Endangered Species Act Status Review Report: Oceanic Whitetip Shark (*Carcharhinus longimanus*)


Photo credit: Andy Mann

2017
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

Acknowledgements

The National Marine Fisheries Service (NMFS) gratefully acknowledges the commitment and efforts of the Extinction Risk Analysis (ERA) team members and thanks them for generously contributing their time and expertise to the development of this status review report.

Several individual fishery scientists and managers provided information that aided in preparation of this report and deserve special thanks. We particularly wish to thank Ms. Marta Nammack, Dr. Jennifer Schultz, Dr. Melanie Hutchinson, Ms. Cassandra Ruck, Dr. Nancy Kohler, Mr. Martín Hall, Ms. Karyl Brewster-Geisz, and Mr. Tobey Curtis for information, data, and professional opinions. We would also like to thank those who submitted information through the public comment process.

We would especially like to thank the peer reviewers Ms. Debra Abercrombie, Dr. Elizabeth Babcock, Dr. Shelley Clarke, Dr. Rui Coelho, and Dr. Mariana Tolotti for their professional review of this report.

This document should be cited as:

Young, C.N., Carlson, J., Hutchinson, M., Hutt, C., Kobayashi, D., McCandless, C.T., Wraith, J. 2018. Status review report: oceanic whitetip shark (*Carcharhinius longimanus*). Final Report to the National Marine Fisheries Service, Office of Protected Resources. December 2017. 170 pp.

Oceanic Whitetip Shark ERA Team Members:

Dr. John Carlson	NMFS, SEFSC, Panama City, FL
Dr. Clifford Hutt	NMFS, HMS, Silver Spring, MD
Dr. Donald Kobayashi	NMFS, PIFSC, Honolulu, HI
Dr. Camilla T. McCandless	NMFS, NEFSC, Narragansett, RI
Mr. James Wraith	NMFS, SWFSC, La Jolla, CA
Ms. Chelsey N. Young	NMFS, OPR, Silver Spring, MD

Executive Summary

This report was produced in response to a petition received from Defenders of Wildlife on September 21, 2015, to list the oceanic whitetip shark (*Carcharinus longimanus*) as endangered or threatened under the Endangered Species Act (ESA). On January 12, 2016, the National Marine Fisheries Service (NMFS) announced in the *Federal Register* that the petition has sufficient merit for consideration and that a status review was warranted (81 FR 1376). This report is summarizes the best available data and information on the species and presents an evaluation of its status and extinction risk.

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 that has low-moderate productivity.

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 one of the most common and ubiquitous shark species in tropical waters around the world. More recently, however, numerous lines of evidence from all three ocean basins 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 high encounter and 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 retention and finning of the species for the international shark fin trade. Although there is considerable uncertainty regarding the species' current abundance throughout its range, the best available information indicates that the species has experienced population declines of potentially significant magnitude 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 experiencing various levels of decline 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 trafficking 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 Fauna and Flora (CITES) Appendix II. As such, we conclude that overutilization will continue to be a threat to the oceanic whitetip shark through the foreseeable future (~30 years), placing the species at a moderate risk of extinction throughout its range.

Table of Contents

Contents

1. INTRODUCTION

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). This document is a status review of the oceanic whitetip shark (*Carcharhinus longimanus*). 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 oceanic whitetip: 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. 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.

Therefore, this document reports the scientific review as well as the team's conclusions regarding the extinction risk of the oceanic whitetip shark. The conclusions in this status review are subject to revision should important new information arise in the future. Where available, we provide literature citations to review articles that provide even more extensive citations for each topic. Data and information were reviewed through October 2017.

2. LIFE HISTORY AND ECOLOGY

2.1 Taxonomy and Distinctive Characteristics

The oceanic whitetip shark is a large open ocean 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: 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).

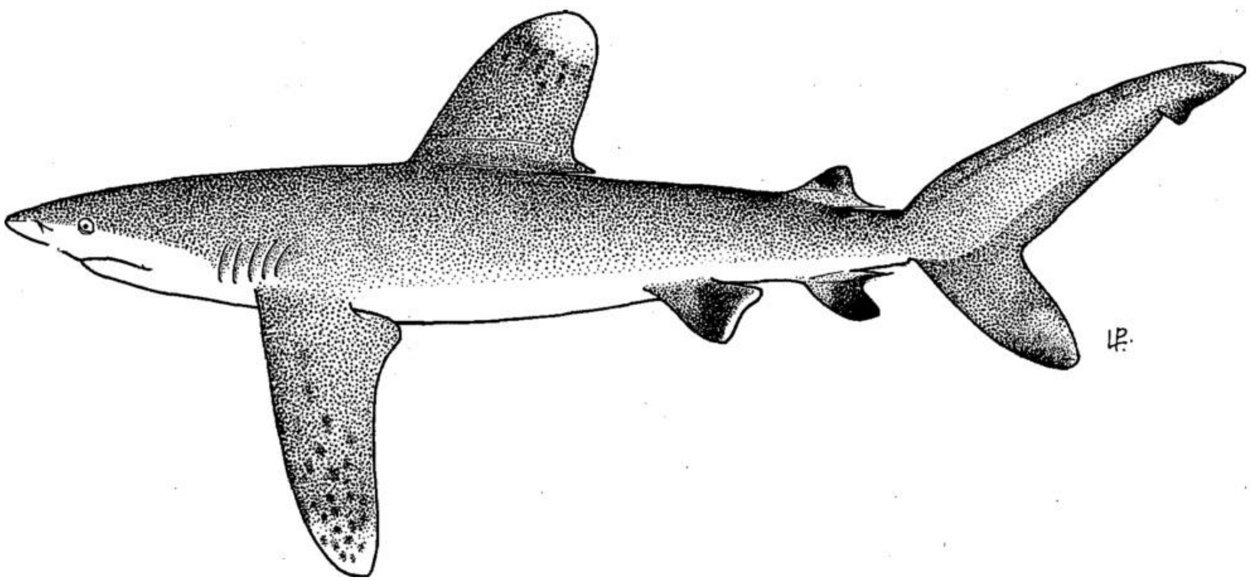

Figure 1 Oceanic whitetip. Source: Compagno 1984.

