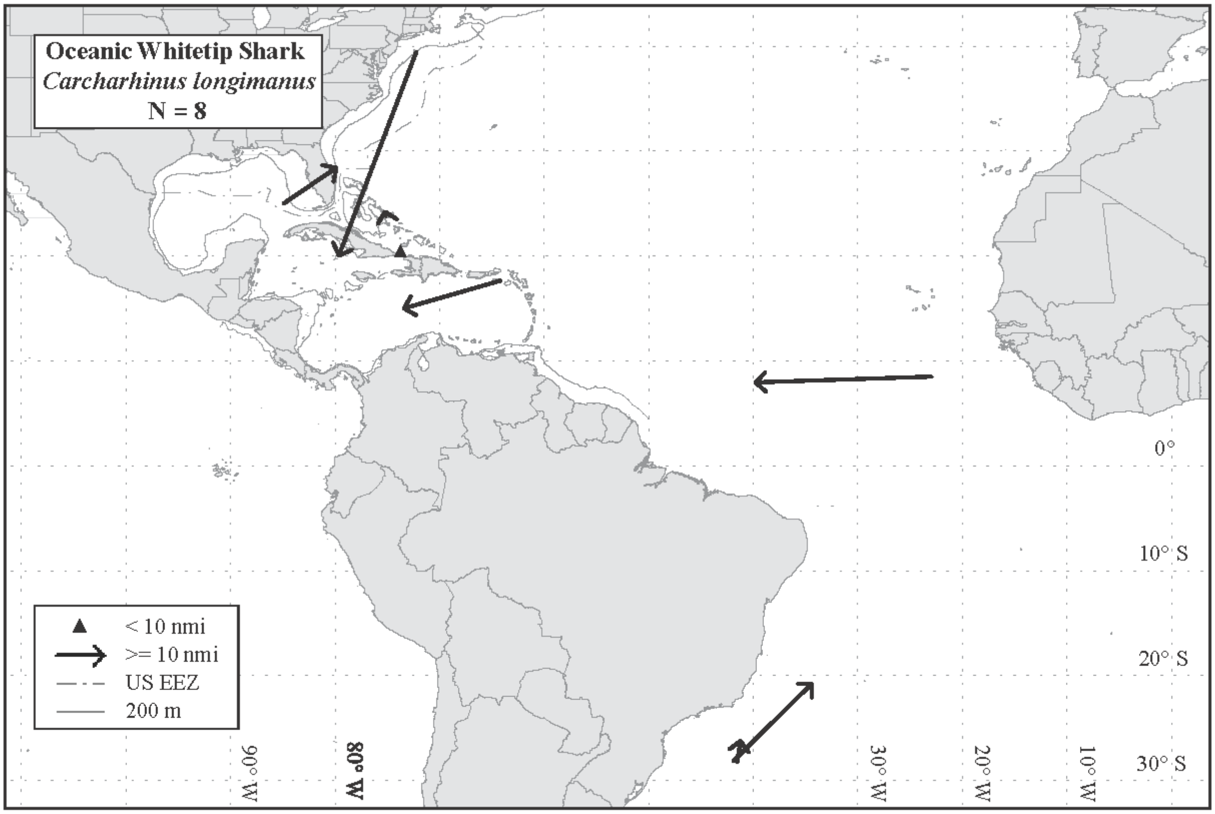

Figure 4. Recapture distribution for the oceanic whitetip shark, C. longimanus, from the NMFS Co-operative Shark Tagging Program during 1962-93 and NMFS unpublished data.

In the Gulf of Mexico, a satellite tagged oceanic whitetip shark moved a straight-line distance of 238 km from southeast Louisiana to the edge of the continental shelf about 300 km north of the Yucatan Peninsula. During the track, the shark rarely dove below 150 m staying above the thermocline, and only one dive to 256 m was recorded. The most frequently occupied depth during the entire track was 25.5-50 m (49.8% total time) and temperature was 24.05-26 °C (44.7% total time) (Carlson and Gulak 2012). More recently, a study from Cat Island, Bahamas tagged and tracked 11 mature oceanic whitetip sharks (10 females, 1 male). Individuals tagged at Cat Island stayed within 500 km of the tagging site for ~30 days before scattering across 16,422 km^2 of the western North Atlantic (Howey-Jordan *et al.* 2013). Times at liberty ranged from 30-245 days with the largest movements ranging from 290-1940 km. Individuals moved to several different destinations thereafter (e.g., the northern Lesser Antilles, the northern Bahamas, and north of the Windward Passage (the strait between Cuba and Haiti)), with many returning to the Bahamas after ~150 days. Howey-Jordan *et al.* (2013) found generally high residency times of oceanic whitetips in the Bahamas Exclusive Economic Zone (mean = 68.2% of time). Similar to the tagging study in the Pacific by Musyl *et al.* (2011), oceanic whitetip sharks in the Bahamas spent 99.7% of their time in waters shallower than 200 m and did not show differences in mean depths between day and night, with average day and night temperatures of 26ºC, respectively. According to Howey-Jordan et al. (2013):

> There was a positive correlation between daily sea surface temperature (SST) and mean depth occupied (i.e., as individuals experienced warmer SST, likely resulting from seasonal sea surface warming or migration to areas with warmer SST, mean daily depth increased, suggesting possible behavioral thermoregulation. All individuals made short duration (mean=13.06 minutes) dives into the mesopelagic zone (down to 1,082 m and 7.75˚C), which occurred significantly more often at night.

These tracking data also suggest that oceanic whitetip sharks exhibit site fidelity to Cat Island, Bahamas, although the reasons for this are still unclear. NMFS CSTP data (discussed earlier) from an adult oceanic whitetip, tagged and recaptured three years later in this area, provides supporting evidence of site fidelity to the waters around Cat Island. This information is important given the characterization of this species as highly migratory (Howey-Jordan *et al.* 2013).

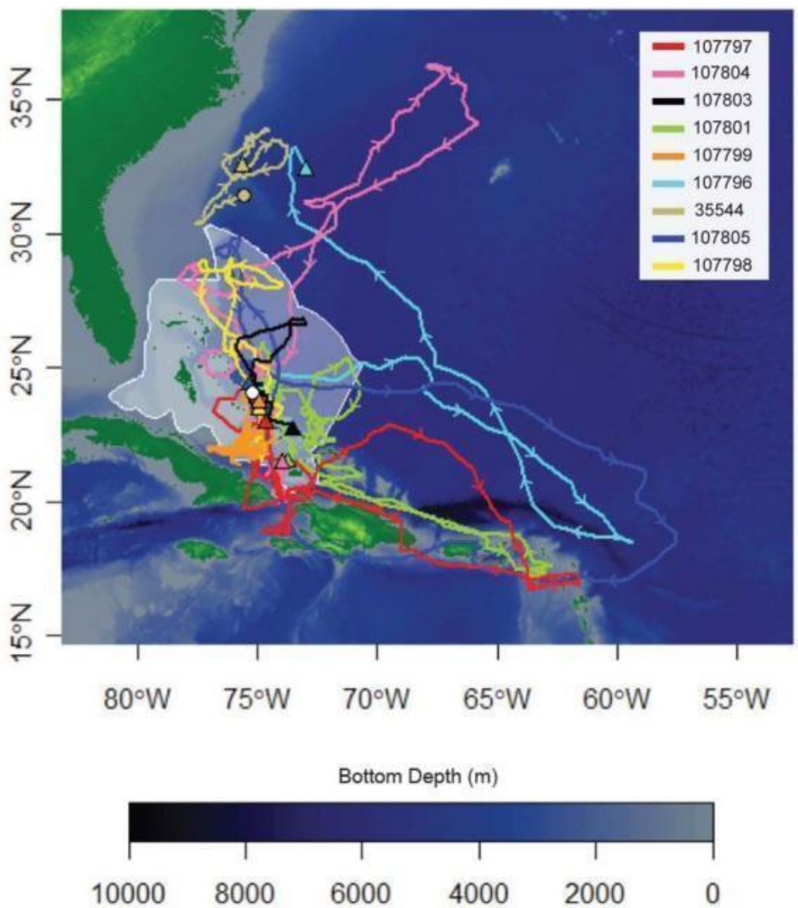

Figure 5. Map with bottom depth (m) showing filtered tracks for nine oceanic whitetip sharks equipped with Standard Rate tags. Colored lines represent tracks from individuals (listed by tag ID); triangle indicate pop-up location. Arrows on colored lines show direction of movement (Source: Howey-Jordan et al. 2013).

In the equatorial and southwestern Atlantic, Tolotti *et al*. 2015(a) obtained fisheries independent data from eight oceanic whitetip sharks tagged with PSATs in an area overlapping operations of the Brazilian longline fleet. Tag deployment periods (i.e., the number of days the tag was deployed before it stopped recording data) varied from 60 to 178 days between 2010 and 2012. Similar to the study from Cat Island, Bahamas, oceanic whitetip sharks exhibited some degree of site fidelity. Tagging and pop-up sites were relatively close to each other, although individuals tended to travel long distances before returning to the tagging area. In fact, 5 of the 8 tagged sharks concluded their tracks relatively close to their starting points, even after traveling several thousand kilometers (See Figure 6 below). Overall, the horizontal movements were more prominent in terms of latitude, whereas longitudinal movements were more restricted. Tolotti *et al*. (2015a) demonstrated that the sharks exhibited a strong preference for the warm and shallow waters of the mixed layer, and spent more than 70% of the time above the thermocline and 95% above 120 m. Additionally, for approximately 96% of the monitoring period, tagged individuals remained at temperatures between 24 and 30°C (Tolotti *et al.* 2015a).

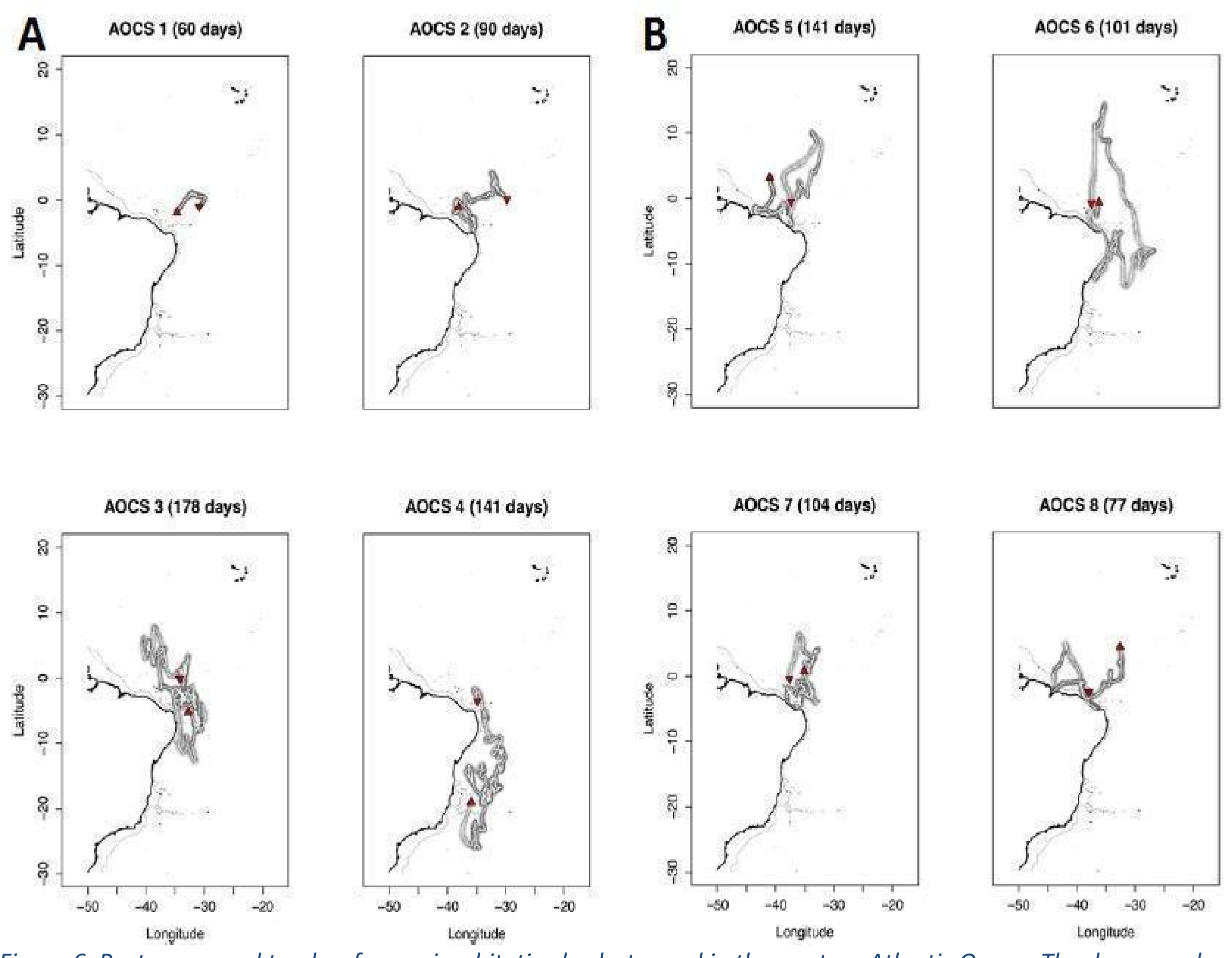

Figure 6. Post-processed tracks of oceanic whitetip sharks tagged in the western Atlantic Ocean. The downward triangles represent the tagging position and the upward triangles the end of the track. The grey-shaded area represents the error around estimated positions. (A) Oceanic whitetip sharks tagged in 2010 and 2011. (B) Oceanic whitetip sharks tagged in March 2012. Source: Tolotti et al. 2015a.

Tagging data from the Indian Ocean is limited. Observations from the Spanish longline fishery targeting swordfish from 1993-2011 indicate that the distribution of oceanic whitetip in the Indian Ocean likely falls mainly within the warm water regions to North of 25ºS and with less probability in some of the nearby areas located slightly farther South, which are influenced by the seasonal expansion of warm water masses (García-Cortés *et al.* 2012).

Filmalter *et al.* (2012) used pop-up archival tags (PATs) as well as mini-PATs to examine the vertical and horizontal behavior of oceanic whitetip sharks in the western Indian Ocean from 2009 to 2012. Similar to studies from the Atlantic and Pacific oceans, the two oceanic whitetip sharks tagged spent the majority of their time between 50 and 100 m depths. Long distance movements were also observed, with one tag remaining attached for 100 days on an individual that traveled a distance of approximately 6,500 km during the study period, moving from the Mozambique Channel up the African east coast of Somalia and then traveling back down towards the Seychelles. The second tagged individual was monitored for only 19 days and traveled ~1,100 km in the southern Mozambique Channel. These results show that oceanic whitetips are capable of traveling large distances in the pelagic environment (Filmalter *et al.* 2012; see Figure 7 below).

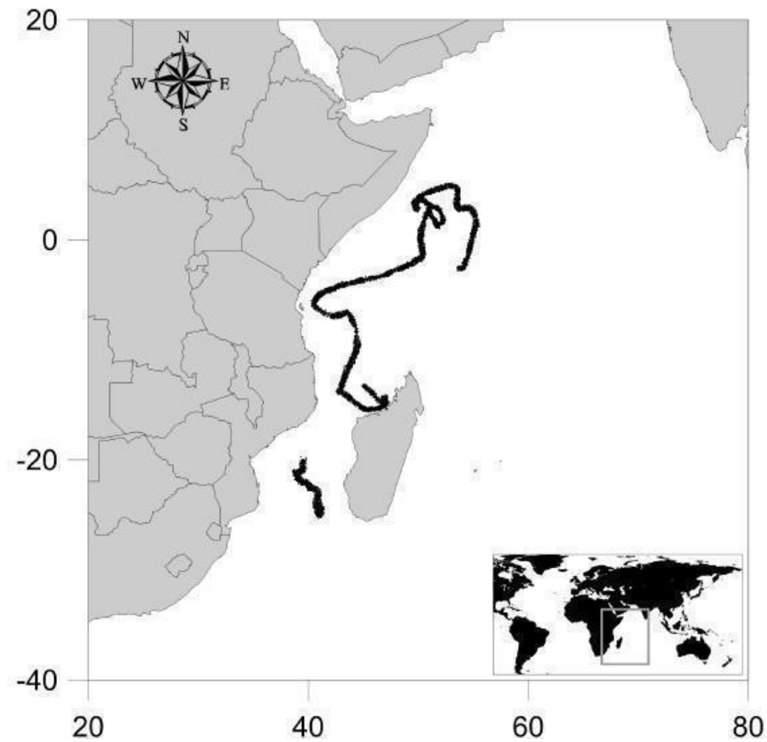

Figure 7. Horizontal movements of oceanic whitetip sharks (n = 2) tagged with PAT and mini-PATs in the western Indian Ocean. Source: Filmalter et al. 2012.

Finally, the Spanish fleet opportunistically tagged and released hundreds of sharks in the Indian Ocean, including oceanic whitetip (n= 56) from 1985-2004 (Mejuto *et al*. 2005). Results from this study (see Figure 8 below) indicate that the oceanic whitetip shark exhibits a trans-equatorial migration in the Indian Ocean (Mejuto *et al.* 2005).

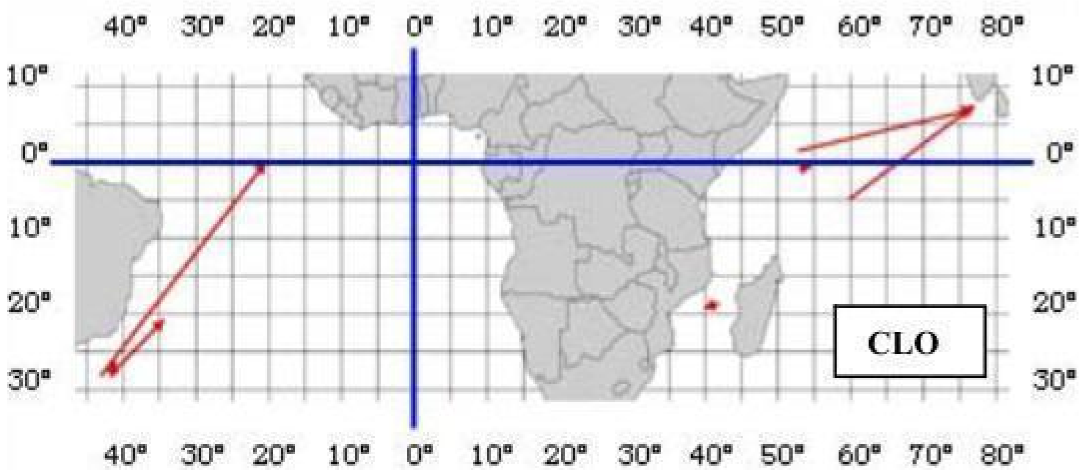

Figure 8. Straight line movements estimated on the basis of the tagging-recapture of oceanic whitetip shark in the Atlantic and Indian Oceans. Source: Mejuto et al. 2005.

2.3 Feeding and Diet

Oceanic whitetip sharks are top-level predators in pelagic ecosystems and feed primarily on teleosts and cephalopods (Cortés 1999; Bonfil *et al.* 2008), although studies have also reported that they consume sea birds, marine mammals, other sharks and rays, molluscs, crustaceans, and even garbage (Compagno 1984; Cortés 1999). Backus *et al.* (1956) recorded various fish species in the stomachs of oceanic whitetip sharks, including blackfin tuna, barracuda, and white marlin. Historically, oceanic whitetip sharks were described as pests to pelagic longline fisheries for tuna, as the sharks would persistently follow boats and cause significant damage to the catches (Compagno 1984). The oceanic whitetip shark has also been observed scavenging dead marine mammal carcasses off South Africa (Bass *et al.* 1973; Compagno 1984). Based on the species' diet, the oceanic whitetip shark has a high trophic level, with a score of 4.2 out of a maximum 5.0 (Cortés 1999). More recently, a study using stable isotope ratios of vertebrae found that the oceanic whitetip shark has an average trophic position of 3.7 ± 0.1 across all growth stages (Shen *et al.* 2021). The available evidence suggests that oceanic whitetip sharks are opportunistic feeders. For example, large pelagic teleosts (e.g. billfish, tunas, and dolphinfish) are abundant in the Bahamas, and anecdotal reports suggest that oceanic whitetip sharks feed heavily on recreationally caught teleosts in the region (Madigan *et al.* 2015). In a study of an oceanic whitetip shark aggregation at Cat Island, Bahamas, Madigan *et al*. (2015) used a stable isotope analysis-based Bayesian mixing model to estimate short-term (near Cat Island) diets, which showed large pelagic teleosts contributed more to the short term diets (72%) than long-term diets (47%), demonstrating a spatial and temporal difference in feeding habits. The study concluded that the availability of large teleost prey and supplemental feeding from recreational sport fishermen may be potential mechanisms underpinning site-fidelity and aggregation of oceanic whitetip sharks at Cat Island (Madigan *et al.* 2015), further supporting the notion they are opportunistic predators.

There is no information regarding established foraging grounds for the oceanic whitetip shark. Recent tracking studies from the Bahamas, Brazil, and the Indian Ocean have revealed complex vertical movements in the species and diel behavior changes (Papastamatiou *et al.* 2018; Tolotti *et al.* 2017; Howey *et al.* 2016). Based on tracking data from the Bahamas, oceanic whitetip sharks regularly exhibit mesopelagic excursions (defined as ≥5 consecutive depth records below

200 m), particularly during dusk periods that may be related to foraging (Howey *et al.* 2016). Tolotti *et al.* (2017) noted that deep dives below 150 m were rare, but the variation seen in the shark's vertical movement patterns could be linked to prey distribution as well. Papastamatiou *et al.* (2018) further reaffirms this possibility with evidence from oceanic whitetip sharks outfitted with cameras. Potential prey (mackerel, scad and squid) were observed during dives (as opposed to when individuals were in shallow water) and at the apex of the dive when bursts of speed were common (Papastamatiou *et al.* 2018). Recently, an oceanic whitetip shark was observed off the coast of Kona, Hawaii, with scars caused by the tentacles of a large cephalopod. This suggests oceanic whitetip sharks dive within the mesopelagic zone and may interact with or even forage for large cephalopods (Papastamatiou *et al*. 2020).

2.4 Growth and Reproduction

Despite its worldwide distribution and common occurrence in most high-seas fishery catches in tropical seas, the oceanic whitetip shark's biology and ecology remain understudied. To date, studies on the life history parameters of the oceanic whitetip shark are limited, with only a few publications available: two from the North Pacific (Joung *et al*. 2016 and Seki *et al*. 1998), one from the Western and Central Pacific in Papua New Guinea (D'Alberto *et al.* 2017), one from the Indian Ocean (Varghese *et al.* 2016) and two from the Southwest Atlantic Ocean (Lessa *et al.* 1999; Rodrigues *et al.* 2015). We summarize the results of these papers below.

The theoretical maximum age for the oceanic whitetip shark ranges from ~25-36 years (D'Alberto *et al.* 2017; Rice and Harley 2012), and observed maximum ages based on vertebral ring counts are much lower, ranging from 12 to 18 years in the North Pacific and Western and Central Pacific, respectively (Joung *et al.* 2016; D'Alberto *et al.* 2017), and from 13 to 19 in the South Atlantic (Seki *et al.* 1998; Lessa *et al.* 1999; Rodrigues *et al.* 2015). However, these maximum observed ages may be underestimates of the species' actual maximum longevity, because vertebral band counts are not necessarily an accurate method for estimating maximum age (D'Alberto *et al.* 2017). Recently, Passerroti *et al.* (2020) evaluated vertebral growth bands for bomb radiocarbon (14C) patterns from archived vertebrae (n=8) in the northwest Atlantic Ocean. Results suggest age estimates based on presumed annual growth bands were accurate, although specimens were not old enough to capture the most informative portion of the bomb radiocarbon reference period.

In terms of size, the maximum length measured for oceanic whitetip shark was 350 cm total length in the 1940s (TL; Bigelow and Schroder 1948 cited in Lessa *et al*. 1999), with "gigantic individuals" perhaps reaching 395 cm TL (Compagno 1984), though Compagno's length was never confirmed (Lessa *et al.* 1999). Given the rarity of specimens larger than 270 cm TL, Lessa *et al.* (1999) noted that the length composition of the species may have been altered since the 1940s due to fishing pressure. D'Alberto *et al.* (2017) reiterated this possibility, given the lack of large specimens >200 cm TL in their study. Lessa *et al.* (1999) recorded a maximum size of 250 cm TL in the Southwest Atlantic, and estimated a theoretical maximum size of 325 cm TL (Lessa *et al.* 1999); however, the most common sizes are below 300 cm TL (Compagno 1984).

Growth rates are variable throughout the species' range. For example, earlier studies suggested that the oceanic whitetip shark is slow growing, but more recent studies have shown faster growth rates similar to blue and silky sharks (Clarke *et al.* 2015b). In the Southwest Atlantic, male and female growth rates are similar; observed and back-calculated length-at age von Bertalanffy parameters from Lessa *et al.* (1999) are as follows:

Observed asymptotic length (L_∞) = 284.9 cm; growth coefficient (K) = 0.099 yr^{-1}, and T_0 = -3.391 yr^{-1}

Back-calculated asymptotic length (L_∞) = 325.4 cm; growth coefficient (K) = 0.075 yr^{-1}, and T_0 = -3.342 yr^{-1}

Growth rates are 25.2 cm yr^{-1} in the first free-living year; 13.6 cm yr^{-1} from ages 1 to 4; 9.7 cm yr^{-1} for adolescents of age 5; and 9.10 cm yr^{-1} for mature individuals (Lessa *et al.* 1999). In a more recent study from the western North Pacific (Joung *et al.* 2016), growth rates were also found to be similar between sexes. The von Bertalanffy growth parameters combining both sexes were as follows:

Asymptotic length (L_∞) = 309.4 cm TL; growth coefficient (K) = 0.0852 yr^{-1}

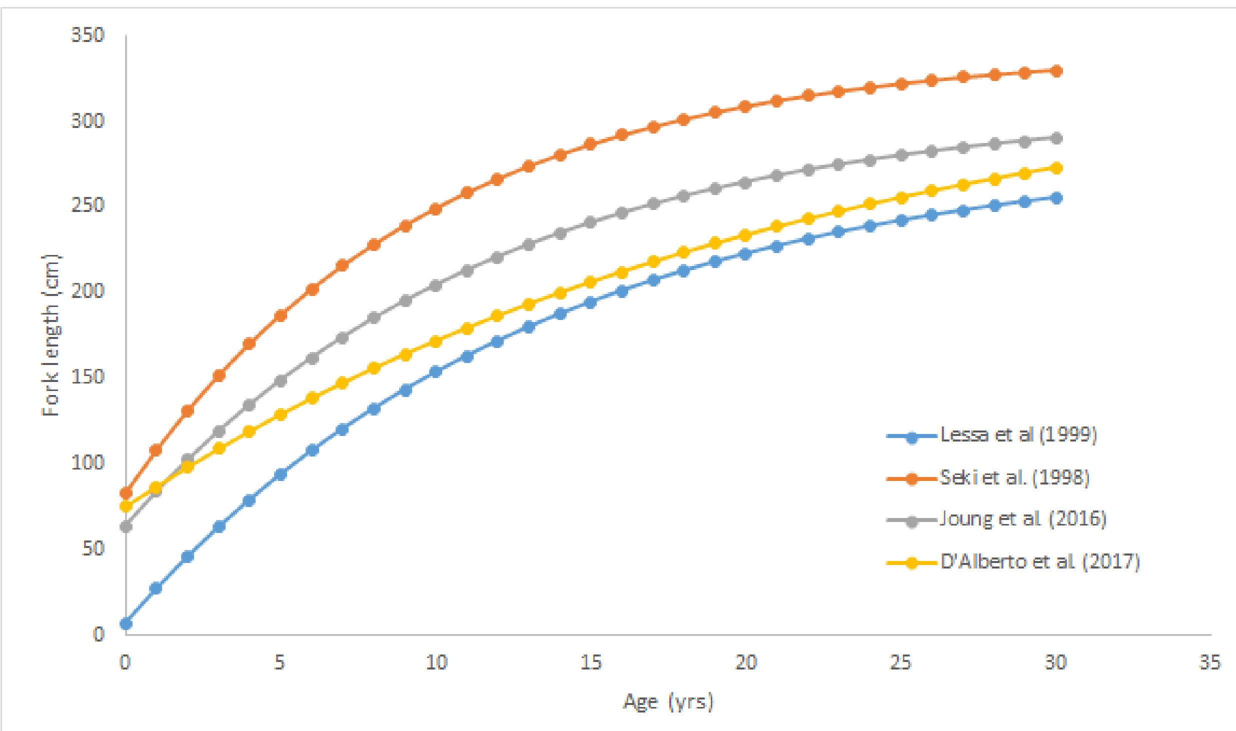

Figure 9. A comparison of the predicted size at age from the von Bertalanffy growth function (VBGF) for oceanic whitetip shark in different regions.

In the Southwest Atlantic, age and size of maturity in oceanic whitetip sharks is estimated to be 6-7 years and 180-190 cm TL, respectively, for both sexes (Lessa *et al.* 1999). In the North Pacific, females become mature at about 168-196 cm TL, and males at 175-189 cm TL, which corresponds to an age of 4 and 5 years, respectively (Seki *et al.* 1998). However, more recently Joung *et al*. (2016) determined a later age of maturity in the North Pacific of approximately 8.5-8.8 years for females and 6.8-8.9 years for males. In the Indian Ocean, both males and females mature at around 185-200 cm TL (Indian Ocean Tuna Commission (IOTC) 2014), although Varghese *et al.* (2016) estimates the lengths of maturity to include slightly larger sizes (189-287 cm for males and 188-311 cm for females). Therefore, age of maturity may vary depending on geographic location.

Like other carcharhinid species, the oceanic whitetip shark is viviparous (gives birth to live young) with placental embryonic development. The reproductive cycle is thought to be biennial, giving birth on alternate years, after a lengthy 9-12 month gestation period (Backus *et al.* 1956; Seki *et al.* 1998; Tambourgi *et al.* 2013), though some studies suggest an annual cycle of at least a proportion of the population (Table 1). The number of pups in a litter ranges from 1 to 14, with an average of 6, and there is a likely positive correlation between female size and number of pups per litter, with larger sharks producing more offspring in all three ocean basins (Bass *et al.* 1973; Seki *et al.* 1998; IOTC 2015a; Varghese *et al.* 2016). Size at birth also varies slightly but is generally similar across geographic locations, ranging 55–75 cm TL in the North Pacific, around 65–75 cm TL in the northwestern Atlantic, and 60–65 cm TL off South Africa. Several studies suggest that oceanic whitetip sharks give birth from late spring to summer (Backus *et al.* 1956; Bass *et al.* 1973; Compagno 1984; Bonfil *et al.* 2008). In contrast, Seki *et al*. (1998) found no apparent parturition period in the North Pacific, as embryo occurrence was observed in almost every month in which data was acquired, which is indicative of an extended parturition duration throughout the year. The locations of the nursery grounds are not well known but they are thought to be in oceanic areas.

Records of pregnant females and newborns from the tropical Pacific are concentrated between 20ºN and the equator, from 170ºE to 140ºW (see original citations in CITES 2013). In the Atlantic, young oceanic whitetip sharks have been observed well offshore along the southeastern coast of the United States, suggesting the possible presence of a nursery area in pelagic waters over the continental shelf (Compagno 1984; Bonfil *et al.* 2008). In the equatorial and southwestern Atlantic, the prevalence of immature sharks, both female and male, in fisheries catch data suggests that this area may serve as potential nursery habitat for the oceanic whitetip shark (Coelho *et al.* 2009; Tambourgi *et al.* 2013; Tolotti *et al.* 2013; Frédou *et al.* 2015). Juveniles seem to be concentrated in equatorial latitudes, while specimens in other maturational stages are more widespread (Tambourgi *et al.* 2013). Pregnant females have been found often close to shore, particularly around the Caribbean Islands, and one pregnant female was found washed ashore near Auckland, New Zealand. This may be indicative of females coming close to shore to give birth (Clarke *et al*. 2015b), however this is likely dependent on the proximity of specific oceanographic features to shore (e.g., length of continental shelf). Sexual segregation has been documented in oceanic whitetip sharks and may be related to the seasonal congregation of females in favored pupping grounds. For example, in the Gulf of Mexico, captures of oceanic whitetip sharks were predominantly female (13 females and 3 males were caught in August 1954; Backus 1956). In contrast, Coelho *et al.* (2009) observed a sex ratio (male:female) of 1.2:1 in the southwestern equatorial region of the Atlantic, and individuals in this region seemed to be spatially segregated by size, with the large majority of individuals (80.7% of males and 89.4% of females) being immature. Similarly, Tambourgi *et al.* 2013) observed a nearly 1:1 ratio in the southwestern equatorial Atlantic. Although many pelagic shark species exhibit spatial/temporal separation between sizes, and are often segregated sexually once they reach reproductive maturity, it is unclear whether this is the case for oceanic whitetip sharks. Table 1 provides a summary of life history characteristics reported in published literature.

Table 1. Life history parameters of the oceanic whitetip shark from published literature (obs. = observed; m = male; f = female; PCL = Pre-caudal length; TL = Total Length).

Parameter	Estimate	Reference
Growth rate (von Bertalanffy k)	0.075-0.099 $year^{-1}$ (Southwest [SW] Atlantic; both sexes)	Lessa *et al.* (1999)
	0.103 $year^{-1}$ (N. Pacific; both sexes)	Seki *et al.* (1998)
	0.0852 $year^{-1}$ (western N. Pacific; both sexes	Joung *et al.* (2016)
	0.045 $year^{-1}$ (western N. Pacific; both sexes	D'Alberto et al. (2017)
Max length	325 cm TL (SW Atlantic)	Lessa *et al.* (1999)
	245 cm PCL (342 cm TL; N. Pacific)	Seki *et al.* (1998)
	246 TL (f; obs; N. Pacific) 268 TL (m, obs; N. Pacific)	Joung *et al.* (2016)
	272 cm TL (Atlantic)	Cortés (2002); (2008b)
	252 cm TL (f; obs; SW Atlantic) 253 cm TL (m; obs; SW Atlantic)	Coelho *et al.* (2009)
	227 cm TL (f; obs; SW Atlantic) 242 cm TL (m; obs; SW Atlantic)	Tambourgi *et al.* (2013)
	252 cm TL (f; obs S. Atlantic) 242 cm TL (m; obs; S. Atlantic)	Rodrigues *et al.* (2015)
Age at maturity (years)	6-7 (SW Atlantic; both sexes)	Lessa *et al.* (1999)
	4–5 (N. Pacific; both sexes)	Seki *et al.* (1998)
	8.5-8.8 years (N. Pacific; females) 6.8 – 8.9 years (N. Pacific; males)	Joung *et al.* (2016)
Length at maturity (cm TL)	180-190 (SW Atlantic; both sexes)	Lessa *et al.* (1999)
	170 (SW Atlantic; f) 170-190 (SW Atlantic; m)	Tambourgi *et al.* (2013)

Parameter	Estimate	Reference
	168-196 (N. Pacific; f) 175-189 (N. Pacific; m) 190 cm TL (N. Pacific; f) 172 cm TL (N. Pacific; m) 190-240 (Indian Ocean; both sexes) 185 cm TL (Arabian Sea; f) 202 cm TL (Arabian Sea; m) 199 cm TL (Cuba; f) 203 cm TL (Cuba; m)	Seki *et al.* (1998) Joung *et al.* (2016) IOTC (2015a) Varghese *et al.* (2016) Ruiz-Abierno *et al*. 2021
Longevity (years)	19 (obs; SW Atlantic) 17 (theoretical; SW Atlantic) 11-12 (obs; N. Pacific) 36 (theoretical; WCPO but based on theoretical max length from N. Pacific from Seki *et al.* 1998) 24.9 (theoretical; WCPO; f) 24.6 (theoretical; WCPO; m) 18 (obs; WCPO; f) 17 (obs; WCPO; m)	Rodrigues *et al.* (2015) Lessa *et al.* (1999) Seki *et al.* (1998); Joung *et al.* 2016 Rice and Harley 2012 D'Alberto *et al.* (2017)
Gestation period	9 months (Pacific) 12 months (Pacific) 10-12 months (SW Atlantic)	Bonfil *et al.* (2008) Chen 2006 in Liu and Tsai (2011) Coelho *et al.* (2009)
Reproductive[1] periodicity	Every year (Pacific) Every other year (SW Atlantic) Resting period of 12 months (Pacific)	Chen 2006 in Liu and Tsai (2011) Tambourgi *et al.* (2013) Backus *et al.* (1956); Seki *et al.* (1998)

[1] Most data suggest a resting period of one year (Clarke et al. 2015b)

Parameter	Estimate	Reference
	Annual (undefined proportion of population)	James Gelsleichter (University of North Florida, unpublished data)
Size at birth	63-77 cm TL (N. Pacific) 64 cm TL (N. Pacific) 50-65 cm TL (Indian Ocean) 64.2-65.0 TL (Arabian Sea)	Seki *et al.* (1998) Joung *et al.* (2016) White (2007) Varghese *et al.* (2016)
Litter size (# of pups)	5-6 (SW Atlantic) 1-14 (average = 6; N. Pacific) 10-11 (N. Pacific) 12 (Indian Ocean) 3-9 (Indian Ocean; Arabian Sea)	Lessa *et al.* (1999) Seki *et al.* (1998); Joung *et al.* (2016) IOTC (2015a) Varghese *et al.* (2016)
Generation Time	10.4 years 11.1 years	Cortés et al. (2012) Smith *et al.* (2008)
Productivity (maximum intrinsic rate of population increase (r_{max},yr^{-1})	0.126 $year^{-1}$ (Atlantic Ocean) 0.135 $year^{-1}$ (Pacific Ocean)	(Cortés 2016; Cortés 2019)

2.5 Population Structure and Genetics

There are few studies on the genetics and population structure of the oceanic whitetip shark. Camargo *et al.* (2016) compared the mitochondrial control region in 215 individuals from the Indian Ocean and eastern and western Atlantic Ocean (Figure 12 below). They identified a total of 12 haplotypes. A total of 129 individuals shared one haplotype, which was the most common haplotype in all locations. Two additional haplotypes were found in all regions, and another two haplotypes were found in eastern and western Atlantic Ocean populations. The remaining seven haplotypes were each found in only one or two sharks. While results showed significant genetic differentiation (based on haplotype frequencies) between the eastern and western Atlantic Ocean (Φ_{ST} = 0.1039, P <0.001; Camargo *et al.* (2016)), pairwise comparisons among populations within the regions revealed a complex pattern. Though some eastern Atlantic populations were significantly differentiated from western Atlantic populations (F_{ST} = 0.09 – 0.27, P < 0.01), others were not (F_{ST} = 0.02 – 0.03, P > 0.01), even after excluding populations with sample sizes of less than 10 individuals (Camargo *et al.* 2016). Additionally, the sample size from the Indian Ocean (N = 9) may be inadequate to detect statistically significant genetic structure between this and other regions (Camargo *et al.* 2016). Furthermore, since this study only used mitochondrial markers, male mediated gene flow is not reflected.

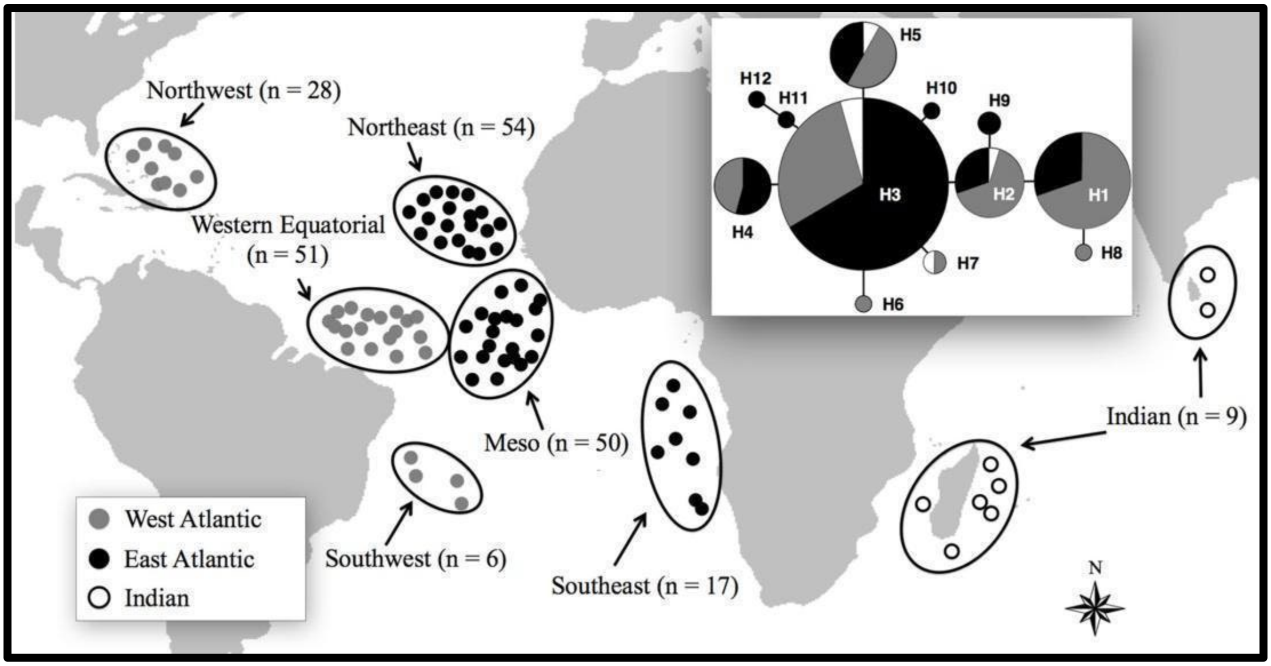

Figure 10. Geographic distribution of oceanic whitetip shark samples with the network haplotypes analyzed and compiled from the sequences of the mitochondrial DNA control region. Source: Camargo et al. 2016.

Expanding on the limited sample size by Camargo *et al.* (2016) in the Indian Ocean, Sreelekshmi *et al*. (2020) used mitochondrial control region sequences to examine intraspecific diversity and genetic stock structure of oceanic whitetip shark. There was a lack of significant genetic differentiation along the Indian coast indicating substantial gene flow and connectivity among populations. Comparisons with the Atlantic Ocean regions indicated significant connectivity and gene flow between Indian and East Atlantic regions and a lack of connectivity between Indian and West Atlantic Ocean regions. Oceanic whitetip sharks have substantial capacity for oceanic migration resulting in gene flow. Based on the results of Sreelekshmi *et al.* (2020), oceanic whitetip sharks can be managed as a single stock along the Indian coast.