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 (Baum *et al.,* 2006). In the Western Atlantic, oceanic whitetips 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 whitetips 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).

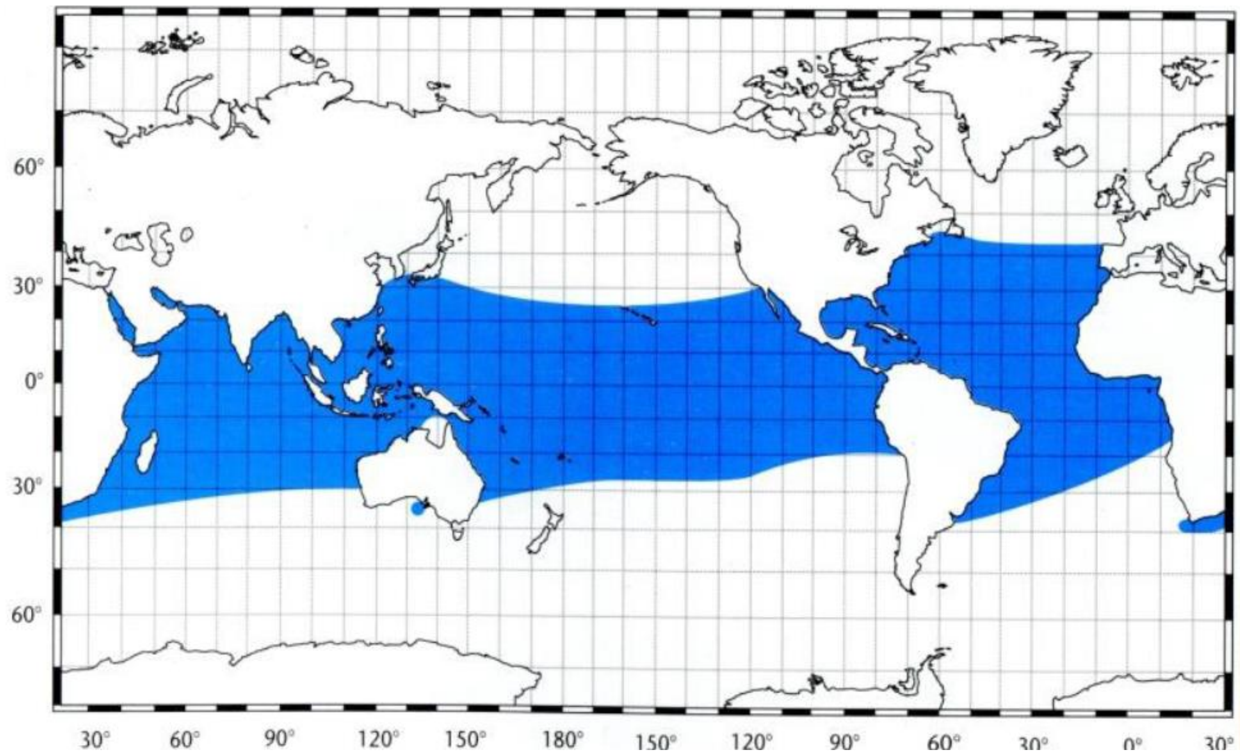

Figure 2 Geographic distribution of oceanic whitetip shark. Source: Last and Stevens 2009.

The oceanic whitetip shark was historically characterized as one of the most abundant oceanic sharks (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 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).

Information regarding movement patterns or possible migration paths for oceanic whitetips 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 whitetips 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).