Ruck (2016) compared the mitochondrial control region, a protein-coding mitochondrial region, and nine nuclear microsatellite loci in 171 individuals sampled from the western Atlantic, Indian, and Pacific Oceans. Using three population-level pairwise metrics (PhiST, F_{ST}, and Jost's D), Ruck (2016) detected no fine-scale matrilineal structure within ocean basins. However, after comparing and analyzing the genetic samples of the two studies together (i.e., Camargo *et al.* 2016 and Ruck 2016), results showed significant maternal population structure within the western Atlantic with evidence of three matrilineal lineages (C. Ruck, personal communication, 2016). Specifically, the Northwest Atlantic samples show significant differentiation from the samples obtained from the rest of the western Atlantic (i.e., the Western Central Atlantic and Brazilian samples; Φ_{ST} Range: 0.058 – 0.078, F_{ST} Range: 0.063 – 0.078 ($P \leq 0.02$)) (Ruck, unpublished data). However, while this information is informative, the data showing population structure within the Atlantic relies solely on mitochondrial DNA and does not reflect male mediated gene flow.

On a global scale, Ruck (2016) found that the most common mitochondrial haplotypes were shared by individuals in the Atlantic, Indian, and Pacific Oceans, with no clear phylogeographic partitioning of haplotypes. Mitochondrial and nuclear analyses indicated weak but significant differentiation between western Atlantic and Indo-Pacific Ocean populations ($\Phi_{ST} = 0.076$, $P = 0.0002$; $F_{ST} = 0.017$, $P < 0.05$ after correction for False Discovery Rate). Although significant inter-basin population structure was evident (see Figure 13 below), Ruck (2016) also noted an association with deep phylogeographic mixing of mitochondrial haplotypes and evidence of contemporary migration between the western Atlantic and Indo-Pacific Oceans.

Figure 11. DISTRUCT plots summarizing STRUCTURE results of all genotyped samples: K = 2. The DISTRUCT plots clearly indicated strong sorting of two clusters: the Western Atlantic and the Indo-Pacific. Source: Ruck 2016.

Philopatry is another factor that could influence population structure within ocean basins. For example, Camargo *et al.* (2016) notes that the trans-Atlantic genetic structure observed in their study may have developed in oceanic whitetip sharks because females remain within or return to give birth on one side of the basin or the other (Camargo *et al.* 2016). This is supported by recent tagging studies described previously, that suggest although oceanic whitetip sharks are highly migratory in terms of extensive travel distances, they seem to exhibit a high degree of philopatry to certain sites and may not mix with other regional populations (Howey-Jordan *et al.* 2013; Tolotti *et al.* 2015a). The shortest physical distance between the western and eastern Atlantic is between Brazil and Guinea-Bissau, requiring an oceanic crossing of approximately ~2,400 km (Camargo *et al.* 2016). Although the oceanic whitetip shark is likely physically capable of making this migration distance, this does not seem to be a typical behavioral characteristic of oceanic whitetip females, evidenced by genetic differentiation in those regions (western and eastern Atlantic) by female lineages (Camargo *et al*. 2016). However, as noted previously, this study relied on mitochondrial DNA (mtDNA) and does not reflect male mediated gene flow. Additionally, although the current telemetry tracking studies indicate patterns of site philopatry (Musyl *et al.* 2011; Howey-Jordan *et al.* 2013; Tolotti *et al.* 2015a), sample sizes and track durations in the tracking studies are limited and may not necessarily be representative of the behavior of the species as a whole (Ruck 2016). For example, as shown previously in the NMFS CSTP tagging data, an immature female showed a large East to West Atlantic equatorial movement (Figure 4).

Both global studies discussed above differ in genetic markers and sampling locations, but neither provides strong evidence for genetic discontinuity. Camargo *et al*. (2016) compared mitochondrial DNA sequences of samples collected in eight locations, including the southeast Atlantic and the southwest Indian Oceans (i.e., on either side of the southern tip of Africa). They concluded an absence of genetic structure between the East Atlantic and Indian Ocean subpopulations. Though the Indian Ocean sample size was small (n = 9), it included four haplotypes, all of which were also found in Atlantic Ocean subpopulations. Camargo *et al.* (2016) explained that this genetic connectivity (i.e., the existence of only one genetic stock around the African continent) may be facilitated by the warm Agulhas current, which passes under the Cape of Good Hope of South Africa and may transport oceanic whitetips from the Indian Ocean to the eastern Atlantic. Ruck (2016) compared longer mitochondrial DNA sequences and 11 microsatellite DNA loci of samples collected in seven locations; however, there were no samples from the southeast Atlantic and the southwest Indian Oceans (i.e., the closest sampling locations were Brazil and Arabian Sea). Ruck (2016) found weak but statistically significant differentiation between West Atlantic and Indo-Pacific subpopulations but explained that her study shows genetic evidence for contemporary migration between the West Atlantic and Indo-Pacific as a result of semi-permeable thermal barriers (i.e., the warm Agulhas current). Thus, we compare one study which may lack resolution but demonstrates genetic connectivity between the southeast Atlantic and the southwest Indian Ocean subpopulations (i.e., across the Agulhas current; Camargo *et al.* 2016) to another that finds weak genetic structure and low-level contemporary migration across great distances (i.e., the West Atlantic and the northern Indian Ocean; Ruck 2016). We conclude that neither study provides unequivocal evidence for genetic discontinuity or marked separation between Atlantic and Indo-Pacific subpopulations.

In both global studies, genetic diversity appears to be low. Compared to eight other circumtropical elasmobranch species, including the basking shark (*Cetorhinus maximus*), smooth hammerhead (*Sphyrna zygaena*), great hammerhead (*Sphyrna mokarran*), tiger shark (*Galeocerdo cuvier*), blacktip reef shark (*Carcharhinus limbatus*), sandbar shark (*Carcharhinus plumbeus*), silky shark (*Carcharhinus falciformis*), and the whale shark (*Rhincodon typus*), the oceanic whitetip shark ranks the fourth lowest in global mitochondrial control region (mtCR) genetic diversity (0.33% ± 0.19%). The oceanic whitetip shark has diversity similar to the smooth hammerhead (0.32% ± 0.18%, (Testerman 2014) and greater than tiger and basking sharks (0.27% ± 0.16%; Bernard 2014 and 0.13% ± 0.09%; Hoelzel *et al.* 2006, respectively). The mtCR genetic diversity of the oceanic whitetip shark is about half that of the closely related silky shark (0.61% ± 0.32%; Clarke *et al.* 2015a) and about a third that of the whale shark (1.1% ± 0.6%; Castro *et al.* 2007). Ruck (2016) noted that the relatively low mtDNA genetic diversity (concatenated mtCR-ND4 nucleotide diversity $\pi = 0.32\% \pm 0.17\%$) compared to other circumtropical elasmobranch species raises potential concern for the future genetic health of this species. Camargo *et al.* (2016) also observed low levels of genetic variability for the species, with both haplotype and nucleotide diversity significantly lower in the eastern Atlantic population than the western Atlantic population (34.2% and 36.9%, respectively). Low genetic variability rates, as exhibited by the oceanic whitetip shark, may represent a risk in terms of the species' ability to adapt, leading to a weaker ability to respond to environmental changes (Camargo *et al.* 2016).

2.6 Demography

Oceanic whitetip sharks exhibit life history traits and population parameters that are generally moderate among other shark species, although there has been some disagreement in the literature regarding the species' productivity. Estimates of natural mortality have ranged from 0.119 to 0.203 year-1 (Smith et al, 2008; Cortés et al. 2012; Cortés 2016) but the range in estimates are influenced by the methods used and assumptions on inputs. Estimated generation times have also varied and range from 9.8 to 11.1 years (Cortés *et al.* 2012; 2008b; Smith *et al.* 2008).

In a 1998 study of Pacific sharks, productivity values and rebound rates were derived for 26 shark species, in which the oceanic whitetip shark ranked among the most productive species (6 out of 26) (Smith *et al.* 1998). Cortés (2019) recently updated estimates of vital rates using five methods (see Cortés 2016 for details) for a NMFS workshop (https://www.fisheries.noaa.gov/event/oceanic-whitetip-shark-recovery-planning-workshop-november-2019). The maximum intrinsic rate of population increase (r_{max}) averaged 0.126 $year^{-1}$ in the Atlantic Ocean and 0.135 $year^{-1}$ in the Pacific Ocean. Based on these values, the oceanic whitetip shark is considered a medium-growing species when compared to 65 other shark species and populations (Cortés 2016). However, these estimates are meant to approximate maximum values, as it is unclear to what level of exploitation the vital rates used correspond and there is a need to improve basic life history information.

3. GLOBAL AND REGIONAL ABUNDANCE ESTIMATES AND TRENDS

Overall, global quantitative abundance estimates and trends are lacking for the oceanic whitetip shark. However, there are several studies on the abundance trends and a recent stock assessment for the oceanic whitetip shark in the WCPO (Tremblay-Boyer et al. 2019). The oceanic whitetip shark is predominantly caught as bycatch and the reporting requirements for bycatch species have changed over time and differ by organization, and have therefore affected the reported catch.

3.1 Global Population Trends

To date, there is no global population abundance estimate for the oceanic whitetip shark, and only one assessment has been conducted to determine a global population trend for the species. Rigby et al. (2019) used a Bayesian state-space tool for trend analysis of abundance indices (Just Another Red List Assessment, JARA) to determine a global abundance trend for the oceanic whitetip shark, which builds on the Bayesian state-space tool for averaging relative abundance indices by Winker *et al.* (2018). The percentage change is calculated from the estimated population time series that are available (see Table 2 below). If the length of the time series is longer than 3 generation lengths (GL), the percentage change in abundance was automatically calculated as the difference between the average of the first three years and the average of the last three years of the time series. If the span of time series was shorter than 3 GLs, JARA projected forward, by passing the number of desired future years without observations to the model, to attain a trend that spans 3 GLs. The oceanic whitetip shark was assessed globally by calculating the expected rate of change (%) for each of the regional rates of change weighted by an area-based estimate of the size of each region as a proportion of the species' global distribution. The current distribution map was used to calculate areas (Ebert *et al.* 2013). Following this methodology, the estimated area-weighted global population trend was a decline of 98-100%, with the highest probability of 80-99% reduction over three generation lengths (61.2 years based on IUCN criteria). However, it should be noted that there was no abundance data that spanned over three generations and the decline was based on the projected trend from the current observed data.

Table 2. Population change (%) and probabilities for changes All probabilistic statements are based on the rate of change over three generation lengths (GL) from projections within JARA. The Global change is based on weighting the regional probabilities by the proportional area (PA) weighting (see Rigby et al. 2019). Data sources for Table 2: 1. Young et al. 2017: Figure 26, page 36; 2. Tolotti et al. 2013: Figure 3, page 138; 3. Brodziak and Walsh 2013

*(Hawaii): Figure 2, zero-inflated negative binomial (ZINB), page 1730, *(not used in global weighted trend); 4. Rice and Harley 2012 (Western Central Pacific): Figure 13, biomass, page 39; 5. Rice et al. 2015 (Western Central Pacific): Figure 41, page 88; 6. Ramos-Cartelle et al. 2012: Figure 5, page 15.*

Region	GL (yr)	Data length (yr)	PA weighting	Median change
N. Atlantic[1]	20.4	24	0.15	−93.1
S. Atlantic[2]	20.4	7	0.08	+150.9
N. Pacific (H.)[3*]	20.4	16	-	−100
Pacific 1 (WC.)[4]	20.4	15	0.57	−100
Pacific 2 (WC.)[5]	20.4	19	0.57	−98.6
Indian[6]	20.4	14	0.20	−92.9
Global 1	–	–	–	**−100**
Global 2	–	–	–	**−98.0**

Aside from this assessment, there is currently no other global population trend information for the oceanic whitetip shark. In section 3.2 below, we discuss various regional trends to paint a more detailed picture of population status and trends for the oceanic whitetip shark in specific parts of its range.

3.2 Regional Population Trends

The following section describes the available information regarding regional catch rates and abundance trends for the oceanic whitetip shark from the following regions: Eastern Pacific, Western and Central Pacific, North Atlantic, South Atlantic, and Indian Ocean. Some of the available information is from the relevant RFMOs, which are international organizations formed by countries with fishing interests in a particular region of international waters or who are interested in fishing for a highly migratory species. Their purpose is to sustainably manage these shared fishery resources and they may advise cooperating countries on their fishing practices or even set catch and effort limits or other management measures. As the oceanic whitetip shark is a global, highly migratory species that crosses international boundaries, they are often caught as bycatch in the convention areas of those RFMOs for highly migratory fish stocks. Descriptions and information on these RFMOs and available catch data of oceanic whitetip sharks from vessels operating in these convention areas are provided below.

<u>Eastern Pacific Ocean (EPO)</u>

In the EPO, oceanic whitetip sharks were historically the second most common shark species caught in the tropical tuna purse seine fishery after silky sharks (*C. falciformis*), and comprised approximately 20% of the total shark catch from 2000–2001 (Roman-Verdesoto and Orozco-Zoller 2005) and 9% of the estimated yearly average capture of sharks from 1993-2009 (Hall and Román 2013). However, both nominal catches and encounters with oceanic whitetip sharks in all set types declined significantly since 1994, representing an 80-95% population decline (Hall and Román 2013). Further, size trends in this fishery show that small oceanic whitetip sharks (<90 cm), which comprised 21.4% of the oceanic whitetip sharks captured in 1993, have been virtually eliminated from the population, indicating the possibility of recruitment failure in the population (Hall and Román 2013; Martin Hall personal communication to Chelsey Young 2016). Although it is possible other factors aside from fishing pressure may have affected catches of oceanic whitetip shark during this period, such a significant level of decline makes it unlikely (Hall and Román 2013).

Figure 12 below shows the nominal catch per set of oceanic whitetip shark in purse seine floating object sets in the EPO, and Figure 13 shows the distribution of encounters with oceanic whitetip sharks. Both figures show four periods of time (1994-1997; 1998-2001; 2002-2005; and 2006-2009).

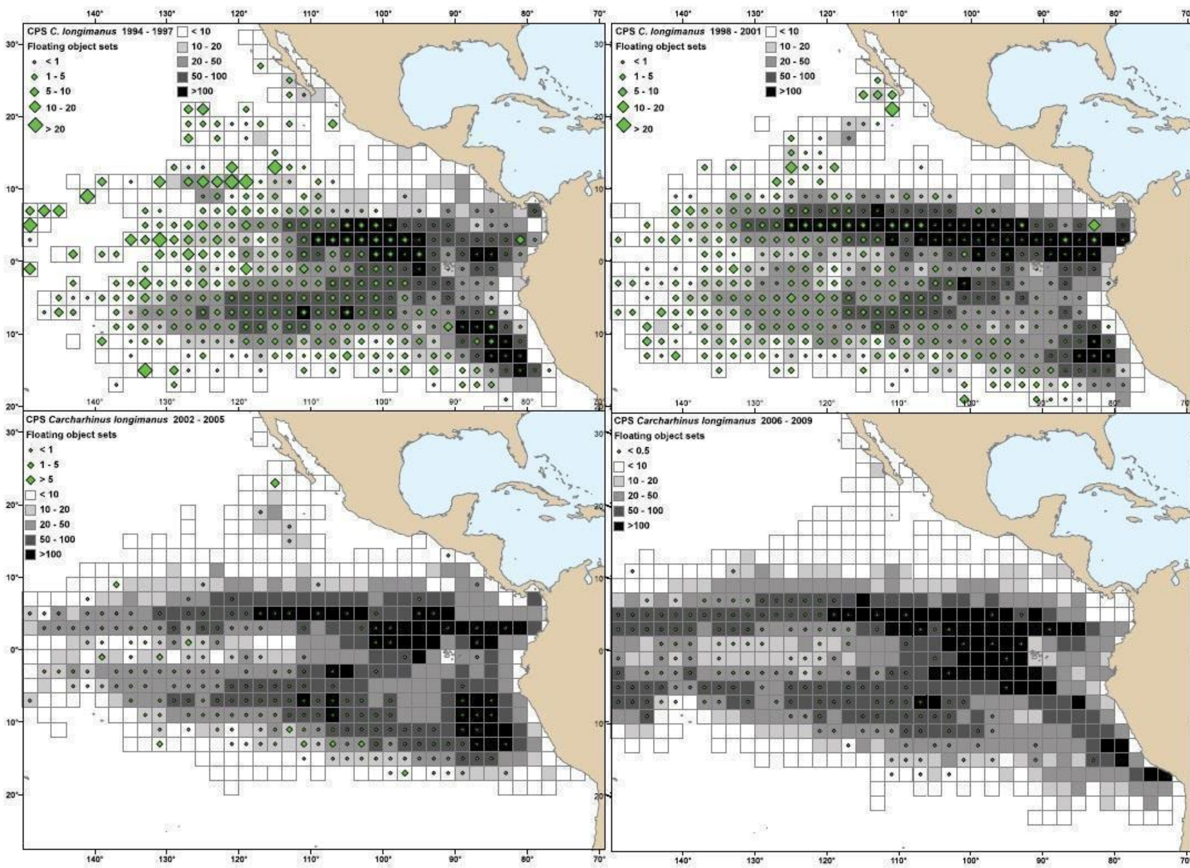

Figure 12. Numbers per set of oceanic whitetip sharks in floating object sets in four periods (1994-1997; 1998-2001; 2002-2005; 2006-2009. The green diamonds represent numbers of oceanic whitetip sharks caught; the gray shaded squares represent fishing effort (numbers of sets deployed). Source: Hall and Román 2013.

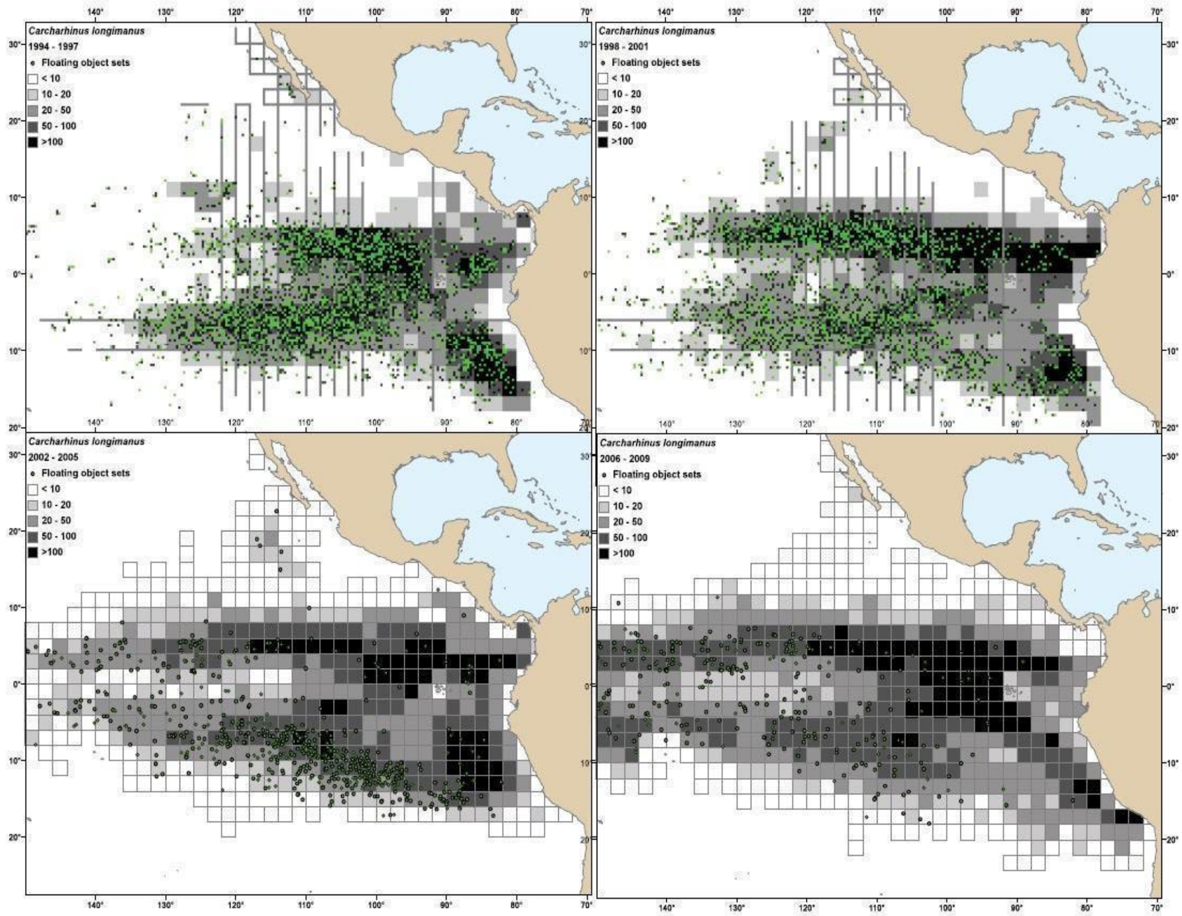

Figure 13. Encounters with oceanic whitetip sharks in floating object purse seine sets in the EPO in four periods (1994-1997; 1998-2001; 2002-2005; 2006-2009). The green dots represent encounters with oceanic whitetip sharks in floating object sets (i.e., sets with oceanic whitetip sharks present); the gray shading represents fishing effort (number of sets deployed). Source: Hall and Román 2013.

Figures 12 and 13 above provide a clear illustration of the decline in catches per set that accompanied a significant reduction in oceanic whitetip frequency (Hall and Román 2013). Based on Figures 12 and 13 above, it is evident that the species has virtually been wiped out from the fishing grounds, in a seemingly north to south progression, with similar trends also observed in purse seine sets on dolphins and tuna schools. These declines in nominal catch per unit effort (CPUE) or the frequency of occurrence equates to an 80–95% decline from population levels in the late 1990s (Hall and Román 2013).

<u>Western and Central Pacific Ocean</u>
The oceanic whitetip shark was historically considered one of the most abundant pelagic shark species throughout the Western and Central Pacific Ocean (WCPO). For example, tuna longline survey data from the 1950s indicate oceanic whitetip sharks comprised 28% of the total shark catch of fisheries south of 10ºN (Strasburg 1958). Likewise, Japanese research longline records during 1967-1968 indicate that oceanic whitetip sharks were among the most common shark species taken by tuna vessels in tropical waters of the WCPO, and comprised 22.5% and 23.5% of the total shark catch west and east of the International Date line, respectively (Taniuchi 1990).

However, several recent lines of evidence indicate that the oceanic whitetip shark has suffered significant population declines throughout the region, including declining trends in standardized CPUE, biomass and size indices (suggesting growth overfishing).

A number of studies utilizing data from fisheries operating across the WCPO (including Hawaii, Japan, and observer data from the Secretariat of the Pacific Community) have been conducted to assess the status and trends of oceanic whitetip shark over time. These include a "status snapshot" of the species across the WCPO (Clarke 2011), CPUE analyses from Hawaii (Walsh and Clarke 2011; Brodziak et al. 2013), and other assessments and indices (Clarke et al. 2012; Rice et al. 2015) that all showed significant declines of the species in both longline and purse seine fisheries across the region.

However, the most comprehensive analyses on the status of oceanic whitetip shark are from stock assessments conducted under the auspices of the WCPFC (Rice and Harley 2012; Tremblay-Boyer et al. 2019). Most recently, Tremblay-Boyer *et al.* (2019) utilized the Stock Synthesis modeling framework (Methot and Wetzel 2013), which is an integrated age-structured population model. The population dynamics model was informed by three sources of data: historical catches, time series of CPUE and length frequencies. The longline fishery was split into bycatch and target fleets, and the purse-seine fishery into fleets of associated and unassociated sets. This assessment also included scenarios of discard mortality assuming 25%, 43.75% and 100% mortality on the discard. The stock of oceanic whitetip shark was found to be overfished and experiencing overfishing based on SB/SBMSY and F/FMSY reference points. The current spawning stock biomass (232–507 metric tonnes) is predicted to be below 5% of the unfished spawning biomass and the population could go extinct over the long-term based on current levels of fishing mortality (Tremblay-Boyer *et al.* 2019; see Figure 14 below).

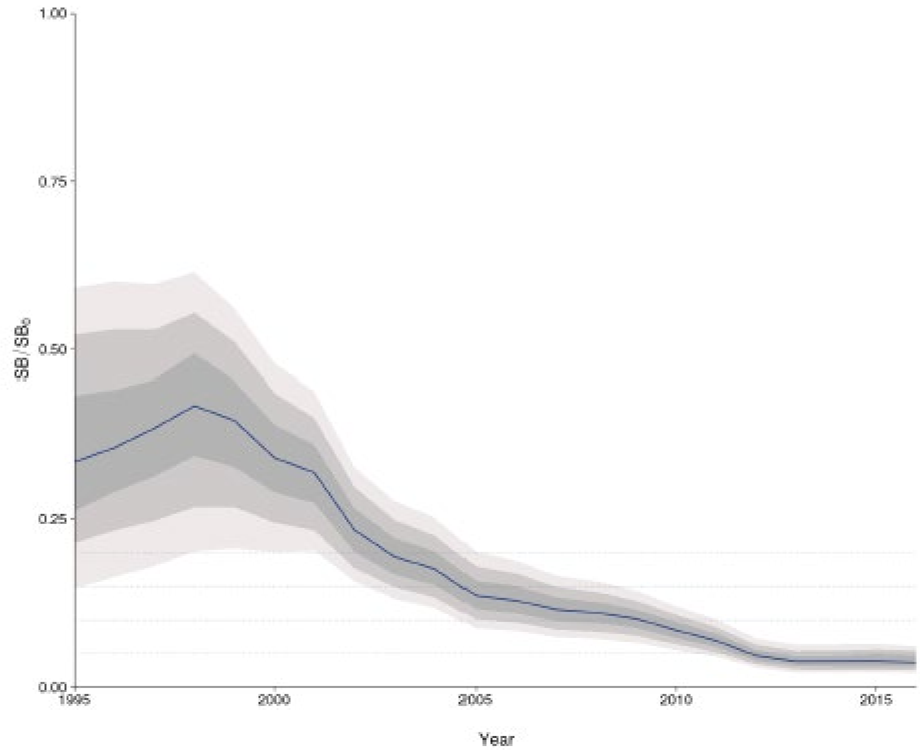

Figure 14. Median prediction of depletion in spawning biomass over all (unweighted) grid runs, with 0.025th-0.975th, 0.10th-0.90th and 0.25th-0.75th quantile intervals. The horizontal grey lines are placed at intervals of 5% in the lower part of the graph to aid visualization. Source: Tremblay-Boyer et al. 2019.

Based on the foregoing information, the oceanic whitetip shark has experienced, and likely continues to experience, significant abundance declines across the WCPO.

Atlantic Ocean

Northwest and Central Atlantic and Gulf of Mexico
Historically, the oceanic whitetip shark was described as widespread, abundant, and the most common pelagic shark in the warm parts of the North Atlantic (Mather and Day 1954; Backus *et al.* 1956; Strasburg 1958). Historical accounts of the oceanic whitetip shark during exploratory research surveys in the western North Atlantic during the 1950s noted that several individuals (up to 25 individuals in some cases) often gathered at the surface around longlines, persistently investigated baited hooks, and attacked dead or dying tuna before they were hauled in (Bullis 1955; Backus *et al.* 1956). In fact, the sharks were so persistent, even attempts to drive them away via the use of underwater explosives were unsuccessful (Backus *et al.* 1956). Recent information suggests the species is now relatively rare in this region and large population declines have been reported, although there has been significant debate regarding the magnitude (Burgess *et al.* 2005 a,b). Declines in abundance from the 1990s to the early 2000s have ranged from 9% to 70% depending on the data source and area (Baum *et al.* 2003; Cortés *et al.* 2007; Baum and Blanchard 2010). The most significant decline reported was a 99.9% decrease in abundance in the Gulf of Mexico since the 1950s based on a comparison of longline research surveys from 1954-1957 and data from fisheries observers collected on commercial pelagic longline sets from 1995-1999. However, the claim of such drastic declines was criticized for a

lack of understanding of data, and for not taking into consideration the increase in the average depth of sets and the discontinued use of wire leaders that could have reduced catchability (Burgess et al. 2005a,b). The Food and Agriculture Organization of the United Nations (FAO) (2012) utilized data from Driggers *et al.* (2011) to demonstrate the catch rates of Baum and Myers (2004) for the recent period would have been 0.55 sharks per 1000 hook-hours rather than 0.02 per 1000 hook-hours when using wire leaders. Comparing the recent 0.55 value with the Baum and Myers (2004) of 4.62 for the 1950s gives an estimated extent of decline of 88 percent.

An analysis of the most recent observer data (subset to reflect the statistical grids of highest occurrence for oceanic whitetip shark) from the U.S. Northwest Atlantic Pelagic Longline Fishery from 1992-2018 indicated a 2% decline in abundance over the length of the time series (Figure 15 below). Thus, while it is likely that significant historical declines occurred, it appears that the population in the Northwest Atlantic may have stabilized with some evidence of recent increases in abundance since 2010. Although not confirmed, this may be due to management actions implemented in 1993, including the first Federal Fishery Management Plan for Sharks (NMFS 1993), and subsequent regulations that include trip limits, quotas, time and area closures, and gear restrictions.

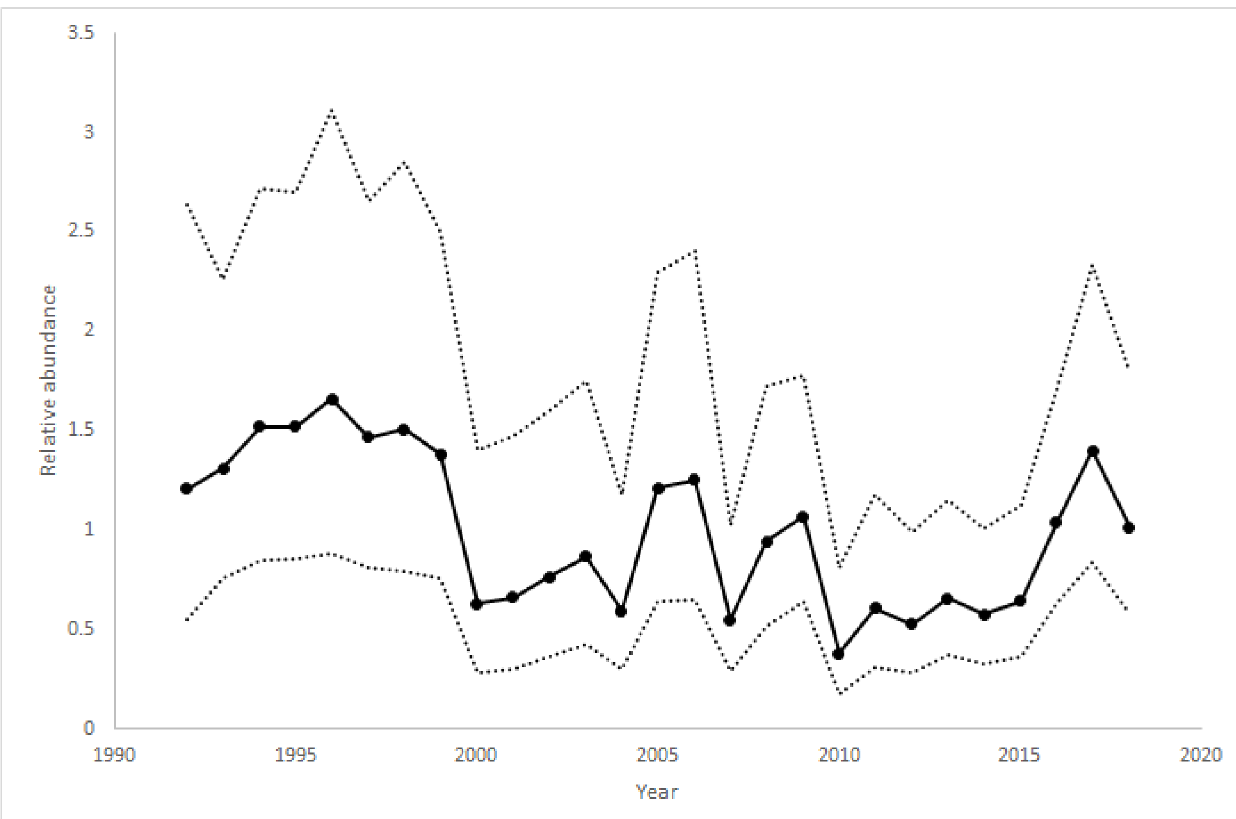

Figure 15. Estimated change in relative abundance (standardized catch per 1000 hooks) between 1992 and 2019 based on the Northwest Atlantic Pelagic Longline observer data for oceanic whitetip sharks. Relative abundance is expressed as the year's estimated mean index divided by the maximum estimated yearly mean index in each time series. Dotted lines represent upper and lower 95% confidence limits. Source: NMFS Observer Database.

Northeast Atlantic and Mediterranean

There is very little information regarding oceanic whitetip sharks in the Northeast Atlantic and Mediterranean. According to the International Council for the Exploration of the Sea (ICES), there is limited information with which to examine the stock structure of oceanic whitetip, and the ICES area (which pertains to the North Atlantic, including the adjacent Baltic Sea and North Sea), would only be the northern extreme of its Northeast Atlantic distribution range. Oceanic whitetip sharks are found mostly in the southwestern parts of the ICES areas (e.g., Iberian Peninsula), though some may occasionally occur farther north (ICES 2014). Although oceanic whitetip sharks have been recorded from Portuguese waters, landings of the species are unconfirmed (Correia and Smith 2001). In the Mediterranean, Bigelow and Schroeder (1948) (cited in Backus *et al.* 1956) assumed the oceanic whitetip shark was historically common; however, they were not included in a comprehensive species checklist of cartilaginous fishes in the Mediterranean (Bradai *et al.* 2012) or overview of elasmobranchs of the Mediterranean Sea (Cavanagh and Gibson 2007). Additionally, of twelve species of shark identified in a study of incidental catch and estimated discards of pelagic sharks from the swordfish and tuna fisheries in the Mediterranean Sea, oceanic whitetip sharks were not identified as present (Megalofonu *et al.* 2005). Thus, it appears that the occurrence of oceanic whitetip shark in the Northeast Atlantic and Mediterranean is likely rare, as these areas represent the northern extent of the species' range.

South Atlantic
Information from the South Atlantic on the abundance and population trends of ocean whitetip shark is limited, with most information coming from a few countries in South America. In equatorial waters of Brazil, the oceanic whitetip shark was historically reported as the second most abundant elasmobranch species, outnumbered only by the blue shark (*P. glauca*) in research surveys conducted during the 1990s, and comprised 29% of the total elasmobranch catch (Lessa *et al.* 1999). Analyses of fisheries data from 1980-2011 indicate the oceanic whitetip shark has undergone at least an 85% decline (Barreto *et al.* 2015). However, it was noted in Young et al. (2017) that there were issues with the methodology used in this study, including the use of year as a continuous variable and the removal of all zero catches from the analysis. Confidence intervals are extremely high and overlapped in most cases, raising the possibility that the trends may be "noise" rather than truly tracking abundance.

Tolotti *et al.* (2013) analyzed catch and effort data from 14,835 longline sets conducted by foreign tuna longline vessels chartered by Brazil from 2004-2010 to assess the size, distribution and relative abundance of the oceanic whitetip shark in the southwestern and equatorial Atlantic Ocean. Standardized CPUE data showed a gradually increasing trend in oceanic whitetip shark abundance from 2004 to 2010. However, the authors noted that the CPUE standardization may have been compromised due to the low number of years in the data series as well as a lack of a homogeneous distribution of fishing effort and fishing strategy, both spatially and temporally. Overall, the authors concluded that the oceanic whitetip shark was encountered more frequently but in fewer numbers over time (Tolotti *et al*. 2013) and that CPUE of this species is particularly sensitive to changes in fishing strategy. However, definitive conclusions regarding abundance trends from this study could not be determined. Recently, Barcellos *et al*. (2022) provided detailed data on the size and age distribution of oceanic whitetip shark captured in the two Ecologically or Biologically Significant Marine Areas off Brazil. Neonates and juveniles accounted for 76% of the total number of individuals and the authors concluded that fishing in these areas could have a negative impact on their populations because these individuals have not yet contributed to the population through reproduction.

Farther south in Uruguay, oceanic whitetip shark abundance is seemingly low and patchy. In 6 years of observer data from the Uruguayan longline fleet (1998-2003), with about 660,000 hooks deployed between latitudes 26° and 37° S, catches of oceanic whitetip shark were described as "occasional" with CPUE rates of only 0.006 individuals/1,000 hooks (Domingo 2004). Domingo (2004) noted that it is unknown whether the low abundance of oceanic whitetip sharks in Uruguayan longline fisheries is because the species has always occurred in low numbers in this region of the South Atlantic, or because the population has been affected significantly by fishing effort. Sampling in this study took place in waters with sea surface temperatures ranging between 16° and 23° C, which are largely below the preferred temperature of the species. In a more recent analysis of observer data, Domingo *et al.* (2007) found similar results as the earlier study. For example, observer data from the Uruguayan longline fleet operating in this region reported low CPUE values for oceanic whitetip sharks from 2003 to 2006, with the highest CPUE recorded not exceeding 0.491 individuals/1,000 hooks. In total, only 63 oceanic whitetip sharks were caught on 2,279,169 hooks and 63% were juveniles. All catches occurred in sets with sea surface temperatures ≥ 22.5° C (Domingo *et al.* 2007). Again, these data do not indicate whether a decline in the population has occurred, but it does seem to reflect the species' low abundance in this area (Domingo *et al.* 2007).

Information regarding oceanic whitetip shark abundance and trends is largely unavailable from the eastern Atlantic and off the coast of western Africa. Domingo *et al.* (2007) recorded 0.098 sharks per 1000 hooks in the Gulf of Guinea and only 10 individuals caught in 3 years, whereas Castro and Mejuto (1995) reported 0.26 sharks per 1000 hooks in this same area 10 years prior in 1993, with 63 oceanic whitetip sharks caught in only 4 months. As such, the population status of the oceanic whitetip shark in this area is highly uncertain.

<u>Indian Ocean</u>

In the Indian Ocean, there is no quantitative stock assessment for the oceanic whitetip shark at this time, and only limited basic fishery indicators are available, making it difficult to determine abundance trends within this ocean basin. Nonetheless, historical research data shows overall declines in both CPUE and mean weight of oceanic whitetip sharks, with anecdotal reports suggesting that the species has become rare throughout much of the Indian Ocean over the past 20 years (Romanov *et al.* 2008; IOTC 2015a). In addition, the IOTC reports that despite limited data, oceanic whitetip shark abundance has likely declined over recent decades (IOTC 2015a).

Standardized CPUE data from Japanese and Spanish longline fisheries operating in the Indian Ocean also indicate variable population declines ranging from 25-40% since the late 1990s (Yokawa and Semba 2012; Ramos-Cartelle *et al*. 2012). Data on shark abundance from the Maldives from the mid-1980s to mid-2000s (Anderson and Waheed 1990; Anderson *et al.* 2011) indicate a potentially significant decline of oceanic whitetip shark abundance of up to of 90% (FAO 2012), with sightings of the species in Maldives and Reunion Island increasingly rare (IOTC 2011). Tolotti *et al*. (2015b) also reported a marked decline in the proportion of fish aggregating devices (FADs) with oceanic whitetip sharks present in the French tuna purse seine fishery operating in the western Indian Ocean, from 20% in the mid 1980s-1990s, to less than

10% from 2005 to 2014. Due to the significant increase in FADs since the 1990s, this could be indicative of a significant population decline (Tolotti *et al.* 2015b). However, the studies discussed have caveats and limitations making the abundance trend information from the Indian Ocean fairly limited. Therefore, the current population status for the oceanic whitetip shark is highly uncertain in this part of its range and more robust research and data are needed.

Regional Population Trends Summary

Overall, evidence (both quantitative and qualitative) suggests that while oceanic whitetip sharks were once considered to be one of the most abundant and commonly encountered pelagic shark species wherever it occurred, this oceanic species has likely undergone population abundance declines of varying but likely significant magnitudes throughout its global range. While it is likely that significant historical declines occurred in the Northwest Atlantic, it appears that the population there may have stabilized with some evidence of recent increases in abundance since 2010. Information from the South Atlantic, while limited, suggests potential declines up to 85%, keeping in mind the caveats and limitations of the available studies. In the Indian Ocean, the current population status for oceanic whitetip shark is highly uncertain with standardized CPUE data suggesting declines ranging from 25–40% since the late 1990s but other studies suggest declines of oceanic whitetip abundance of up to 90%. In the Eastern Pacific, nominal catches in the purse seine fishery with oceanic whitetip sharks declined significantly since 1994, representing an 80–95% population decline. The most robust information is from the Western and Central Pacific Ocean where an integrated age-structured population model predicted spawning stock biomass has declined below 95% of unfished spawning biomass with some scenarios declining to 99%.

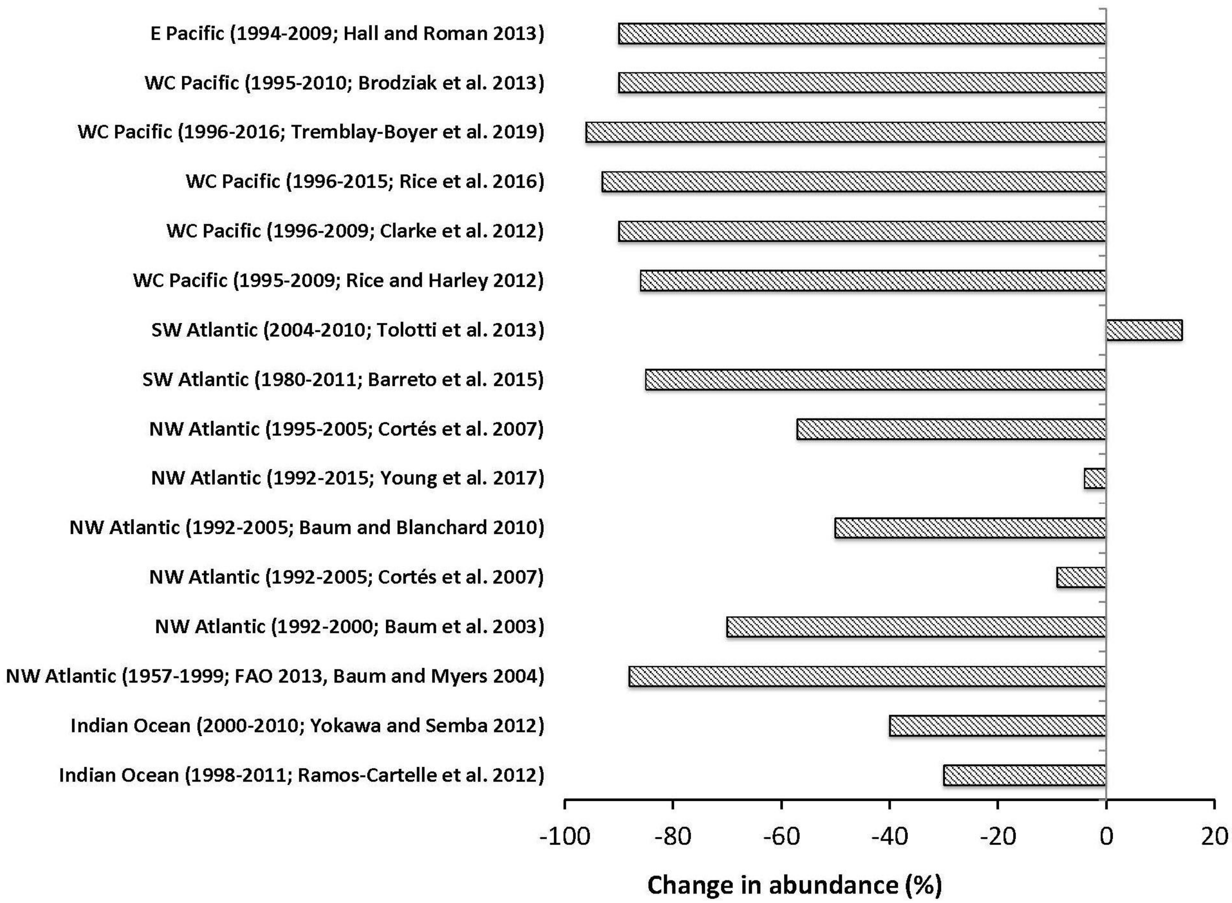

Fig. 16. Summary of the trends in abundance for oceanic whitetip shark based on stock assessments and standardized catch rates (Source: Young and Carlson 2020).