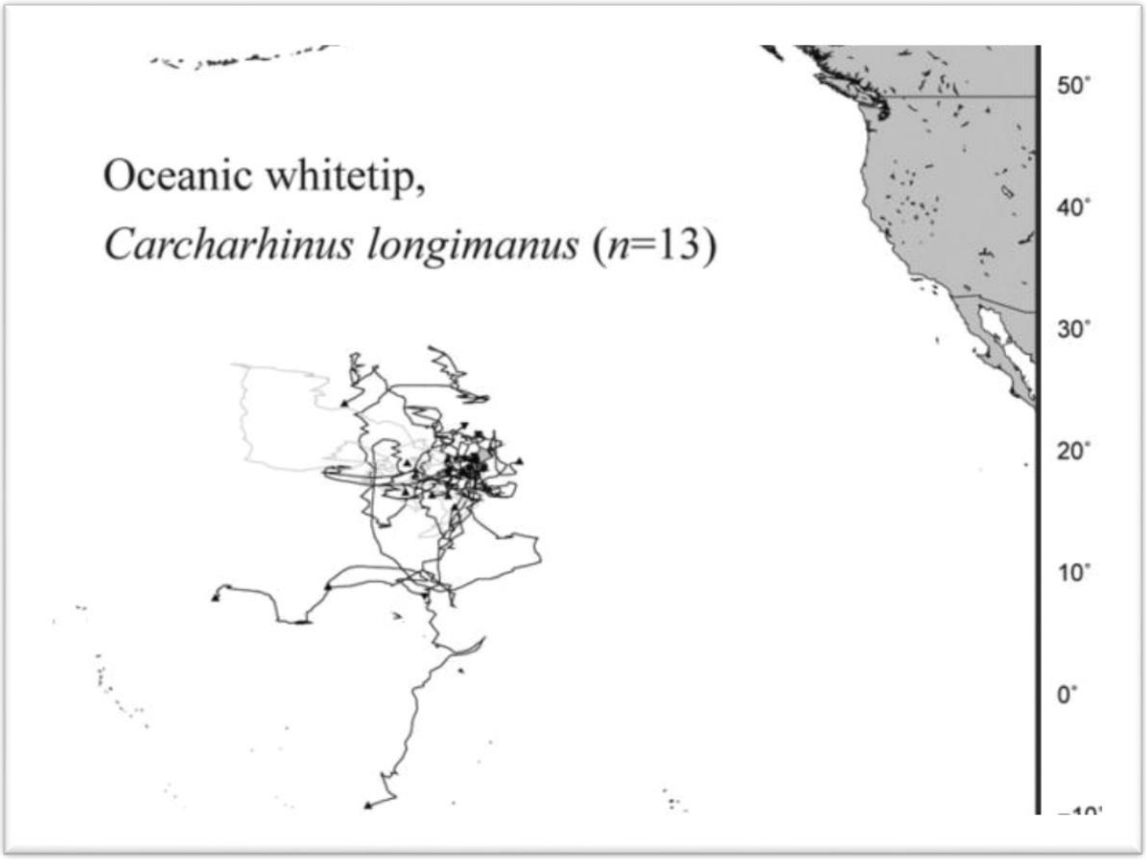

Figure 3 Most probable tracks for oceanic whitetip sharks tagged with PSATs and released in the central Pacific Ocean were estimated from the raw geolocations using the Kalman filter-sea surface temperature state-space model (see Appendix 1 in Musyl et al. 2011).

In the Atlantic Ocean, participants in the NMFS Cooperative Shark Tagging Program (CSTP) tagged 645 oceanic whitetips 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 *et al.,* (1998); 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).

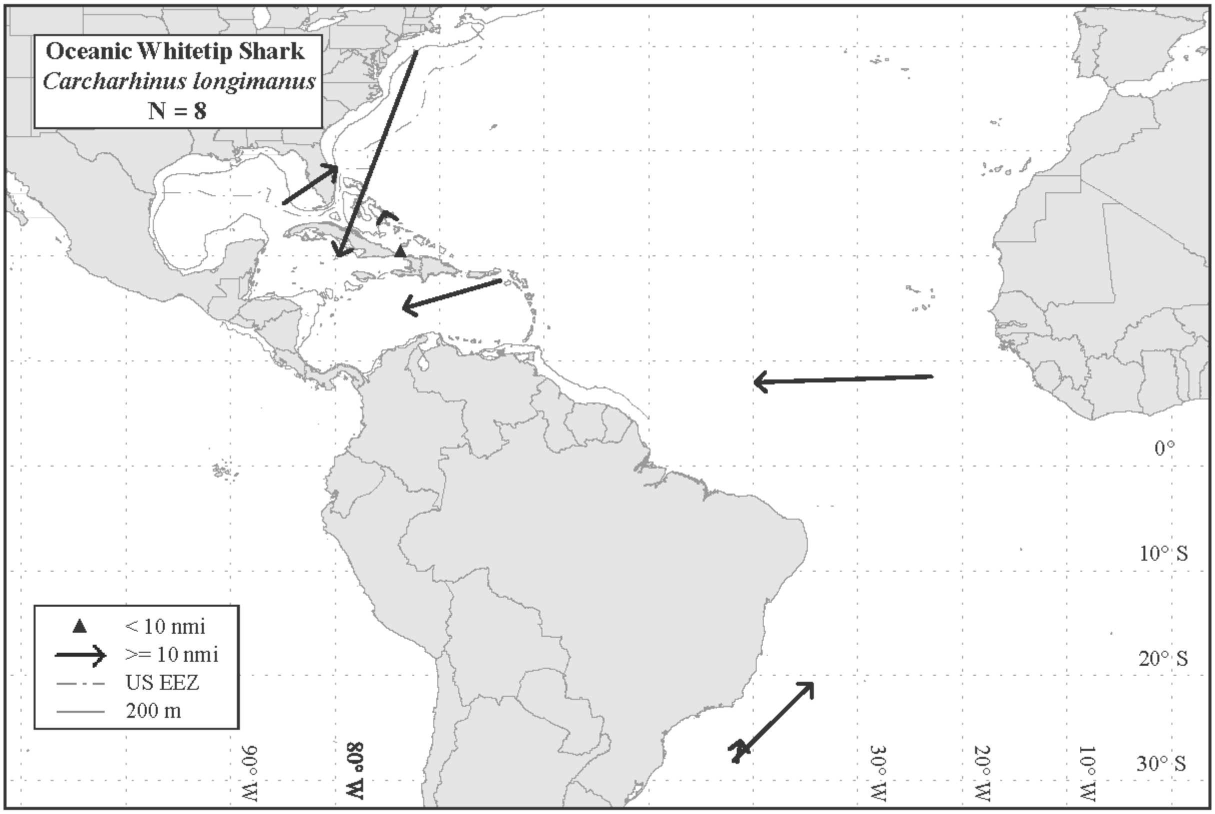

Figure 4 Recapture distribution for the oceanic whitetip shark, *C. longimanus*, from the NMFS Co-operative Shark Tagging Program during 1962-93 and NMFS unpublished data.