4. THREATS TO THE OCEANIC WHITETIP SHARK

In determining whether to list, delist, or reclassify a taxon under the ESA, five threat factors are evaluated, including:

- Factor A. the present or threatened destruction, modification, or curtailment of its habitat or range;
- Factor B. overutilization for commercial, recreational, scientific, or educational purposes;
- Factor C. disease or predation;
- Factor D. the inadequacy of existing regulatory mechanisms; and
- Factor E. other natural or manmade factors affecting its continued existence.

The final listing rule (83 FR 4153) identified substantial levels of fishing mortality due to incidental capture (bycatch) in numerous commercial fisheries throughout its range, including longline and purse seine fisheries (Factor B), opportunistic harvest for fins (Factor B) and inadequacy of existing regulatory mechanisms (Factor D) as significant factors affecting the survival of the species. The following sections describe threats to the oceanic whitetip shark categorized into the above ESA 4(a)(1) factors.

4.1 (Factor A) Present or Threatened Destruction, Modification or Curtailment of Habitat or Range

This section analyzes potential threats to oceanic whitetip shark habitat, including impacts from fishing and climate change.

U.S. Atlantic

The geographic range of the oceanic whitetip shark in the Northwest Atlantic and Caribbean is reportedly very broad, occurring from Maine to Florida on the East Coast, in the Gulf of Mexico and in U.S. territorial waters within the Caribbean (U.S. Virgin Islands and Puerto Rico) (Compagno 1984). However, the NMFS Northeast Fisheries Science Center (NEFSC) describes this species as ''uncommon'' in the U.S. Atlantic exclusive economic zone (EEZ) (NMFS 2017). Essential fish habitat (EFH) is defined under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity (16 U.S.C. 1802(10)). EFH was first designated for the oceanic whitetip shark in 2006, and revised in 2017 based on newer observer, survey, and tag/recapture data collected by the NMFS and the public since 2009. EFH boundaries for all life stages of oceanic whitetip shark were reduced from a continuous designation spanning the U.S. EEZ between Georges Bank and the western Gulf of Mexico to a more refined and localized EFH designation in both Atlantic and Gulf of Mexico. EFH was also expanded in the Caribbean (Figure 16). The current EFH designation for the oceanic whitetip shark includes waters greater than 200 m in depth from offshore of the North Carolina/Virginia border to the Blake Plateau, which is a broad, relatively flat portion of the upper continental slope that extends from the coast of North Carolina to central Florida. Essential fish habitat was not designated north of Virginia (NMFS 2017a). Designated EFH in the Gulf of Mexico includes offshore habitats of the northern Gulf of Mexico at the Alabama/Florida border (e.g., the Mississippi plume shows high occurrence of juveniles and adults) to offshore habitats of the western Gulf of Mexico south of eastern Texas. Additionally, the entire U.S. Caribbean (waters of Puerto Rico and the U.S. Virgin Islands) is considered EFH (NMFS 2017a). These designations were based on high encounters of the species in fisheries observer data from the U.S. pelagic longline fishery as well as movement data from archival satellite tags (NMFS 2017a), which confirms the historical and current presence of oceanic whitetip sharks in these waters. Areas of high occurrence are also off the east coast of Florida, Charleston Bump off the southeast United States, and between Florida, Cuba and the Yucatan Peninsula (J. Carlson, unpublished analysis, 2019). However, while we can confirm that the geographical areas occupied by the oceanic whitetip shark includes U.S. waters, there is no information regarding the specific habitat use of oceanic whitetip sharks in any of these areas, and nurseries and pupping grounds have not been identified in U.S. waters (NMFS 2017a; CITES 2013).

Despite a lack of identified nurseries or pupping grounds in U.S. waters, Aquino (unpublished) reported on the prevalence of small juveniles captured by artisanal fishermen in Caribbean waters off the coast of Haiti with up to 80 captures in 2019. This could indicate a potentially important pupping area for the oceanic whitetip shark, where the species does not have any protections at this time. Identification and subsequent protection of these areas will be crucial for ensuring recovery of the species.

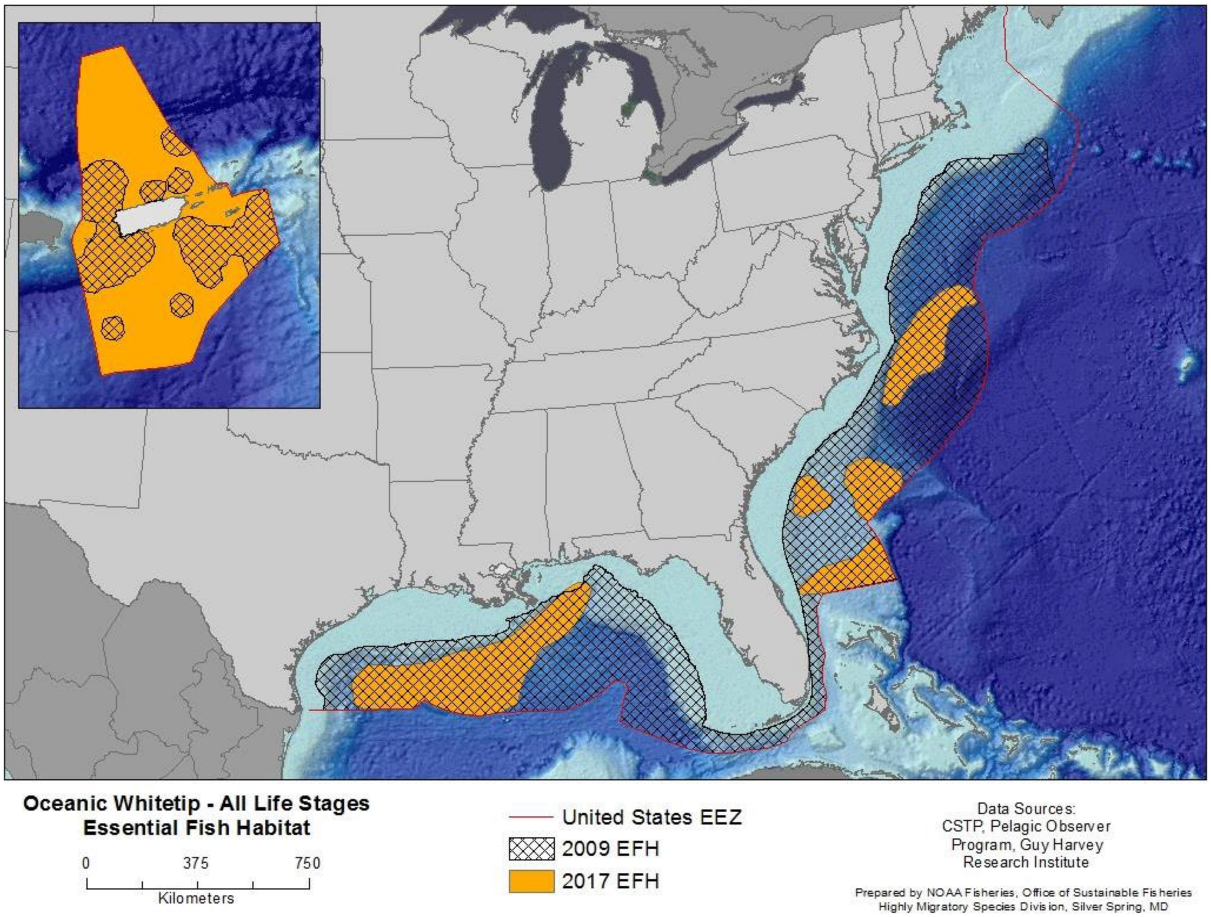

Figure 17. Essential Fish Habitat for oceanic whitetip shark in the Northwest Atlantic (Source: NMFS 2017a).

<u>U.S. Pacific</u>

In the U.S. western Pacific, including Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands, EFH for oceanic whitetip sharks is broadly defined as the water column down to a depth of 1,000 m (547 fm) from the shoreline to the outer limit of the EEZ (Western Pacific Fishery Management Council [WPFMC] 2009). Based on an examination of published literature and anecdotal evidence, NMFS assessed the impact of fishing gears on highly migratory species (HMS) EFH and determined that there are few anticipated impacts from federally regulated and non-federally regulated gears to HMS EFH (which includes oceanic whitetip shark EFH) (NMFS 2006). Because EFH is defined for the oceanic whitetip shark as the water column or attributes to the water column, cumulative impacts from HMS and non-HMS fishing gears on EFH are anticipated to be minimal. However, a better understanding of the specific habitat types and characteristics that influence the abundance of these sharks within those habitats is needed in order to determine the effects of fishing activities on habitat suitability for oceanic whitetip sharks. In addition, EFH regulations also require that fishery management plans (FMPs) identify non-fishing related activities that may adversely affect EFH of managed species, either quantitatively or qualitatively, or both. These waters are or may be used by humans for a variety of purposes that often result in degradation of these and adjacent habitats, posing threats, either directly or indirectly, to the biota they support (NMFS 2006). These effects, either alone or in combination with effects from other activities within the ecosystem, may contribute to the decline of some species or degradation of the habitat; however, the cumulative anthropogenic effects on the species' continued existence are difficult to quantify. Currently, there is no evidence to suggest a range contraction based on habitat degradation for the oceanic whitetip shark.

Non-U.S. Habitat

Aside from impacts from overfishing, information on threats to oceanic whitetip shark habitat areas outside of the United States is largely unavailable, although climate change is anticipated to threaten or modify habitats both inside and outside the United States (see below).

Climate Change

The impacts of climate change on oceanic whitetip sharks, and pelagic sharks in general, have not been well studied. However, large-scale impacts of climate change such as ocean warming and acidification have the potential to threaten the species, and its prey base, given projected impacts to open ocean shelf habitats where these animals occur. The Intergovernmental Panel on Climate Change (IPCC 2019) reports that the global ocean has warmed unabated since 1970 and has taken up more than 90% of the excess heat in the climate system with high confidence. It is virtually certain that the ocean will continue warming throughout the 21st century and by 2100, the top 2000 m of the ocean will very likely take up 5 to 7 times more heat under representative concentration pathway 8.5 (RCP8.5) than observed heat uptake since 1970 (IPCC 2019). It is very likely that the ocean has taken up 20 to 30 percent of total anthropogenic carbon dioxide emissions since the 1980s, leading to ocean acidification rates of 0.017– 0.027 pH units per decade since the late 1980s (IPCC 2019). It is virtually certain that continued carbon uptake through 2100 will exacerbate ocean acidification, and RCP8.5, open ocean surface pH is projected to decrease by around 0.3 pH units by 2081–2100, relative to 2006–2015 (IPCC 2019).

Specific studies on the potential impacts of climate change to the oceanic whitetip shark are limited. However, because oceanic whitetip shark habitat is comprised of open ocean environments occurring over broad geographic ranges, large-scale impacts such as global climate change that affect ocean temperatures, currents, and potentially food chain dynamics, may affect the species in the future. Data from the Northwest Atlantic suggest oceanic whitetip sharks may face metabolic challenges with habitats close to upper thermal limits and potential overheating. If ocean warming raises temperatures in habitats to upper thermal limits in the future, potential habitat mismatches may occur between oceanic whitetip sharks and their prey, reducing the overall habitat in which they can feed (Andrejaczek *et al*. 2018). Additionally, while avoidance of surface waters will reduce the vulnerability of these sharks to fishing gears targeting this zone, it may increase their vulnerability to deeper-set longlines by minimizing the available habitat and magnifying the spatial overlap of the species' distribution with pelagic longline fisheries that already occurs on a latitudinal scale (Andrejaczek *et al*. 2018).

In another study on potential effects of climate change to sharks, Hazen *et al.* (2012) used data from electronic tagging and a climate change model to predict shifts in habitat and diversity in top marine predators in the Pacific out to the year 2100. Results of the study showed significant differences in habitat change among species groups, which resulted in species-specific “winners” and “losers.” The shark guild as a whole had the greatest risk of pelagic habitat loss (Figure 18).

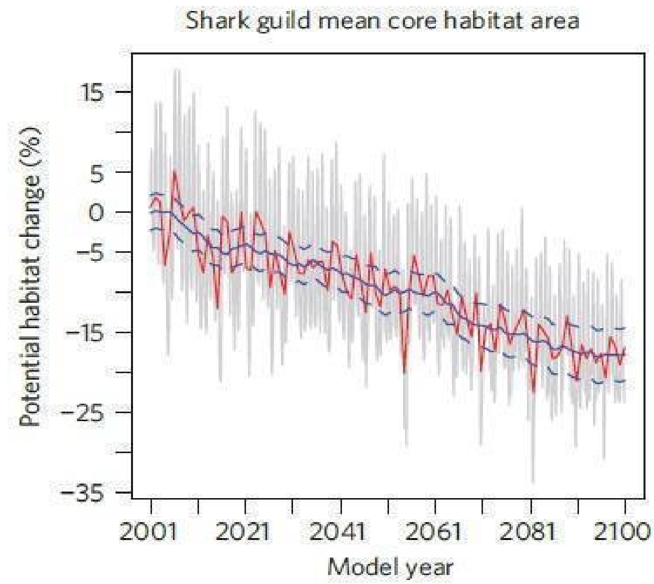

Figure 18. Core habitat area for sharks from the year 2000 to 2100 shown as monthly (grey), yearly (red) and 5-year filtered (blue) time series with 1 standard deviation marked by dashed lines. Source: Hazen et al. 2012.

The model predictions in Hazen *et al.* (2012) do not account for factors such as species interactions, food web dynamics, and fine-scale habitat use patterns required to more comprehensively assess the effects of climate change on the pelagic ecosystem. Further, results are not specific to the oceanic whitetip shark. Finally, the complexity of ecosystem processes and interactions complicate the interpretation of modeled climate change predictions and the potential impacts on populations. Thus, the potential impacts from climate change on oceanic whitetip shark habitat are highly uncertain. While their broad distribution and ability to move to areas that suit their biological and ecological needs may buffer impacts from climate change, climate change still has the potential to pose a threat to oceanic whitetip sharks, including habitat changes (e.g., changes in currents and ocean circulation, compression of habitat zone) and potential impacts to prey species.

4.2 (B) Overutilization for Commercial, Recreational, Scientific or Educational Purposes

Threats to the oceanic whitetip shark related to overutilization stem from commercial fisheries, largely driven by bycatch-related mortality and opportunistic utilization of fins in the international shark fin trade. The oceanic whitetip shark is not generally targeted, but the species is caught as bycatch in numerous fisheries around the world. This species is caught in pelagic longlines, purse seines, gillnets, handlines, trolling gear, and occasionally pelagic and even bottom trawls (Young and Carlson 2020). Because of interactions in commercial fisheries, oceanic whitetip sharks experience fishing mortality during and after fishing interactions (i.e., at-vessel and post-release mortality). Although thought to be of low commercial value, oceanic whitetip shark meat is utilized fresh, smoked, and dried and salted for human consumption. Additionally, oceanic whitetip shark meat from longline bycatch has been marketed in the past in Europe, North America and Asia (Rose 1996; Vannuccini 1999). Oceanic whitetip sharks are also used for hides, for fins (for shark fin soup), and for liver oil (extracted for vitamins) and fishmeal. In contrast to the low commercial value of the meat (Mundy-Taylor and Crook 2013), oceanic whitetip shark fins are highly prized in the international shark fin market and sell for USD $45 to USD $85 per kg (CITES 2013).

This section includes relevant information from the following geographic regions: Eastern Pacific, Western and Central Pacific, Northwest and Central Atlantic, South Atlantic, and Indian Ocean. Much of the data come from localized study sites and over short time periods and thus is difficult to extrapolate to the global population.

4.2.1 Fisheries Interactions and Mortality

Global Trends

Worldwide catches of oceanic whitetip shark are reported in the FAO Global Capture Production dataset. According to the FAO, total catches of oceanic whitetip shark increased drastically in the late 1990s, peaking at 1,480 mt in 2000, and declining to 271 mt as of 2013 (Figure 18). Reported worldwide catches for oceanic whitetip shark for the last 5 years of available data (2012-2017) have ranged from 62 to 519 mt per year.

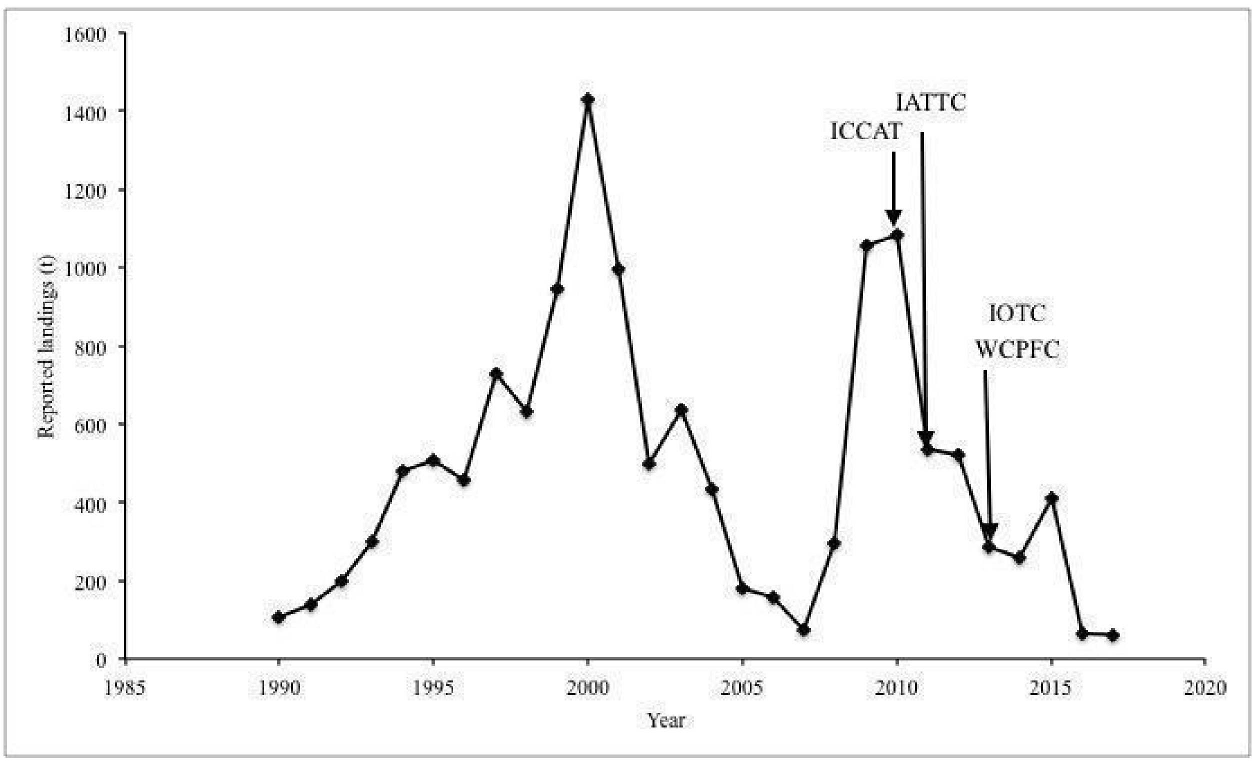

Figure 19. Global capture production for oceanic whitetip shark from 1990-2017. Global capture production is production weight of the retained individuals before processing and thus may differ from landings weights. Arrows

indicate the year the specific Regional Fishery Management Organization no-retention measures were implemented relative to oceanic whitetip shark. ICCAT= The International Commission for the Conservation of Atlantic Tunas, IATTC= Inter-American Tropical Tuna Commission, IOTC= Indian Ocean Tuna Commission, WCPFC= The Western and Central Pacific Fisheries Commission. Source: FAO Global Capture Production; accessed July 15, 2019 as cited in Young and Carlson (2020).

Although the FAO dataset supposedly represents the most comprehensive data available on world fisheries production, there are several caveats to interpreting these data and the data are likely not representative of oceanic whitetip shark catches throughout the time series. FAO data are generated from fishery agency reports from individual countries, and the data has historically suffered from limitations in reporting capabilities, including issues related to species identification and a lack of species-specific reporting altogether (Rose 1996). Further, some species may only be reported by a few nations despite the species having a very wide distribution and records in local fisheries. Additionally, many nations that report catch volumes to the FAO do not include catches that are discarded at sea (e.g., incidental catch or bycatch) (Rose 1996), with others not reporting discards at all. An evaluation of data quality in the FAO global capture production database found over half of developing countries were reporting inadequately, and one-fourth of reports by developed countries were not satisfactory (Garibaldi 2012). Although more countries and RFMOs are working towards improving reporting of species-specific fish catches, catches of oceanic whitetip sharks have likely gone and continue to go unrecorded in many countries. Further, some catch records that do include oceanic whitetip sharks may not even differentiate between shark species in general. As described previously, these numbers are also likely under-reported as many catch records report dressed weights as opposed to live weights and/or do not account for discards (e.g., fins are kept but the carcass is discarded; IOTC 2015b). Additionally, in the case of no-retention rules (either RFMO or national laws) many annual catch records are now zero, either because species are discarded whole or because they simply aren't reported. Research suggests that annual global catch data compiled by the FAO are significantly underestimated for all sharks (Clarke et al. 2006b).

Regional Trends

Pacific Ocean

Eastern Pacific Ocean

In the Eastern Pacific, the oceanic whitetip shark is caught on a variety of gear, including longline and purse seine gear targeting tunas and swordfish. While the range of the oceanic whitetip shark in the Eastern Pacific has been described as extending as far north as southern California waters (Compagno 1984), based on the available data, the distribution of the species appears to be concentrated in areas farther south, and in more tropical waters. Observer data of the West-Coast based U.S. fisheries further confirms this finding, with oceanic whitetip sharks not observed in the catches over several decades. For example, in the California/Oregon drift gillnet fishery, which targets swordfish and common thresher sharks and operates off the U.S.

Pacific coast, observers recorded 0 oceanic whitetip sharks in 8,698 sets conducted over the past 25 years (from 1990-2015[2]).

Oceanic whitetip sharks are commonly caught as bycatch in the tropical tuna purse seine fishery. From 1993-2009, oceanic whitetip sharks comprised approximately 9% of the total shark catch, and was the second most abundant shark in these catches behind the silky shark (Hall and Roman 2013). Fisheries information and catch data for the Eastern Pacific are available from the Inter-American Tropical Tuna Commission (IATTC), which is the RFMO responsible for the conservation and management of tuna and other marine resources in this region. To date, the IATTC has not conducted a stock assessment for the oceanic whitetip shark. The IATTC requires the collection of data on the primary shark species caught as bycatch in its fisheries. Since 1993, observers have recorded shark bycatch data onboard large purse seiners in the EPO. However, much of this data (especially data collected prior to 2005), is aggregated under the category of "sharks," as opposed to species-specific records. In an effort to improve species identifications in these data, a one-year Shark Characteristics Sampling Program was conducted to quantify at-sea observer misidentification rates. Oceanic whitetip sharks represented approximately 20.8% of the species observed during this project (Roman-Verdesoto and Orozco-Zoller 2005). More recently, species-specific observer data have become publicly available via the IATTC observer database. Estimates of shark catches (tons/year) by species for all purse seines operating in the Eastern Pacific Ocean for all set types combined (floating object + unassociated + dolphin) are based on that data (See Figure 20 below).

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2 http://www.westcoast.fisheries.noaa.gov/fisheries/wc_observer_programs/sw_observer_program_info/data_summ_report_sw_observer_fish.html

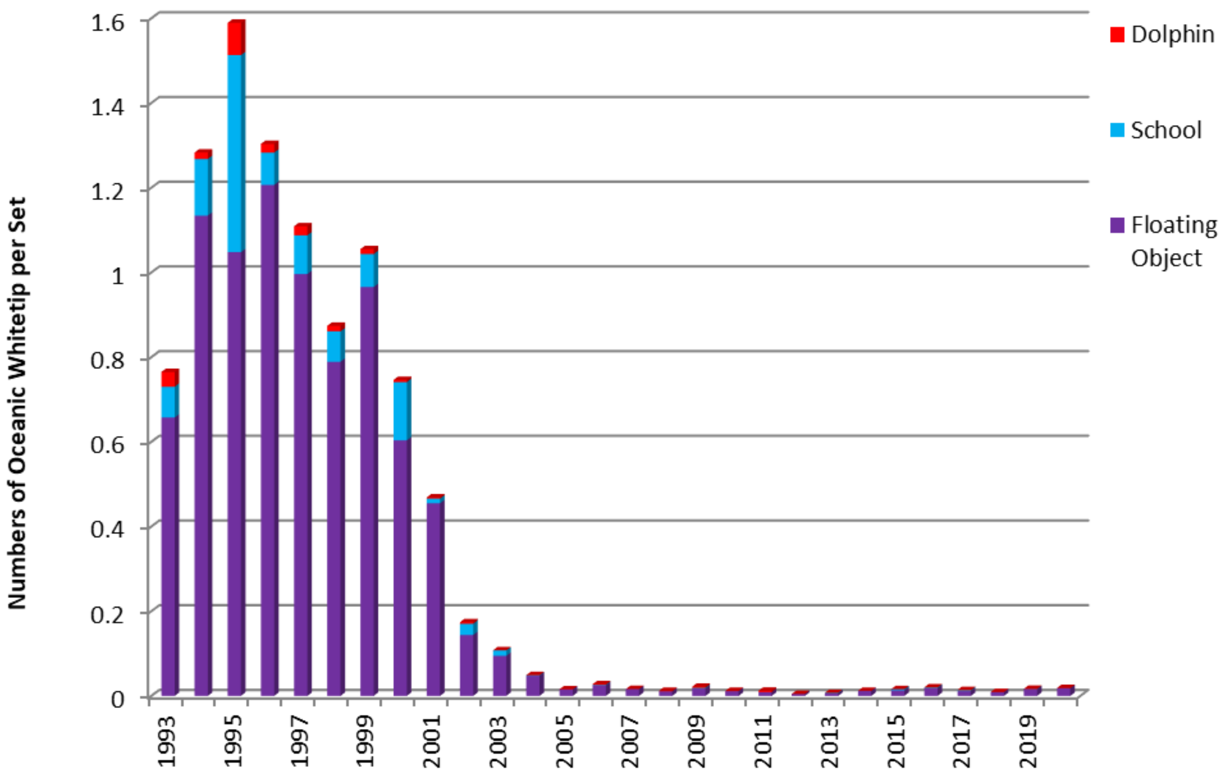

Figure 20. Annual estimated numbers of oceanic whitetip caught per set as bycatch in the tropical tuna purse seine fishery of the Eastern Pacific Ocean. Source: IATTC Observer Database.

Floating object sets are responsible for 90% of oceanic whitetip shark catches. The species' capture probability in floating object purse seine sets has decreased over time from a high of 30% capture rate per set between 1994 and 1998, to less than 5% from 2004 to 2008 (Morgan 2014). Estimated number of sharks caught by set (CPUE) regardless of set type of oceanic whitetip shark peaked in 1995, with approximately 0.52 individuals caught per set. Within 10 years, CPUE dropped dramatically to only 0.005 remaining low through 2020. This is in drastic contrast to catches of the closely related silky shark (*C. falciformis*), with CPUE remaining relatively constant over the same time period. As congeners with similar physiologies that co-occur in similar habitats, this provides some indication that the declines in oceanic whitetip shark catches are not likely the result of environmental factors causing the species to leave the area. As noted previously in the *Regional Population Trends* section of this status review, declines in the nominal CPUE and frequency of occurrence of oceanic whitetip is compatible with a drop of 80–95% from the population levels in the late 1990s (Hall and Román 2013). Further, size trends in this fishery show that small oceanic whitetip sharks, which comprised 21.4% of the oceanic whitetip sharks captured in 1993, have been virtually eliminated from the population, indicating the possibility of recruitment failure in the population (see Figure 20 below). Unfortunately, total annual shark bycatch from 2003 to 2018 indicate captures generally below 100 sharks per year and follows the trend from Hall and Román (2013).

Capture of oceanic whitetip sharks by size interval in the Eastern Pacific Ocean, 1993–2008

	Number				Percent		
Year	Small	Medium	Large	Total	Small	Med	Large
1993	220	494	310	1024	21.4	48.3	30.3
1994	95	1130	1440	2665	3.5	42.4	54.1
1995	408	2984	2149	5541	7.4	53.9	38.8
1996	647	2765	2483	5895	11.0	46.9	42.1
1997	592	2258	2995	5845	10.1	38.6	51.2
1998	452	1862	2683	4997	9.1	37.3	53.7
1999	340	1213	2210	3764	9.0	32.2	58.7
2000	18	547	1426	1991	0.9	27.5	71.6
2001	80	729	1252	2662	3.9	35.4	60.7
2002	15	122	540	677	2.2	18.0	79.8
2003	0	105	266	371	0.0	28.4	71.6
2004	4	38	132	174	2.3	21.8	75.9
2005	1	23	30	54	1.9	42.6	55.6
2006	1	33	48	82	1.2	40.2	58.5
2007	1	18	23	42	2.4	42.9	54.8
2008	0	11	19	30	0.0	36.7	63.3

Figure 21. Capture of oceanic whitetip sharks by size interval in the Eastern Pacific Ocean from 1993-2008. Note: Small < 90 cm; medium 90-150 cm, large >150 cm. Source: Hall and Roman 2013.

During this same period, there was an increase in both the total catch of tunas by purse seiners that employ drifting FADs and the number of FADs deployed (Eddy *et al.* 2016; Hall and Román 2016). Over the past decade, the total number of FADs deployed per year has continued to increase steadily, from about 4,000 in 2005 to almost 15,000 in 2015, which is the highest number of FADs observed (Hall and Román 2016). The total number of sets has also continued increasing, with 2015 being the highest number observed. This indicates that the drastic decline in oceanic whitetip catches was not due to declines in effort in the fishery.

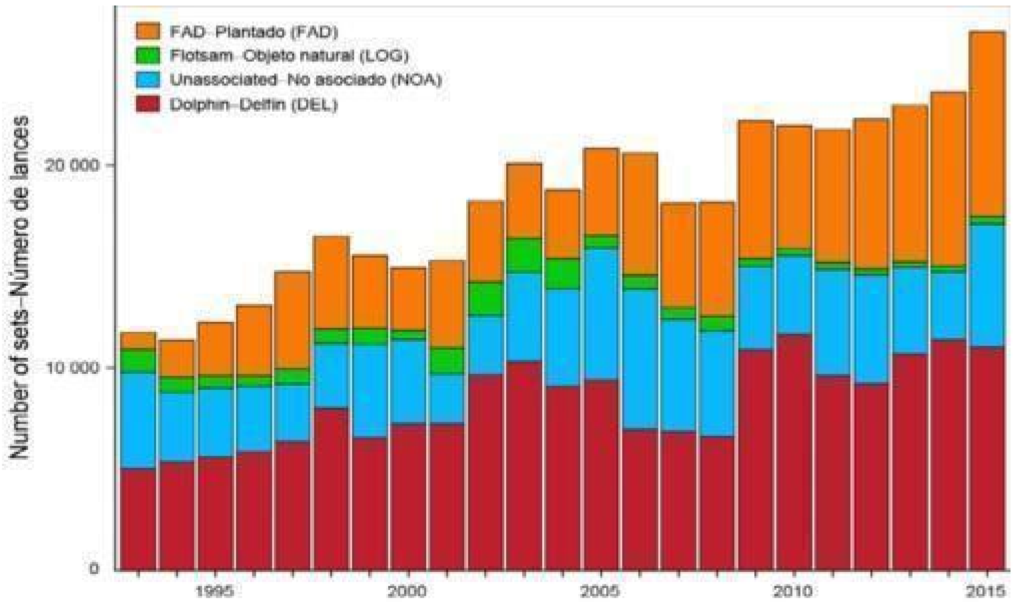

Figure 22. Number of purse seine sets, by type, in the Eastern Pacific Ocean. Source: Hall and Román 2016.

A recent study examining environmental predictors with shark bycatch in the eastern Pacific purse-seine fishery indicates oceanic whitetip shark captures on sets with floating objects are more likely to occur in waters with temperatures lower than 28°C and chlorophyll-a concentrations lower than < 2 (<0.1 mg m^{-3}), in oceanic waters (>1000 km from shore) with depths greater than 4000 m, and where fishing activity on this set type is higher. Spatiotemporal predictions of oceanic whitetip shark catches indicated that higher catches occurred during the boreal spring (Apr-Jun) with higher catches in the Humboldt current (79− 87°W; 10−16°S), along the central Eastern Pacific between 2− 8°N from 105°W to the westernmost of the IATTC management area, north- west to French Polynesia (147°W, 5°S); and along of central eastern Pacific between 2− 8°S from 111 to 135°W (Díaz-Delgado et al. 2021).

Because fishing effort in the EPO continues to increase, fishing pressure and associated mortality of oceanic whitetip sharks is expected to continue. Although mortality rates of oceanic whitetip sharks in purse seine fisheries are not available, it is likely they experience high mortality rates similar to closely related silky sharks, with mortality rates >85% in Western and Central Pacific and Indian Ocean purse seine fisheries (Poisson *et al.* 2014; Hutchinson *et al.* 2015). Although management measures are now in place that prohibit retention of oceanic whitetip sharks in the Eastern Pacific Ocean (IATTC 2011), they will not likely be sufficient to prevent further population declines due to likely high bycatch-related mortality rates in purse seine nets, including post-release mortality (see *Inadequacy of Existing Regulatory Mechanisms* section for more details). Therefore, due to the significant decline in catches and virtual disappearance of oceanic whitetip sharks from purse seine fishing grounds in the EPO, it appears that these declines are likely the result of overutilization of the species.

Oceanic whitetip sharks are also sometimes a significant component of the bycatch in longline fisheries and are likely taken in artisanal fisheries in several countries around the EPO (IATTC 2007). While information regarding catch rates of oceanic whitetip shark in these fisheries is not readily available, some limited information is available from countries party to the IATTC. For example, the oceanic whitetip shark was identified as one of several principal species taken by Mexican fisheries targeting pelagic sharks (Sosa-Nishizaki *et al.* 2008). Farther south in the Eastern Pacific, three countries (Costa Rica, Ecuador and Peru) contribute significantly to shark landings, and are important suppliers of shark fins for the Asian market. In a recent 61-year analysis of Peruvian shark fisheries, Gonzalez-Pestana *et al.* (2014) reported the oceanic whitetip shark in the Peruvian fishery, but provided no additional information on the level of catch. Oceanic whitetip sharks have also been recorded in the catches of the Ecuadorian artisanal fishery. In an analysis of landings from the five principal ports of the Ecuadorian artisanal fishery from 2008-2012, 37.2 mt of oceanic whitetip shark were recorded out of a total 43,492.6 mt of shark catches (Martinez-Ortiz *et al.* 2015). In Costa Rica, only 10 oceanic whitetip sharks were reported by observers in the Costa Rican longline fishery from 1999 to 2010 (Dapp *et al.* 2013). However, according to a recent report, landings data from the Costa Rican Fisheries Institute shows that 2,074 oceanic whitetip shark bodies were landed in 2011 alone in Puntarenas, Costa Rica (Arauz 2017). This provides some evidence that the oceanic whitetip shark is much more prevalent in Costa Rican longline fisheries than the observer data indicates; as such, this fishery may be contributing further to the overutilization of the species in the eastern Pacific. In addition to longline fleets of Eastern Pacific countries, international fishing fleets operate in the region, particularly around Ecuador's EEZ including the Galápagos Marine Reserve, and illegal retention of oceanic whitetip sharks has been documented. For example, in August 2017, the vessel Fu Yuan Yu Leng 999, of Chinese flag, was detained while crossing through the Galápagos Marine Reserve without authorization. This vessel contained 7,639 sharks with oceanic whitetip shark representing 20% of the catch (~1527 sharks) based on genetic analysis (Bonaccorso *et al.* 2021).

Western and Central Pacific Ocean
The Western and Central Pacific Ocean (WCPO) supports the world's largest industrial tuna fishery. In recent years, several quantitative assessments have become available regarding the impact of this level of fishing on shark populations. Fisheries information and catch data for the WCPO are available online from the Western and Central Pacific Fisheries Commission (WCPFC[3]). The WCPFC is the RFMO that manages highly migratory fish stocks in the WCPO. Like other regions, there is a historical lack of shark reporting on logbooks for most fleets in the Pacific, although this has improved in recent years with the implementation of Conservation Management Measures (CMM) that require catches of key shark species to be reported to the Commission. Under CMM 2009-04, members shall include catch information of key shark species in their annual reporting to the Commission, including oceanic whitetip shark. This has since been updated with CMM 2019-04.

Despite the lack of historical data, shark catches in this region can be estimated from observer data and it is clear that the majority of pelagic sharks are captured by longlines (Lawson 2011). Even when sharks are caught as bycatch, survival is often low due to the practice of illegal finning or rough handling during gear retrieval, but with proper handling and removal of trailing gear post-hooking survival rates can be relatively high, exceeding 75% (Hutchinson et al. 2021). Although total shark catch in this region is highly uncertain due to caveats related to under-

[3] See http://www.wcpfc.int/wcpfc-data-catalogue-0 (last visited January 3, 2023).

reporting and non-reporting of sharks and gaps in observer coverage, estimates from observer data indicate that total catches of sharks have averaged approximately 2 million sharks per year since the mid-1990s (Lawson 2011; Clarke *et al.* 2012; Peatman and Nicol 2020). Overall, total effort in the longline fleet has increased from 1995–2013 to the current effort level of approximately 800 million hooks annually; additionally, nearly half this effort occurs in the core tropical habitat area of the oceanic whitetip shark (Rice *et al.* 2015).

Oceanic whitetip sharks commonly interact with longline fisheries throughout the Pacific, with at least 20 member nations of the WCPFC recording the species in their fisheries. In addition to being caught indirectly as bycatch, observer records indicate that some targeting of oceanic whitetip shark has occurred historically in the waters near Papua New Guinea, and given the high value of oceanic whitetip fins and low level of observer coverage, it is likely that targeting has occurred in other areas as well (Rice and Harley 2012). From 2005–2012, estimates of longline observer coverage in Pacific Island countries' tropical EEZs (10°S – 15°N) and sub-tropical EEZs (10°S – 25°S) ranged only from 0–2.4% per year (Clarke 2013), though observer coverage has increased since 2011, and reached 6% in 2018 (Peatman and Nicol 2020). In the United States, longline observer coverage has been 20% for 20+ years. However, longline observer coverage data is lacking for the distant-water fleets of Japan, South Korea, and Chinese Taipei, which comprise a significant proportion of longline effort in the WCPO (SPC 2010).

The WCPFC CMMS also apply to the active tuna purse seine fleet in this region, which has expanded significantly since the 1980s. Available data suggest oceanic whitetip sharks were once frequently encountered by the purse seine fleets (though not as frequently as the longline fishery), with the oceanic whitetip shark being the 2nd most common species of shark caught as bycatch in purse seine fisheries in this region, and representing nearly 11% of the total shark catch (Molony 2007). Since 2009, the required observer coverage in the purse seine fleet has increased to 100% (Clarke 2013); however, it should be noted that although the required observer coverage level is 100%, the actual achieved level of observer coverage is much less (Williams *et al.* 2015). Although the oceanic whitetip shark was historically the 2nd most commonly identified shark in associated sets, this species is now rarely observed (Rice *et al.* 2015).

The previously discussed stock assessment (refer back to section 3.2) of oceanic whitetip shark in the WCPO (which used the same data as discussed previously in Clarke *et al.* 2011a, Clarke *et al*. 2012, and Rice and Harley 2012), analyzed fisheries data from 1995-2016 and determined that the greatest impact on the species is attributed to bycatch from the longline fishery, with impacts from target longline activities and purse-seining being negligible (Tremblay-Boyer *et al.* 2019). Historical catches were reconstructed based on observer catch rates as logbook-reported catches of oceanic whitetip shark were considered unreliable over the assessment period of 1995–2016. Tremblay-Boyer and Neubauer (2019) developed a prediction-model from observer catch rates to apply to known longline and purse-seine effort across the WCPO. Estimated historical catches were developed for the longline bycatch fleet (Figure 23), the longline target fleet and the purse seine fleet split between associated and unassociated sets (Figure 24). The catches by the longline bycatch fleet are estimated to be much higher than those for the longline target fleet and the purse seine fleets. According to the longline bycatch reconstruction, catches increased steadily from 1995 from 140,000 individuals (median) to peak in 2001 at 563,352 individuals and have declined steadily since. Catches declined to 154,600 individuals in 2010 to 7,440 in 2016. For the longline target fleet, catches fluctuated more than for the bycatch fleet. Catches fluctuated from 1,000 individuals in 1995, peaked in 1999 at 4,800 sharks and again in 2010 at 9,000 individuals, which later declined to 100 sharks in 2016, likely because retention of these sharks became illegal in 2013.

Predicted catches for the purse seine fleets were highest early in the time series (Figure 24). In 1996, median catches were 27,600 and 7,500 sharks for associated and unassociated sets, respectively. Catches declined until 2002, but then peaked again at 18,200 animals in 2003 and then declined to 800 animals in 2016 for associated sets. Catches in unassociated sets were much lower, but had a similar pattern with a peak in 2003 of 1,600 sharks in 2003 and then declined to 400 in 2016. These predicted catches were much lower than those estimated in an earlier assessment by Rice (2012), but a different measure of effort was used for this fleet in the most recent assessment (Tremblay-Boyer et al. 2019; Figure 24).