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, after which the largest movement by an individual from the tagging site ranged from 290–1,940 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 mean depths between day and night, with average day and night temperatures of 26.26±0.003°C and 26.23±0.003°C, 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).

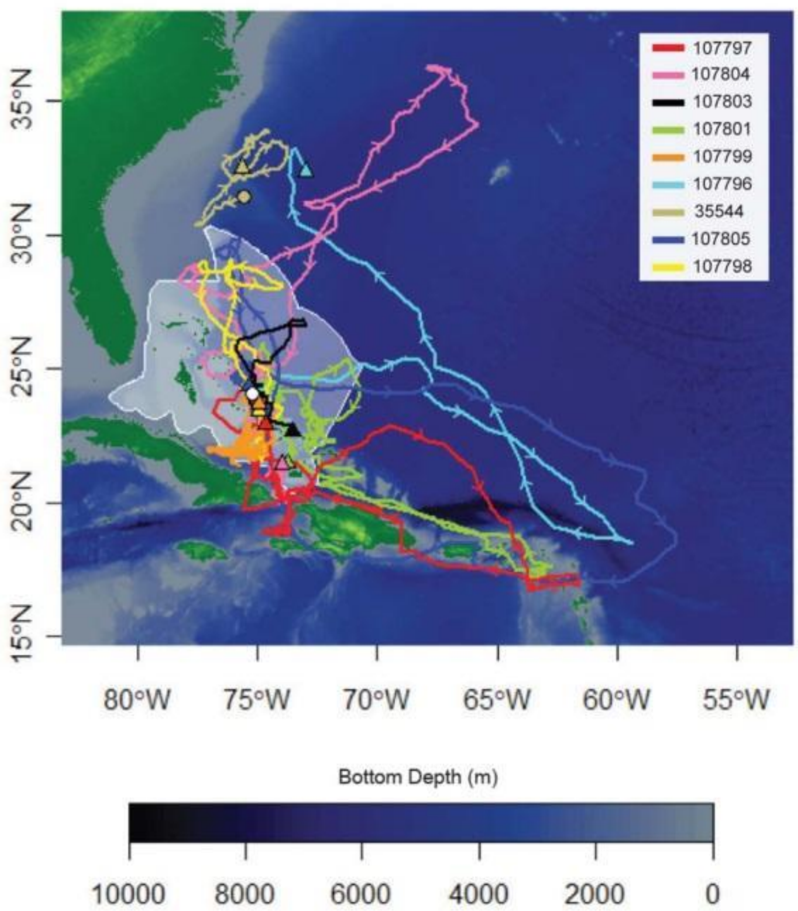

Figure 5 Map with bottom depth (m) showing filtered tracks for nine oceanic whitetip sharks equipped with Standard Rate tags. Colored lines represent tracks from individuals (listed by tag ID); triangle indicate pop-up location. Arrows on colored lines show direction of movement. Source: Howey-Jordan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