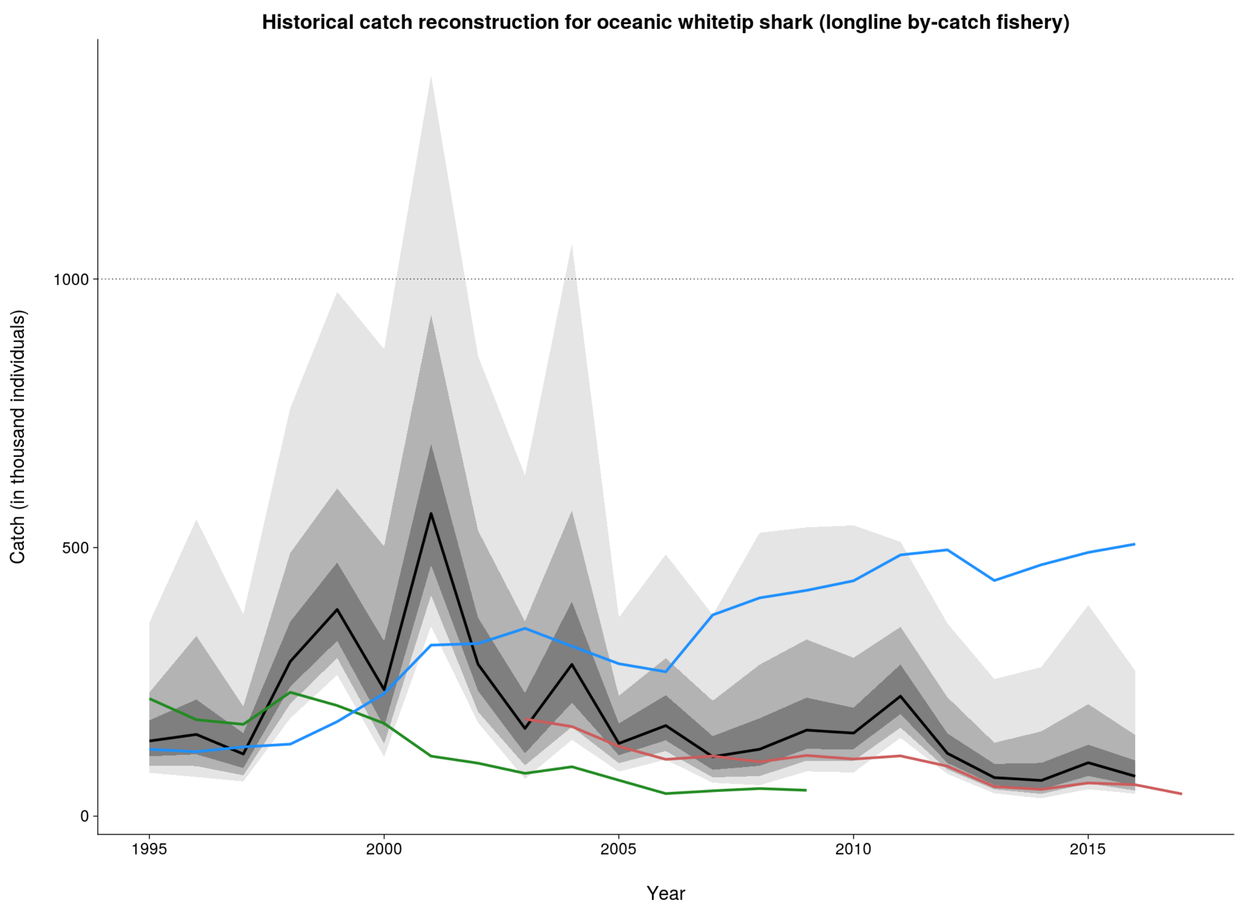

Figure 23. Median predictions of oceanic whitetip shark catch in the WCPO for the longline bycatch fleet based on a model of longline observed catch rates applied to LBEST effort. The light, dark and darker grey bounds show the 0.025th-0.975th, 0.10th-0.90th and 0.25th-0.75th uncertainty bounds. For comparison with the current study's estimates, the blue line shows the median prediction of historical catch based on global fin trade statistics, the red line shows the prediction of historical catch published in (Peatman et al. 2018), and the green line shows the historical catches used for this fleet in the reference case for the 2012 assessment.

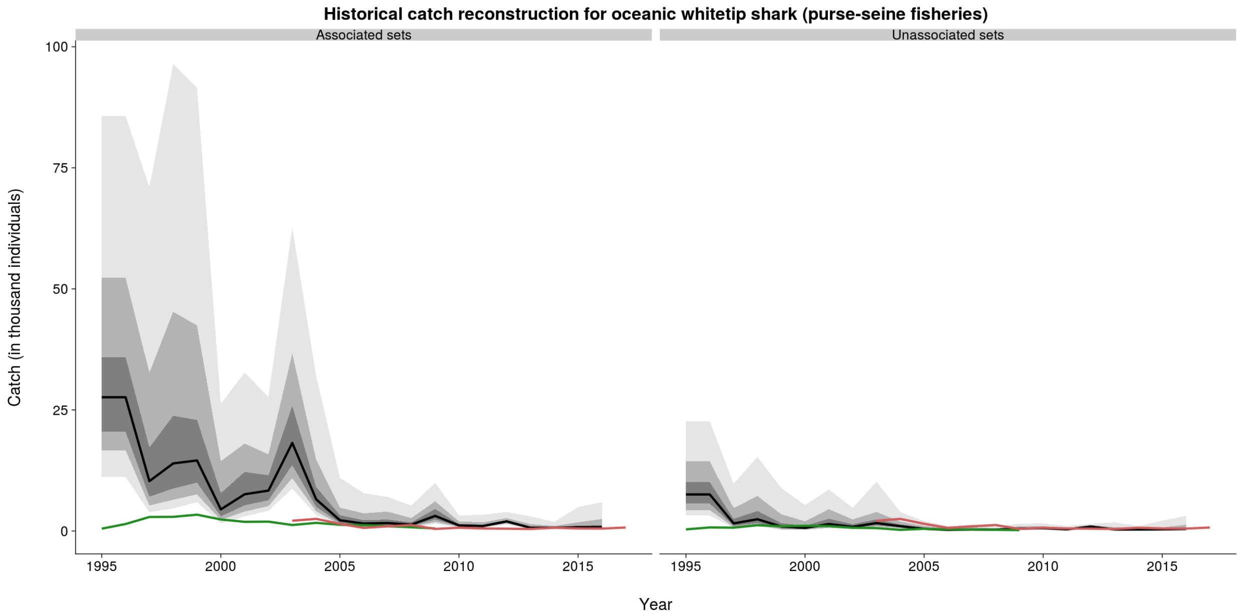

Figure 24. Median predictions of oceanic whitetip shark catch in the WCPO for the associated and unassociated purse-seine fleets based on a model of purse seine observed catch rates applied to SBEST effort. The light, dark and darker grey bounds show the 0.025th-0.975th, 0.10th-0.90th and 0.25th-0.75th uncertainty bounds. Source: Tremblay-Boyer and Neubauer 2019).

Due to continued and increasing fishing pressure in the WCPO, size trends for oceanic whitetip shark have also declined, which is indicative of overutilization of the species. For example, declining median size trends were observed in all regions and sexes in both longline and purse seine fisheries until samples became too scarce for analysis in the study. These size trends were significant for females in the longline and purse seine fisheries within the species' core tropical habitat areas (Clarke *et al.* 2011a). This is particularly concerning due to the potential correlation between maternal length and litter size, which has been documented in the Atlantic and Indian Oceans (Bass *et al.* 1973; Lessa *et al.* 1999; Bonfil *et al.* 2008; Varghese *et al.* 2016). While Rice *et al*. (2015) more recently report that trends in oceanic whitetip median length are stable, the majority of sharks observed are immature. Likewise, from 2000–2009, 100% of oceanic whitetips sampled in purse seine fisheries were immature (Clarke *et al.* 2012).

In the U.S. Pacific, the oceanic whitetip shark was historically a common bycatch species in the Hawaii-based pelagic longline (PLL) fisheries and comprised approximately 3% of the total shark catch from 1995–2006 (Brodziak *et al.* 2013). An observer program for the Hawaii-based PLL was initiated in 1994, with an observer coverage rate ranging between 3% and 10% from 1994–2000, and increased to a minimum of 20% in 2001. The deep-set fishery targeting tuna is currently observed at a minimum of 20% and the shallow-set fishery targeting swordfish has 100% observer coverage. The Hawaii-based PLL fishery is a limited entry fishery with a maximum of 164 permits available. Current participation is about 145 vessels, which target a range of pelagic species.

Brodziak *et al*. (2013) concluded that the relative abundance of oceanic whitetip sharks (discussed previously in the *Regional Abundance Trends* section) declined within a few years of the expansion of the longline fishery, which suggests these fisheries are contributing to the commercial overutilization of oceanic whitetip sharks within this portion of its range, although retention of oceanic whitetip sharks in these fisheries has been prohibited since 2011. It should be noted that the majority of oceanic whitetip sharks are now released alive in this fishery, with the number of individuals kept exhibiting a declining trend until 2011, after which retention was prohibited. Based on fishery logbook data, a total of 701 oceanic whitetip sharks were caught in 2014 and 100% were released. In addition, the U.S. National Bycatch Report First Edition Update 2[4] estimated the weight of species caught by the Hawaii-based commercial longline fisheries. These data show that from 2011 to 2013, the shallow-set fishery released an estimated 91–96% of all oceanic whitetip sharks caught alive. During the same time period, the deep-set fishery released an estimated 78-82% of all oceanic whitetip sharks caught alive. However, it is unknown how many of these sharks survived after being released.

Hutchinson et al. (2021) show post-release survival rates are high (85%) up to 30 days post-release for sharks if they are in good condition at release and if trailing gear is minimized. The amount of trailing gear left on an animal has a negative effect on post release survival potential. Because most sharks are released by cutting the line, making recommendations to remove as much trailing gear as possible will enhance post release survival rates. In the WCPFC, no-retention measures for oceanic whitetip sharks may have the intended effect of reducing mortality if the measure included recommendations to reduce the amount of trailing gear left on animals to less than 2.5 m.

Oceanic whitetip sharks are also caught as bycatch in the American Samoa longline fishery. The American Samoa longline fishery targets albacore tuna and is managed under the Pacific Pelagic Fishery Ecosystem Plan (FEP). This fishery has had an observer program since 2006, with coverage ranging between 6–8% from 2006–2009, and between 19–33% since 2010. While landings of sharks in general have declined in American Samoa, this trend is largely attributed to regulations pertaining to shark finning (e.g., the Shark Finning Prohibition Act) (NMFS 2011).

Recently, wire leaders were prohibited in Hawaii deep-set longline fisheries in an effort to reduce mortality rates for hooked oceanic whitetip shark. This rule was developed after longline fishermen voluntarily stopped using wire in favor of monofilament nylon leaders. This regulation is anticipated to reduce mortality rates of hooked oceanic whitetip sharks by about 30% (Bigelow and Carvalho 2021). In addition, new regulations require the removal of trailing gear in all FEP longline fisheries, including the American Samoa, Hawaii deep-set, and Hawaii shallow-set longline fisheries.

Australia

While oceanic whitetip sharks are known to be taken from Australian waters and are known bycatch in two major pelagic tuna fisheries (the Eastern and Western Tuna and Billfish fisheries - ETBF and WTBF), oceanic whitetip sharks are caught in low numbers (Australian Fisheries Management Authority 2010, 2015) and have little commercial value in Australia (Bray 2017). The ETBF operates from the eastern part of the Australian Fishing Zone (AFZ) from the tip of Cape York (142º31’49”E) to the South Australian/Victorian border (141ºE). It includes

[4] https://www.st.nmfs.noaa.gov/observer-home/first-edition-update-2

Commonwealth waters off Queensland, New South Wales, Victoria and Tasmania out to the 200 nmi limit of the AFZ and includes waters around Norfolk Island. The ETBF consists of three main fishing methods (longlining, poling and minor line), of which the most common method is pelagic longlining. A 2009 Shark Assessment Report shows that the oceanic whitetip shark is a bycatch species in the Eastern ETBF, with estimated discard rates of up to 77% (Bensley *et al.* 2010), although no other information was provided. In 2007, an Ecological Risk Assessment (ERA) was conducted for the oceanic whitetip shark in the ETBF. In the ERA, average annual logbook catch of oceanic whitetip sharks was 17,199 kg (17.2 mt) from 2001–2004. The ERA used typical productivity and sensitivity attributes to derive an overall vulnerability score and risk category to overfishing. In this study, the oceanic whitetip shark received a vulnerability score of 2.95 (range for all scores = 1.41 to 4.24) and an overall medium risk ranking to overfishing (Webb *et al.* 2007). For reference, a medium risk ranking means that overfishing is occurring but the population can be sustainable. In general, catches of oceanic whitetip sharks in Australia have seen a decline from over 25 t in 2002 to less than 5 t in 2012 (Figure 24 below).

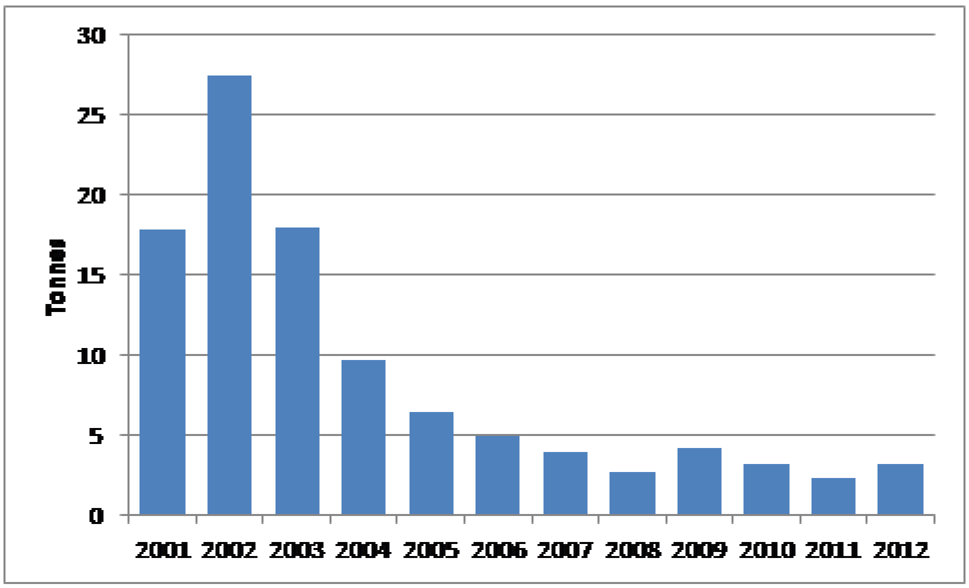

Figure 25. Annual catches (t) of oceanic whitetip shark in Australia from 2001 to 2012. Source: Koopman and Knuckey 2014.

However, this decline in catch has been largely attributed to the implementation of stricter management and regulations (e.g., ban on wire traces, trip/trigger limits, ban on shark finning, carriage of line cutters) and a decrease in effort in both the ETBF and WTBF (Koopman and Knuckey 2014). In accordance with conservation and management measures agreed by the WCPFC and IOTC, retention of oceanic whitetip shark is prohibited in the Commonwealth ETBF and WTBF, the two fisheries most likely to encounter the oceanic whitetip shark (Australia Department of the Environment 2014). Although small numbers of oceanic whitetip sharks are possibly caught in state-managed fisheries operating far offshore, the total Australian catch of oceanic whitetip sharks is estimated to be less than 5 t per year (Koopman and Knuckey 2014). There is also reported take due to illegal, unreported, and unregulated (IUU) fishing in Australian waters, with the oceanic whitetip shark comprising an estimated 5.9% (in numbers, 3.6% in biomass) of the catch by foreign IUU operations (Simpfendorfer 2014). The estimated take by Indonesian based IUU operators in 2006 was about 700 t, and has declined since. As such, current catches in IUU fisheries are probably minimal in Australian waters (Simpfendorfer 2014).

New Zealand
Oceanic whitetip sharks are rarely caught in fisheries operating in New Zealand waters. In a government study aimed at documenting and describing oceanic whitetip shark interactions with commercial fisheries, only 19 observer and two commercial fishery records were located (one of which occurred in both datasets) from 2008–2014. All records came from surface longlines set in the Kermadec Fisheries Management Area (FMA) or off the northeastern coast of the North Island (Francis and Lyon 2014). Catches of oceanic whitetip shark around the North occurred in warmer months of the year whereas catches in the Kermadec FMA occurred primarily in cooler months. Most (84%) of the observed sharks were alive when hauled to the vessel; approximately half were processed in some way with the remainder being discarded. Although few of the observed sharks were sexed or measured (n=10), there was an equal number of males and females, with fork lengths ranging between 158 and 190 cm. Given the low commercial reporting rate (only 1 out of 19 observed sharks are actually reported) and the low observer coverage of domestic surface longliners (< 9% up to 2009–2010), Francis and Lyon (2014) estimate that the actual interaction of the surface longline fisheries with oceanic whitetip sharks is substantially underestimated. Nevertheless, the study concluded that oceanic whitetip sharks are not frequently caught in New Zealand, and are therefore not regarded as a high priority species for research or management (Francis and Lyon 2014).

Pacific Island Countries and Territories
Approximately 25% and 45% of longline and purse seine catches, respectively, that occur in the WCPFC Convention Area are taken in the Pacific Islands Countries and Territories (PICT). Observer data for longline fisheries in the PICTs reveal that the 12 highest risk shark species, including oceanic whitetip, comprise less than 15% of the observed shark catch (Lack and Meere 2009). According to a 2009 Regional Shark Assessment, oceanic whitetip sharks have been observed in longline and purse seine fisheries within PICT waters, with oceanic whitetip sharks comprising 6% of the total shark catch in both fisheries (Lack and Meere 2009). In the Pacific Islands Regional Plan of Action for sharks, the oceanic whitetip shark consistently ranked in the top ten shark species identified by observers in PICT longline fisheries, including the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu (Lack and Meere 2009). At the time of the assessment, oceanic whitetip sharks experienced various finning and discard rates throughout PICT waters, ranging from 51% and 68% in the tropical shallow and deep longline fisheries, respectively, to 76% in the tropical albacore fishery (Lack and Meere 2009). It should be noted that this study is several years old and may not represent the current situation. Additionally, data from these fleets were incorporated into the previously discussed stock assessment for the oceanic whitetip shark (Tremblay-Boyer et al. 2019).

In the Republic of the Marshall Islands (RMI), average annual catches of sharks are estimated to be between 1,583 and 2,274 mt. The oceanic whitetip shark is one of only five species that comprises 80% of the total annual shark catch in the RMI. In an analysis of aggregated observer data from RMI and Chinese fleets from 2005–2009, Bromhead *et al.* (2012) report a CPUE rate (fish/1000 hooks) for the oceanic whitetip shark of 0.2904 in RMI longline fisheries. However, 97.4% of oceanic whitetip sharks caught in these fisheries were finned and discarded. The RMI prohibited all shark take in late 2011; therefore, the Bromhead *et al.* (2012) study may not be representative of the current situation.

Based on observer data in the shark longline fishery in Papua New Guinea from May and June 2014, oceanic whitetip sharks represent only 1.0% of the total catch. Most catches occurred in the Solomon Sea and Bismarck Archipelago. This fishery unexpectedly closed in July 2014, and it is currently unknown if this fishery will reopen in the future (White *et al.* 2020).

Oceanic whitetip sharks are also caught as bycatch in the Fijian longline fishery. According to data provided by the Fiji Department of Fisheries, which includes longline sets targeting both tunas and sharks, for the period 2011–2012, 17 oceanic whitetip sharks were captured and discarded after finning (Piovano and Gilman 2016). In 2013, 62 oceanic whitetip sharks were captured, of which 13% were retained, 60% were discarded after finning, 8% were discarded dead and 19% were released alive. Of the 30 oceanic whitetip sharks captured in 2014, 7% were retained, 3% were discarded after finning, 27% were discarded dead and 63% released alive (Piovano and Gilman 2016). This indicates that Fiji did not immediately implement the WCPFC no-retention rule for oceanic whitetip sharks.

Taiwan

Taiwan's fleet has the 4th largest shark catch in the world, with a declared 6 million sharks caught annually, accounting for almost 6% of the global figures. However, these numbers could be greatly underestimated (Liu *et al*. 2013). Although the oceanic whitetip shark is considered to be one of the dominant shark species in Taiwanese landings, it only comprises an average of 0.38% of the sharks landed. Between 1996 and 2006, annual Taiwanese shark landings (coastal, offshore, and pelagic combined) averaged between 39,000 and 55,000 mt. A genetic barcoding study was conducted in 2013 on shark meats from various Taiwan fish markets to determine which species may be vulnerable to high rates of utilization. Amongst the 548 tissue samples collected and sequenced, approximately 80% of the species composition was dominated by four species (*A. pelagicus*, *C. falciformis*, *Isurus oxyrinchus*, and *P. glauca*) indicating that these species might be heavily consumed in Taiwan. Oceanic whitetip sharks were also identified in the shark meat samples, although they comprised a very small percentage of the samples at 0.016% (Liu *et al.* 2013).

<u>Western and Central Pacific Summary</u>

Based on the best available historical and current information, it appears that the once ubiquitous oceanic whitetip shark has experienced significant and ongoing declines in the Western and Central Pacific Ocean because of unsustainable fishing mortality in both longline and purse seine fisheries operating in the species' core tropical habitat area. Numerous lines of evidence, including a recent stock assessment report and other analyses of species-specific fisheries data, indicate that oceanic whitetip shark abundance has declined across the region, with declines in excess of 90% in some areas, and declining trends in overall biomass and size indices as well. Similar results between analyses of observer data from the Western and Central Pacific SPC observer data and the observer data from the Hawaii-based pelagic longline fishery suggest that the population decline of oceanic whitetip in this portion of its range is not just a localized trend, but rather a Pacific-wide phenomenon. The significant declining trends observed in all available abundance indices (*e.g.,* standardized CPUE, biomass and median size) of oceanic whitetip sharks as a result of fishing mortality in both longline and purse seine fisheries indicate that overutilization of the species is occurring throughout the Western and Central Pacific. Given the impacts to the species from significant fishing pressure in this portion of the species' range, with the majority of effort concentrated in the species' core tropical habitat area, and the species' relatively low-moderate productivity, we conclude that the oceanic whitetip shark is experiencing overutilization in this portion of its range.

Atlantic Ocean

International fisheries information and catch data for the Atlantic are available from ICCAT. ICCAT is the RFMO responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas. Reported catches of oceanic whitetip sharks from ICCAT vessels in the Atlantic are shown below in Figures 26 and 27 (Figure 26 is the same as Figure 25 minus data from Brazil to show the differing scales). Oceanic whitetip sharks are taken in the ICCAT convention area by longlines, purse seine nets, gillnets, trawls, and handlines; however, the large majority of the catch from 1990-2014 was caught by longline gear.

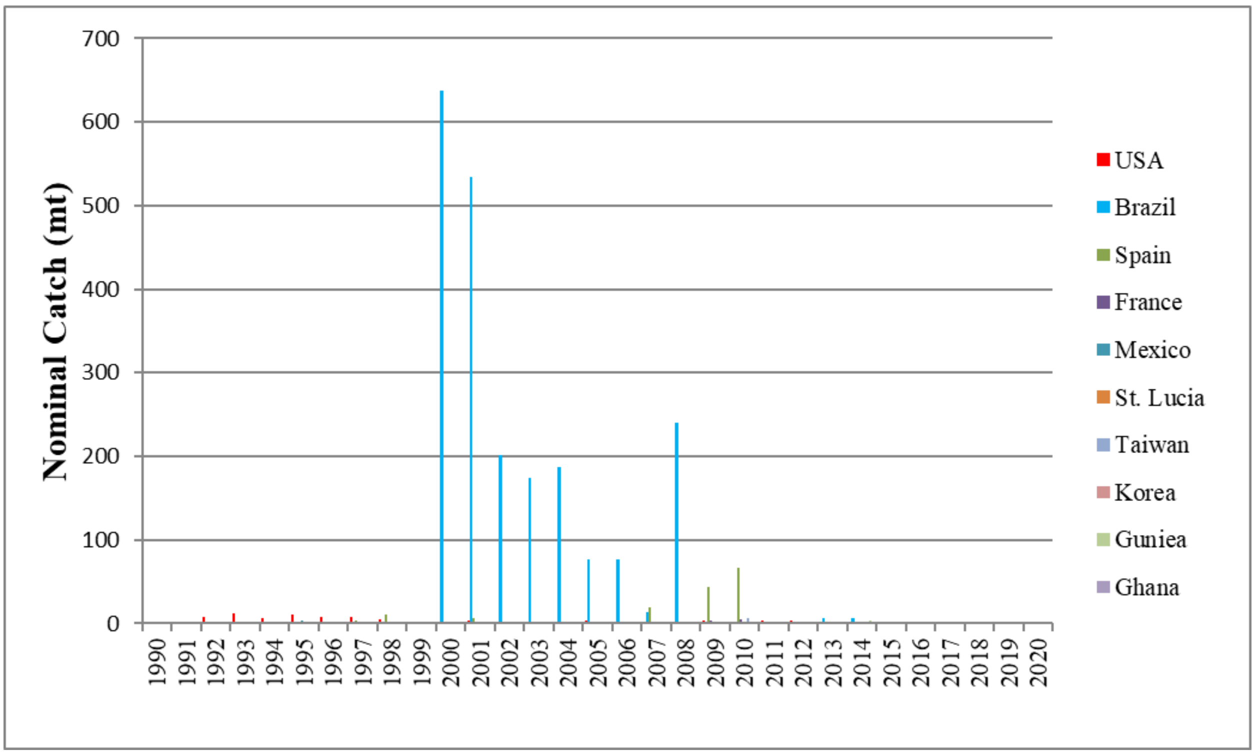

Figure 26. Nominal catches (mt) of oceanic whitetip shark reported to ICCAT by CPC vessel flag from 1990-2014. Source: ICCAT nominal catch information: Task I web-based application; accessed January 2022.

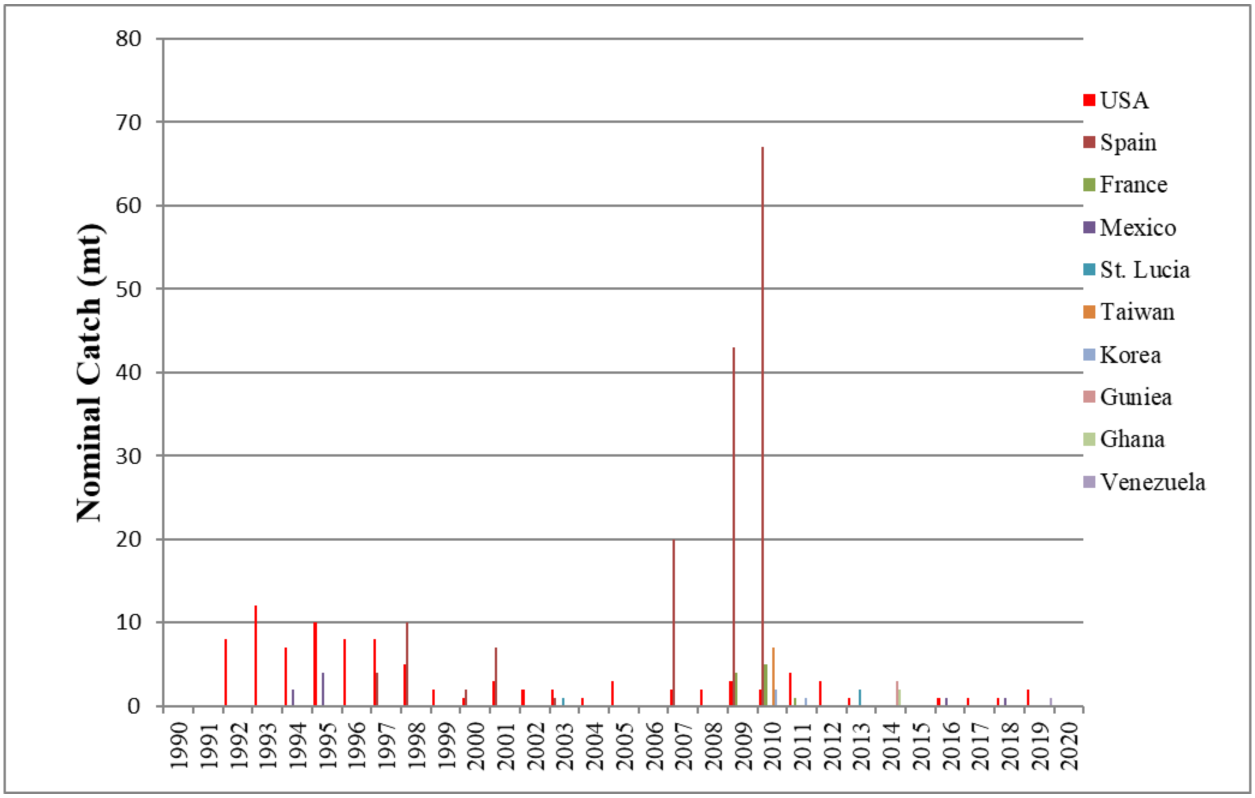

Figure 27. Nominal catches (mt) of oceanic whitetip shark reported to ICCAT by CPC vessel flag (except Brazil) from 1990-2014. Source: ICCAT nominal catch information: Task I web-based application; accessed January 2022.

In total, approximately 2,430 mt of oceanic whitetip shark catches were reported to ICCAT from 1990-2014, with approximately 89% of the total catch (n = 2,153 mt) caught by the Brazilian fleet. While catches reported to ICCAT by some countries (e.g., Spain) declined after the implementation of Recommendation 10-07 (which prohibits the retention of oceanic whitetip shark in ICCAT fisheries), significant declines in Brazil's catches occurred prior to Recommendation 10-07 (see South Atlantic section below for more details), and the species is still caught as bycatch. In fact, ICCAT vessels reported catching a total of 29 mt of oceanic whitetip sharks for years 2011–2014, which is after the prohibition was implemented. Since 2014, Only 6 countries reported catching oceanic whitetip shark landings to ICCATs in 2014 (Brazil, Guinea, and Ghana, Mexico, United States, and Venezuela).

Northwest and Western Central Atlantic and Gulf of Mexico

As in the Pacific, the oceanic whitetip shark was once described as the most common pelagic shark throughout the warm-temperate and tropical waters in the Atlantic and beyond the continental shelf in the Gulf of Mexico. The species is caught incidentally as bycatch by a number of fisheries, including the U.S. pelagic longline (PLL) fishery, Cuban longline fishery, Mexican longline, and has been recently recorded in the oceanic industrial longline fishery in the Colombian Caribbean (CITES 2013). An ERA conducted by ICCAT's Standing Committee on Research and Statistics (SCRS) for shark and ray species typically taken in Atlantic pelagic longline fisheries in 2012, found the oceanic whitetip shark to be a moderately productive species that shows varying levels of susceptibility to the combined pelagic longline fisheries in the Atlantic Ocean, ranking 8th most vulnerable out of 20 stocks of pelagic sharks (Cortés *et al.* 2012). In contrast, another recent study determined that oceanic whitetip sharks have relatively low vulnerability to Atlantic fisheries. Gallagher *et al.* (2014) found the oceanic whitetip shark to be one of the least vulnerable species to longline bycatch mortality, as a result of the species' "combined relatively high fecundity and productivity, moderate age of maturity ranking, and high mean survival rate when caught" (i.e., 77.3%; Gallagher *et al*. 2014). However, it should be noted that the age at maturity used in this study was based on a combination of estimates from the Atlantic and Pacific (i.e., 5.5 years) and was prior to the new estimate from the Pacific of approximately 9 years. Additionally, the high rate of mean survival noted in Gallagher *et al* (2014) refers to the immediate at-haulback mortality and does not account for unknown post-release mortality rates. Thus, the relative vulnerability of oceanic whitetip shark to Atlantic longline fisheries is somewhat unclear. While the oceanic whitetip shark's life history does not make it as vulnerable as other shark species, the species' susceptibility to capture in longline fisheries is likely the main reason for its increased vulnerability overall.

In the United States, oceanic whitetip sharks were caught historically as bycatch in PLL fisheries targeting tuna and swordfish in this region. Pelagic longlining for Atlantic highly migratory species (HMS) began on the U.S. East Coast and Atlantic Canada in the early 1960s, with this gear primarily used to target swordfish, yellowfin tuna, and bigeye tuna in various areas and seasons (Beerkircher *et al.* 2006). Secondary target species included dolphin fish, albacore tuna, and to a lesser degree, sharks. With the current restrictions on the use of the gear, sharks are rarely landed (NMFS 2021).

Relative to target species, oceanic whitetip sharks are caught infrequently and only incidentally on PLL vessels fishing for tuna and tuna-like species. Landings and dead discards of sharks by U.S. PLL fishers in the Atlantic are monitored every year and reported to ICCAT.

Table 3. U.S. commercial landings of Atlantic oceanic whitetip sharks (lbs, dressed weight) from 2003-2018. Source: NMFS 2019.

Year	Landings (lbs, dressed weight)
2003	2,559
2004	1,082
2005	713
2006	354
2007	787
2008	1,899
2009	933
2010	769
2011	2,435
2012	258
2013	62
2014	22
2015	0
2016	0
2017	0
2018	0

*Consistent with ICCAT Recommendation 10-07, retention of oceanic whitetip sharks was prohibited for U.S. Atlantic fishermen with pelagic longline gear onboard as of 2011.

Commercial landings of oceanic whitetip sharks in the U.S. Atlantic has been variable, but averaged approximately 1137 lbs per year from 2003-2010, prior to being prohibited. Consistent with ICCAT, in 2011 the United States prohibited the landing or retention of oceanic whitetip sharks caught in association with ICCAT fisheries, including the U.S. pelagic longline fishery. The species, however, can still be caught as bycatch, caught with other gears, and are occasionally landed by fishermen with those other gears. Since the ICCAT retention prohibition was implemented in 2011, estimated commercial landings of oceanic whitetip shark declined from 1.1 mt in 2011 to only 0.03 mt in 2013 (NMFS 2012; 2014). Since 2015, there have been no reported commercial or recreational landings of oceanic whitetip shark (Table 2; NMFS 2021). While there have been no landings of oceanic whitetip sharks since 2015, there are still levels of bycatch and discards in the pelagic longline fishery that result in mortality. Total estimated interactions averaged 453 animals with dead discards averaging about 93 animals (Table 4 below).

Table 4. Oceanic Whitetip Shark Estimated Take and Mortalities (on retrieval, not accounting for post-release mortality) in the HMS PLL Fishery 2005–2018 (Southeast Fisheries Science Center [SEFSC] data). (Note that 2014 and 2016 had estimates for unknown disposition, as follows: 2014: 2.4282; 2017: 2.5279. To be conservative, those were added in as "dead" in the table below. The coefficients of variation (CVs) for 2014 and 2017 dead are based on numbers before adding in the estimates with unknown dispositions.)

Year	Estimated Alive on Retrieval	CV for Alive	Estimated Dead on Retrieval	CV for Dead	Estimated Total Interactions
2005	484.0	0.228	155.0	0.368	**639.0**
2006	229.6	0.265	29.6	0.580	**259.2**
2007	133.1	0.236	53.6	0.434	**186.7**
2008	283.3	0.203	21.0	0.533	**304.3**
2009	297.8	0.187	121.8	0.271	**419.6**
2010	234.8	0.338	60.3	0.402	**295.1**
2011	178.4	0.293	63.5	0.517	**241.9**
2012	364.8	0.206	70.8	0.391	**435.6**
2013	449.9	0.244	87.9	0.448	**537.8**
2014	384.6	0.192	120.9	0.378	**505.5**
2015	332.4	0.193	113.4	0.335	**445.8**

Year	Estimated Alive on Retrieval	CV for Alive	Estimated Dead on Retrieval	CV for Dead	Estimated Total Interactions
2016	426.6	0.151	129.2	0.243	**555.8**
2017	871.4	0.125	171.4	0.444	**1042.8**
2018	382.8	0.164	101.6	0.284	**484.4**
Average	**361.0**		**92.9**		**453.9**

Cuba

According to data from the 1960s, the oceanic whitetip shark once represented the highest percentage of shark catches in northwestern Cuba by weight (25.4%; Guitart 1975 cited in Cuba Department of Fisheries, 2016). Overall, shark catches in Cuba increased until 1981 and have been variable since. Since 1985, a substantial decline was observed in some species, including the oceanic whitetip shark. Variations in fishing effort and changes in the fishery make it difficult to assess the current status of sharks in Cuba, but since 1981 there has been a tendency towards decline (Claro *et al.* 2001). More recently, Cuba's Department of Fisheries, Fisheries Research Center, determined that the percentage of landings of oceanic whitetip shark relative to that of other shark species has declined from 1963 to 2011 in the northwestern region of Cuba. In a study conducted on the private commercial fishing base of Cojimar during the winter (October-March) between 2008 and 2010, a single oceanic whitetip shark was observed in the samples, which represented 2% of the shark landings with drift longline at night (Cuba Department of Fisheries 2016). In another study on the same base, oceanic whitetip shark landings accounted for 5% of landings of sharks with drift longline with two sampled individuals from October 2010 to May 2011. However, Aguilar *et al.* (2014) states that a direct comparison between the two time periods cannot be made with respect to the relative order of abundance. In the historical reports, relative abundance is given by weight (kg) of landings whereas more recent monitoring results refer to number of individuals. Aguilar *et al*. (2014) also concluded that it is difficult to make a comparative analysis of the shark fishery in these two periods, because the economic crisis in Cuba has had an impact on fishing activity that cannot be adequately measured, and thus it is unknown whether and to what extent fishing effort has declined over time. For these reasons, the available information at this time does not allow for a definitive determination as to why shark catches are currently lower than what was historically reported (Aguilar *et al*. 2014).

In contrast, Valdés *et al.* (2016) show a stable catch trend for the oceanic whitetip shark in Cuban fishery landings along the northwestern coast from 2010 to 2016. The authors noted that their findings are consistent with Guitart (1975) who, as previously noted, reported the oceanic whitetip shark as the most abundant species in Northwest Cuba landings in the 1960s. However, the authors noted that the fishery-dependent results are preliminary and should be interpreted with caution. Nonetheless, when sharks are caught in the fishery, they are never discarded but rather utilized for either human consumption or bait. Additionally, in all the aforementioned studies, the majority of oceanic whitetip sharks caught have been juveniles. Valdez *et al*. (2016) concluded that: "the prevalence of small, immature individuals suggests the possibility of an important nursery area for this species in the northwestern Atlantic region. Because these animals are small and of less value to the fishermen, they are typically using the juvenile *C. longimanus* as bait while at sea, a practice which may be in conflict with sustainable fisheries management and conservation objectives."

A recent monitoring study of the longline fleet based in Cojímar, Cuba from 2011–2019 found oceanic whitetip shark was one of the most abundant shark species caught. Catch abundance showed seasonal differences with oceanic whitetip sharks more common in summer and autumn. By year, catches increased to 2016 but had an abrupt decline in 2017, increased in 2018, then sharply declined again in 2019. There was a predominance of young oceanic whitetip sharks in the catches suggesting the importance of the area as juvenile habitat, possibly as a pupping or nursery area (Ruiz-Abierno *et al.* 2021). Given the foregoing information, it is unclear whether the oceanic whitetip shark has declined significantly in Cuban waters; however, the ongoing retention and utilization of immature individuals as bait is concerning and may be contributing to overutilization of the species.

Elsewhere across the region, the oceanic whitetip shark comprises a very small percentage of catches in various fisheries. For example, in the Venezuelan pelagic longline fishery, the oceanic whitetip shark is caught as bycatch in low numbers. Based on observer data from 1994–2000, only 28 individuals were caught, representing 1.5% of the total shark catch. On average, the size of individuals caught was 125.0 cm fork length (FL) (Arocha *et al.* 2002), which is well below the size of maturity estimated for this region (i.e., 180–190 cm).

Northwest and Central Atlantic Summary

Recent data from the U.S. PLL fishery indicate that landings of oceanic whitetip shark have declined over time and are currently low, particularly since regulations were implemented that prohibit retention of the species in ICCAT associated fisheries in 2011. Whether overutilization is occurring in other fisheries of the Northwest Atlantic (e.g., Cuba) is uncertain at this time, though the reported practice of using small immature individuals as bait is concerning. Given that the oceanic whitetip shark appears to have a relatively high at-vessel survivorship rate in Northwest Atlantic longline fisheries, recent management measures, including the retention prohibition by the United States and ICCAT, may confer conservation benefits to the population in this area to some degree. However, given that post-release mortality rates for oceanic whitetip sharks are still unknown, we recognize that the efficacy of these prohibitions is still largely unclear and overutilization may still be a threat to the species.

South Atlantic

Fishing effort has been high in the southern Atlantic Ocean, intensifying after the 1990s (Camhi *et al.* 2008). However, most of the information on the effect of fishing on large pelagic sharks comes from the North Atlantic Ocean, while data analyses from the South Atlantic Ocean are patchy and typically pertain only to the most abundant species (Barreto *et al.* 2015). The oceanic whitetip shark is caught as bycatch in a number of fisheries in the South Atlantic, including Brazilian, Uruguayan, Taiwanese, Japanese, Venezuelan, Spanish, French and Portuguese longline and purse seine fisheries; however, the largest oceanic whitetip shark catching country in this region is Brazil and recent information indicates that the oceanic whitetip shark may be experiencing overutilization in this part of its range because of unsustainable fishing mortality.

In a study that synthesized information on shark catch rates (based on 871,177 sharks caught on 86,492 longline sets) for the major species caught by multiple fleets in the South Atlantic between 1979 and 2011, generalized linear models were used to standardize catch rates and identify trends in three identified fishing phases: a first phase (1979–1997), characterized by a few fleets mainly fishing for tunas; a second phase (1998–2007), where many fleets were fishing for tunas, swordfishes and sharks; and a third phase (2008–2011), where fewer fleets were fishing for multiple species and restrictive measures were being implemented (Barreto *et al.* 2015). In total, 3,288 oceanic whitetip sharks were reported during the time period. Overall results indicate that most shark populations in the South Atlantic are currently depleted, but can recover where fishing effort is reduced accordingly (Barreto *et al.* 2015). More specifically, results indicate that catch rates for most of the species analyzed, including the oceanic whitetip shark, have declined precipitously from considerable fishing pressure and the absence of regulatory measures to control fishing effort, particularly in phase B. These declines coincided with significant increases in fishing effort, inadequate regulations to deal with issues such as shark bycatch, finning and directed fishing for sharks by some fleets. Considering the percentage rate of change between the last year of phase A in relation to the last year of the phase B, the authors determined that that with exception of *P. glauca* and *A. superciliosus*, catch rates of all species, including oceanic whitetip shark, have declined by more than 85% (Barreto *et al.* 2015). In Phase C (2008-2011), when the presence of onboard observers became mandatory, catch rates of oceanic whitetip shark declined by 14%, but overall conclusions regarding the status of the oceanic whitetip shark were inconclusive. Figure 28 below shows trends in standardized catch rates for oceanic whitetip sharks for each of the three phases.

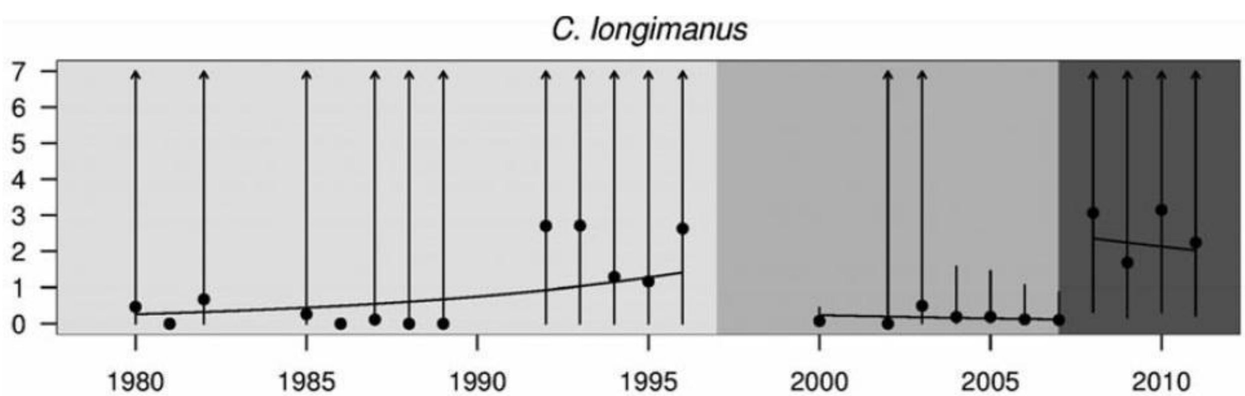

Figure 28. Trends in standardized catch rates of oceanic whitetip sharks (estimated from generalized linear models with a zero truncated negative binomial distribution) in 3 fishing phases (shadings); solid lines, overall trends with year as continuous variable; dots, individual year estimates with year as factor; vertical lines, 95% confidence interval (CI); arrows, CIs larger than the y-axis scale in a particular year. Source: Barreto et al. 2015.

Reviewers had some serious concerns regarding the methodologies of the Barreto *et al.* (2015) study, and pointed out several caveats and limitations, including the use of year as a continuous variable and the stripping out of all zero catches. Confidence intervals are extremely high and overlapped in most cases, raising the possibility that the trends may be "noise" rather than truly tracking abundance. Given these caveats and limitations, confidence in the results of this study is low.

Oceanic whitetip sharks are caught infrequently in the Uruguayan longline fishery, and an analysis of observer data established 3 fishing zones for oceanic whitetip sharks based on catches and relative abundance: Zone 1: Western South Atlantic and southern Brazil; 2: International waters on the Chain of Montes Vitoria- Trindade near the Bank Davis; Zone 3: east Atlantic in the Gulf of Guinea. In total, only 63 oceanic whitetip sharks were caught on 2,279,169 hooks and 63% were juveniles (see Figure 28 below; Domingo et al. 2007). Average length and CPUE values were also analyzed in these areas. The lowest values of average size were observed in Zone 2, which is also where the highest values of CPUE were observed (followed by zone 3 and 1, respectively). CPUE values decrease with increasing median size. The differences in median sizes, from 145 cm FL in Zone 1 (temperate SW) to <100 cm FL in other more tropical and sub-tropical areas could support the idea of spatial patterns and size distribution of the species; alternatively, this could also be a result of differing levels of historical fishing pressure in these regions. For example, while Domingo et al. (2007) recorded a CPUE of 0.098 in Zone 3 and only 10 individuals caught in 3 years, Castro and Mejuto (1995) reported a CPUE of 0.26 in this same area 10 years prior in 1993, with 63 oceanic whitetip sharks caught in only 4 months. These data suggest that this species is currently not abundant in these areas (FAO 2012) likely due to its preference for warm, tropical waters.

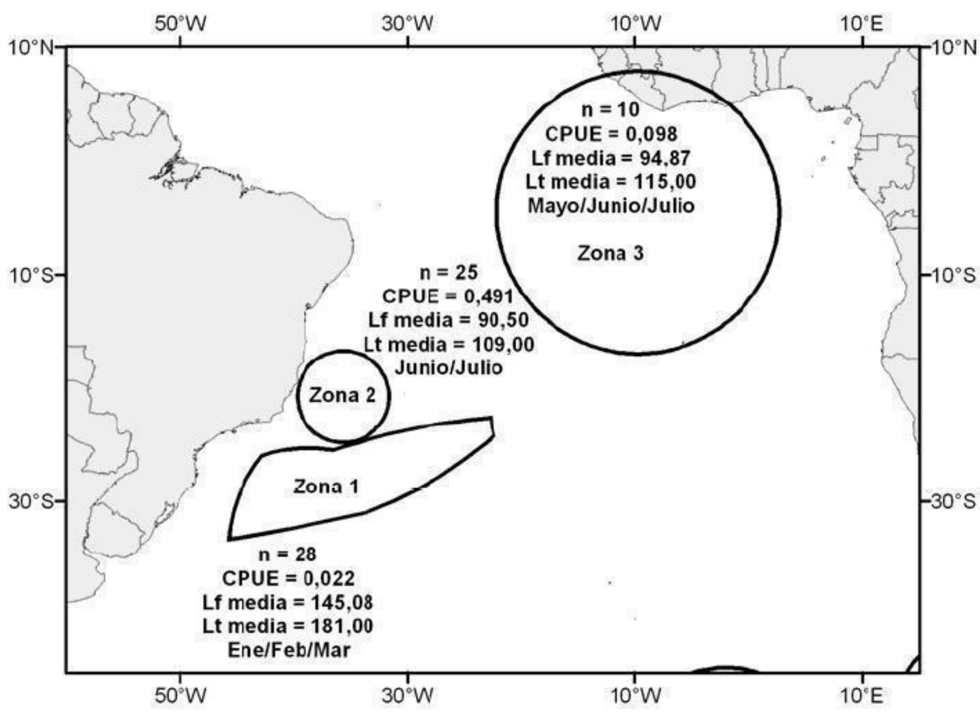

Figure 29. Areas (Zones 1-3), number (n), CPUEs, Lf and Lt media (average lengths) and times of observed oceanic whitetip sharks by the Uruguay National Observer Program from 2003-2006. Source: Domingo et al. 2007.

Oceanic whitetip sharks are also caught as bycatch in Taiwanese longline fisheries operating in the South Atlantic. According to Taiwanese observer data, from 1999–2003 the oceanic whitetip shark was the least caught shark species from 5°N–15°S, with only three individuals caught, comprising 0.1% in number and 0.1% in weight of total shark catches. However, oceanic whitetip shark was not found from 15°S–40°S, which are more southern and temperate waters (Joung *et al.* 2005) and outside of the species' preferred habitat. Species-specific CPUE for the oceanic whitetip shark was extremely low at 0.003 (n/1,000 hooks) from 5°N–15°S and 0.002 for the entire South Atlantic; however, trends over time are not currently available from this fishery.

A recent study covering a wide area of the Atlantic in both hemispheres from 2008–2011 indicated that the oceanic whitetip shark bycatch in pelagic longline fisheries comprises less than 1% of the total elasmobranch catches (Coelho *et al.* 2012). This study analyzed observer data from the Portuguese longline fishery targeting swordfish in the Atlantic Ocean, including areas of the temperate NE, tropical NE, equatorial, and southern Atlantic Ocean (see Figure 29 below). Between August 2008 and December 2011, the oceanic whitetip shark comprised only 0.01% of the total elasmobranch catch (n = 281) and exhibited an at-vessel mortality rate of 34.2% (Coelho *et al.* 2012).

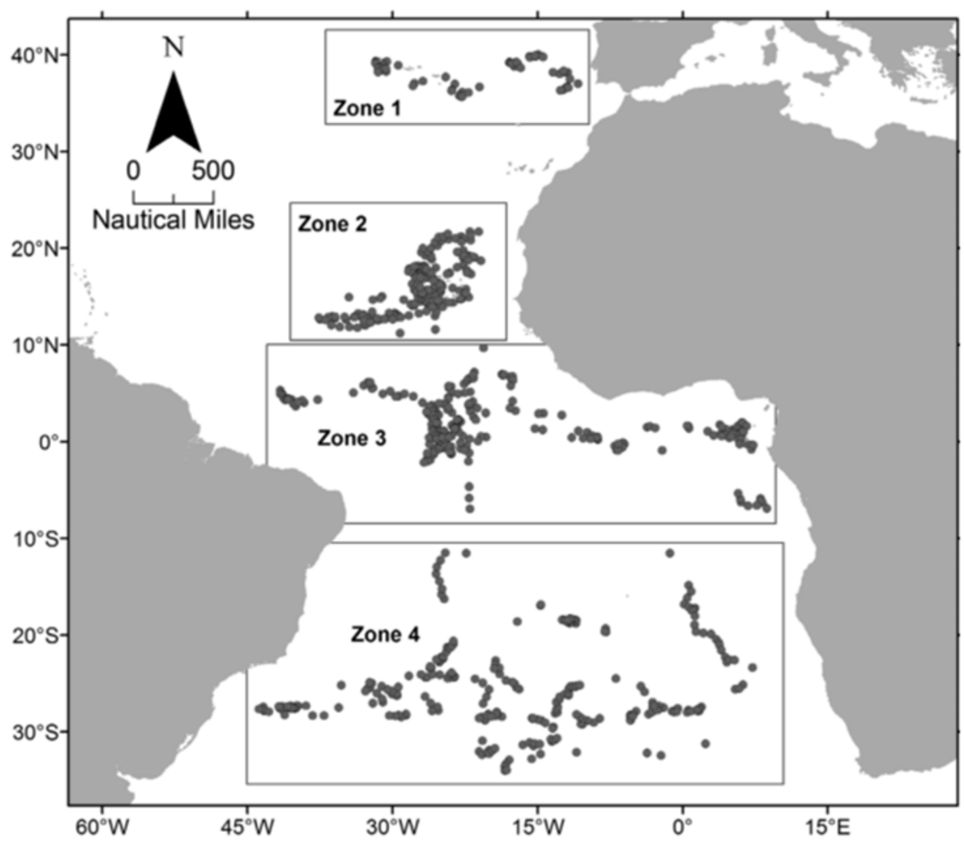

Figure 30. Locations of observed Portuguese longline operations in the Atlantic Ocean from 2008 to 2011. Source: Coelho et al. 2012.

Southwest Atlantic

Historically, the oceanic whitetip shark was considered one of the most dominant species of pelagic shark captured in this region. For example, it was the third most commonly caught shark species out of a total 33 shark species caught year-round in the prominent Brazilian Santos longline fishery, and one of 7 species that comprised >5% of total shark catches from 1971–1995 (Amorim 1998). In Itajai, southern Brazil, oceanic whitetip sharks were considered “abundant” and “frequent” in the surface longline and gillnet fleets, respectively, from 1994–1999 (Mazzoleni and Schwingel 1999). Abundant means the oceanic whitetip shark was observed in most of the landings (i.e., surface longline), whereas frequent means the species occurred in at least half of the landings recorded in one of the seasons of the year (i.e., surface gillnet). In northern Brazil, the oceanic whitetip shark was considered one of the most abundant shark species landed from 2000–2002, comprising 3% of the total catch weight (including tunas, billfishes and other sharks; Asano-Filho *et al.* 2004). García-Cortés and Mejuto (2002) found that the oceanic whitetip shark comprised 17% of the total shark catch in the Spanish longline fishery targeting swordfish from 1990–2000. The research surveys conducted in the 1990s covered a limited area that ranged from 1◦N to 9◦S latitude and 40◦W to 30◦W longitude, which corresponds to the northeastern sector of the Brazilian EEZ.

The oceanic whitetip shark has commercial importance in Brazil mainly due to its fins. As described by Tolotti *et al*. (2013), the Brazilian foreign chartered tuna longline fleet operates in a wide area of the equatorial and southwestern Atlantic Ocean, but the area of highest fishing effort is concentrated in the equatorial region of northeastern Brazil, which also happens to overlap with the areas of highest habitat utilization by oceanic whitetip sharks. This is evidenced by tagging data from Tolotti *et al.* (2015a), which indicate that this region off Northeast Brazil is an area where the species may have some degree of philopatry (i.e., site fidelity), as well as observer data collected from 14,860 longline sets (21,156,374 hooks), carried out by the Brazilian foreign chartered tuna longline fleet from 2004 to 2010. Thus, it appears that the Brazilian longline fishery area of operation completely overlaps the preferred vertical and horizontal habitat of oceanic whitetip sharks in this region (see Figures 31 and 32 below).

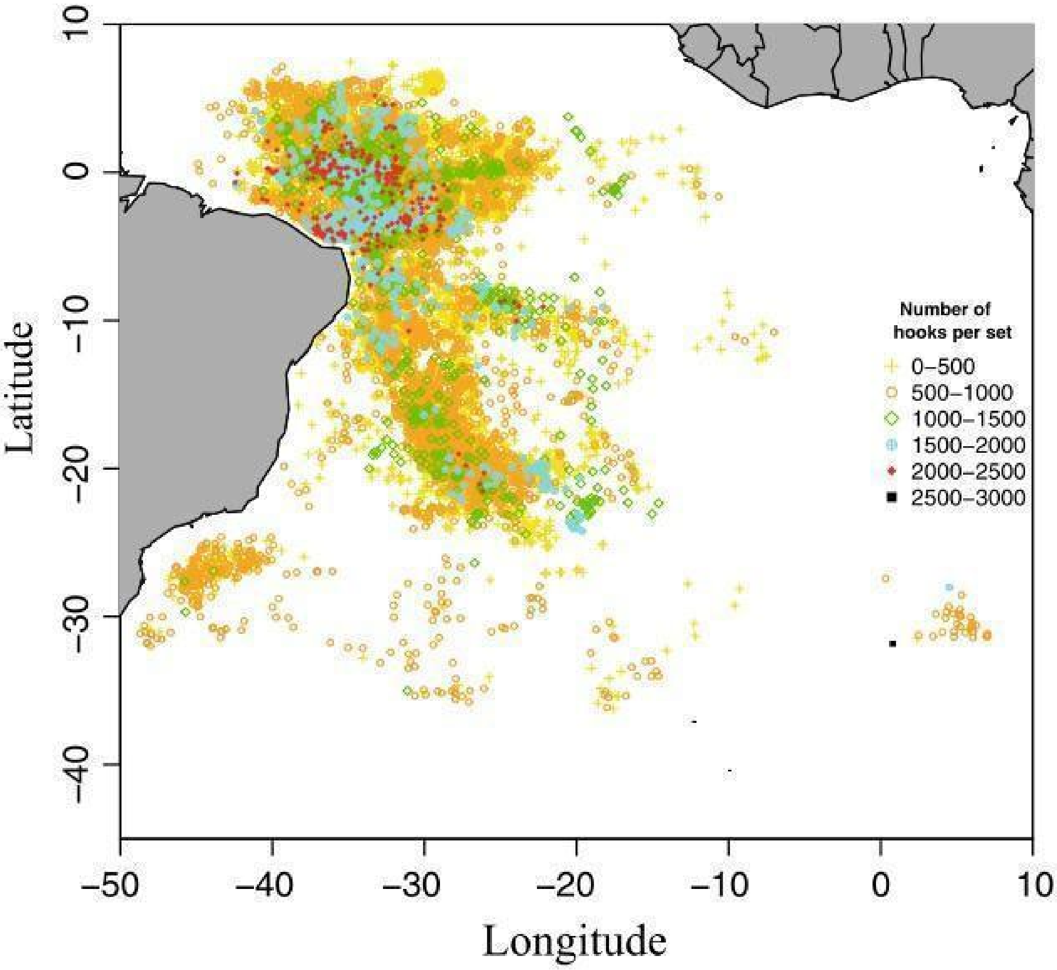

Figure 31. Distribution of fishing effort (number of hooks per set) by the Brazilian chartered tuna longline fleet in the Atlantic Ocean, from 2004 to 2010. Source: Frédou et al. 2015.

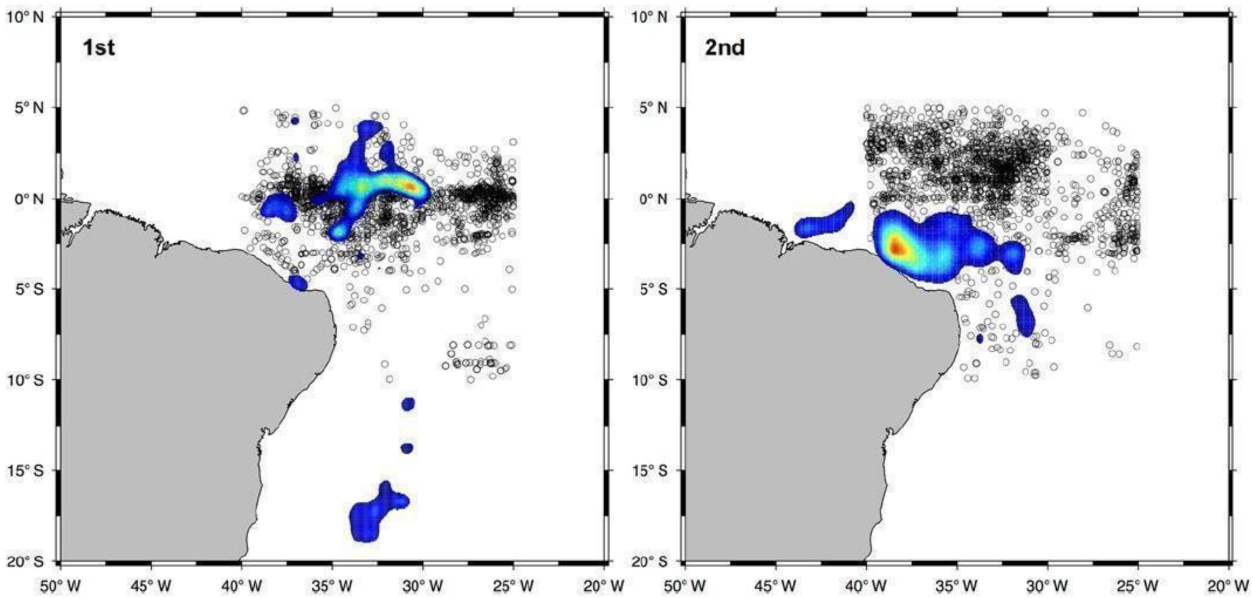

Figure 32. Kernel density estimation of post-processed tracks showing the areas of high utilization by oceanic whitetip sharks tagged in the western Atlantic Ocean between 2010 and 2012. The left panel represents the 1st quarter of the year and the right represents the 2nd. Small circles are fishing set locations from foreign tuna longline vessels chartered by Brazil operating from 2004 to 2010. Source: Tolotti et al. 2015a.

Catches of oceanic whitetip sharks in the Brazilian tuna longline fishery have also shown a continuous decline, decreasing from about 640t in 2000 to 80t in 2005 (Hazin *et al.* 2007). According to the ICCAT nominal catch database, landings of oceanic whitetip shark by Brazilian vessels continued to decline to 0 mt reported from 2009-2012 and 6 mt in 2013 and 2014 (refer back to Figure 26 above). Thus, the decline in landings reported to ICCAT by Brazil prior to 2010 may be indicative of a population decline, though this is highly uncertain given the sensitivity of the species to changes in fisheries strategies. Although there was a shift in some fishing effort of the Brazilian chartered foreign longline fleet to more temperate waters in 2006 (Frédou *et al.* 2015), which may account for some decline in reported catches of the species, other species-specific information (as previously discussed above) suggests the species is still experiencing significant fishing pressure in areas of its preferred habitat where the species exhibits a high degree of site fidelity (Tolotti *et al.* 2015a).

Further, many studies show a substantially high percentage of juveniles in the catches from this region (Coelho *et al.* 2009; Tambourgi *et al.* 2013; Tolotti *et al.* 2013; Frédou *et al.* 2015), which suggests the presence of nursery habitat. For example, the oceanic whitetip shark was among the most abundant shark species captured during research cruises from November 2000 to September 2002 along the North coast of Brazil, comprising 3% of the total catch in weight (including tunas, billfishes and other sharks); however, more than half of the oceanic whitetip sharks landed were under the size of maturity for this region (Asano-Filho *et al.* 2004). Likewise, juveniles (<180-190 cm TL) represented 57.1% of the sample in Northeast Brazil (Santana *et al.* 2004) and 47% of species landings on the North Coast (Asano-Filho *et al*. 2004). A large number of newborns were also sampled in the Southeast region of Brazil (Amorim 1992), further suggesting the existence of nursery grounds in the region. Similarly, Tambourgi *et al*. (2013) found that 80.5% of females were immature and 72.4% of males were immature in the Brazilian pelagic longline fishery between December 2003 and December 2010. Thus, in this region, areas of high fishing effort likely overlap significantly with oceanic whitetip shark nursery habitat, suggesting that these areas are at a direct risk from the industrial longline fishery (Frédou *et al.* 2015).

More recently, Frédou *et al.* (2015) analyzed catch and effort data of 14,860 longline sets from the Brazilian chartered tuna longline fleet, between 2004 and 2010 and found that oceanic whitetip sharks in the equatorial and southern Atlantic were comprised of the smallest individuals throughout the fishing ground, with 78% measuring <180 cm and most likely juveniles. Coelho *et al.* (2009) suggested that the high percentage of small individuals in the southwestern equatorial Atlantic (also found in Tolotti *et al*. 2013 and Tambourgi *et al*. 2013), might indicate size segregation in the Atlantic Ocean. Alternatively, Lessa *et al*. (1999) hypothesized that the large proportion of juveniles might be a result of ongoing fishing pressure on the entire population.

Although robust CPUE data are not available for the species, making it difficult to evaluate whether the decline in catches resulted from decreased abundance or from changes in catchability (e.g., fishing strategies) (Hazin *et al.* 2007), it is clear that the majority of fishing effort in Brazil is concentrated in the same areas of highest habitat utilization by oceanic whitetip sharks (Tolotti *et al.* 2015a), including potential nursery areas. Thus, it is likely that the intensive fishing pressure on oceanic whitetip sharks across its preferred vertical and horizontal habitat areas in Brazilian waters is negatively impacting oceanic whitetip sharks at all life stages.

Southeast Atlantic
In the southeastern Atlantic, a study on the impact of longline fisheries in the Benguela Current Large Marine Ecosystem (defined as west of 20º E, north of 35º S and south of 5º S) reported observer data from the South African longline fishery. This study found that oceanic whitetip shark was only a minor component of the shark bycatch from 2000–2005 (n = 125), and comprised only 1.2% of the shark bycatch composition (Petersen *et al.* 2007). However, this is not surprising given the species' preference for more tropical waters.

Oceanic whitetip sharks are also captured in the French tropical tuna purse seine fishery operating off the western coast of Africa. A study of elasmobranch bycatch in this fishery between 2005 and 2017 indicated only 78 oceanic whitetip sharks were captured, representing 0.5% of the total shark bycatch. Oceanic whitetip sharks were captured primarily in international waters (36%) but also in the Gabonese EEZ (23%) and Angola EEZ (5%). Mortality rate for captured sharks was 38%, with 60% of mortality being juveniles (Clavareau *et al.* 2020). This low level of bycatch is somewhat surprising given the location of the fleet's operations overlaps with preferred habitat in the southeast Atlantic (i.e., near the equator).

South Atlantic Summary
Overall, while quantitative studies regarding catch trends of oceanic whitetip sharks are limited, oceanic whitetip sharks, while once one of the most abundant shark species encountered in longline fisheries in the southern and equatorial Atlantic, are now seemingly rare with low, patchy abundance across the region, and the majority of catches are comprised of immature individuals. Given that both average CPUE and commercial landings of oceanic whitetip shark

have likely declined in recent decades, combined with the species' low-moderate productivity, it is likely that overutilization of oceanic whitetip sharks is occurring in the South Atlantic. This is likely a result of the fact that high levels of fishing effort overlap significantly with the preferred vertical and horizontal habitat of the species in this region. Of particular concern is the overlap of fishing effort with potential nurseries and areas where the species shows a high degree of site fidelity. However, without any robust standardized fisheries data to account for various factors that may affect the catch rate of oceanic whitetip sharks, the species' current abundance and trends in this region are highly uncertain.

Indian Ocean
There is limited data on the catch, retention and mortality of oceanic whitetip sharks in the Indian Ocean, due to lack of full compliance with IOTC data reporting measures on reporting sharks to the species level at the regional level (Rice 2017). According to the IOTC, catches of oceanic whitetip shark are ranked as "High," meaning the accumulated catches from 1950–2010 make up 5% or more of the total catches of sharks recorded (Herrera and Pierre 2011). In fact, a recent study estimated that oceanic whitetip sharks comprise 11% of the total estimated shark catch in the Indian Ocean (Murua *et al.* 2013a). It is also considered to be the 5th most vulnerable shark species caught in longline fisheries in the region (out of 16 species assessed), and the most vulnerable shark species caught in purse seine gear, due to its high susceptibility (Murua *et al.* 2012; IOTC 2015a).

The oceanic whitetip shark is reported as bycatch in all three major fisheries operating in the Indian Ocean; the species is considered "frequent" in both longline and purse seine fisheries, and "very frequent" in the gillnet fishery (Murua *et al.* 2013b), with gillnet fisheries reporting the highest nominal catches of sharks in 2014, and making up nearly 40% of catches (Ardill *et al.* 2011; IOTC 2015a). Large numbers of fishing vessels that use gillnets in the Indian Ocean have been identified, with 1,000 estimated for Iran and 2,000 estimated for Sri Lanka; however, due to their small sizes and artisanal status (despite often fishing very far from their countries), the total annual numbers of fishing vessels utilizing gillnets in the Indian Ocean remain largely unknown. Additionally, fishing zones of the gillnet fishery also remain widely or completely unknown, with no logbooks or observers present on these vessels (Fontenau 2011). With an estimated 3,000 vessels that deploy nets of 2.5 miles in length, 6,000 miles of nets may be deployed on a daily basis (Fontenau 2011; Figure 33 below).

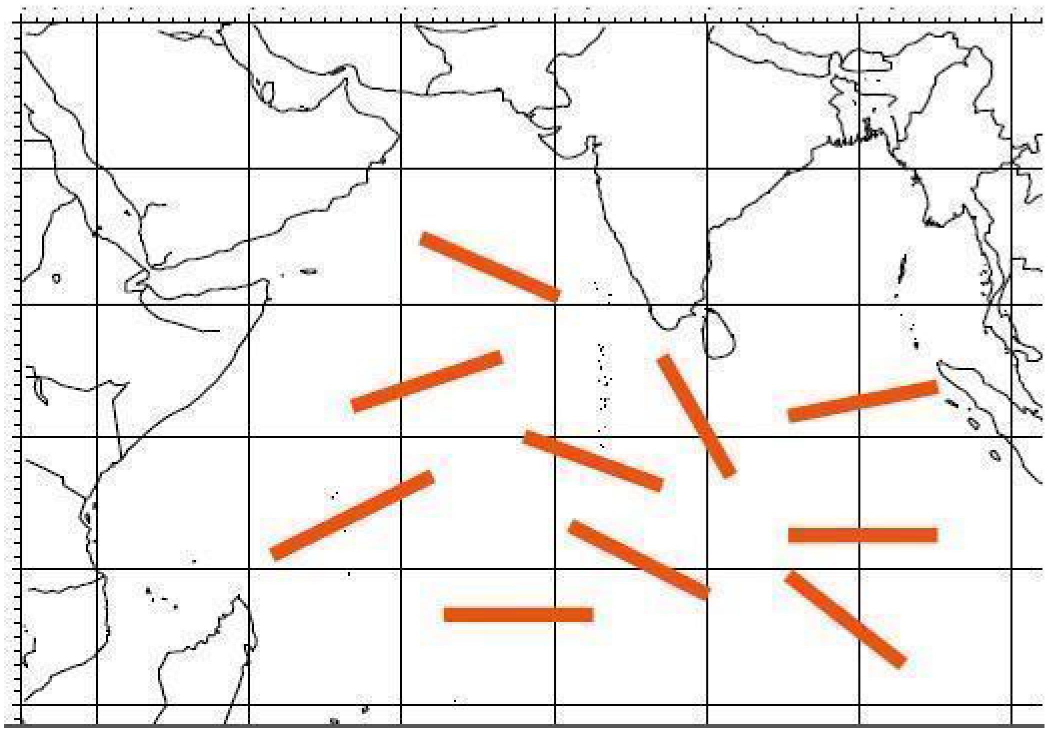

Figure 33. Schematic conceptual view of the total length of drifting nets that may be deployed daily by a fleet of 3,000 vessels using 2.5 miles long nets. Source: Fontenau 2011.

The main fleets catching oceanic whitetip sharks in the Indian Ocean from 2011-2014 include: Indonesia, Sri Lanka, I.R. Iran, EU (Spain), China, Madagascar, and Seychelles. Fisheries catch data for the Indian Ocean are available from the IOTC, which requires Cooperating Non-Contracting Parties (CPCs) to annually report oceanic whitetip shark catch data (See IOTC Resolutions 05/05, 10/07, 10/12, 12/09, 13/06). However, prior to the adoption of resolution 05/05 by the IOTC, there was no requirement for sharks to be recorded at the species level in logbooks. As such, it was not until 2008 that some very sporadic statistics became available on shark catch, mostly representing retained catch and not accounting for discards (Ardill *et al.* 2011). Additionally, the IOTC acknowledges that despite reporting requirements, catches of sharks are usually not reported. In fact, reporting by species is very uncommon for gillnet fleets, where the majority of catches are reported in aggregate (IOTC 2020). Further, when catch statistics are provided, they may not represent the total catches of the species, but those simply retained on board, with weights that likely refer to processed specimens (IOTC 2011b). Therefore, the current reported catches are thought to be incomplete and largely underestimated. In fact, a recent study estimated possible oceanic whitetip shark catches for fleets/countries based on the ratio of shark catch to target species, and highlighted a potentially significant underestimation of oceanic whitetip shark in the IOTC database. Murua *et al.* (2013a) concluded that the estimated catch of oceanic whitetip shark is approximately 20 times higher than declared/reported and contained in the IOTC database. In fact, once the requirement to record and report oceanic whitetip shark incidental catches and discards to the IOTC was implemented in 2013, estimated catches increased substantially from an annual average of 347 mt from 2007-2011 to 5,413 mt and 5,383 mt in 2013 and 2014, respectively (see Figures 34 below). Catches of oceanic whitetip shark averaged 203 mt (2015-2018) despite a moratorium on catches.

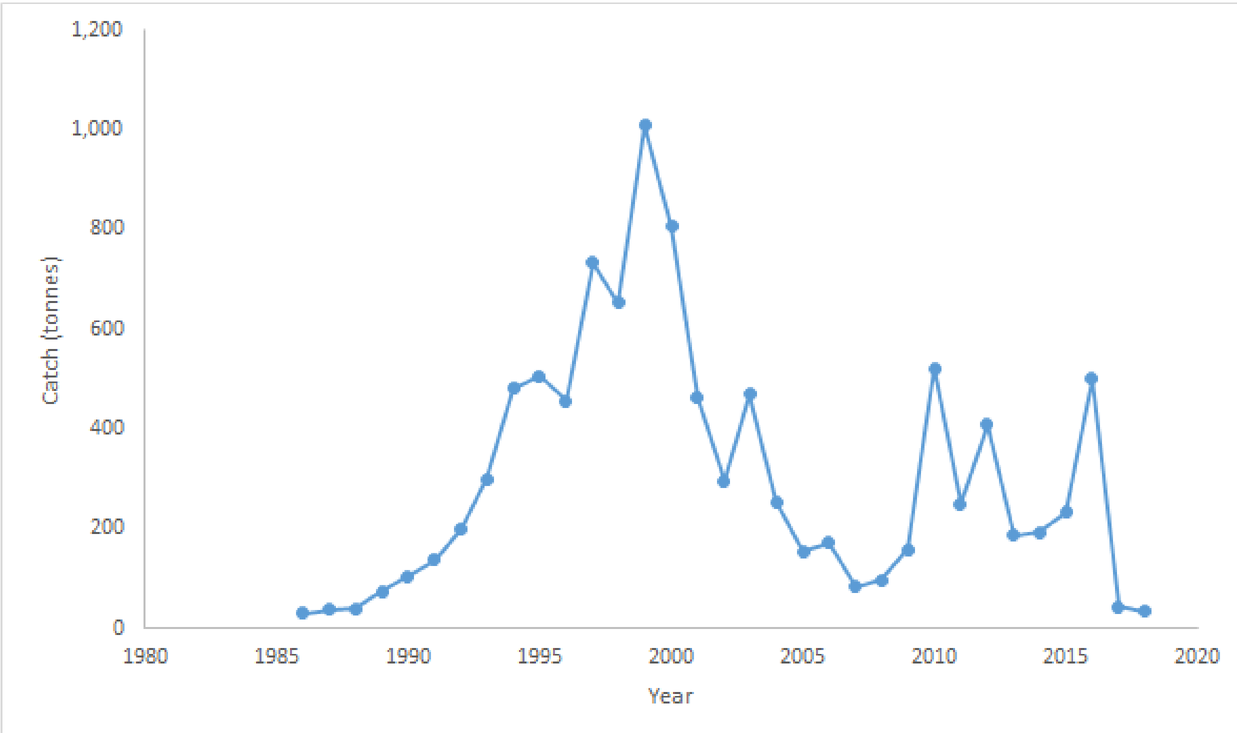

Figure 34. Total catches (mt) (all gears) of oceanic whitetip shark as reported to the IOTC from 1986-2018. Source: IOTC nominal catch database accessed January 2022.

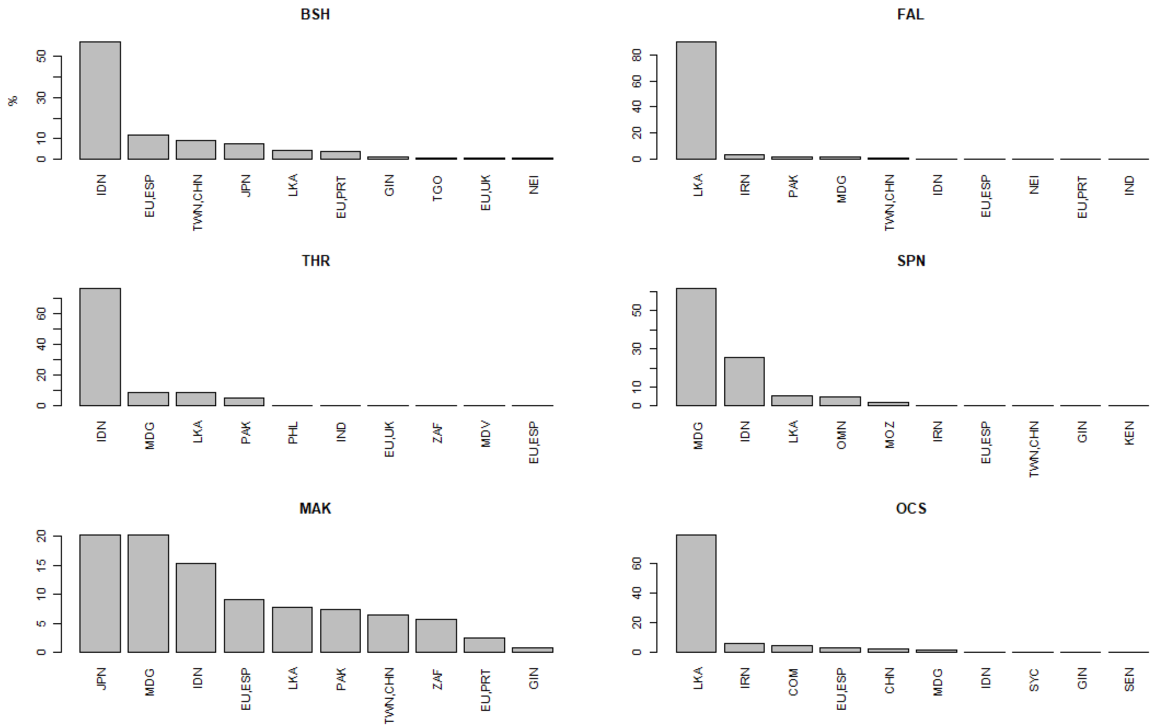

Figure 35. IOTC cooperating parties contribution (%) by major shark species for blue (BSH), silky (FAL), thresher (THR), hammerhead (SPN), mako (MAK) and oceanic whitetip (OCS) sharks. Source: IOTC 2020.

Since 2014, catches of oceanic whitetip sharks continue to be reported in the nominal catches for several fleets, including China, I.R. Iran, Maldives, Seychelles, Sri Lanka, Tanzania (and India) (Rice 2017). Overall, Sri Lanka dominates reported catches of oceanic whitetip sharks.
The reporting of catches of oceanic whitetip sharks (shown in Figure 35 above) shows a substantial increase throughout the 1990s, which likely corresponds with the rise in the shark fin trade (Clarke *et al.* 2007), a peak at 1,008 tonnes in 1999, followed by a variable but overall sharp decline in the 2000s. The IOTC's Working Group on Ecosystems and Bycatch stated that at current catch levels (i.e., average of 169 mt from 2015-2019) the Indian Ocean stock of oceanic whitetip was at considerable risk (IOTC 2021). Given the high level of fishing pressure on oceanic whitetip sharks in the Indian Ocean, and the species' low-moderate productivity, it is therefore likely that the ongoing catch and retention of oceanic whitetip sharks in the Indian Ocean are in excess of what is sustainable and may be contributing to overutilization of the species in this region. Additionally, oceanic whitetip sharks appear to have higher at-vessel mortality rates in longlines in the Indian Ocean (e.g., 50% (Coelho 2016) compared to mortality rates observed in other portions of its range (e.g., ~24% in NW Atlantic (Beerkircher *et al*. 2002; Carlson *et al.* 2019); 11-28% in the South Atlantic (Fernandez-Carvalho *et al.* 2015); 30% in RMI (Bromhead *et al.* 2012)). Further, gillnets fisheries remain the predominant source of oceanic whitetip shark catch in the Indian Ocean (Rice 2017), which likely have even higher at-vessel mortality rates. It should also be noted that these rates only account for at-vessel mortality and do not account for post-release mortality. Information regarding some of the main countries that catch oceanic whitetip sharks in the Indian Ocean is provided below where available.

Indonesia

Indonesia is the largest shark-catching country in the world, with an estimated total elasmobranch catch of 110,000 t in 2007 (Camhi *et al.* 2009). According to a recent study by Dent and Clarke (2015), total captures of chondrichthyan fishes from 2000–2011 averaged 106,034 t. This level of catch has likely caused declines in abundance for many species. For example, research cruise data show that catch rates of elasmobranchs in the Java Sea declined by at least one order of magnitude between 1976 and 1997. Results strongly indicate that many shark and ray species in Indonesia are overfished (Blaber *et al.* 2009).

The population status of oceanic whitetip shark in Indonesia is unknown because fishers rarely land this species. A 2001–2006 survey conducted in waters south of Java, Lombok and Bali found that few oceanic whitetip sharks were landed either as bycatch of tuna fisheries or as target catch of shark longline fisheries in Lombok (Dermawan *et al.* 2013). The authors noted that landings are mostly comprised of juveniles with few adults recorded in this part of Indonesia. Adults are commonly caught in east Indonesia, from Lombok in West Nusa Tenggara to the Leti Islands in Southeast Maluku. The size of the shark fins found at fin collectors in east Indonesia indicate that most of the oceanic whitetip sharks landed by fishers in this region are adults. Although all parts of this shark species are utilized in Indonesia, the fins are most sought after due to their high economic value (Dermawan *et al.* 2013).

In 2014, a study was conducted using DNA barcoding of 582 shark fins collected from numerous traditional fish markets and shark-fin exporters across Indonesia from mid-2012 to mid-2014, including Aceh, Jakarta, West Java, Central Java, East Java, Bali, West Kalimantan, South Sulawesi, North Sulawesi, Maluku, and West Papua. Additional samples were collected from shark fin export warehouses in Cilacap (Central Java) and Tanjung Luar (West Nusa Tenggara). In this study, Sembiring *et al.* (2015) discovered a fishery that targets particularly vulnerable shark species, including oceanic whitetip sharks. Oceanic whitetip sharks comprised a small portion of the tested fins, representing 1.72%. Additionally, in an analysis of Indonesian longline scientific observer data in the Indian Ocean from 2005–2013, oceanic whitetip sharks represented 1.66% of the total catch (Novianto *et al.* 2014). In October 2015, Indonesian authorities seized about 3,000 shark fins belonging to oceanic whitetip sharks that were reportedly caught in waters around Java Island. The fins, which were about to be flown to Hong Kong, were seized at the international airport that serves the capital Jakarta (South China Morning Post 2015[5]). The oceanic whitetip shark is a protected species in Indonesia and banned from export. However, based on the genetic results of shark fins from numerous fish markets throughout Indonesia and the evidence of illegal trade of oceanic whitetip shark fins, it is evident that oceanic whitetip sharks are commonly caught as bycatch and are potentially targeted for fins in this portion of its range.

India

India is the second largest shark producing nation in the world. In one study, survey vessels collected data on the CPUE of sharks in the longline tuna fishery in various regions of the Indian EEZ from 1984–2006 (three vessels operated along the west coast of India, two vessels operated

[5] http://www.scmp.com/news/asia/southeast-asia/article/1864948/indonesia-seizes-3000-shark-fins-destined-hong-kong

in the east coast and one vessel in the Andaman and Nicobar waters). During the survey, a total of 3.092 million hooks were deployed, with sharks representing 45–50% of the catch, equaling approximately 588.9 t (John and Varghese 2009). A sharp decline in CPUE from all three regions was observed, with the most concerning scenario on the east and west coasts, where the average hooking rate recorded during the last five years was less than 0.1%. The oceanic whitetip shark represented 0.6% and 4.7% of the catch from the East Coast (Arabian Sea) and Andaman and Nicobar waters, respectively. In the Andaman and Nicobar region, where catch of oceanic whitetip shark is most prevalent, total shark CPUE declined sharply by approximately 81% from 1992–1997. On the East Coast, total shark CPUE also declined significantly by approximately 89% from 1984–2005. More recently from 2004–2010, Varghese *et al.* (2015) report that oceanic whitetip shark comprised only 0.23% of the total shark catch and had an extremely low hooking rate (number of sharks caught per 100 hooks) of 0.001 in Andaman and Nicobar waters, which is significantly lower than what John and Varghese (2009) reported for years 1984–2006. Overall, Varghese *et al.* (2015) shows that the index of relative abundance of sharks was considerably lower than earlier studies, indicating a decline in abundance over the years. While the lack of standardized CPUE trend information for oceanic whitetip shark in these studies makes it difficult to evaluate the potential changes in abundance for this species in this region, based on the best available information, it is likely that the oceanic whitetip shark has experienced some level of population decline in this region as a result of fishing mortality. Additionally, it is important to note that India has objected to the IOTC Resolution prohibiting the retention of oceanic whitetip sharks (since 2013), and thus this Resolution is not binding for India. Therefore, oceanic whitetip sharks may still be retained in Indian fisheries.

Iran (Islamic Republic of)
The Iranian fishing fleet primarily operates in the Caspian Sea, Persian Gulf and Oman Sea, and comprises approximately 11,498 vessels (of which about 6,762 fishing vessels are active in large pelagic fisheries as of 2015) (Rice 2017). Gillnet and purse seine vessels dominate the fleet. All data are collected by in-port fisheries monitors. However, the overall quality of the data is not known and at-sea discards are not likely to be reported. The market for shark meat in Iran is small but there is a market in Pakistan and some (largely undocumented) trade is thought to exist. Landings records of sharks from 1997–2015 indicate that the overall shark fishery lands approximately 11,000 metric tons (MT) per year and this amount comprises 2–3% of the total (target + bycatch) landings. Data on shark landings by species from the tuna fleet is only available in 2015 and indicates that 118 mt of oceanic whitetip sharks were caught, comprising 0.05% of the total landed catch (Rice 2017).