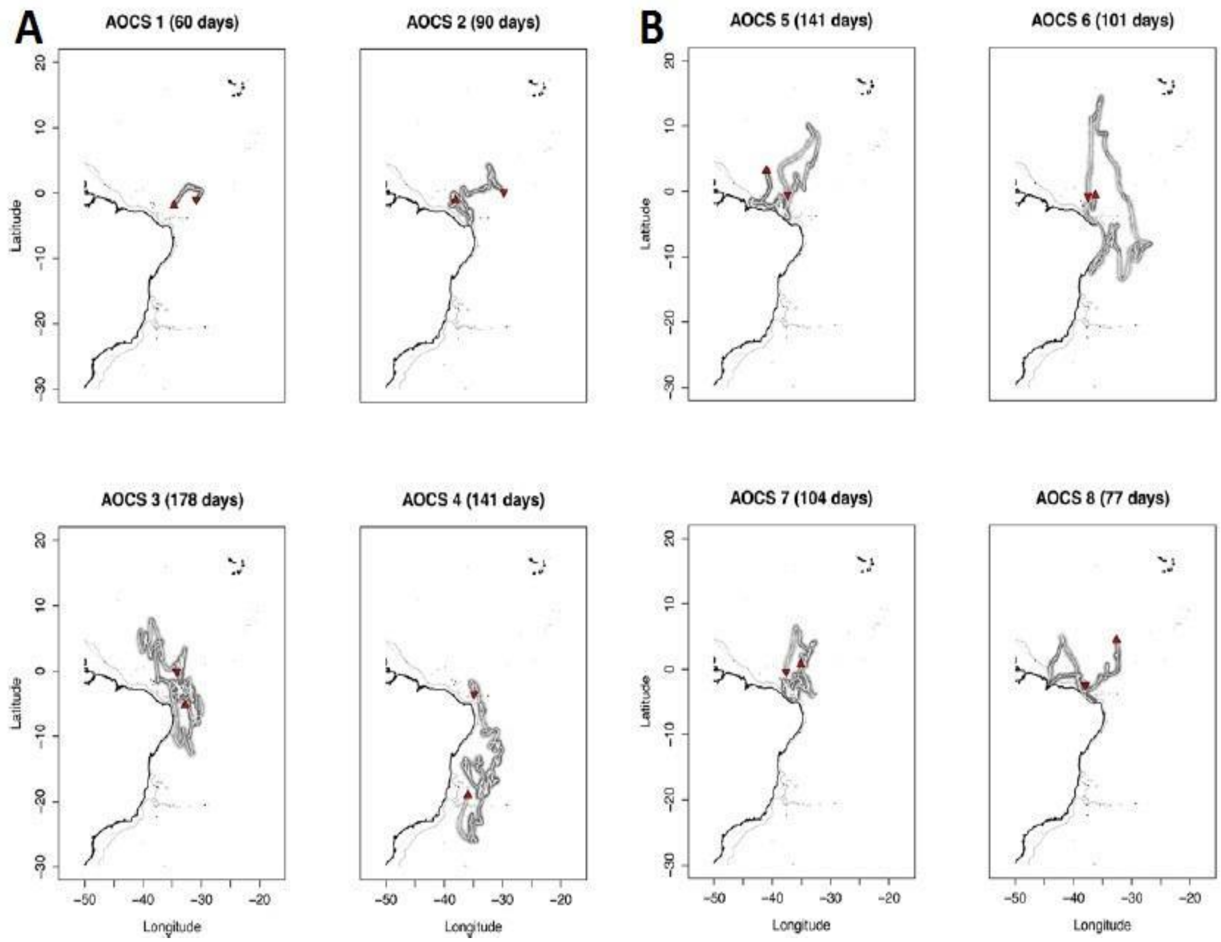

Figure 6 Post-processed tracks of oceanic whitetip sharks tagged in the western Atlantic Ocean. The downward triangles represent the tagging position and the upward triangles the end of the track. The grey-shaded area represents the error around estimated positions. (A) Oceanic whitetip sharks tagged 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 (Zones 1 and 2; see Figure 7 below) 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). It should be noted that in this case, the distribution of oceanic whitetip sharks is shown in total catches rather than CPUE; therefore, the results and patterns shown in the figure are highly influenced by the effort of the fleet.

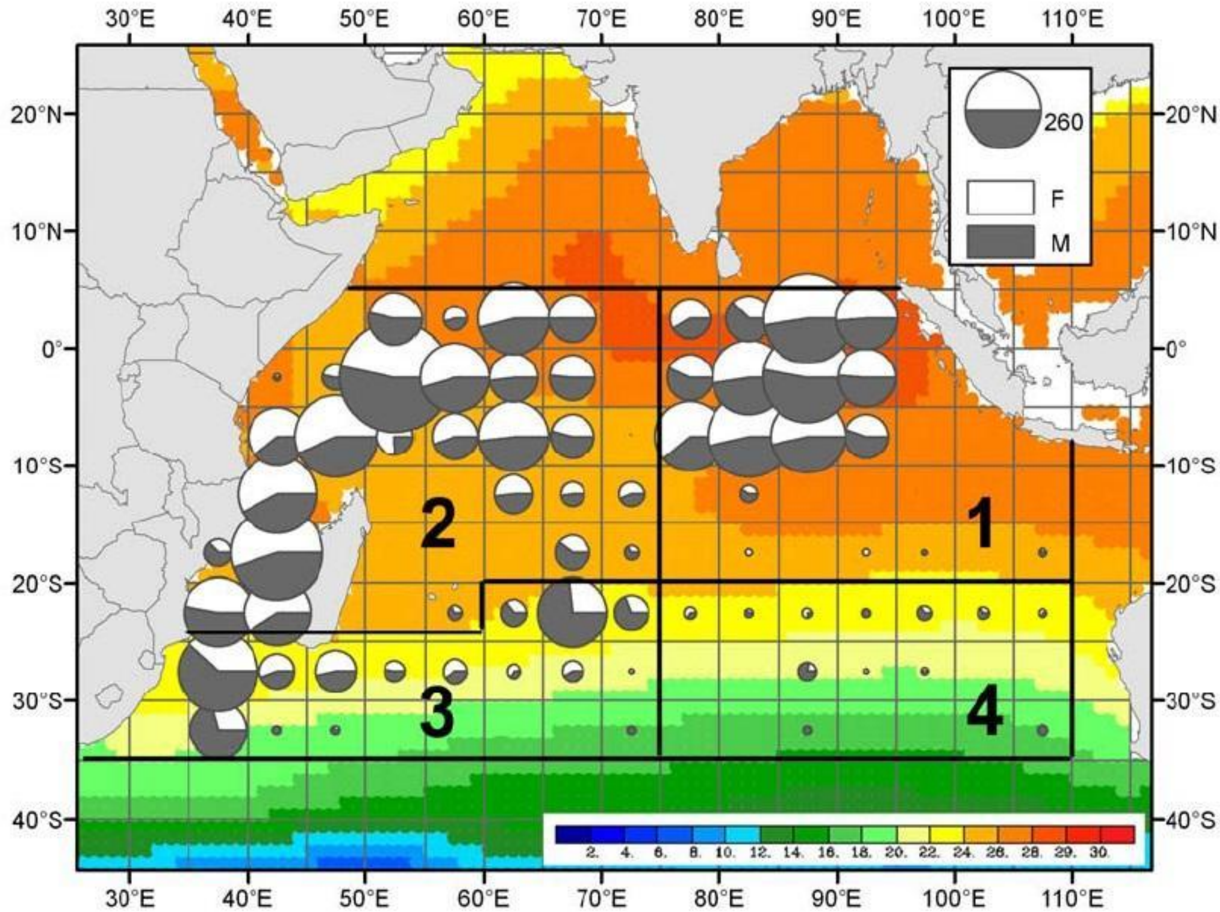

Figure 7 Observations of *C. longimanus* by 5ºx5º areas and sex in the Spanish longline fleet. The size of the circles is proportional to the number of observations available for both sexes combined. Sea temperature at 50m depth (yearly average) according to a color scale. Source: Garcia-Cortes *et al.* 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 that remained attached for 100 days. Filmalter *et al*. (2012) noted that this particular individual showed extensive horizontal movement; the shark 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, during which time Filmalter *et al*. (2012) estimated the shark traveled 1,100 km in the southern Mozambique Channel. Both results demonstrate the ability of these sharks to travel large distances in the pelagic environment (Filmalter *et al.*, (2012); see Figure 8 below).