Pakistan
While there are no targeted shark fisheries in Pakistan currently, sharks are common bycatch in a number of fisheries and an important component of commercial landings. Pelagic sharks are caught as bycatch of the gillnet fleet targeting tuna in Pakistan, which operates in coastal and offshore waters (Moazzam and Osmany 2022). The oceanic whitetip shark was once among the most common species of pelagic sharks in Pakistan, but now it is rarely found, with landings decreasing significantly over the past 20 years (Moazzam and Osmany 2022). Oceanic whitetip sharks are valuable in local markets mainly because of their large fins. Despite its listing in CITES Appendix II, oceanic whitetip shark fins are exported illegally (without the appropriate permits) from Pakistan to Hong Kong under the disguise of dried fish. Additionally, despite the

IOTC retention prohibition for oceanic whitetip sharks, they are still landed regularly in Karachi Fish Harbor (where most sharks are landed in Pakistan; see Figure 36 below).

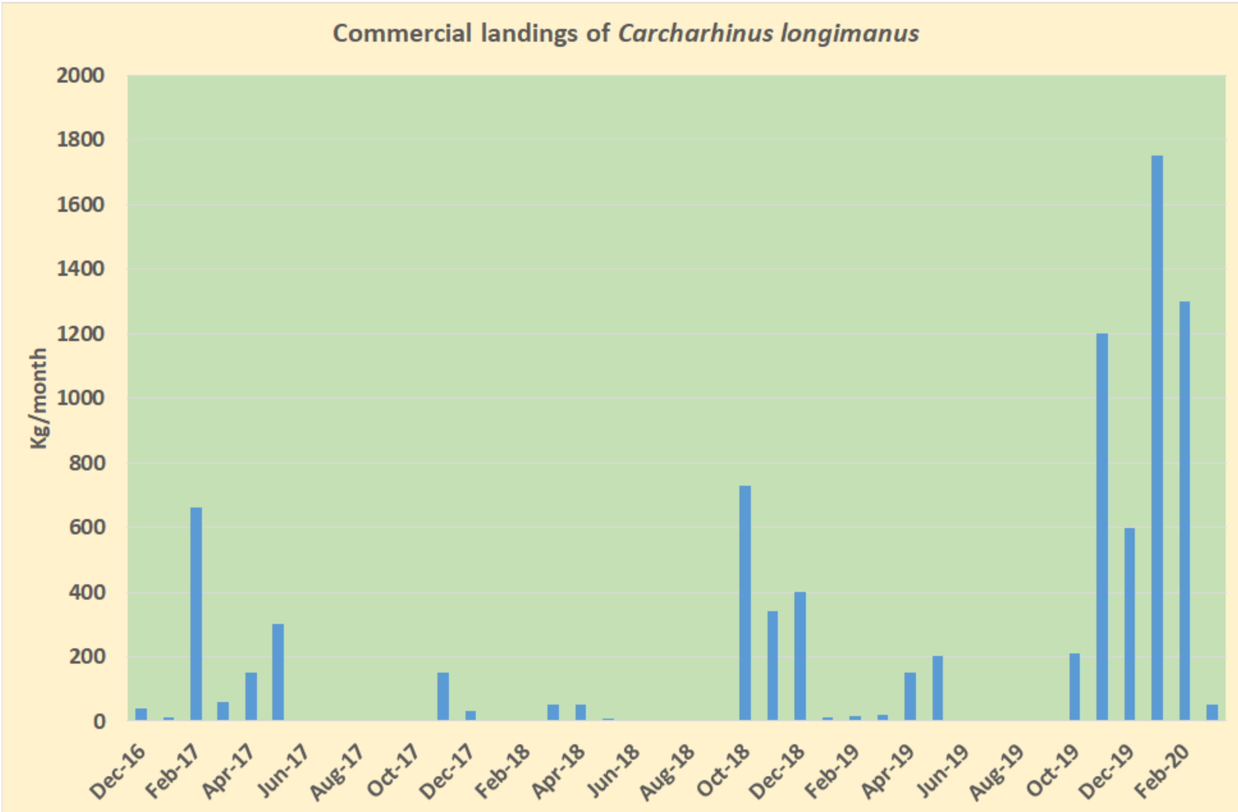

Figure 36. Commercial landings of oceanic whitetip sharks in Karachi Fish Harbor, Pakistan from 2016-2020 (Moazzam and Osmany 2022).

Overall, oceanic whitetip sharks are still caught, landed, and exported in Pakistan despite the IOTC prohibition. Pelagic sharks, including oceanic whitetip sharks, continue to be utilized unabated despite declines in landings over the past couple of decades and concerns over its conservation status.

Sri Lanka

There are 5,023 registered large pelagic fishing vessels of which 1607 are engaged in high seas fishing. The dominant type of gear was large mesh gillnet with 53% of the effort. The remainder of the fleet was ringnet (20%), gillnet-long line (17%), longline (10%), handline and trolling account for the rest of the fishery. Total tuna catch has ranged from approximately 80,000 MT to 90,000 MT over the years 2013-2015. Reported catch of oceanic whitetip shark is 268, 149 and 42 MT in 2011, 2012, and 2013 respectively.

Although sharks were dominant in the historical large pelagic fish landings in Sri Lanka, their current production is low (Hasarangi *et al.* 2012), with the majority of shark landings in Sri Lanka originating as bycatch from offshore tuna longline and gillnet fisheries (Rice 2017). From 1950 to 1974, more than 45% of the total large pelagic fish production was attributed to sharks (Hasarangi *et al.* 2012). As of 2014, however, the estimated contribution of sharks to the total large pelagic fish production by weight currently remains at 2% (Jayathilaka and Maldeniya 2015). Previous attempts to estimate the potential sustainable yield in Sri Lankan waters suggested harvest rates of all species of 250,000 t year^{-1}, with around 170,000 t for pelagic species. Reconstructed catches from O'Meara *et al.* (2011) indicate that this sustainable level was likely exceeded as far back as 1974. In this study, O'Meara *et al.* (2011) highlighted the lack of proper accounting for total fisheries catches and concluded that without a realistic estimate of removals, pelagic fisheries are likely mismanaged and potentially overexploited (O'Meara *et al*. 2011). Among the shark landings in Sri Lanka, silky shark (*C.falciformis*) is the dominant species followed by thresher shark (*Alopias* spp.), blue shark *(P. glauca*) and oceanic whitetip shark, respectively. The oceanic whitetip shark has commercial importance in Sri Lanka, and comprised approximately 5% of the total shark catch in 2014 (down from 6.1% in 2011; Jayathilaka and Maldeniya 2015). From 1996–2004, landings of oceanic whitetip shark peaked in 1999 at approximately 3,000 mt and show a declining trend thereafter (Hasarangi *et al.* 2012). More recent information suggests that oceanic whitetip shark landings have seemingly declined continuously from a peak of 3,000 mt in 1999 to less than 300 mt in 2014. It is important to note that the significant decline in shark production can be attributed to regulatory mechanisms only in the last two years. Most recently, Sri Lanka reported only 88 mt of oceanic whitetip shark to IOTC in 2015. Thus, the decline in oceanic whitetip shark catches occurred prior to the implementation of any regulatory measures, and may therefore be indicative of declining catches due to population decline in Sri Lankan waters.

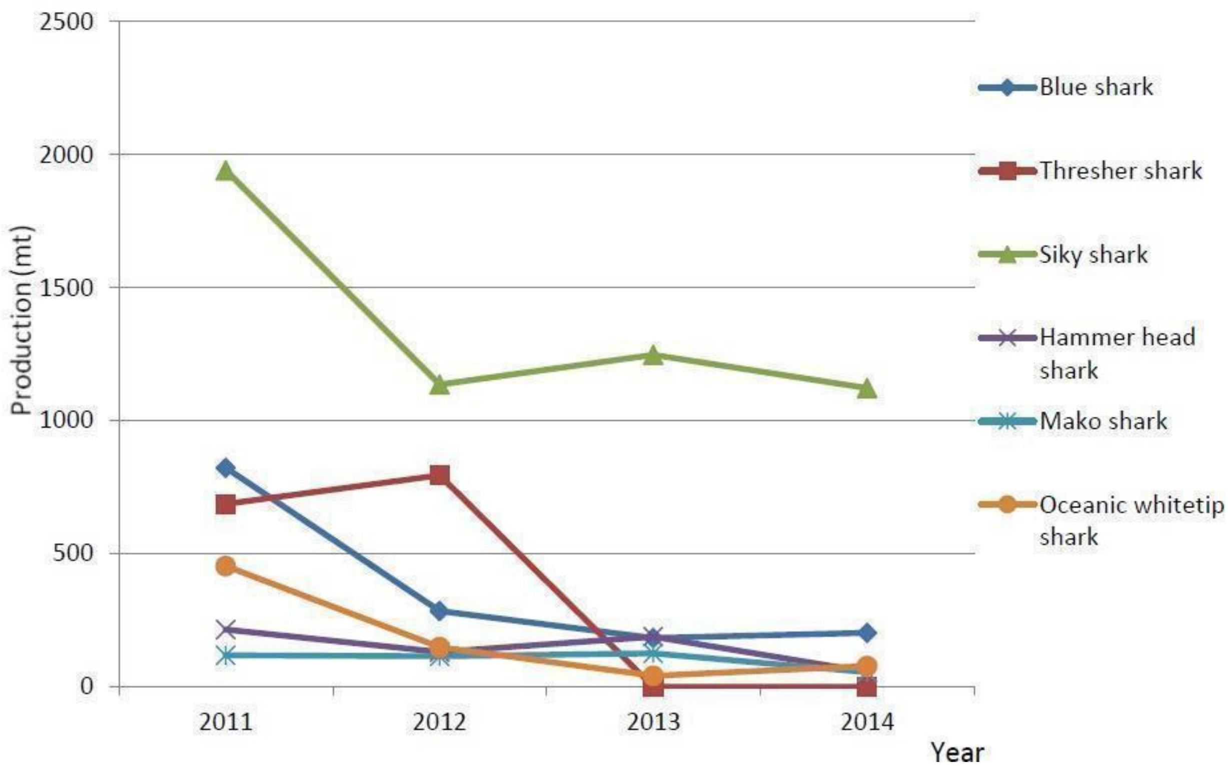

Figure 37. Sri Lanka shark landings by major species 2011-2014. Source: Jayathilaka and Maldeniya 2015.

Taiwan

Oceanic whitetip sharks have also been recorded as bycatch in the Taiwanese longline fishery operating in the Indian Ocean. Estimates of discards and incidental catch are difficult to obtain due to a lack of discard data reporting in captains' logbooks and because the Taiwanese fleet rarely identifies the various shark species (Huang and Liu 2010; Moreno and Herrera 2013). Observer data collected from 77 trips on Taiwanese large-scale longline fishing vessels in the Indian Ocean from June 2004 to March 2008 were used to estimate the extent of bycatch. The oceanic whitetip shark was recorded in the yellowfin, bigeye and albacore tuna fisheries (Huang and Liu 2010). In total, only 77 individuals were recorded during the study period, despite most fishing effort taking place in tropical latitudes between 10ºN and 10ºS, where the species would likely be most prevalent (see Figure 37 below). During the study, the average discard rate for sharks was 54.2% (Huang and Liu 2010).

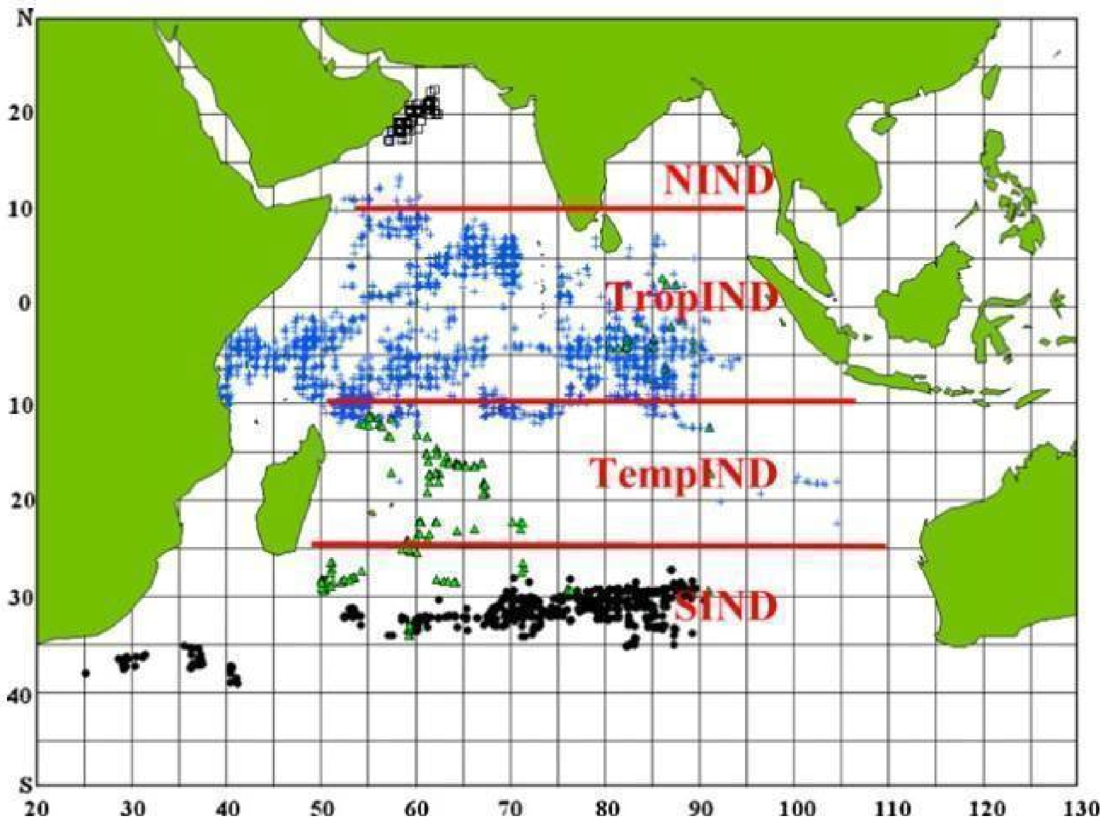

Figure 38. Areas and observed effort distributions of the Taiwanese longline fishery in the Indian Ocean. Black squares, yellowfin tuna fleet; blue crosses, bigeye fleet; green triangles, albacore fleet; black circles, bluefin tuna fleet. Source: Huang and Liu 2010.

African semi-industrial fleet

The African semi-industrial fleet (including Madagascar, Mauritius, Reunion, and Seychelles) is opportunistic and fishes exclusively in the Western Indian Ocean. Seychelles started its fishing operations in 1983 and Reunion in 1991 with one vessel each. The fleet reached a peak of 62 vessels in 2007 and 2012. In 2012, Reunion had 41, Madagascar had 8, Mauritius had 5 and Seychelles had 4 vessels. It was not until 2010 that this fleet reported shark catches down to the species level. Based on reported catches, catches per vessel is low (~1 mt per vessel per year), with the oceanic whitetip shark comprising approximately 52% of the catch (Moreno and Herrera M. in IOTC Secretariat 2013).

Indian Ocean Summary

Overall, it appears that the oceanic whitetip shark is likely heavily utilized in the Indian Ocean basin due to direct and indirect fishing pressure. The species is highly valued for its fins in this region, and historically comprised a significant portion of the total shark catch (Murua *et al.* 2013b), and is impacted by all three major fisheries in the region, including longlines, gillnets, and purse seine fisheries. The oceanic whitetip shark has been prohibited from retention in this region since 2013 and reported catches have since declined. As discussed previously in the *Regional Population Trends* section of this recovery status review, and based on the limited data available, it appears that the Indian Ocean oceanic whitetip shark population has likely experienced varying magnitudes of decline as a result of intense historical and ongoing fishing mortality driven by bycatch-related mortality and economic demand for the fin trade. While there is considerable uncertainty regarding the current status of oceanic whitetip sharks in the Indian Ocean, given the high level of fishing effort in this region and high catches of the species, combined with the species' relatively high mortality on longlines in this region and low-moderate productivity, it is likely that overutilization of oceanic whitetip shark is occurring in the Indian Ocean.

4.2.2 At-vessel and Post-Release Mortality

As noted previously, regulations that mandate the release of oceanic whitetip sharks have the potential to be effective for their protection and reduce overutilization if the majority of sharks are brought to the vessel alive. Some studies suggest that oceanic whitetip sharks have lower at-vessel mortality rates when compared to other sharks. For example, in the U.S. Atlantic pelagic longline fishery, estimates of at-vessel mortality since 1992 have fluctuated from about 15–40% (average=24%; Carlson *et al.* 2019; Figure 39).

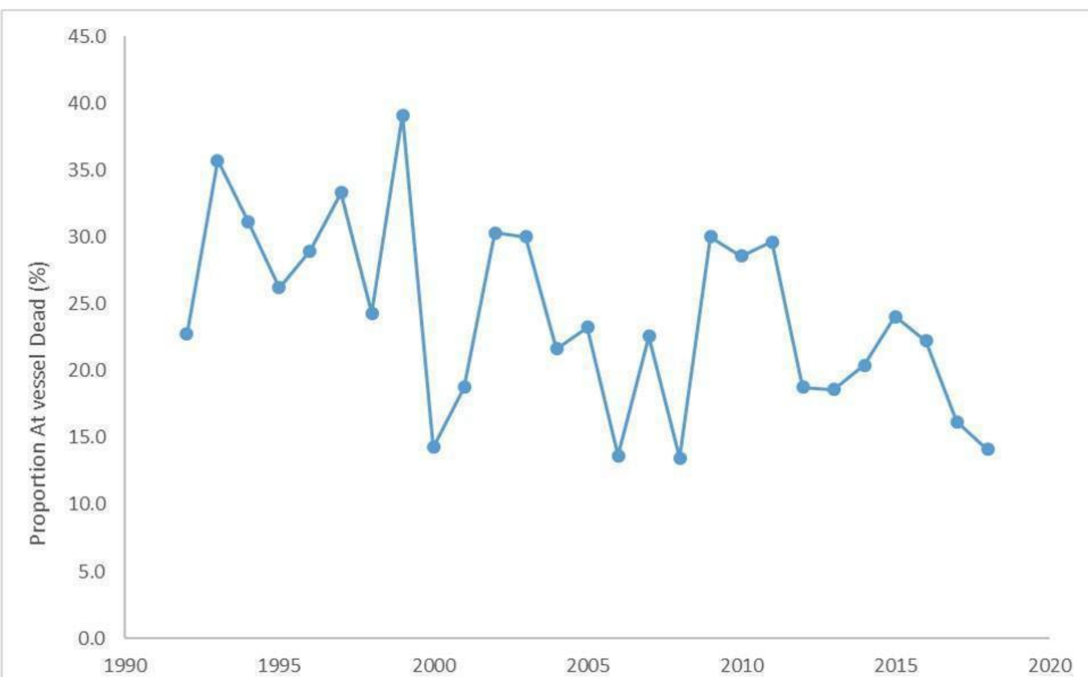

Figure 39. Proportion of oceanic whitetip shark reported dead at the vessel caught in the U.S. pelagic longline fishery.

A study from the Portuguese longline fishery in the Atlantic found oceanic whitetip sharks exhibited an at-vessel mortality rate of 34.2% (Coelho *et al.* 2012). In an experimental pelagic longline fishery in the Tropical Northeast Atlantic Ocean comparing various hook and bait types, oceanic whitetip sharks also had relatively low at-vessel mortality rates (11–28%) (Fernandez-Carvalho *et al.* 2015). In the longline fleets fishing in the western Pacific from the Republic of the Marshall Islands (RMI) and China, Bromhead *et al.* (2012) determined a relatively low at-vessel mortality rate of approximately 30% (n = 917). These data suggest that oceanic whitetip sharks could benefit from live release. However, it may only be partially effective in the Indian Ocean as oceanic whitetip sharks caught on longline vessels in this region exhibited an at-vessel mortality rate of 50% (Coelho 2016). Massey *et al.* (2022) analyzed scientific data collected during monitored longline fishing experiments conducted in French Polynesia to estimate at-vessel mortality for oceanic whitetip shark. Oceanic whitetip sharks are more likely to die when caught in waters below 20ºC and their odds of survival increase with body length.

While at-vessel mortality is relatively low, oceanic whitetip sharks likely experience some level of post-release mortality due to the capture and handling process. There is little data on post-release survivorship for oceanic whitetip shark with information only available from the central Pacific. Hutchinson *et al.* (2021) found that post-release mortality can be as low as 15% in both the Hawaii deep-set longline fishery and American Samoa Longline Fishery. However, a common practice for longline fishers is to cut the line once a shark is sighted, leaving up to 20 m of trailing gear and resulting in significantly increased post-release mortality (Hutchinson et al. 2021). There are currently no other studies with published post-release survival in commercial longline fishery data for comparison.

4.2.3 International Trade in Shark Products

Demand for shark products has existed since the early 1900s, including liver oil, hides, fins, meat, teeth and jaws. Since the 1980s, demand for shark products was largely focused on fins due to the increasing demand for shark fin soup (Biery and Pauly 2012). Traditionally consumed in Hong Kong, Singapore, Macao, Taiwan, China, and other countries with large ethnic Chinese populations, shark fins are one of the most valuable food items in the world (Fong and Anderson 2000). According to official FAO statistics, the average declared value of total world shark fin imports from 2011–2014 was estimated at USD $377.9 million per year from 2000 to 2011, with an average annual volume imported of 16,815 tonnes (Dent and Clarke 2015). From 2000–2011 annual average figures for imported shark meat were 107,145 tonnes, worth a total of USD $239.9 million; while in 2011 alone, the reported figures for total global imports of shark meat were USD $379.8 million and 121,641 tonnes for value and volume, respectively (Dent and Clarke 2015). Clarke *et al.* (2006b) used the shark fin trade data to estimate the total number of sharks traded worldwide, and found that between 26 and 73 million individual sharks are traded annually in the market (median = 38 million/year), with a median biomass estimate of 1.70 million t/year (range: 1.21 - 2.29 million t/year).

The oceanic whitetip shark is considered a “preferred” species for its fins and makes up part of the “first choice” category in the China, Hong Kong Special Administrative Region (SAR) fin market (Vannuccini 1999). Demand from the international shark fin trade is the main economic force driving illegal retention and subsequent opportunistic finning of oceanic whitetip sharks taken as bycatch, as their large, morphologically distinct fins command high prices on the international market of USD $45–85/kg (CITES 2013). In order to determine the species composition of the shark fin trade, Clarke *et al.* (2006a) analyzed 1999-2001 Hong Kong trade auction data in conjunction with species-specific fin weights and genetic information to estimate the annual number of globally traded shark fins. Using this approach, the authors discovered that oceanic whitetip sharks are sold under their own category "*Liu Qiu*" and represent approximately 1.8% of the Hong Kong shark fin market. This level of oceanic whitetip shark fins in the trade translates to an estimated total annual catches of oceanic whitetip shark of approximately 200,000–1,200,000 individuals (median ~700,000) or ~9,000–48,000 tonnes (median ~21,000 t) (Clarke *et al.* 2006b). In 2003, a peak year for fin imports to Hong Kong, Clarke (2008) estimated that 80-210,000 oceanic whitetip sharks were sourced from the Atlantic Ocean alone to supply the Hong Kong fin market. Hong Kong is still one of the largest shark fin trade hubs in the world, importing a total of 5,528,862 kg in 2015, and annually trading with an average of 83 exporting nations (Dent and Clarke 2015; Shea and To 2017).

Although Clarke's seminal study on the global fin trade is dated, recent genetic testing conducted in various fish markets demonstrate the continued utilization of oceanic whitetip sharks in the shark fin trade. Genetic sampling was conducted on shark fins collected from several fish markets throughout Indonesia that identified oceanic whitetip shark fins as present, and comprised approximately 1.72% of the fins tested (Sembiring *et al.* 2015). In a genetic barcoding study of shark fins from markets in Taiwan, the oceanic whitetip shark was 1 of 20 species identified and comprised 0.38% of collected fin samples (Liu *et al.* 2013). In another genetic barcoding study of fins from the United Arab Emirates, oceanic whitetip shark comprised 0.45% of fins tested (Jabado *et al.* 2015). Oceanic whitetip shark fins were also identified in markets in southern Africa using DNA barcoding (Asbury *et al.* 2021). Although it is uncertain whether these studies are representative of the entire market within each respective country, results of these genetic tests confirm the continued presence of oceanic whitetip shark fins in various markets throughout its range despite retention bans globally since 2013. In 2015, seven nations reported trading CITES listed sharks with Hong Kong, with oceanic whitetip sharks comprising 5.6% of all species by weight (Cardeñosa *et al.* 2018). Oceanic whitetip sharks also comprised 1.0% (by weight) of the genetically identified fin trimmings from the retail market of Hong Kong in 2014–2015 (Fields et al. 2017). From 2015–2017, Cardeñosa *et al.* (2020) used molecular identification protocols on processed fin trimmings (n = 2000) to investigate the species composition of the Guangzhou retail market and compare the species diversity between the Guangzhou and Hong Kong shark fin retail markets. Oceanic whitetip shark represented 1.58% and 0.83% of the samples in Guangzhou and Hong Kong, respectively.

Moreover, illegal trade is also an ongoing threat to oceanic whitetip sharks. In the first two months of 2017 alone, more than a ton of shark fins from hammerhead and oceanic whitetip sharks were seized by Hong Kong customs[6]). In November 2018, fishermen from Indonesia were caught illegally smuggling oceanic whitetip shark fins in and out of ports in Honolulu, Hawaii[7] (Young and Carlson 2020). In 2017, a Vancouver-based herbal medicine company illegally imported 20,196 dried, processed shark fins in violation of CITES (12,984 of which were identified as oceanic whitetip sharks through genetic testing) labeled as "fish bone." The

[6] https://phys.org/news/2017-03-massive-hong-kong-shark-fin.html
[7] https://www.apnews.com/870efac8a5024a35b92f70b12249a569

fins were confiscated by Canada's Department of Fisheries and Oceans.[8] Assuming fins came from the most valued set (i.e., dorsal, 2 pectorals, and lower lobe of caudal), 12,000 fins could potentially represent ~4,000 individuals.

In terms of global trends, China, Hong Kong SAR remained the world's largest trader of shark fins from 2000 to 2011, and controlled the majority of global trade (Dent and Clarke 2015). During this time, China, Hong Kong SAR recorded average annual shark fin imports of 10,490 t, worth $302 million and represents about 80% of the global total in terms of value (62% of total volume). The majority of these imports originated in Spain or Singapore (Dent and Clarke 2015). Overall, the trade in shark fins through China, Hong Kong SAR, which has served as a reliable measure of the global trade for many years, rose by 10% in 2011 but fell by 22% in 2012. This decline in the trade was attributed to a number of potential factors, including:

- increased domestic chondrichthyan production by the Chinese fleet;
- new regulations in China government officials' expenditures;
- consumer backlash against artificial shark fin products;
- increased monitoring and regulation of finning;
- a change in trade dynamics related to China's entry into the World Trade Organization in 2001 and subsequent trade agreements with China, Hong Kong SAR;
- other trade bans and curbs; and
- a growing conservation awareness.

A number of indicators also suggest that the decline in the shark fin trade through China, Hong Kong SAR and China will continue. The shark fin trade as a whole has declined slightly since 2003 (Figure 40), and is contrary to expectations of an increase in demand with the continued growth of the Chinese economy (Eriksson and Clarke 2015). The pattern of trade decline closely mirrors the pattern in chondrichthyan capture production; this suggests a strong linkage between the quantity harvested and the quantity traded (Eriksson and Clarke 2015). However, a government-led backlash against "conspicuous consumption" of shark fins in China, combined with increasing momentum of global conservation movements, appears to have had some impact on the trade (Eriksson and Clarke 2015).

[8]https://www.cbc.ca/news/canada/british-columbia/shark-fins-fine-herbal-medicine-1.6319221?fbclid=IwAR0y4i3pB1nBdhyftECgbEDAb3auQHVYRnZzv2-VJVTdk4_P5jf3HAmENRQ

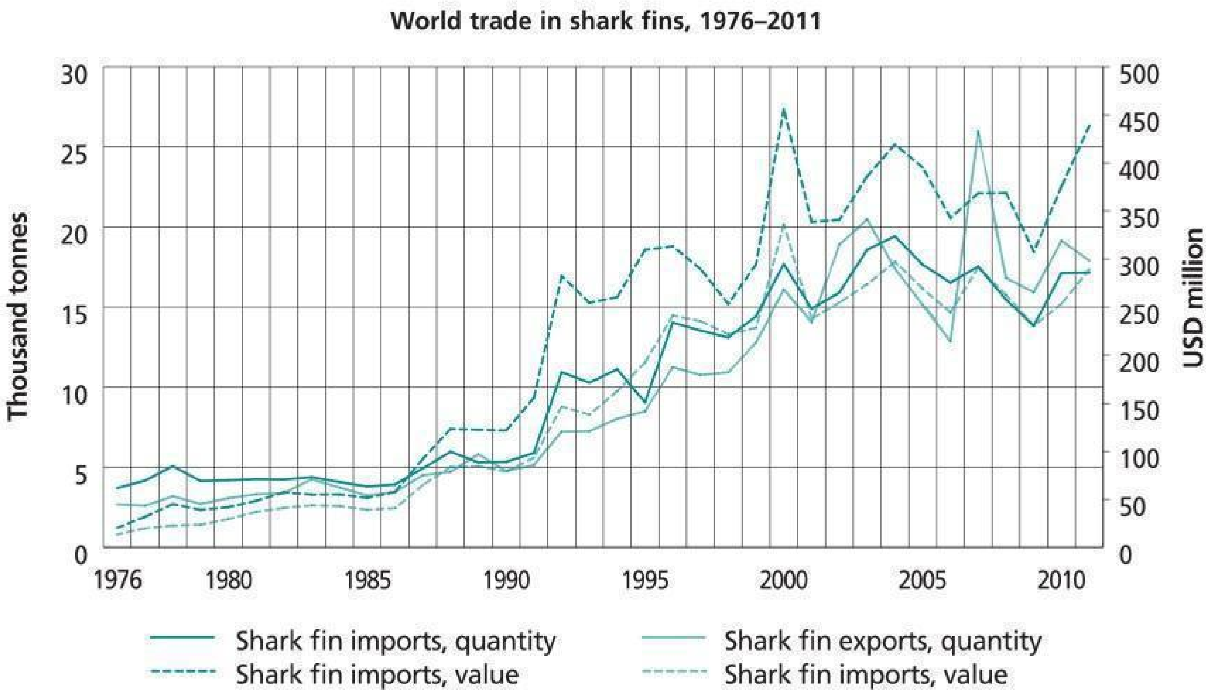

Figure 40. The trend in the global trade in shark fins from 1976 to 2011. Source: Dent and Clarke 2015.

Despite the potential improvements in the trade, it is clear that the shark fin trade has asserted and continues to assert significant pressure on oceanic whitetip sharks, as they are a preferred species, obtain a high price in the international market, continue to comprise a substantial proportion of total shark fins in the market, and routinely show up in seizures of illegal shark fins. Although quantifying the magnitude of impact on the global population abundance of oceanic whitetip shark is difficult, it is likely that the trade has had a significant impact, as it has been the main economic driver for opportunistic illegal retention of oceanic whitetip sharks in commercial fisheries throughout its range. Although the global trade in shark fins appears to have decreased slightly since the early 2000s, it appears that there has been a major surge in the shark meat trade, with global trade data showing a steady expansion of the shark meat trade over the last decade or so (Dent and Clarke 2015). In fact, the latest official FAO figure of chondrichthyan meat imported in 2011 (121,641 t worth $379.8 million) represents a 42% increase by volume compared with 2000. Additionally, the trend observed in shark meat trade unit values in many key trading countries has increased in the past decade, even as the quantity of shark meat being traded has risen substantially. This suggests that underlying demand for these products is increasing. Thus, there are likely to be some areas where demand for shark meat is high enough that even if demand for shark fins wanes, fishing pressure will not decline (Dent and Clarke 2015). However, given that oceanic whitetip shark retention is prohibited in fisheries of all the relevant RFMOs, it is unlikely new markets would develop for this species.

Summary

Overall, there is a paucity of quantitative data with which to determine global trends in this widely-distributed tropical oceanic shark. However, based on best available scientific and commercial information, it appears that the oceanic whitetip shark has experienced significant population declines throughout a large portion of its range due to pressures associated with bycatch-related retention and mortality in commercial fisheries (e.g., Western and Central Pacific, Northwest and Southwest Atlantic, and Indian Oceans). Although the Northwest Atlantic population may have stabilized, all other populations are likely experiencing some level of decline or their status is currently unknown. All stocks of oceanic whitetip shark are experiencing some level of exploitation from commercial fisheries, but the level of fishing mortality likely varies, and is unknown for all stocks except one (Western and Central Pacific) due to the general lack of stock assessments on oceanic whitetip sharks. However, a number of other abundance indices are available to make inferences regarding population trends in several areas.

In the EPO, fisheries data from the tropical tuna purse seine fishery indicates a significant population decline in this region as a result of bycatch-related mortality in both purse seine and longline fisheries. Based on catches per set, as well as presence/absence of oceanic whitetip shark on associated sets in the tuna purse seine fishery, the oceanic whitetip shark population in the tropical Eastern Pacific has potentially declined by 80-95%. Although these data represent nominal catch rates and are not standardized to account for factors unrelated to abundance (e.g., fishery changes and environmental related factors) the rate of decline is very similar to the decline in abundance seen in the WCPO over the same period. There is no evidence to suggest that other factors besides overutilization have caused the significant observed decline, as the species is now rarely encountered, while catches and encounters of the closely related silky shark have remained relatively constant. Given the continued increase in fishing effort in this region, including a steady increase in the number of FAD sets (which account for 90% of oceanic whitetip shark catch in this region), oceanic whitetip sharks will likely continue to experience overutilization in the Eastern Pacific Ocean.

In the Northwest Atlantic and Gulf of Mexico, several studies indicate large historical declines in oceanic whitetip shark abundance (e.g., up to 70% from 1992–2000 and up to 88% between the 1950's and 1990's, respectively); but, more recent analyses indicate this population may have stabilized in recent years, with an estimated decline of approximately 1% from 1992–2018. However, fishing pressure on oceanic whitetip sharks began several decades prior to the start of this time series; thus, the estimated declines are not from historical unfished biomass. There is still disagreement in the literature regarding the current status of oceanic whitetip shark in the U.S. Atlantic, and a stock assessment has not been conducted. Currently, the best available scientific information indicates that current catch levels of oceanic whitetip shark in this region are low, which may be a result of past declines; however, landings of the species in this region have also continued to decline since species-specific regulations have been implemented that prohibit this species in U.S. commercial ICCAT-associated fisheries. In addition, at-vessel mortality in the northwest Atlantic is also relatively low when compared to other sharks. Therefore, based on the potentially stabilizing trend, low catches, and retention prohibition, overutilization may not be as significant of a threat in this region in the foreseeable future.

In the Southwest Atlantic, oceanic whitetip sharks were once considered common bycatch in commercial longline fisheries in Brazil, comprising nearly 30% of all shark catches in surveys from the 1990s. Recently, however, it appears that oceanic whitetip shark is less abundant in the Southwest Atlantic region, with very low CPUE rates across the region and most captures comprised of juveniles. In Brazil, which is the largest oceanic whitetip shark catching country in the region, a combination of tagging data and fisheries information suggests that the species' preferred vertical and horizontal habitat is significantly exploited by the Brazilian longline fishery. A demographic analysis from this region also suggests that the species has undergone at least a 50% population decline as a result of unsustainable fishing effort.

In the WCPO, historical information and observations suggest this species was once one of the most abundant pelagic shark species encountered in commercial fisheries; however, several lines of evidence suggest significant and continued population declines of oceanic whitetip shark across the Western and Central Pacific, with some areas exhibiting declines in excess of 90% since the 1990s. In particular, the most recent stock assessment of oceanic whitetip shark determined that the species is experiencing overfishing and the stock is in an overfished state (Tremblay-Boyer *et al.* 2019). The main cause of these declines identified in the stock assessment was bycatch-related mortality in longline fisheries, with targeted longlining and purse seine fisheries being secondary sources of mortality. These fisheries tend to concentrate their efforts in tropical latitudes, which is the species' preferred core habitat, thereby contributing to substantial fisheries-related mortality. Thus, due to the high fishing effort on large pelagic species in this region, with reported increases in fishing effort in recent years, oceanic whitetip sharks are likely experiencing overutilization across the Western and Central Pacific, as evidenced by declines in catch rates as well as biomass and size indices.

In the Indian Ocean, a combination of qualitative and quantitative data suggests that the oceanic whitetip shark has undergone population declines in this region. Oceanic whitetip sharks have been recorded in fisheries data for over 60 years; however, due to a lack of catch and abundance information, the status of oceanic whitetip sharks in the Indian Ocean is largely uncertain. While robust species-specific fisheries information is largely unavailable, decreases in nominal CPUE and mean weight of individuals have been demonstrated for the oceanic whitetip shark. Additionally, a few quantitative assessments of various longline and purse seine fisheries operating in the Indian Ocean indicate potential abundance declines between 25–90%, though these estimates are uncertain due to the lack of robust datasets. Overall, catches of oceanic whitetip shark reported to the IOTC are notably high in this region, with high at-vessel mortality rates and no indication of fishing pressure ceasing in the foreseeable future; thus, given the prevalence of oceanic whitetip shark as bycatch in fisheries in this region, representing approximately 11% of the total shark catch (prior to retention prohibition in 2013), combined with their relatively low-moderate productivity, it is likely that the impact to oceanic whitetip shark is significant in the Indian Ocean.

In terms of the international trade in shark products, current studies using fin trimmings show that oceanic whitetip sharks represent approximately 0.83% of the Hong Kong shark-fin market (which has been used as an indicator of the global trade for many years) and 1.58% of the Guangzhou shark-fin market. This level of oceanic whitetip fins in the trade translates to an annual estimate of up to 1.2 million individuals killed and traded per year. Given the relative ease of identifying oceanic whitetip shark fins, it is likely that the estimate is more reliable than for other species. Genetic studies of fins from markets in Indonesia, Taiwan, and United Arab Emirates also recorded oceanic whitetip shark at the species level, indicating the prevalence of oceanic whitetip fins in various markets throughout its range. Thus, it is clear that the shark fin trade is asserting significant pressure on the global oceanic whitetip shark population, as it is the main driving factor behind illegal retention of this species, though the exact magnitude of impact is uncertain. Although demand for shark fins is seemingly on the decline in recent years, it is clear that the demand for oceanic whitetip shark fins is still high, given their high preference and value in the Hong Kong market. This is evidenced by several incidents of seizures of illegal oceanic whitetip shark fins in recent years, despite national and international regulations to protect the species. Additionally, since 2014, several shipments of oceanic whitetip shark fins have been confiscated upon arrival in Hong Kong because they lacked proper CITES export permits from the countries of origin. In fact, in the first two months of 2017 alone, more than a ton of shark fins from hammerhead and oceanic whitetip sharks were seized by Hong Kong customs.[9] Although the demand for shark meat has increased in recent years, it is unlikely that new markets would develop for oceanic whitetip shark meat, given retention of the species has been prohibited in all relevant RFMOs.

4.3 (C) Disease or Predation

Disease

Disease is not thought to be a factor influencing the status of oceanic whitetip shark. If the oceanic whitetip shark is similar to other shark species, it likely harbors a diverse assemblage of macroparasites including cestodes, nematodes, leeches, copepods, and amphipods. In addition, at least some oceanic whitetip sharks are infected with highly pathogenic *Vibrio harveyi* (Zhang, *et al.* 2009). This bacterium is known to cause deep dermal lesions, gastro-enteritis, eye lesions, infectious necrotizing enteritis, vasculitis, and skin ulcers in marine vertebrates (Austin and Zhang 2006). *Vibrio harveyi* is considered to be more serious in immunocompromised hosts (Austin and Zhang 2006), and therefore may act synergistically with the high pollutant loads that oceanic whitetip sharks potentially experience to create an increased threat to the species. However, there is no additional information available regarding the magnitude of impact these parasites may have on the health of oceanic whitetip shark populations. Therefore, we cannot conclude that disease is an operative threat to the oceanic whitetip shark.

Predation

Predation is also not thought to be a factor influencing the status of oceanic whitetip sharks; the most significant predator on oceanic whitetip sharks is likely humans. Given that oceanic whitetip shark pups are born at a small size (about 65 cm), pups born in oceanic tropical waters are more vulnerable to predation. It may take the oceanic whitetip shark 2-3 years to attain a size that would deter predation, although the larger litter size may serve to counteract the longer exposure and vulnerability to predators (Branstetter 1990 *In:* Pratt 1990). However, information regarding natural predation rates of oceanic whitetip sharks and how predation may be impacting the global population is unavailable. Therefore, we cannot conclude that predation is an operative threat to the oceanic whitetip shark.

4.4 (D) Inadequacy of Existing Regulatory Mechanisms

Existing regulatory mechanisms for oceanic whitetip shark include federal, state, and international regulations. Below is a description and evaluation of current domestic and international management measures that may affect oceanic whitetip sharks. Though there are

[9] https://phys.org/news/2017-03-massive-hong-kong-shark-fin.html

numerous regulatory mechanisms that may impact the status of sharks in general, as well as species-specific regulations for oceanic whitetip shark in particular, the lack of data reporting on oceanic whitetip catches, combined with a the lack of information on implementation of and compliance with management measures in most countries, makes it difficult to measure the adequacy of current regulatory mechanisms as they relate to the global population of the oceanic whitetip shark. The oceanic whitetip shark is a highly migratory species found worldwide and thus requires protection in every ocean basin through international cooperation. Below is an analysis of existing regulatory mechanisms.

United States Regulations

There are a number of management authorities governing U.S. fisheries, including the Magnuson-Stevens Fisheries Conservation and Management Act (MSA), 16 U.S.C. 1801 *et seq*. The MSA establishes the authority and responsibility of the Secretary of Commerce to develop FMPs and subsequent amendments for managed stocks. The MSA requires NMFS to allocate both overfishing restrictions and recovery benefits fairly and equitably among sectors of the fishery. In the case of an overfished stock, NMFS must establish a rebuilding plan. The FMP or amendment to such a plan must specify a time period for ending overfishing and rebuilding the fishery that shall be as short as possible, taking into account the status and biology of the stock of fish, the needs of fishing communities, recommendations by international organizations in which the U.S. participates, and the interaction of the overfished stock within the marine ecosystem. The rebuilding plan cannot exceed ten years, except in cases where the biology of the stock of fish, other environmental conditions, or management measures under an international agreement in which the U.S. participates dictate otherwise. The U.S. Atlantic tuna and tuna-like species fisheries are managed under the dual authority of the MSA and the Atlantic Tunas Convention Act (ATCA) of 1975 (16 U.S.C. 971 *et seq*.). U.S. vessels that fish for tuna and associated species in the eastern tropical Pacific Ocean may be subject to management measures under the Tuna Conventions Act of 1950 (16 U.S.C. 951 *et seq*.) and potentially the U.S.-Canada Albacore Treaty (Miller *et al*. 2014). U.S. vessels that fish for highly migratory fish species in the WCPO may be subject to management measures under the Western and Central Pacific Fisheries Convention Implementation Act (16 U.S.C. 6901 *et seq*.).