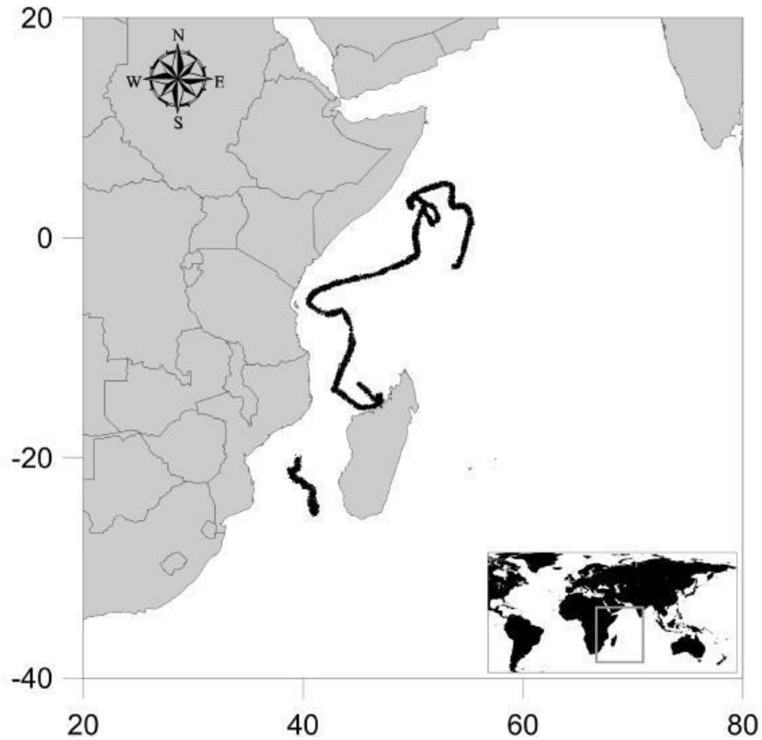

Figure 8 Horizontal movements of oceanic whitetip sharks (n = 2) tagged with PAT and mini-PATs in the western Indian Ocean. Source: Filmalter *et al.* 2012.

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 9 below) indicate that the oceanic whitetip shark exhibits a trans-equatorial migration in the Indian Ocean (Mejuto *et al.*, 2005).

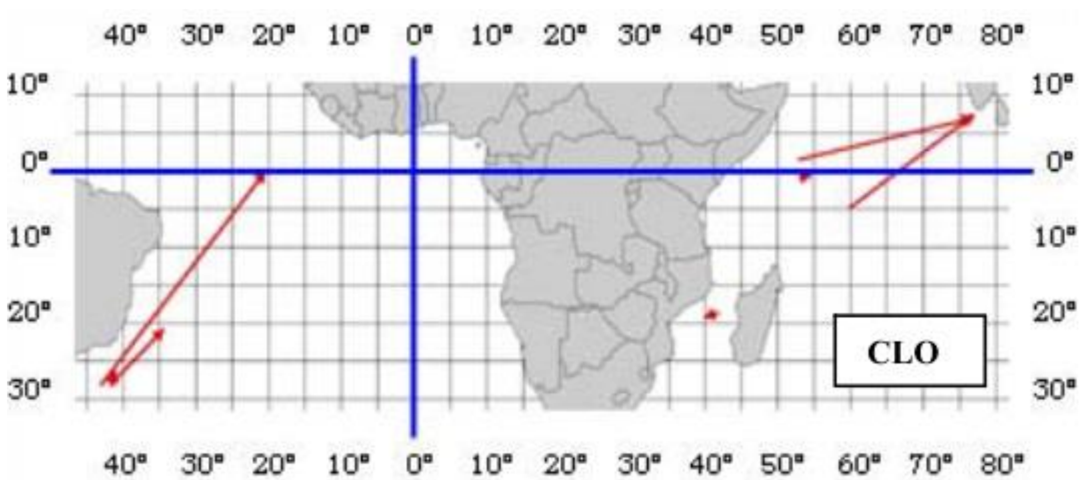

Figure 9 Rectilinear movements estimated on the basis of the tagging-recapture of Carcharhinus longimanus in the Atlantic and Indian Oceans. Source: Mejuto *et al.* 2005.

2.3 Feeding and Diet

Oceanic whitetip sharks are top-level predators in pelagic ecosystems and feed primarily on teleosts and cephalopods (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 has also been observed scavenging off dead marine mammal carcasses off South Africa (Bass *et al.,* 1973; Compagno 1984). Based on the species' diet, the oceanic whitetip has a high trophic level, with a score of 4.2 out of a maximum 5.0 (Cortés 1999). 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 whitetips feed heavily on recreationally caught teleosts in the region (Madigan *et al.*, 2015). In a recent study of an oceanic whitetip shark aggregation at Cat Island, Bahamas, Madigan *et al*. (2015) used SIA-based Bayesian mixing model to estimate short-term (near Cat Island) diets, which showed more large pelagic teleosts (72%) than in long-term diets (47%), thus showing a spatial and temporal difference in feeding habits of oceanic whitetip sharks. 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 whitetips at Cat Island (Madigan *et al.*, 2015). This further supports the notion that oceanic whitetip sharks are opportunistic predators.