State fishery management agencies have authority for managing fishing activity only in state waters (0-3 miles in most cases; 0-9 miles off Texas and the Gulf coast of Florida). As mentioned above, in the case of federally permitted shark fishers along the Atlantic coast and in the Gulf of Mexico and Caribbean, fishers are required to follow federal regulations in all waters, including state waters. Additionally, other states have implemented or are working towards the implementation of fin bans and efforts are being made to allow/preserve subsistence harvest in some of the U.S. territories.

Pacific Ocean

In the U.S. Pacific, HMS fishery management is the responsibility of adjacent states and three regional management councils that were established by the MSA, including: the Pacific Fishery Management Council (PFMC), North Pacific Fishery Management Council (NPFMC), and the Western Pacific Fishery Management Council (WPFMC). However, because of the oceanic whitetip shark's more tropical distribution, only the WPFMC directly manages this species. The WPFMC has jurisdiction over the EEZs of Hawaii, Territories of American Samoa and Guam, Commonwealth of the Northern Mariana Islands, and the Pacific Remote Island Areas, as well as the domestic fisheries that occur on the adjacent high seas. The WPFMC developed the Pelagics FEP (formerly the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region) in 1986 and NMFS, on behalf of the U.S. Secretary of Commerce, approved the Plan in 1987. Since that time, the WPFMC has recommended, and NMFS has approved, numerous amendments to the Plan as necessary for conservation and management purposes. The WPFMC manages HMS fisheries pursuant to the FEP, and species that are managed under FMPs or FEPs are called Management Unit Species (MUS) and typically include those species that are caught in quantities sufficient to warrant management or specific monitoring by NMFS and the Council. In the FEP, the oceanic whitetip shark is designated as a Pelagic MUS and, thus, is subject to regulations under the FEP. These regulations are intended to minimize impacts to targeted stocks as well as protected species. Fishery data are also analyzed in annual reports and used to amend the FEP as necessary. As previously described, oceanic whitetip sharks are caught in longline fisheries of both Hawaii and American Samoa. The Hawaii-based and American Samoa longline fisheries are similar, in that they operate under extensive regulatory measures, including gear, permit, logbook requirements, vessel monitoring system, and protected species workshop requirements. In 2002, vessels 50 feet and longer were prohibited from fishing for pelagic fish around Tutuila, the Manua Island, Rose Atoll, and Swains Islands in American Samoa. However, due to a change in fishery conditions, NMFS finalized a rule to allow federally-permitted U.S. longline vessels 50 ft and longer to fish in certain portions of the Large Vessel Prohibited Area (LVPA) (86 FR 36239). Specifically, the rule allows large U.S. vessels that hold a Federal American Samoa longline limited entry permit to fish within the LVPA seaward of 12 nm around Swains Island, Tutuila, and the Manua Islands.

In 2015, NMFS issued final regulations to implement decisions of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPFC) to prohibit the retention of oceanic whitetip sharks in fisheries operating within the WCPFC's area of competence (or Convention Area), which comprises the majority of the Western and Central Pacific Ocean. The regulations were published in the *Federal Register* on February 19, 2015 (80 FR 8807) and include prohibitions on the retention of the oceanic whitetip shark, as well as requirements to release any oceanic whitetip caught, and are applicable to all U.S. fishing vessels used for commercial fishing for HMS in the Convention Area (PIRO 2015). Given the relatively lower at-vessel mortality of oceanic whitetip sharks, adequate implementation of these regulations has the potential to be beneficial for the species. Additionally, in 2021, the Western Pacific Regional Fishery Management Council voted to prohibit wire leaders in the Hawaii deep-set longline fishery and require removal of trailing gear for all longline vessels operating under the Pacific Pelagic Fishery Ecosystem Plan to improve the post-hooking survivorship of oceanic whitetip sharks. However, given the severely depleted state of the oceanic whitetip shark in the Western and Central Pacific, less than full implementation and enforcement may not be adequate to prevent continued population declines of the species given the high level of fishing mortality the species experiences in this portion of its range (see the *Regional Analysis* section for the Western and Central Pacific below for more details).

Atlantic Ocean (U.S. Northwest Atlantic and Gulf of Mexico)

On November 28, 1990, the President of the United States signed into law the Fishery Conservation Amendments of 1990. This law amended the MSA and gave the Secretary of Commerce the authority to manage HMS in the U.S. EEZ of the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea (16 U.S.C. 1811 and 16 U.S.C. 1854(f)(3)). The Atlantic HMS Management Division within NMFS develops regulations for Atlantic HMS fisheries and primarily coordinates the management of HMS fisheries in Federal waters (domestic) and the high seas (international), while individual states establish regulations for HMS in state waters. However, in the case of federally permitted shark fishermen, as a condition of their permit, the fishers are required to follow Federal regulations in all waters, including state waters, unless the state has more restrictive regulations. For example, the Atlantic States Marine Fisheries Commission (ASMFC) recently developed an interstate coastal shark FMP that coordinates management measures among all states along the Atlantic coast (FL to ME) in order to ensure that the states are following Federal regulations. This interstate shark FMP became effective in 2010.

In the Atlantic, oceanic whitetip sharks are managed under the pelagic species complex of the Consolidated Atlantic HMS FMP. The first FMP for sharks of the Atlantic Ocean (1993) classified the status of pelagic sharks as unknown because no stock assessment had been conducted for this complex. At that time, the maximum sustainable yield (MSY) for pelagic sharks was set at 1,560 mt dressed weight (dw), which was the 1986-1991 commercial landings average for this group. However, as a result of indications that the abundance of Atlantic sharks had declined, commercial quotas for pelagic sharks were reduced in 1997. The quota for pelagic sharks was then set at 580 mt. In 1999, the FMP for Atlantic Tunas, Swordfish, and Sharks[10] implemented the following measures affecting pelagic sharks: 1) a reduction in the recreational bag limit to 1 Atlantic shark per vessel per trip, with a minimum size of 137 cm fork length for most sharks, 2) an increase in the annual commercial quota for pelagic sharks to 853 mt dw, apportioned between porbeagle (92 mt), blue sharks (273 mt dw), and other pelagic sharks (488 mt dw), with the pelagic shark quota being reduced by any overharvest in the blue shark quota, and 3) making the bigeye sixgill, sixgill, sevengill, bigeye thresher, and longfin mako sharks prohibited species that cannot be retained.

The implementing regulations for the conservation and management of the domestic fisheries for Atlantic swordfish, tunas, sharks, and billfish are published in the 2006 Consolidated HMS FMP[11] (71 FR 58058, NMFS 2006). Since 2006, this FMP has been amended 11 times through the end of 2020. Amendment 2, finalized in June 2008, requires that all fins remain naturally attached through landing in both the commercial and recreational fisheries (June 24, 2008, 73 FR 35778; corrected on July 15, 2008, 73 FR 40658).

Any commercial fisher who fishes for, retains, possesses, sells, or intends to sell, Atlantic sharks needs a Federal Atlantic Directed or Incidental shark limited access permit. Generally, directed shark permits allow fishers to target sharks while incidental permits allow fishers who normally fish for other species to land a limited number of sharks. The limited access permits are administered under a limited access program and NMFS is no longer issuing new shark limited access permits. To enter the directed or incidental shark fishery, fishers must obtain a permit via

[10] http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/index.html
[11] http://www.fisheries.noaa.gov/sfa/hms/documents/fmp/consolidated/index.html

transfer from an existing permit holder who is leaving the fishery, subject to the vessel upgrading restrictions. Under a directed shark permit, there is no directed numeric retention limit for pelagic sharks, subject to quota limitations. An incidental permit allows fishers to keep up to a total of 16 pelagic or small coastal sharks (all species combined) per vessel per trip. Authorized gear types include: pelagic or bottom longline, gillnet, rod and reel, handline, or bandit gear. All fins must remain naturally attached. The annual quota for pelagic sharks (other than blue sharks or porbeagle sharks) is currently 488.0 mt dressed weight.

NMFS monitors the different commercial shark quota complexes annually and will close the fishing season for each fishery after 80% of the respective quota has been landed or is projected to be landed. Atlantic sharks and shark fins from federally permitted vessels may be sold only to federally permitted dealers; however, as noted previously, all sharks must have their fins naturally attached through offloading. The head may be removed and the shark may be gutted and bled, but the shark cannot be filleted or cut into pieces while onboard the vessel. Logbook reporting is required for selected fishers with a federal commercial shark permit. In addition, fishers may be selected to carry an observer onboard, and some fishers are subject to vessel and electronic monitoring systems depending on the gear used and where they fish. Since 2006, pelagic longline, bottom longline and gillnet fishermen fishing for sharks have been required to attend workshops every three years to learn how to release sea turtles, protected species, and prohibited shark species in a manner that maximizes survival. Additionally, NMFS published a final rule on 7 February, 2007 (72 FR 5633), that requires participants in the Atlantic shark bottom longline fishery to possess, maintain, and utilize handling and release equipment for the release of sea turtles, other protected species, and prohibited shark species. Additionally, in efforts to reduce bycatch in the first place, NMFS has implemented a number of time/area closures with restricted access to fishermen with HMS permits who have pelagic longline gear onboard their vessel (see Figure 41 below).

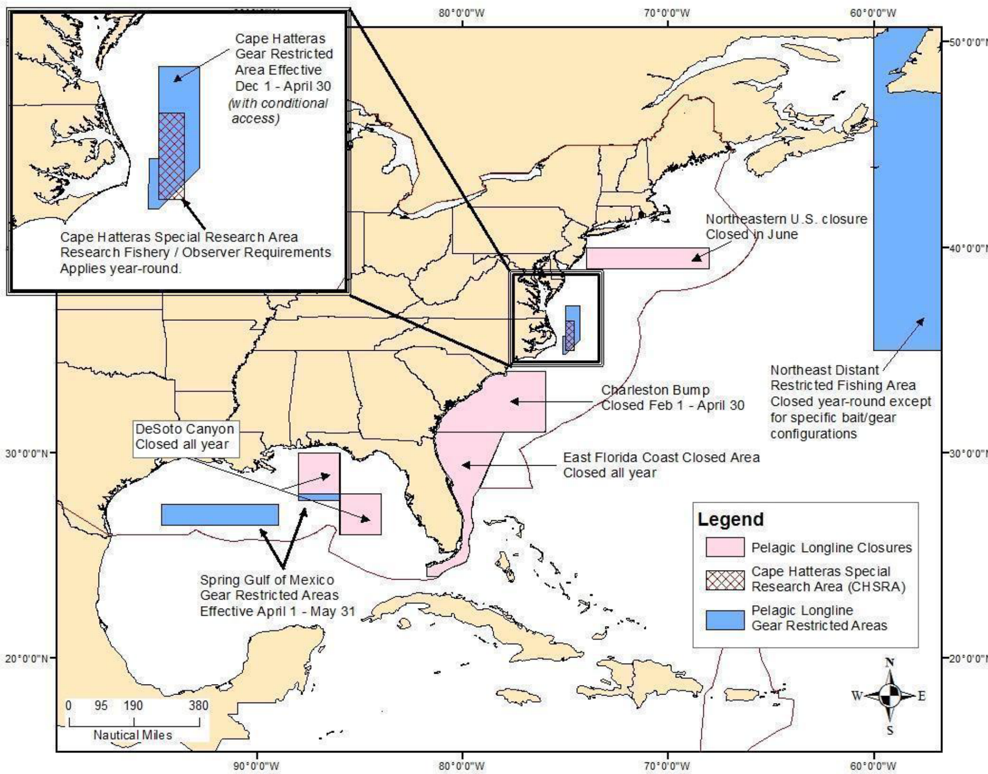

Figure 41. Time/area closures and gear restricted areas in the Atlantic, Gulf of Mexico, and Caribbean Sea that limit use of pelagic longline gear (HMS Compliance Guide) Source: NMFS 2019.

Although there has been no scientific study conducted to confirm whether these time/area seasonal closures have reduced bycatch of oceanic whitetip sharks, it is possible these regulations have had a positive impact on reducing bycatch of oceanic whitetip shark in the Northwest Atlantic pelagic longline fishery. In particular, the area of the Charleston Bump has historically proven to be a hotspot for oceanic whitetip shark catches (John Carlson, personal communication 2017); therefore, that particular closure has likely benefited oceanic whitetip sharks to some degree.

The HMS Management Division also published an amendment to the Consolidated Atlantic HMS FMP that specifically addresses Atlantic HMS fishery management measures in the U.S. Caribbean territories (77 FR 59842; Oct. 1, 2012). Due to substantial differences between some segments of the U.S. Caribbean HMS fisheries and the HMS fisheries that occur off the mainland of the United States (including permit possession, vessel size, availability of processing and cold storage facilities, trip lengths, profit margins, and local consumption of catches), the HMS Management Division implemented measures to better manage the traditional small-scale commercial HMS fishing fleet in the U.S. Caribbean Region. Among other things, this rule created an HMS Commercial Caribbean Small Boat (CCSB) permit, which: allows fishing for and sales of bigeye, albacore, yellowfin, and skipjack tunas, Atlantic swordfish, and Atlantic sharks within local U.S. Caribbean market; collects HMS landings data through existing territorial government programs; authorizes specific gears; is restricted to vessels less than or equal to 45 feet (13.7 m) length overall; and may not be held in combination with any other Atlantic HMS vessel permits. Fishermen who hold the CCSB permit may now land a limited number of some species of sharks, but are prohibited from retaining oceanic whitetip sharks.

These fishermen are restricted to fishing with only rod and reel, handline, and bandit gear under the permit. Both the CCSB and Atlantic HMS regulations will help protect oceanic whitetip sharks while in the Northwest Atlantic Ocean, Gulf of Mexico, and Caribbean Sea.

In order to implement the ICCAT Recommendation 10-07 for the conservation of oceanic whitetip sharks, NMFS published a final rule in 2011 that prohibits retention of oceanic whitetip sharks in the PLL fishery and on recreational (HMS Angling and Charter headboat permit holders) vessels that possess tuna, swordfish, or billfish (76 FR 53652). See Appendix 1 for a table that describes relevant regulatory mechanisms in U.S. states and territories in the Atlantic. The implementation of regulations to comply with ICCAT Recommendation 10-07 for the conservation of oceanic whitetip sharks is likely the most influential regulatory mechanism in terms of reducing mortality of oceanic whitetip sharks in the U.S. Atlantic. It should be noted that oceanic whitetip sharks are still occasionally caught as bycatch and landed (NMFS 2012; 2014), as retention is permitted in other authorized gears other than pelagic longlines (e.g., gillnets, bottom longlines); however, these numbers have decreased. Prior to the implementation of the retention prohibition on oceanic whitetip shark, an analysis of the pelagic longline observer data from 1992–2018 indicated that, on average, 13% of oceanic whitetip sharks were kept per year (Carlson *et al* 2019). Following the prohibition, no oceanic whitetip sharks have been retained according to data collected by on-board observers. In addition, from 1992–2018 an average of 67% of sharks were released alive while 13% were released dead. However, since the prohibition was implemented in 2011, estimated commercial landings of oceanic whitetip shark declined from only 1.1 mt in 2011 to 0.03 mt in 2013 and have since declined to zero (NMFS 2012; 2014; 2021). While the retention ban for oceanic whitetip shark does not prevent incidental catch or subsequent at-vessel and post-release mortality, it is likely effective in reducing overall fishing mortality on the species in the Atlantic PLL fishery. In fact, analysis of the observer data indicates 76% of oceanic whitetip sharks are alive when brought to the vessel while 24% are dead (Carlson *et al.* 2019; see Figures 42 and 43 below).

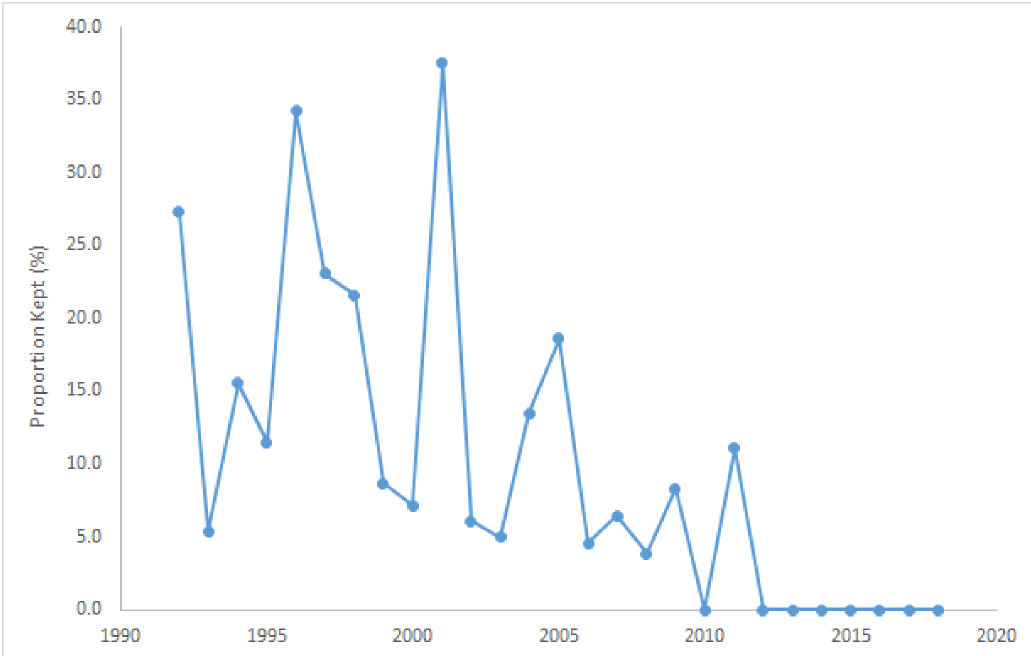

Figure 42. Proportion of oceanic whitetip shark reported kept for sharks caught in the U.S. Atlantic pelagic longline fishery.

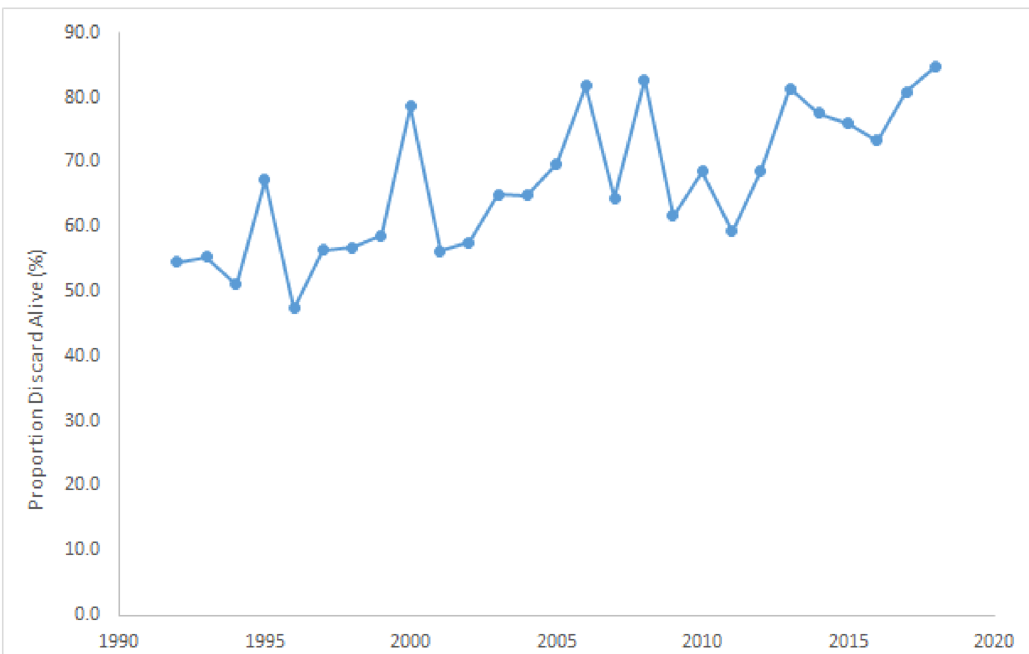

Figure 43. Proportion of oceanic whitetip shark reported discarded alive for sharks caught in the U.S. Atlantic pelagic longline fishery.

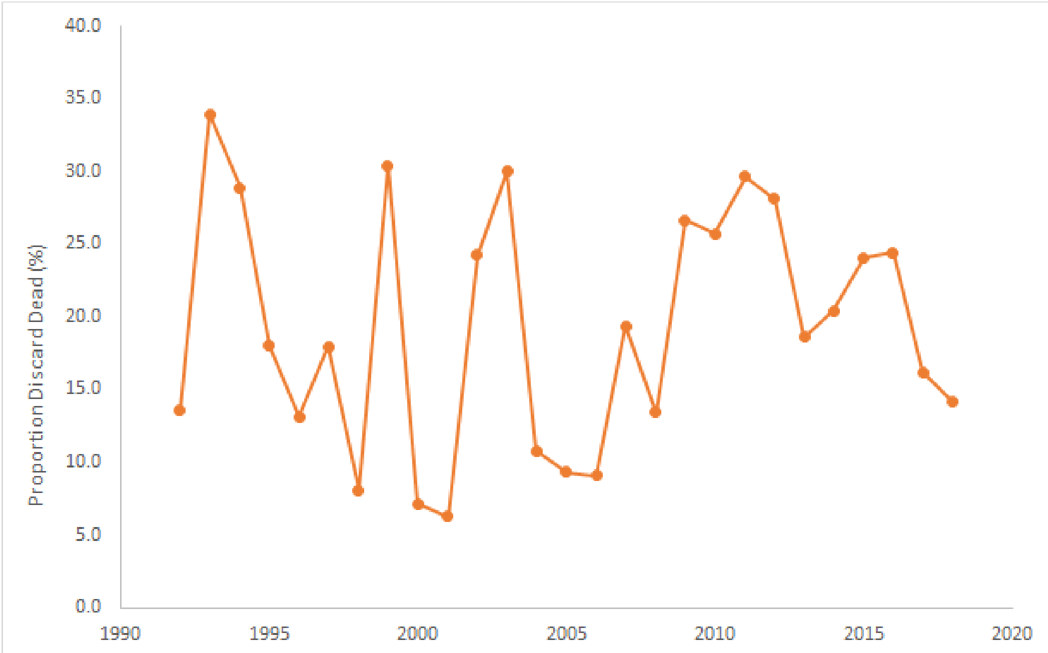

Figure 44. Proportion of oceanic whitetip shark reported discarded dead for sharks caught in the U.S. Atlantic pelagic longline fishery.

Overall, these regulations may have had a positive effect on reducing bycatch and fisheries-related mortality of oceanic whitetip shark in the Northwest Atlantic pelagic longline fishery, particularly given the stabilized trend shown by the update in this report of observer data from the U.S. fishery. Overall, we conclude the regulatory mechanisms in the Northwest Atlantic in general have likely improved the status of the oceanic whitetip shark in this portion of its range.

U.S. Finning Laws and Regulations

Two influential domestic national laws for the conservation and management of sharks in the United States include the Shark Finning Prohibition Act and the Shark Conservation Act. The Shark Finning Prohibition Act was enacted in December 2000 and implemented by final rule on February 11, 2002 (67 FR 6194). Section 3 of the Shark Finning Prohibition Act amended the MSA to prohibit any person under U.S. jurisdiction from: (i) engaging in the finning of sharks; (ii) possessing shark fins aboard a fishing vessel without the corresponding carcass; and (iii) landing shark fins without the corresponding carcass. In addition, Section 3 of the Shark Finning Prohibition Act contains a rebuttable presumption that any shark fins landed from a fishing vessel or found on board a fishing vessel were taken, held, or landed in violation (of the Act) if the total weight of shark fins landed or found on board exceeds 5% of the total weight of shark carcasses landed or found on board. Section 9 of the Act defines finning as the practice of taking a shark, removing the fin or fins from a shark, and returning the remainder of the shark to the sea. The Shark Conservation Act was signed into law on January 4, 2011 and implemented by final rule on July 29, 2016 (50 CFR 600, June 29, 2016). It amended the High Seas Driftnet Fishing Moratorium Protection Act and the MSA to improve existing domestic and international shark conservation measures. To address concerns over the practice of shark finning, the Shark Conservation Act, among other things, prohibits any person from removing shark fins at sea (with a limited exception for smooth dogfish); or possessing, transferring, or landing shark fins unless they are naturally attached to the corresponding carcass.

After the passage of the Shark Finning Prohibition Act, U.S. exports of dried shark fins dropped substantially, which was expected. For example, in 2004 50.6 tonnes of fins were exported but in 2013 the weight of fins dropped to 12 tonnes (NMFS 2018). This reduction in weight exported is in contrast to the price per kg of shark fin and suggests that existing regulations have likely been effective at discouraging fishing for sharks solely for the purpose of the fin trade. In 2012, the value of fins also decreased suggesting that the worldwide demand for fins may be on a decline. According to NOAA's 2017 and 2018 Shark Finning Reports to Congress, the mean value of U.S. exports per metric ton has continued to decline since 2012, but average value increased to $71,000/mt in 2016 compared to $57,000/mt in 2015, the highest mean value since 2013, when it was $66,000/mt (NMFS 2017b; 2018). Therefore, while the international shark fin trade is likely a driving force behind the overutilization of many global shark species, U.S. participation in this trade appears to be generally diminishing. For example, due to the implementation of fin bans in various U.S. states in 2012 and 2013, U.S. fin prices decreased dramatically and U.S. shark fin exports have continued on a declining trend. However, it should be noted that the continued decline is also likely a result of the waning demand for shark fin altogether (Dent and Clarke 2015).

Similarly, many U.S. states, especially on the West Coast and U.S. Flag Pacific Island Territories, have also passed fin bans and trade regulations, which likely contributed to the apparent decline in the United States' contribution to the fin trade. For example, after the state of Hawaii prohibited finning in its waters and required shark fins to be landed with their corresponding carcasses in 2000, the shark fin imports from the United States into Hong Kong declined significantly (54% decrease, from 374 to 171 t). This was because Hawaii could no longer be used as a fin trading center for the international fisheries operating and finning in the Central Pacific (Figure 44; Clarke *et al.* 2007).

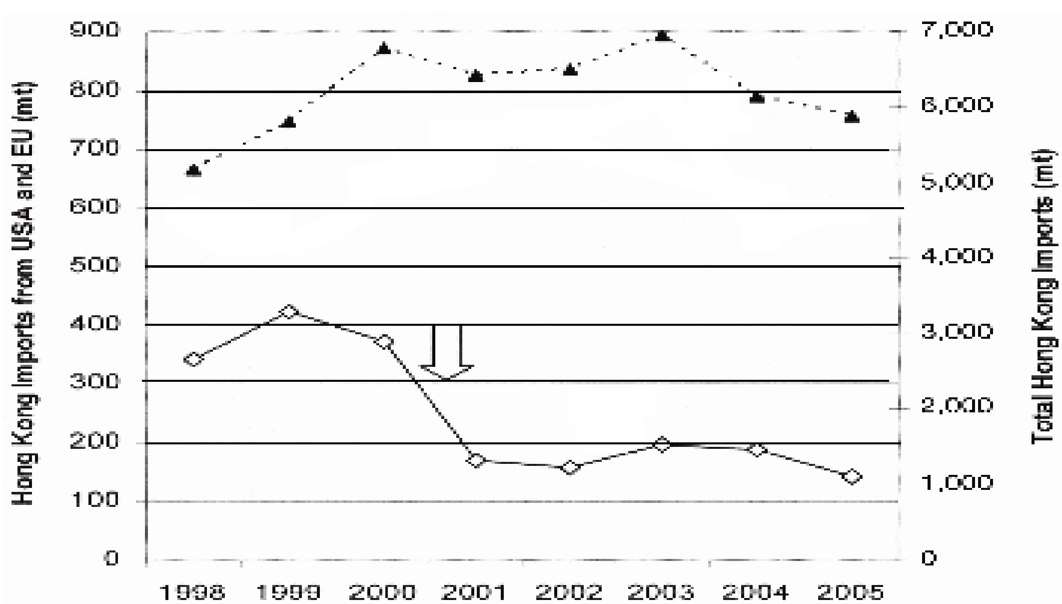

Figure 45. Annual imports of shark fin to Hong Kong from the U.S. (◊) and total Hong Kong imports (▲) from 1998-2005. The large arrow indicates the implementation of finning regulations in the state of Hawaii. Source: Adapted from Clarke et al. 2007.

More specifically to oceanic whitetip sharks, the finning regulations introduced in 2001 in the U.S. Hawaii-based longline fishery have reduced mortality on oceanic whitetip sharks and other large shark species (Walsh *et al*. 2009). Prior to the ban from 1995–2000, fins were taken from a large proportion of captured oceanic whitetip sharks, with the remaining carcasses discarded (72.3% in deep sets and 52.7% from shallow sets) (Walsh *et al.* 2009). Following the implementation of the new regulations, almost all sharks were released from 2004–2006, although some individuals were dead on release. Consequently, minimum mortality estimates declined substantially from 81.9% to 25.6% in deep sets and from 61.3% to 9.1% in shallow sets (Walsh *et al*. 2009).

Aside from this example, there is little information on the level of compliance with the various fisheries management measures for sharks, including oceanic whitetip sharks, with compliance likely variable among other countries and regions. In other parts of the world, finning and retention bans may not be adequate for the oceanic whitetip shark given the continued high value for their large fins. For example, despite being protected in Indonesia, an illegal seizure of approximately 3,000 oceanic whitetip shark fins occurred as recently as October, 2015 (see the *International Regulatory Mechanisms* section below for more details). This provides some evidence that despite species-specific regulations to protect the species, these regulatory mechanisms are only effective when implemented and enforced adequately.

International Regulations

Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES)[12]

CITES is an international agreement with the aim of ensuring that international trade in specimens of wild animals and plants does not threaten their survival. CITES contains three appendices: Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances; Appendix II includes species not necessarily threatened with extinction, but for whom trade must be controlled to ensure utilization is compatible with their survival; and Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

Due to reported population declines driven by the trade of oceanic whitetip shark fins, the oceanic whitetip shark was listed under Appendix II of CITES in 2013. This listing went into effect as of September 2014. International trade in specimens of Appendix-II species may be authorized by the granting of an export permit or re-export certificate. No import permit is necessary for these species under CITES (although a permit is needed in some countries that have taken stricter measures than CITES requires). Because the oceanic whitetip shark is a pelagic species mostly occurring in waters not under the jurisdiction of any State, introduction from the sea (i.e., transport of captured specimens from international waters to areas under national jurisdiction) would be expected to occur frequently in fisheries regulated by RFMOs that allow the species to be landed (FAO 2012). Under CITES, such transport of specimens listed on Appendix II would require a certificate from the State to whose jurisdiction the specimens are

[12] https://www.cites.org/eng

brought, including a non-detriment finding and a legal acquisition finding. However, given that all RFMOs now prohibit the retention of the oceanic whitetip shark (with the exception of some countries that have taken reservations to the prohibition (e.g., India)), export of oceanic whitetip shark fins from most RFMO member countries should not be occurring. However, recent data suggests this is not the case. From 2015–2019, approximately 2,294 kg (5,057 lbs) of illegal oceanic whitetip shark fins have been confiscated upon entry into Hong Kong (Hong Kong government, unpublished data). Many of these shipments involved countries that are members of RFMOs.

Convention on the Conservation of Migratory Species of Wild Animals[13]

The Convention on the Conservation of Migratory Species of Wild Animals (CMS) is an environmental treaty under the auspices of the United Nations Environment Programme. The CMS provides a global platform for the conservation and sustainable use of migratory animals and their habitats, and works to bring together the Range States (i.e., the States through which migratory species pass), and lay the legal foundation for coordinating international conservation measures throughout a migratory range. In 2020, the 13th Meeting of the Conference of the Parties to CMS agreed to list the oceanic whitetip shark in Appendix I of the Convention. Migratory species listed in Appendix I are endangered. Parties that are a Range State of a migratory species listed under Appendix I shall endeavor to: conserve and, where feasible and appropriate, restore those habitats of the species which are of importance in removing the species from danger of extinction; prevent, remove, compensate for or minimize, as appropriate, the adverse effects of activities or obstacles that seriously impede or prevent the migration of the species; and, to the extent feasible and appropriate, to prevent, reduce or control factors that are endangering or are likely to further endanger the species, including strictly controlling the introduction of, or controlling or eliminating, already introduced exotic species. Parties that are Range States of migratory species listed in Appendix I shall prohibit the taking of animals belonging to such species. In February 2020, CMS Signatories listed oceanic whitetip shark on Appendix I of CMS which prohibits catch of the species throughout its range.

The Memorandum of Understanding on the Conservation of Migratory Sharks (Sharks MOU)

The Sharks MOU is one of several CMS instruments. It is the first global instrument for the conservation of migratory shark species. The Sharks MOU is a non-legally binding international instrument. It aims to achieve and maintain a favorable conservation status for migratory sharks based on the best available scientific information and taking into account the socio-economic value of these species for the people in various countries. In 2018 at the third Meeting of Signatories, Signatories agreed to list oceanic whitetip sharks in Annex I of the Sharks MOU. The Sharks MOU applies to all migratory species included in Annex I with the objective of achieving and maintaining a favorable conservation status for those species.

2009 FAO Port State Measures Agreement (PSMA)

The PSMA was adopted in 2009 by the United Nations Food and Agriculture Organization as a tool to combat IUU fishing. It aims to prevent illegally caught fish from entering international markets through ports. Under the terms of the treaty: foreign vessels will provide advance notice and request permission for port entry, countries will conduct regular inspections in accordance

[13] http://www.cms.int/en

with universal minimum standards, offending vessels will be denied use of port or certain port services, and information sharing networks will be created. As IUU fishing is also a threat to vulnerable shark species, implementation of the PSMA can have a positive effect on the conservation of sharks.

International Shark Fishing and Finning Regulations

Finning bans have been implemented by a number of countries including the EU, as well as by nine RFMOs. These finning bans range from requiring fins remain attached to the body, to allowing fishers to remove shark fins if the weight of the fins does not exceed 5% of the total weight of shark carcasses landed or found onboard. In fact, all of the relevant RFMOs prohibit fins onboard that weigh more than 5% of the weight of sharks to curb the practice of shark finning. Although the fins:body weight ratios have the potential to reduce the practice of finning, these regulations do not prohibit the fishing of sharks and a number of issues associated with reliance on the 5% fins:body weight ratio requirement have been identified. For instance, some disagree that the ratio has a clear scientific basis as a conservation measure for sharks. For example, Lack and Sant (2009) note that: the percentage of fins:body weight varies widely among species, fin types used in calculation, the type of carcass weight used (whole or dressed) and fin cutting techniques. Additionally, under the fins:body weight ratio measure, sharks that are not landed with fins attached to the body make it difficult to match fins to a carcass (Lack and Sant 2009). There are also issues with using the ratios for dried vs. fresh fins, which can affect the ratio substantially. In a Fins Attached report, Arauz (2017) notes inaccurate data recording as a major issue, and provides an example from Costa Rica that demonstrates highly variable fin-to-body-weight ratios for oceanic whitetip sharks from one landing event to another. Again, such controls have no impact on the mortality of sharks that are discarded because their fins have either no or very low market value. Controls on finning also lack the capacity to provide differential protection to those shark species most at risk from overfishing (Lack and Sant 2009). In addition, with the rise in the shark meat market in recent years (Dent and Clarke 2015), retention of the full carcass for commercial purposes may be an advantage for fishers, as the product is worth keeping on board for landing. Overall, despite their existence, laws and regulations are rapidly changing and are not always effectively enforced by countries and RFMOs (Biery and Pauly 2012).

In addition to regulations specific to shark finning, numerous RFMOs and countries have implemented various regulations regarding shark fishing in general, which are described in Appendix 4 and discussed in detail below in the *Regional Analysis* section. A number of countries have enacted complete shark fishing bans (i.e., bans on retention and possession of sharks and shark products), with the Bahamas, Marshall Islands, Honduras, Sabah (Malaysia), and Tokelau (an island territory of New Zealand) adding to the list in 2011, the Cook Islands in 2012, and the Federated States of Micronesia in 2015. So-called “shark sanctuaries” (i.e., locations where harvesting sharks is prohibited) can also be found in the Eastern Tropical Pacific Seascape (which encompasses around two million km^2 and includes the Galapagos, Cocos, and Malpelo Islands), in waters off the Maldives, Mauritania, Palau, French Polynesia, New Caledonia and Raja Ampat, Indonesia. However, it should be noted that sharks can still be caught as bycatch in these areas. See Appendices 2 and 3 for a description of the existing regulatory mechanisms in place for shark fishing and finning, respectively, throughout the range of the oceanic whitetip shark.

A number of countries and territories also prohibit the sale or trade of shark fins or products, including:

- Bahamas
- Canada - The cities of Brantford, Oakville, Newmarket, Mississauga, London, Pickering and Toronto, as well as six municipalities in British Columbia: Abbotsford, Coquitlam, Nanaimo, Port Moody, North Vancouver, and Maple Ridge, have all passed bans on the sale of shark fins.
- Commonwealth of the Northern Mariana Islands (CNMI)
- American Samoa
- Cook Islands
- Egypt
- French Polynesia
- Guam (with an exception for subsistence fishing)
- Republic of the Marshall Islands
- Sabah, Malaysia

Regional Analysis

Pacific Ocean

In the EPO, the IATTC is the RFMO responsible for the conservation and management of tuna and tuna-like species. As noted previously, the IATTC adopted a no-retention measure for oceanic whitetip sharks by implementing Resolution C-11-10 in 2012 for the conservation of oceanic whitetip sharks caught in association with fisheries in the Antigua Convention Area. This Resolution prohibits Members and Cooperating non-Members (CPCs) from retaining onboard, transhipping, landing, storing, selling, or offering for sale any part or whole carcass of oceanic whitetip sharks in the fisheries covered by the Antigua Convention. As discussed in the *Overutilization* section of this recovery status review, this measure is not likely adequate to prevent capture and mortality in the tropical tuna purse seine fishery in the EPO. Though mortality rate estimates of oceanic whitetip shark in EPO purse seine fisheries are not available, it is likely that oceanic whitetip sharks experience high mortality rates similar to *C. falciformis* (i.e., ~85% in Western and Central Pacific and Indian Ocean tropical purse seine fisheries; Poisson *et al.* (2014); Hutchinson *et al.* (2015)) if captured in the brailer or brought onboard. Given that sharks are captured in a net and/or brail where they are unable to swim, and subjected to the weight of whatever tonnage is on top of them, oceanic whitetip sharks likely experience high levels of stress that can lead to mortality even if they are released alive. Given the high level of stress experienced by the animals, and with no studies on post-release survivorship in purse seine gear, oceanic whitetip sharks released alive are actually considered to be dead by the IATTC observer program (Martín Hall, Pers. Comm. 2016). In 2016, the IATTC adopted Resolution C-16-05 to help improve safe release of shark species, including the oceanic whitetip shark. This Resolution requires purse seine vessels to follow safe-release requirements for all sharks, whether alive or dead (with the exception of those retained), including prompt release as soon as the shark is seen in the net or on deck. The Resolution provides “to the extent practicable, as soon as it is seen in the net or on the deck, without compromising the safety of any persons...” sharks must be released out of the net directly from the brailer into the ocean and the use of gaffs, hooks, or similar instruments is prohibited. Resolution C-16-05 also bans the use of “shark lines” in longline vessels targeting tuna or swordfish in the Convention Area and entered into force in January 2018. Additionally, given the depleted status of the population in this region (resulting in lower encounter rates), and that this Resolution does not prevent oceanic whitetip sharks from being initially encircled in purse seine nets, it is unclear how effective these measures will be.

In the WCPO, the WCPFC is the main regulatory body for the management of sharks. Like other RFMOs, the WCPFC also has regulatory measures for the conservation of sharks in general, as well as specific measures for the conservation of oceanic whitetip sharks. Clarke (2013) identifies three main objectives of the shark CMMs in this region: 1) promote full utilization and reduce waste of sharks by controlling finning (perhaps as a means to indirectly reduce fishing mortality for sharks); 2) increase the number of sharks that are released alive (in order to reduce shark mortality); and 3) increase the amount of scientific data that is collected for use in shark stock assessments. Clarke (2013) found variable implementation rates of the CMM requirements by the WCPFC members and a lack of effectiveness of these measures in terms of reducing mortality of shark stocks. In addition to CMMs for sharks in general, CMM 2011-04 (which prohibits WCPFC vessels from retaining onboard, transshipping, storing on a fishing vessel, or landing any oceanic whitetip shark, in whole or in part, in the fisheries covered by the Convention), is likely the most influential management measure for the conservation of oceanic whitetip sharks in the Western and Central Pacific. In the first year of the no-retention measure, proportionally more oceanic whitetip sharks were retained, and observations from the longline fishery showed that the CMM was not being strictly adhered to, with non-negligible proportions of oceanic whitetip sharks retained or finned. Due to changes in observer coverage and lack of data from U.S. and Australian longline fisheries for years 2012–2014 and 2014, respectively, evaluating the efficacy of this measure is complicated (Rice *et al*. 2015). However, Tremblay-Boyer *et al.* (2019) developed a model on the probability of an individual oceanic whitetip shark being discarded by fleet over the years based on observer data. The model predicted a slow increase in discard rates over time from 1995, and a distinct increase after 2012, which indicates an increased adherence to the no-retention CMM.

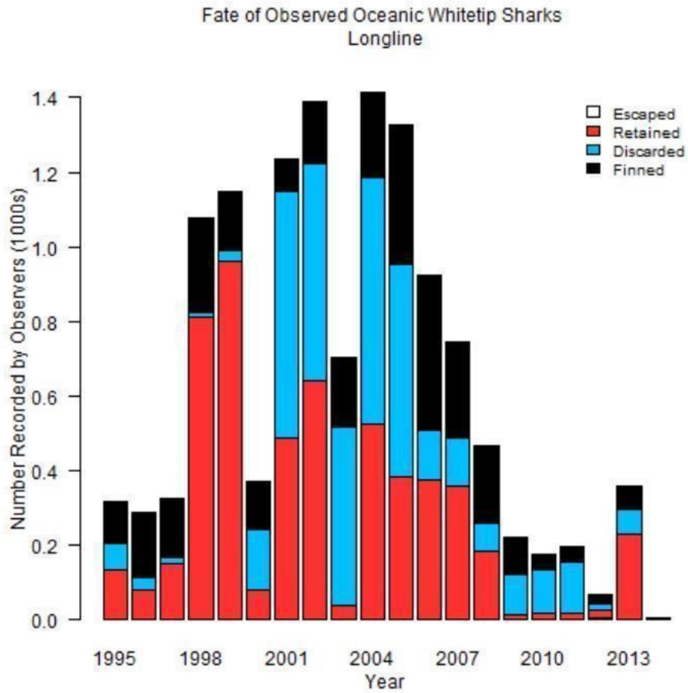

Figure 46. Fate of observed oceanic whitetip sharks caught by longline in the WCPO from 1995-2013. Source: Rice et al. 2015.

While a retention ban for oceanic whitetip sharks is a step in the right direction, a retention ban does not address incidental catch of oceanic whitetip sharks and the subsequent mortality that may result during and after release; thus, this management measure may not necessarily prevent mortality of oceanic whitetip sharks. Rice *et al.* (2020) conducted population projection scenarios following the stock assessment of Tremblay-Boyer et al (2019). Scenarios were considered with three levels of post-release mortality, a 100% mortality on all catches independently of discard status, a 25% mortality on discards and a 25% mortality on individuals released alive (total discard mortality of 43.75% =0.25+0.25*0.75), and a 25% mortality on discards (0% mortality on live release). The most optimistic scenario of a 20% reduction in the 2016 catch suggests it will take 16 years for the biomass to reach 50% of 2016 levels (which represents 95% depletion; Table 5 below). Thus, even under a no-retention measure, the oceanic whitetip shark is still experiencing at-vessel and post-release mortality, which is likely limiting its ability to recover given its depressed population levels in the region.

Table 5. The number of years for the western central Pacific population to reach 50%, 25% and 12.5% of the 2016 population levels. Source: Rice et al. 2020.

Future Catch Scenario	Percent of 2016 Biomass	Mean	Standard Deviation	Median
2016 catch	12.5%	13.8	1.8	14.0
2016 catch	25%	12.7	2.4	12.0
2016 catch	50%	10.6	3.2	10.0
10% Decline	12.5%	16.0	0.0	16.0
10% Decline	25%	15.9	0.4	16.0
10% Decline	50%	15.1	1.6	16.0
20% Decline	12.5%	16.0	0.0	16.0
20% Decline	25%	16.0	0.0	16.0
20% Decline	50%	16.0	0.0	16.0

It remains impossible to evaluate the proportion of sharks released alive in WCPFC purse seine fisheries because purse seine observers do not record the sharks' condition at release. Nonetheless, studies of shark mortalities in various purse seine fisheries have shown that ~60-80% of sharks are dead when they are first observed at net retrieval and approximately half of those which survive retrieval die after release (Poisson *et al.* 2014; Hutchinson *et al.* 2015). Therefore, even if live release is strictly practiced in purse seine fisheries, the number of sharks expected to survive is low. The analysis of the oceanic whitetip shark retention prohibition CMM in the purse seine fishery is also hampered by the fact that there were no available data showing observations of oceanic whitetip sharks in 2014. In 2013, the proportion of oceanic whitetip sharks that were either finned or discarded in the purse seine fishery increased, but the proportion retained decreased. Thus, it appears that this measure is only partially successful (Rice *et al.* 2015).

Overall, while it is likely that existing controls on shark finning and species retention bans are reducing fishing mortality of oceanic whitetip sharks in the Western and Central Pacific to some degree, these conservation measures appear only partially effective, and implementation and enforcement rates are likely variable. Additionally, an increase in the percentage of sharks released alive will not likely translate into substantial increases in survival due to the fact that most sharks have been found to suffer high mortality rates when caught in purse seine nets and on longline gear (Clarke 2013). Although oceanic whitetip sharks have relatively lower at-vessel mortality rates in longlines compared to other shark species, given the severely depleted state of oceanic whitetip shark in this portion of its range, it is likely that anything less than full implementation and enforcement of current shark conservation measures contained in CMM 2019-04 would likely undermine any potential conservation benefit (Clarke 2013), and may not be adequate to prevent further population declines of the species in this region.

In addition to finning controls and species retention bans, the WCPFC has also adopted some conservation measures related to fisheries gear. For example, CMM 2014-05 became effective in July 2015 and requires each national fleet to either ban wire leaders *or* ban shark lines, both of which have potential to reduce shark bycatch in the first place. Using Monte Carlo simulations, Harley and Pilling (2016) determined the following: if flag-states choose to exclude the technique least used by their vessels, the median predicted reduction in fishing-related mortality is only 10% for oceanic whitetip shark. If flag-states exclude the technique most used by their vessels, this would reduce the fishing mortality rate by 30%. This compares to a reduction of 37% if choice is removed and both techniques are prohibited. Thus, allowing flag states to choose which fishing technique they exclude has the potential to significantly undermine any benefits to the oceanic whitetip shark (Harley and Pilling 2016), particularly given the high levels of fishing mortality experienced by this species. However, in November 2022, the WCPFC passed a new shark measure to ban the use of both wire leaders and shark lines on all longline vessels operating in the region, which will likely reduce mortality of oceanic whitetip sharks significantly. In an updated assessment from Harley and Pilling (2016), Bigelow and Carvalho (2021) estimated that the transition from wire to monofilament leaders alone in the Hawaii deep-set longline fishery reduced catch and mortality of oceanic whitetip sharks by 32% and 30%, respectively. Given the foregoing information, we conclude that existing regulatory mechanisms in the Western and Central Pacific are likely inadequate to control for overutilization of the species.

Atlantic Ocean
The United States has reported oceanic whitetip shark catches in the ICCAT convention area to ICCAT since the 1980s, but other ICCAT Parties did not begin reporting this information until the early 1990s. In 2004, following the FAO International Plan of Action for Sharks (IPOA-Sharks), ICCAT published Recommendation 04-10 requiring Contracting Parties, Cooperation non-Contracting Parties, Entities or Fishing Entities (CPCs) to annually report data for catches of sharks, including available historical data. In 2010, ICCAT developed Recommendation 10-07, which specifically prohibits the retention, transshipping, landing, storing, selling, or offering for sale any part or whole carcass of oceanic whitetip sharks in any fishery; however, the retention ban implemented by ICCAT does not necessarily prevent all fisheries-associated mortality. Although oceanic whitetip sharks have a relatively lower at-vessel mortality (average 24%) rate than other pelagic sharks in the Atlantic, some will still likely die due to capture.

According to ICCAT data as shown previously in Figure 25, approximately 89% of the total reported catch for Atlantic oceanic whitetip sharks was caught by Brazil. Countries fishing in the South Atlantic within the ICCAT Convention Area are also required to adhere to management measures implemented by ICCAT, of which the most consequential for oceanic whitetip sharks is the prohibition on retention of the species. As noted previously, regulations that mandate the release of oceanic whitetip sharks back to the sea have the potential to be somewhat effective for their protection, since the majority of the specimens are captured alive and exhibit relatively low at-vessel mortality rates in this region of 11–28% (Fernandez-Carvalho *et al.* 2015). However, whether the retention ban is fully implemented and enforced is unknown. Brazil is the largest oceanic whitetip shark-catching country in the region. The significant decline in reported catches by the Brazilian fleet (as discussed in the *Overutilization* section of this document) occurred prior to any management recommendations by ICCAT to prohibit retention of oceanic whitetip sharks in ICCAT-associated fisheries. It is clear that despite the retention prohibition, oceanic whitetip sharks are still being caught and continue to experience fisheries-related mortality in this portion of its range.

In 2004, the oceanic whitetip shark was designated as a "species threatened by overexploitation" by Brazil's Ministério do Meio Ambiente (Ministry of Environment), and listed under Annex II of Brazil's Normative Ruling No. 5 of May 21, 2004. In 2014, Brazil finalized its national assessment regarding the extinction risk of Brazilian fauna, and listed the oceanic whitetip shark as "Vulnerable" under Brazil's "Lista Nacional Oficial de Espécies da Fauna Ameaçadas de Extinção - Peixes e Invertebrados Aquáticos" (National Official List of Endangered Species of Fauna - Fish and Aquatic Invertebrate; ICMBio 2014). Species listed as "Vulnerable" enjoy full protection, including, among other measures, the prohibition of capture, transport, storage, custody, handling, processing and marketing. The capture, transport, storage, and handling of specimens of the species shall only be allowed for research purposes or for the conservation of the species, with the permission of the Instituto Chico Mendes. However, it appears these regulations are not likely complied with or enforced adequately. In fact, a recent study that compared 179 legal instruments implemented for regulating Brazil's fisheries from 1934–2014 with fisheries landings from 1996–2011 concluded that there is a "complete disrespect for the regulations" and that fleets continued landing prohibited or size limited species, including the oceanic whitetip shark (Fiedler *et al.* 2017). For example, the prohibition for fishing oceanic whitetip sharks went into effect between 2004 and 2005. However, the species continued to be landed by national and leased foreign fleets, and was one of several species landed in the port of Itajaí despite a prohibition for catching this species (Fiedler *et al.* 2017). This study concluded that the current set of regulations for Brazil's fisheries are inconsistent, thereby rendering any management of fishing activities incompatible with species conservation. Additionally, there is strong opposition from the fishing industry and some ordinances guaranteeing protection to endangered species in the country have recently been canceled (Di Dario *et al.* 2014). Further, systematic data collection from fleets fishing over Brazilian jurisdiction ended in 2012, and onboard observer programs have been canceled, which renders any further monitoring of South Atlantic shark populations difficult or impossible (Barreto *et al.* 2015). Given the foregoing information, it appears that existing regulatory mechanisms in Brazil are not likely adequate to effectively manage the threat of fishing pressure and associated mortality on oceanic whitetip sharks in this region.

In Central American and Caribbean waters, management of shark species remains largely disjointed, with some countries lacking basic fisheries regulations and others lacking the capabilities to enforce what has already been implemented (Kyne *et al*. 2012). However, there are some regional mechanisms and fisheries management organizations focusing on marine resource management and conservation in the region. The Organization of the Fisheries and Aquaculture Section of the Central American Isthmus (OSPESCA) was established to address this situation by assisting with the development and coordination of fishery management measures in Central America. The OSPESCA recently approved a common regional finning regulation for eight member countries from the Central American Integration System (SICA) (Belize, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, and Panama). The regulation specifically requires sharks to be landed with fins still attached for vessels fishing in SICA countries or in international waters flying a SICA country flag. If fins are to be traded in a SICA country, they must be accompanied by a document from the country of origin certifying that they are not the product of finning (Kyne *et al.* 2012). Another mechanism addressing fisheries and resource management in the Wider Caribbean Region is the United Nations Environment Programme Specially Protected Areas and Wildlife Protocol (SPAW

Protocol) under the Cartagena Convention. The oceanic whitetip shark was listed under Annex III of the Protocol in 2017, which calls for all Parties to develop management strategies to ensure the sustainability and conservation of listed species.

Other Central American and Caribbean country-specific regulations include the banning or restriction of longlines in certain fishing areas (Bahamas, Belize, Panama), seasonal closures (Guatemala), shark fin bans (Colombia, Mexico, Venezuela) and the prohibition of shark fishing (Bahamas and Honduras). However, enforcement of these regulations is generally weak, with many reports of IUU fishing activities (see below for more information). For example, in May 2012, the Honduran navy seized hundreds of shark fins from fishers operating illegally within the borders of its shark sanctuary. As Kyne *et al.* (2012) reports, it is basically common practice to move shark fins across borders for sale in countries where enforcement is essentially lacking in this region.

In the Sub Regional Fisheries Council (SRFC) region in the Atlantic (off West Africa), regulations specific to shark fishing are minimal. Fishing occurs year-round, including during shark breeding season, and, consequently, both pregnant and juvenile shark species may be fished (Diop and Dossa 2011). In fact, fins from fetal sharks are included on balance sheets at landing areas (Diop and Dossa 2011). Many of the state-level management measures in this region lack standardization at the regional level (Diop and Dossa 2011), which weakens some of their effectiveness. For example, Sierra Leone and Guinea both require shark fishing licenses; however, these licenses are much cheaper in Sierra Leone. As a result, fishers from Guinea will fish for sharks in Sierra Leone, thereby minimizing the benefits that could have been gained from having mutually supported management measures (Diop and Dossa 2011). In addition, Camara (2008) notes that fishery regulations are usually not adequately enforced due to a lack of funds, trained staff, and proper monitoring equipment. Corruption is also prevalent, especially in Mauritania, whereby enforcement officials are paid off by fishermen caught committing offenses (Camara 2008). However, many fishermen in this region are also unaware (or claim to be unaware) of the current fishing regulations, legal fishing zones, and gear restrictions, which has also contributed to deterioration of the West African fisheries (Camara 2008). However, it is unclear how important oceanic whitetip sharks are in this region's fisheries. As of 2011, the only member state of the SRFC in which oceanic whitetip sharks have been reported is Cape Verde, which reported the oceanic whitetip shark as "very rare" (Diop and Dossa 2011), although information from this region is fairly limited and other African countries (Guinea and Ghana) reported catches of oceanic whitetip shark to ICCAT in 2014.

Indian Ocean

In Indian Ocean waters, the main regulatory body is the IOTC, which has management measures in place for sharks in general, and also specifically for the oceanic whitetip shark. The IOTC requires CPCs to annually report shark catch data and provide statistics by species for a select number of sharks, including oceanic whitetip sharks (Resolutions 11/04, 08/04, 10/03, 10/02). The IOTC also developed additional shark conservation and management measures that aim to further reduce shark waste and encourage the live release of sharks, especially juveniles or pregnant females, caught incidentally (and not used for food or other purposes) in fisheries for tunas and tuna-like species. In 2017, IOTC adopted Resolution 17/05 on the Conservation of Sharks Caught in Association with Fisheries Managed by IOTC. This measure applies to all fishing vessels flying the flag of a Contracting Party or Cooperating Non-Contracting Party (CPC) and on the IOTC Record of Authorized Vessels, or authorized to fish for tuna or tuna-like species managed by the IOTC. CPCs shall take the necessary measures to require that their fishermen fully utilize their entire catches of sharks, with the exception of species prohibited by the IOTC (e.g., oceanic whitetip shark). Full utilization is defined as retention by the fishing vessel of all parts of the shark excepting head, guts and skins, to the point of first landing. However, the efficacy of these measures remain unclear. For example, in a recent status report, the IOTC's Working Party on Ecosystems and Bycatch noted that the International Plan of Action for sharks was adopted in 2000, which requires each CPC to develop a National Plan of Action (NPOA) for sharks; however, despite the time that has elapsed since then, very few CPCs have developed NPOAs for sharks, or even carried out assessments to determine whether the development of a plan is prudent. As of 2019, only 15 of the 31 CPCs had developed NPOAs for sharks (IOTC 2019).

With regard to species-specific management measures for the oceanic whitetip shark, the IOTC passed Resolution 13-06 in 2013 as a pilot measure that prohibits the retention, transshipment, landing, or storing of any part or whole carcass of oceanic whitetip sharks. However, unlike similar regulations implemented by other RFMOs, the IOTC retention prohibition of oceanic whitetip shark exempts "artisanal fisheries operating exclusively in their respective EEZ for the purpose of local consumption." However, the definition of artisanal vessels in the IOTC encompasses a wide array of boats with vastly different characteristics. These vessels range from the pirogue that fishes close to shore for subsistence purposes with no motor, no deck and no holding facilities, to a longliner, gillnetter or purse seiner of less than 24 m with an inboard motor, deck, communications, fish holding facilities, and in some cases chilling or freezing capabilities. The latter vessel type could potentially conduct fishing operations offshore, including outside its EEZ (Moreno and Herrera 2013). For example, in 2014 and 2015 the Islamic Republic of Iran and Sri Lanka reported 239 mt of oceanic whitetip sharks caught by gillnets that fall under the definition of "artisanal" fisheries. Additionally, while some no-retention measures ban the "selling or offering for sale" of any products from the specified shark species, the IOTC oceanic whitetip shark measure does not (Clarke 2013). Further, this measure is not binding on India, which is one of the main oceanic whitetip shark catching countries identified by the IOTC in the Indian Ocean. Although the 2021 Compliance Committee Report (IOTC 2021b) notes an overall compliance rate with this measure at 86%, some CPCs are still reporting oceanic whitetip shark as landed catch despite the prohibition under Resolution 13/06; therefore, there is a serious need to strengthen mechanisms to ensure CPCs comply fully with the measure (IOTC 2021b). Finally, with an estimated at-vessel mortality rate of 50% in this region (Coelho 2016), a substantial proportion of oceanic whitetip sharks will die at the vessel even if they are not retained, which raises questions regarding the efficacy of no-retention measures. Therefore, it appears that the retention ban of oceanic whitetip sharks in the Indian Ocean is limited in scope relative to other RFMO no-retention measures, and only partially protective.

In Indonesia, which accounts for the largest global removals of sharks, there are few restrictions pertaining to shark fishing. In fact, Indonesian small-scale fisheries, which account for around 90% of the total fisheries production, are not required to have fishing permits (Varkey *et al.* 2010), increasing the incentive for shark finning by this sector (Lack and Sant 2012). Although Indonesia adopted an FAO recommended shark conservation plan (National Plan of Action-

Shark) in 2010, due to budget constraints, it can only focus its implementation of key conservation actions in one area, East Lombok (Satria *et al.* 2011). Further, current Indonesian regulations pertaining to sharks are limited to those necessary for fulfilling obligations under international agreements (e.g., trade controls for certain species listed under CITES or prescribed by RFMOs) (Fischer *et al.* 2012). Ultimately, Indonesian fishing activities remain largely unreported (Varkey *et al.* 2010), which suggests that the estimates of Indonesian shark catches are greatly underestimated. For example, in Raja Ampat, an archipelago in Eastern Indonesia, Varkey *et al.* (2010) estimated that 44% of the total shark catch in 2006 was unreported (includes small-scale and commercial fisheries unreported catch and IUU fishing). In 2013, the Regency Government of Raja Ampat officially declared its 46,000 km^2 marine waters a shark and manta ray sanctuary, the first established in Indonesia that bans the harvesting and trade of sharks and manta rays from its marine waters. However, for the most part, without proper fishery management regulations in place, many of the larger species in Indonesian waters have been severely overfished and have forced Indonesian fishermen to fish elsewhere. Additionally, despite the fact that the oceanic whitetip shark is protected in Indonesia under IOTC Resolution 13-06, evidence suggests that this Resolution may not be strictly followed. For example, in a genetic barcoding study of shark fin samples throughout traditional fish markets in Indonesia from mid-2012 to mid-2014, oceanic whitetip shark was identified as present despite being prohibited as of 2013. In addition, authorities confiscated around 3,000 oceanic whitetip shark fins from sharks caught in waters near Java Island in October 2015 (South China Morning Post 2015).[14]

Thus, while it generally appears that the IOTC has increased its number of management measures for sharks, including the oceanic whitetip, these regulations may only provide partial protection to the oceanic whitetip shark and may not be adequate to prevent further population declines due to overutilization.

Illegal, Unreported, an Unregulated (IUU) Fishing

Despite the number of existing regulatory measures in place to protect sharks and promote sustainable fishing, enforcement tends to be difficult and illegal fishing has emerged as a problem in many fisheries worldwide. In general, illegal fishing occurs when vessels or harvesters operate in violation of the laws of a fishery; however, there are numerous activities that constitute IUU fishing (e.g., misreporting, use of prohibited gear, fishing inside closed waters, fishing without a license, shark finning, illegal transshipping, landing catch in unauthorized ports, etc). For purposes of this review, we focus on illegal finning and trafficking of oceanic whitetip sharks. In order to justify the risks of detection and prosecution involved with illegal fishing, efforts tend to focus on high value products (e.g., shark fins) to maximize returns to the illegal fishing effort. Thus, as the lucrative market for shark products (particularly shark fins) developed, so did increased targeting (both legal and illegal) of sharks around the world. Given that illegal fishing tends to go unreported, it is difficult to determine, with any certainty, the proportion of current fishery-related mortality rates that can be attributed to this activity. A study that provided regional estimates of illegal fishing (using FAO fishing areas as regions) found the Western Central Pacific (Area 71) and Eastern Indian Ocean (Area 57) regions have

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[14] http://www.scmp.com/news/asia/southeast-asia/article/1864948/indonesia-seizes-3000-shark-fins-destined-hong-kong

relatively high levels of illegal fishing (compared to the rest of the regions), with illegal and unreported catch constituting 34% and 32% of the region's catch, respectively (Agnew *et al.* 2009). In the Pacific tuna fisheries alone, the total volume of product either harvested or transshipped involving IUU activity is estimated to be 306,440t (90% CI: 276,546t to 338,475t) and an estimated value of USD $616.11m (90% CI: $517.91m to $740.17m) (MRAG Asia Pacific 2016). The annual worldwide economic losses from all IUU fishing is estimated to be between USD $10–$23 billion (NMFS 2015).

However, as mentioned in the *Overutilization* section of this review, given the recent downward trend in the trade of shark fins (Dent and Clarke 2015; Eriksson and Clarke 2015), illegal fishing for the sole purpose of shark fins may not be as prevalent in the future. It is also a positive sign that most (70%) of the top 26 shark-fishing countries, areas and territories have taken steps to combat IUU fishing, either by signing the Port State Measures Agreement (PSMA) (46%) or by adopting a National Plan of Action to prevent, deter, and eliminate IUU (NPOA-IUU) or similar plan (23%) (Fischer *et al.* 2012). Based on updates from the FAO PSMA website[15] additional countries have become Parties in the last 10 years. However, whether these agreements or plans translate to less IUU fishing activity is unclear. For example, in many countries, effective implementation of monitoring, control, and surveillance schemes is challenging, often due to a lack of personnel and inadequate financial resources (Fischer *et al.* 2012), and a number of instances of IUU fishing, specifically involving sharks, have been documented over the past decade. For instance, in 2014, illegal oceanic whitetip shark fins were discovered in a random sample inspection of three 40 kg sacks slated for export from Costa Rica to Hong Kong (Tico Times 2014).[16] Additionally, and as noted previously, Indonesian authorities confiscated around 3,000 oceanic whitetip shark fins from sharks caught in waters near Java Island as recently as October 2015. This haul was worth an estimated USD $72,000 in Indonesia, but would reportedly earn several times that amount in Hong Kong (South China Morning Post, 2015).[17] In February 2013, oceanic whitetip shark fins were found in a large seizure of fins from a Taiwanese vessel fishing in the Marshall Islands.[18] In September 2015, Greenpeace activists boarded a Taiwan-flagged boat fishing near Papua New Guinea and found 110 shark fins but only 5 shark carcasses (which was in violation of both the Taiwanese and the WCPFC rules requiring onboard fins to be at most 5% of the weight of the shark carcasses).[19] Recreational fishers have also been caught with illegal shark fins. A report from June 2015 identified three unlicensed recreational fishers operating in waters off Queensland, Australia and in possession of 3,200 illegal shark fins most likely destined for the black market.[20] While these reports provide just a few examples of illegal fishing activities, IUU fishing activities continue to be problematic.

In terms of tracking IUU fishing, most of the RFMOs maintain lists of vessels they believe to be involved in illegal fishing activities, with the latest reports on this initiative seeming to indicate

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[15] https://www.fao.org/port-state-measures/background/parties-psma/en/

[16] http://www.ticotimes.net/2014/11/25/illegal-shark-fins-destined-for-hong-kong-seized-at-costa-rica-airport#comments-53192

[17] http://www.scmp.com/news/asia/southeast-asia/article/1864948/indonesia-seizes-3000-shark-fins-destined-hong-kong

[18] http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11119560

[19] http://www.msn.com/en-us/news/world/taiwan-boat-caught-with-huge-illegal-shark-fin-haul/ar-AAeuKhd

[20] http://www.abc.net.au/news/2015-06-12/fishers-caught-with-shark-fin/6541278

some improvement in combating IUU fishing. In the most recent Biennial Report to Congress (NMFS 2021), NMFS identified 31 nations and entities with vessels engaged in IUU fishing activities or bycatch of protected species on the high seas. China, Costa Rica, Guyana, Mexico, the Russian Federation, Senegal, and Taiwan are identified for having vessels engaged in IUU fishing activities during 2018–2020. The following countries were identified for lacking a regulatory program comparable in effectiveness to the United States to reduce the bycatch of protected marine life in their fishing operations: Algeria, Barbados, China, Côte d'Ivoire, Croatia, Cyprus, Egypt, European Union, France, Greece, Grenada, Guyana, Italy, Japan, Republic of Korea, Malta, Mauritania, Mexico, Morocco, Namibia, Portugal, Saint Vincent and the Grenadines, Senegal, South Africa, Spain, Taiwan, Trinidad and Tobago, Tunisia and Turkey. Some nations or entities were identified for both IUU fishing and bycatch activities.

The 2021 Report also announced certification determinations for nations identified for IUU fishing activities in the previous report. Mexico was identified in 2019 for failing to curb the flow of small vessels fishing illegally in the U.S. waters of the Gulf of Mexico. Failure to remedy these incursions into U.S. waters led to Mexico's negative certification in 2021. In contrast, Ecuador and the Republic of Korea received positive certification determinations for taking actions to remedy the IUU fishing activities for which they were identified in 2019 (NMFS 2021).

Overall, it is clear that the oceanic whitetip shark is subject to IUU fishing, particularly for its valuable fins. Given the recent downturn in the shark fin trade (Dent and Clarke 2015; Eriksson and Clarke 2015), the threat of this IUU fishing for the sole purpose of shark fins may not be as significant into the future. However, based on the best available information on the species' declining population trends throughout its range, as well as current utilization levels, the present mortality rates associated with illegal fishing and impacts on oceanic whitetip shark populations may be contributing to the overutilization of the species.

Marine Protected Areas (MPAs) and Shark Sanctuaries

Marine protected areas are a popular tool to enhance fisheries management. Effectiveness of protected areas depends on implementation and enforcement of regulations, as well as reserve design. Reserves are not always created or designed with an understanding of how they will affect biological factors or how they can be designed to meet biological goals more effectively (Halpern 2003). Since 2009, 15 countries have declared their EEZs as "shark sanctuaries," with primary goals of protecting and recovering shark populations by reducing fishing mortality and eliminating local contributions to the global market for shark products (Ward-Paige 2017). Currently, shark sanctuaries cover approximately 3% of ocean area. However, a variety of limitations exists regarding the size, location, compliance and enforcement of these protected areas. For example, much of the range and habitat of oceanic whitetip sharks overlap with large areas of unregulated fishing activities (e.g., high seas) where there are limited protections for sharks aside from the regulations of RFMOs. Therefore, because the oceanic whitetip shark is a highly migratory species, they only benefit from protected areas when they are actually inside the protected area's boundaries. Additionally, while many of these MPAs prohibit directed shark fishing, incidental bycatch and subsequent mortality of sharks can still occur in these areas. Nonetheless, given the species has exhibited a tendency of site fidelity in certain areas (e.g., Cat Island, Bahamas) this information could prove useful in the location and design of MPAs for the purposes of oceanic whitetip shark management. As mentioned previously, effectiveness of these protected areas also relies on the level of implementation and enforcement of regulations therein. Thus, while MPAs may provide some benefit to sharks in various locations around the world (Ward-Paige and Worm 2017), it is unclear whether and to what degree they confer conservation benefits to oceanic whitetip sharks, specifically.

Summary

A wide variety of existing laws and regulations have been implemented throughout the range of the oceanic whitetip shark that may positively affect the conservation status of the species. For example, all relevant RFMOs have taken steps towards implementing regulations to protect the oceanic whitetip shark, including prohibiting retention of the species, improving data reporting, and expanding research. Measures prohibiting retention of oceanic whitetip sharks, if adequately implemented and enforced, could reduce the overall bycatch mortality of oceanic whitetip sharks to some extent, because the species has relatively higher at-vessel survivorship compared to other shark species (Musyl *et al.* 2011); therefore, a large proportion of individuals caught and released alive may be able to survive. However, as previously emphasized, no-retention measures do not entirely mitigate any potential post-release mortality that may occur. Thus, these measures may only be partially effective. Measures related to safe handling and release have also been implemented recently in most RFMOs, but whether these measures are effectively implemented is currently unknown. Additionally, issues of non-reporting and non-compliance remain problematic. Of note is the fact that compliance with and enforcement of species-specific retention bans are not necessarily adequate, as evidenced by the fact that non-negligible proportions of oceanic whitetip sharks are being retained or finned in areas that prohibit these actions (e.g., Western and Central Pacific and Indian Oceans). In addition, they do not address potential post-release mortality that may occur.

Likewise, although various shark fishing and finning regulations and bans have been increasing in recent years globally, levels of compliance and enforcement are highly variable, as evidenced by numerous incidents of IUU fishing throughout the world's oceans due to the high demand for lucrative shark products, particularly fins. While there has been a recent downturn in the shark fin market, and more information is necessary to determine the magnitude of impact the shark trade is having specifically on oceanic whitetip sharks, the demand for oceanic whitetip shark fins is evident by several recent incidents of illegal finning and trafficking of oceanic whitetip sharks in places like Indonesia, Costa Rica, Galapagos, and southern Africa. Further, while reporting of shark catches to FAO has improved in the last decade (e.g., shark catches reported at species level doubled from 14% in 1995 to 29% in 2010), data collection and research on sharks is still lacking in many regions and many of the top shark-catching countries still report most of their catches at a very high, aggregated level. On the other hand, complete bans on shark fishing have been implemented in some areas, which can help reduce fishing pressure on oceanic whitetip sharks while in these areas (e.g., the Bahamas). Regulatory mechanisms for oceanic whitetip shark in the U.S. Atlantic may be adequate in achieving their intended purpose, with the Northwest Atlantic population of oceanic whitetip shark potentially stabilized. There is also a declining trend of oceanic whitetip mortality in Hawaii fisheries due to various regulations. Overall, we recognize the mere existence of regulatory mechanisms does not necessarily equate to their effectiveness in achieving their intended purpose. Issues related to community awareness, compliance, enforcement, regional priorities, and complex political climates within many countries in which oceanic whitetip sharks occur can limit the effectiveness of well-intended statutes and legislation.

4.5 (E) Other Natural or Manmade Factors

Information regarding the potential impacts of climate change on pelagic shark habitat is described in Section 4.1 (A) *Present or Threatened Habitat Destruction, Modification, or Curtailment*. Below we discuss threats of environmental pollutants and toxins and their potential impacts to oceanic whitetip sharks. As an update to the original status review (Young et al. 2017) we also address potential emerging threats of tourism and aquaculture activities in this section. Threats related to climate change were addressed in section 4.1 above.

Pollution and Toxins

Environmental pollutants may have negative impacts on the oceanic whitetip shark, but this has not yet been demonstrated by any scientific study. Many pollutants in the environment, such as brevetoxins, heavy metals, and polychlorinated biphenyls (PCBs), have the ability to bioaccumulate in fish species. A number of studies have shown that because of the higher trophic level position and longevity of some sharks, these pollutants tend to biomagnify in liver, gill, and muscle tissues (Storelli *et al.* 2003; García-Hernández *et al.* 2007; Escobar-Sanchez *et al.* 2010; Gelsleichter and Walker 2010; Lee *et al.* 2015). These studies have also attempted to quantify the concentration levels of these pollutants in fish, but with a focus on human consumption and safety. As such, many of the results from these studies may indicate either "high" or "low" concentrations in fish, but this is primarily in comparison to recommended safe concentrations for human consumption and does not necessarily infer any impact on the biological status of the species. Most reports of pollutant concentrations in elasmobranch tissues that exceed safe limits for animal health and/or human consumption are restricted to a small number of large upper trophic level sharks (Gelsleichter and Walker 2010). In fact, only one study exists that analyzed the pollutant composition of a liver oil sample from an oceanic whitetip shark, which was an amalgamated liver oil sample that also included two other shark species (silky *C. falciformis* and nurse *Ginglymostoma cirratum* sharks). This sample was used to analyze levels of dioxins and dioxin-like PCBs and found very high levels of both of these pollutants in the tested liver oil (Cruz-Nuñez *et al.* 2009). Based on a comparison of levels found in smooth hammerhead sharks (which were much lower) (Storelli *et al.* 2003), the levels found in oceanic whitetip shark may have a high potential for causing PCB effects in the species, as these levels would likely exceed threshold levels of PCBs for some cell- and molecular-level effects seen in aquatic vertebrates (Gelsleichter and Walker 2010). However, the aquatic vertebrate threshold levels referenced in Gelsleichter and Walker (2010) originate from a study on the California sea otter (Kannan *et al.* 2000), and, at this time, there is no information to confirm that PCB threshold levels in marine mammals are comparable to threshold levels for shark species. Specifically, threshold PCB concentrations at which detrimental effects may occur in cartilaginous fish are virtually unknown (Gelsleichter and Walker 2010). In fact, it is hypothesized that sharks can actually handle higher body burdens of anthropogenic toxins due to the large size of their livers which "provides a greater ability to eliminate organic toxicants than in other fishes" (Storelli *et al.* 2003) or may even be able to limit their exposure by sensing and avoiding areas of high toxins (like during *K. brevis* red tide blooms) (Flewelling *et al.* 2010). The large size and vast lipid stores in the elasmobranch liver provide the capacity for a substantial sequestration of lipophilic contaminants.

Overall, oceanic whitetip sharks are likely exposed to a number of pollutants and contaminants in their habitat that have the potential to cause negative physiological impacts to the species, and the effects of these pollutants in oceanic whitetip shark populations and potential risk to the viability of the species could be of concern. Recent data by Kiszka et al. (2015) supports the premise that the oceanic whitetip shark accumulates high pollutant concentrations. Further, Gelsleichter *et al.* (2020) found mercury levels in muscle of female sharks are higher than those reported in virtually all other shark mercury studies. However, it is still unknown what the effects of these high mercury levels have on the species. Gelsleichter *et al.* (2020) reported toxic, non-essential metal mercury (Hg) concentrations in oceanic whitetip shark were among the highest ever reported among four other pelagic shark species and correlated significantly with shark length (n=26). The authors concluded that Hg poses health risks to oceanic whitetip sharks and can include neurobehavioral effects and reduction of reproductive fitness, with the latter impacting the ability of the population to recover.

Aquaculture and Fish Farming Activities

A potential emerging threat that could alter oceanic whitetip shark behavior is the increasing presence of pelagic fish farms and aquaculture operations, as the structures act as FADs and attract marine wildlife. Personal communications and anecdotal evidence in areas where these farms have existed suggests oceanic whitetip sharks are becoming increasingly associated with these structures, in lieu of normal areas where they are historically known to aggregate. With food security being an increasing issue and priority for human populations, the production of seafood via fish farms will likely significantly increase in the near future, with unknown impacts to pelagic species such as oceanic whitetip sharks.

Tourism

Due to their pelagic habitat use generally farther from shore, human encounters with oceanic whitetip sharks are generally rare because most in-water human activities occur in shallow near-shore waters. However, over the last decade there has been an increase in snorkeling and scuba diving activities that target oceanic whitetip sharks and other species for wildlife viewing in areas where deeper pelagic waters are closer to land. Currently, there are tourism operations in the Bahamas, Red Sea, Hawaii, and French Polynesia where dive companies target both cetaceans (that oceanic whitetip sharks associate with, e.g., pilot whales) and/or the oceanic whitetip sharks themselves. Potential impacts of these activities on oceanic whitetip sharks are currently unknown, but there have been several incidents where interactions with oceanic whitetip sharks during these activities resulted in bites of people (https://www.floridamuseum.ufl.edu/shark-attacks/factors/species-implicated/). More information is needed to determine whether these tourism activities are causing any behavioral changes or other effects to oceanic whitetip sharks.

5. THREATS ASSESSMENT

In this section, we present an assessment of threats and stressors identified as affecting or potentially affecting the status of the oceanic whitetip shark in terms of recovery planning. Table 4 below is largely based on the threats assessment conducted in the 2017 Status Review Report (Young *et al.* 2017) and the 2018 final listing rule for the oceanic whitetip shark (83 FR 4153) with some modifications. For instance, in the final rule we assessed the threat of overutilization as the culmination of bycatch-related mortality and the fin trade globally. In this Recovery Status Review, however, we re-assessed the threats of overutilization in more detail by individually analyzing each major fishery by ocean basin and gear type to better tailor the Recovery Plan and prioritize recovery actions and activities. We will update the threats assessment portion of this Recovery Status Review as we learn more about how threats and stressors continue to act on the species, both individually and synergistically.

We assessed the threats/stressors for each region within the species' range (Atlantic, Eastern Pacific, Western and Central Pacific, and Indian Ocean). We identify those regions as Management Units[21] (MUs) in the Recovery Plan (see section 2.2. of the Recovery Plan for detailed explanation and rationale for identifying MUs). We prioritized threats/stressors that are most urgent and significant for the recovery of the species according to the following criteria: 1) the frequency with which the threat/stressor occurs; 2) the severity of the threat/stressor; 3) the geographic extent of the threat/stressor; 4) the trend of the threat/stressor; and 5) the certainty that the threat/stressor is affecting the species.

The frequency of the threat/stressor refers to its occurrence and regularity over time and is ranked as common (high occurrence), uncommon (moderate occurrence), or rare (infrequent or hypothetical events).

The severity of the threat/stressor refers to the effect it has on individuals of the species. Severity is ranked as:

- high: causes direct mortality (including a high probability of combined at-vessel and post-release mortality for fisheries threats) of a high number of sublethal impacts that result in loss of productivity and fitness;
- moderate: causes moderate probability of direct mortality and/or a moderate number of sublethal impacts that result in decreased productivity and fitness; or
- low: does not cause direct mortality and has a negligible impact on productivity and fitness.

The geographic extent of the threat/stressor refers to the spatial extent of the threat within the management unit and is categorized as: range-wide (occurs throughout all or the vast majority of the distribution); or localized (exists primarily in a portion of the range).

[21] Management units are a tool that can be used in recovery plans to address differing threats, management authority, and/or population viability across geographic areas requiring tailored management programs.

The trend refers to the change in extent, frequency, or severity of a threat/stressor over time and is ranked as increasing, stable, decreasing, or unknown. The certainty of the threat/stressor refers to the amount of evidence that the threat/stressor is affecting the species in that management unit and is ranked as high (direct evidence or multiple lines of indirect evidence); moderate (indirect, limited, or unclear evidence); or low (little or no evidence). In instances where there is insufficient detailed information on a threat/stressor at the management-unit scale, the threat/stressor was assessed for the species range-wide. To determine the overall risk of each threat/stressor to the species within each respective MU, the factors described above were evaluated together qualitatively to determine an overall "risk" level based on the following scale: low, low to moderate, moderate, moderate to high, high.

Table 6. *Oceanic Whitetip Shark Threats Assessment Summary Table.*

Threat or Stressor[22]	Major Effect	Frequency	Severity	Geographic extent	Trend	Certainty	Overall risk ranking
ATLANTIC OCEAN MANAGEMENT UNIT							
Commercial fisheries bycatch: purse seine	Injury/ Mortality	Uncommon	High	Localized	Unknown	Low	Low-moderate
Commercial fisheries bycatch: longline	Injury/ Mortality	Common	High-moderate	Rangewide	Stable to Decreasing	Moderate	Moderate-high
Artisanal fisheries	Injury/ Mortality	Uncommon	High	Localized	Unknown	Moderate	Low-moderate
Illegal retention	Mortality	Uncommon	High	Rangewide	Unknown	Moderate	Low-mod
Inadequacy of fisheries regulations	Injury/ Mortality	Common	Moderate	Rangewide	Decreasing	Moderate	Moderate
EASTERN PACIFIC MANAGEMENT UNIT							
Commercial fisheries bycatch: purse seine	Injury/ Mortality	Common	High	Rangewide	Increasing-stable	High	Moderate-high

[22] The assessment of fishing threats (all gears) also incorporates impacts of IUU fishing on the oceanic whitetip shark.

Threat or Stressor[22]	Major Effect	Frequency	Severity	Geographic extent	Trend	Certainty	Overall risk ranking
Commercial fisheries bycatch: longline	Injury/ Mortality	Common	High	Rangewide	Unknown	Low	Moderate-high
Artisanal fisheries	Injury/ Mortality	Rare	High	Localized	Unknown	Low	Low
Illegal retention	Mortality	Common	High	Rangewide	Unknown	Moderate	Moderate
Inadequacy of fisheries regulations	Injury/ Mortality	Common	Moderate	Rangewide	Decreasing	Moderate	Moderate
WESTERN AND CENTRAL PACIFIC MANAGEMENT UNIT							
Commercial fisheries bycatch: purse seine	Injury/ Mortality	Uncommon	High	Rangewide	Decreasing	High	Moderate-high
Commercial fisheries bycatch: longline	Injury/ Mortality	Common	High	Rangewide	Decreasing	High	High
Artisanal fisheries	Injury/ Mortality	Uncommon	High	Localized	Unknown	Low	Moderate
Illegal retention	Mortality	Common	High	Rangewide	Decreasing	Moderate	Moderate
Inadequacy of fisheries regulations	Injury/ Mortality	Common	Moderate	Rangewide	Decreasing	Moderate	Moderate
INDIAN OCEAN MANAGEMENT UNIT							
Commercial fisheries bycatch: purse seine	Injury/ Mortality	Common	High	Rangewide	Unknown*	Moderate	Moderate-high

Threat or Stressor[22]	Major Effect	Frequency	Severity	Geographic extent	Trend	Certainty	Overall risk ranking
Commercial fisheries bycatch: longline	Injury/ Mortality	Common	High	Rangewide	Increasing	Moderate	Moderate-high
Commercial fisheries bycatch: gillnet	Injury/ Mortality	Common	High	Rangewide	Increasing	Moderate	High
Artisanal fisheries	Injury/ Mortality	Common	High	Localized	Increasing	Moderate	High
Illegal retention	Mortality	Common	High	Rangewide	Increasing	Moderate	High
Inadequacy of existing regulatory mechanisms	Mortality	Common	High	Rangewide	Stable	Moderate	Moderate-high
OTHER THREATS (APPLIES TO GLOBAL POPULATION)							
Climate change	Fitness, Productivity, Reproduction	n/a	Moderate	Rangewide	Increasing	Low	Low-moderate
Pollution and toxins	Fitness, Productivity, Reproduction	n/a	Unknown	Rangewide	Unknown	Low	Low
Illegal fin trade	Mortality	Common	High	Localized	Stable	Moderate	Moderate-high
Inadequacy of fin trade regulations	Mortality	Common	High	Localized	Stable	Moderate	Moderate-high
Emerging threats (aquaculture, tourism, etc)	Fitness, Productivity, Reproduction	Rare	Unknown	Localized	Unknown	Low	Low

Of the identified threats/stressors to the oceanic whitetip shark, those we identified as being of high or moderate-to-high relative concern (as they appear in Table 6) are as follows: incidental bycatch in commercial fisheries, particularly longlines, purse seines and gillnets, international trade of oceanic whitetip shark fins, and inadequate regulatory mechanisms (management) of these threats. There are several other stressors that are of lesser concern but may work synergistically to cause negative effects to oceanic whitetip sharks (e.g., effects of climate change, pollutants). We will update the threats assessment portion of the Recovery Status Review as we learn more about how threats and stressors continue to act on the species, both individually and synergistically.

For information on NMFS' strategy for recovering the oceanic whitetip shark based on the biology, life history, and threats assessment presented in this Recovery Status Review, please refer to the Oceanic Whitetip Shark Recovery Plan and Recovery Implementation Strategy.

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