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). The results of these papers are summarized below.

The theoretical maximum age for the oceanic whitetip shark ranges from ~25-36 years (D'Alberto *et al*., 2017; Rice and Harley 2012). However, observed maximum ages based on vertebral ring counts are much lower, and range 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 a full-proof methodology for estimating maximum age (D'Alberto *et al*., 2017). In fact, several other shark species have documented longevities that double what the vertebral band pair counts estimated (D'Alberto *et al.*, 2017). For purposes of this document, we consider the oceanic whitetip to live at least 20 years, and thus is a long-lived species.

In terms of size, the maximum length effectively measured for oceanic whitetip 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 specimens 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).

The oceanic whitetip shark seems to have variable growth rates throughout its range. 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}

According to Branstetter (1990), growth coefficients (K) falling in the range of 0.05-0.10/yr is a slow-growing species; 0.1-0.2 is a moderate-growing species; and 0.2-0.5 is a fast-growing species. Under these parameters, the oceanic whitetip shark is considered a slow-growing species. Figure 10 below shows the various growth curves for the oceanic whitetip shark.

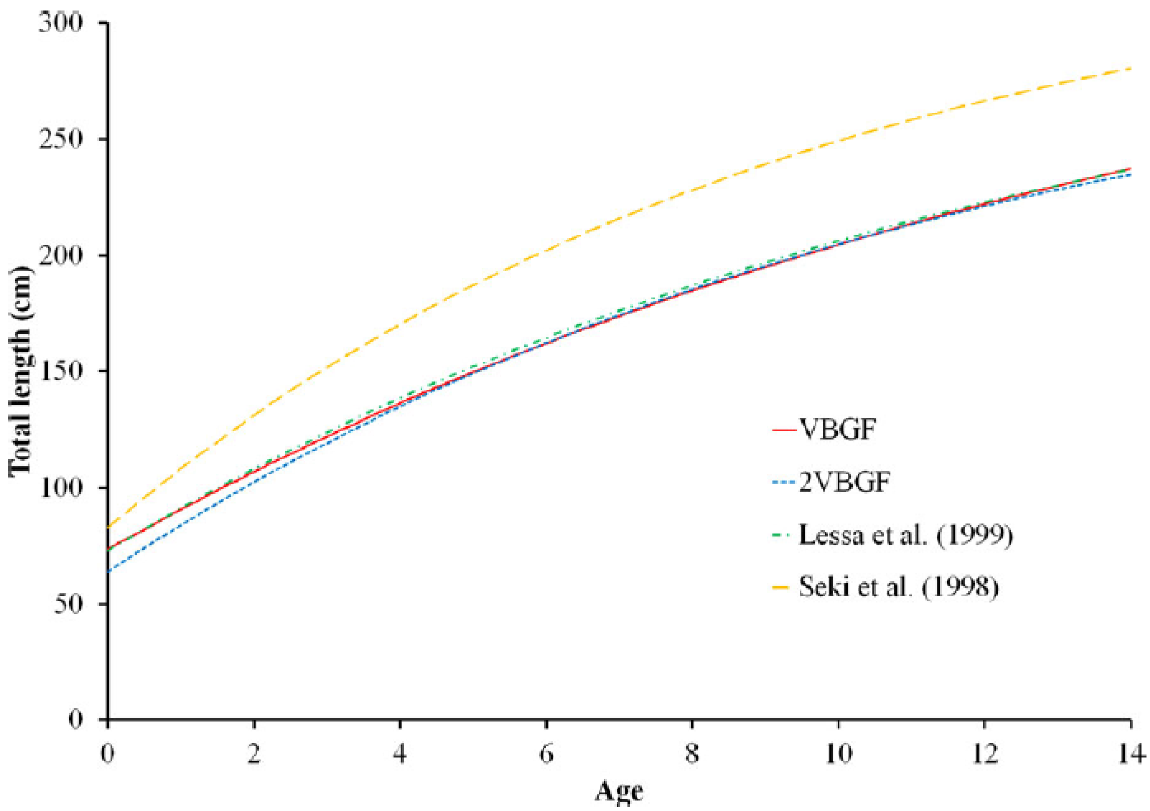

Figure 10 Comparison of the growth curves of the oceanic whitetip shark in different regions, from Seki *et al.* (1998), Lessa *et al.* (1999) and Joung *et al*. (2016). VBGF = von Bertalanffy growth function. 2VBGF was only used in Joung *et al.* (2016) and VBGF was used in the other studies. Source: Joung *et al.* 2016.

A length-weight equation is given by Romanov and Romanova (2009) from the Indian Ocean (Figure 11) for total weight (TW): TW=(.386e-4)*FL^((2.75586)) (n = 587; both sexes).

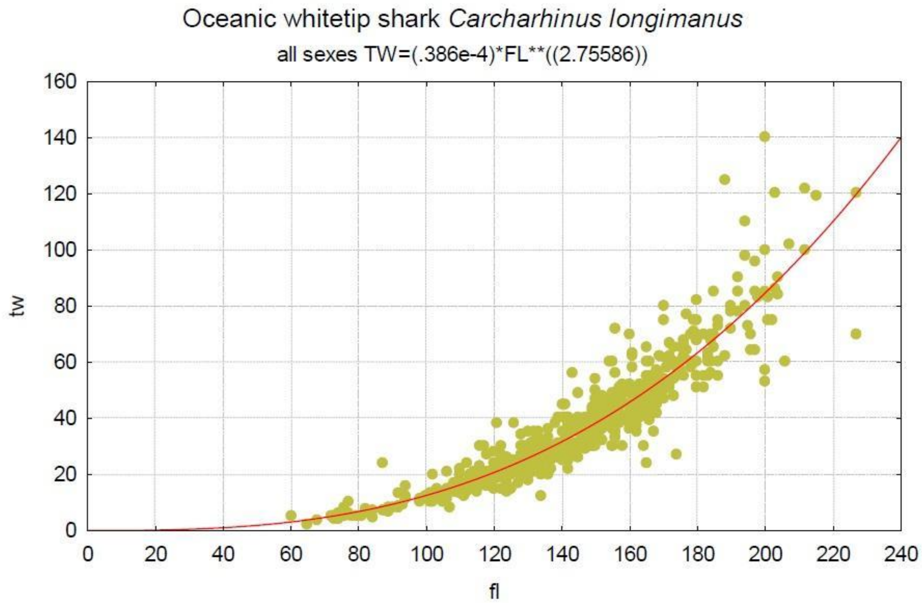

Figure 11 Length-weight scatterplot and relationship for oceanic whitetip shark (all sexes, n=587). Source: Romanov and Romanova 2009.

Age of maturity varies depending on geographic location. For example, in the Southwest Atlantic, age and size of maturity in oceanic whitetips was 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 (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).

Like other carcharhinid species, the oceanic whitetip shark is viviparous (i.e., the species 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 10-12 month gestation period (Backus *et al.*, 1956; Seki *et al.*, 1998; Bonfil *et al.*, 2008; Tambourgi *et al.*, 2013). 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; Compagno 1984; Seki *et al.*, 1998; Bonfil *et al.*, 2008; IOTC 2015a; Varghese *et al.*, 2016). Size at birth also varies slightly but is generally similar across geographic locations, ranging from 55 to 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). 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 whitetips 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 has been demonstrated in the oceanic whitetip shark. Table 1 below provides a summary of life history characteristics reported in published literature.

Table 1 Life history parameters of *C. longimanus* 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} (SW Atlantic; both sexes) 0.103 year^{-1} (N. Pacific; both sexes) 0.0852 year^{-1} (western N. Pacific; both sexes	Lessa *et al.,* (1999) Seki *et al.,* (1998) Joung *et al.* (2016)
Max length	325 cm TL (SW Atlantic) 245 cm PCL (342 cm TL; N. Pacific) 246 TL (f; obs; N. Pacific) 268 TL (m, obs; N. Pacific) 272 cm TL (Atlantic) 252 cm TL (f; obs; SW Atlantic) 253 cm TL (m; obs; SW Atlantic)	Lessa *et al.,* (1999) Seki *et al.,* (1998) Joung *et al.* (2016) Cortés (2002); (2008b) Coelho *et al.,* (2009)

Parameter	Estimate	Reference
	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)
	168-196 (N. Pacific; f) 175-189 (N. Pacific; m)	Seki *et al.,* (1998)
	190 cm TL (N. Pacific; f) 172 cm TL (N. Pacific; m)	Joung *et al.,* (2016)
	190-240 (Indian Ocean; both sexes)	IOTC (2015a)
	185 cm TL (Arabian Sea; f) 202 cm TL (Arabian Sea; m)	Varghese *et al.*, (2016)
Longevity (years)	19 (obs; SW Atlantic)	Rodrigues *et al.,* (2015)
	17 (theoretical; SW Atlantic)	Lessa *et al.,* (1999)
	11-12 (obs; N. Pacific)	Seki *et al.,* (1998); Joung *et al.* 2016
	36 (theoretical; WCPO but based on theoretical max length from N. Pacific from Seki *et al.* 1998)	Rice and Harley 2012
	24.9 (theoretical; WCPO; f) 24.6 (theoretical; WCPO; m) 18 (obs; WCPO; f) 17 (obs; WCPO; m)	D'Alberto *et al.*, (2017)

Parameter	Estimate	Reference
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)
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	7 years 11.1 years	Cortés (2002) Smith *et al.,* (2008)
Productivity (r, intrinsic rate of population increase, yr^{-1})	r= 0.067 (0.028-0.112) r= 0.094 (0.06-0.137) r= 0.111 (0.038-0.197) r= 0.121 (0.104-0.137) r= 0.15 (0.12-0.18)	Cortés (2008b) Cortés *et al.,* (2010)[2] Cortés (2002) Cortés *et al.,* (2012) Murua *et al.,* (2012)

It is not unusual for elasmobranchs to display variation in their life history characteristics across ocean basins or even regions. In fact, many other shark species show similar regional differences like those seen in the oceanic whitetip, including bonnethead sharks (*Sphyrna tib*uro), blacknose sharks (*Carcharhinus acronotus*), and blacktip reef sharks (*Charcharhinus melanopterus*), (Lombardi-Carlson *et al.*, 2003; Driggers *et al.*, 2004; Chin *et al.*, 2013) to name a few. Although regional differences can be indicative of variable population dynamics and resilience to fishing

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

[2] This value was deemed the most reasonable in a review conducted by the Pacific Shark Life History Expert Panel Workshop (Clarke et al. 2015b).

pressure (D'Alberto *et al.*, 2017), variation in life history parameters across ocean basins can also result from temporal and methodological differences across studies (Goldman and Cailliet 2004).

2.5 Population Structure and Genetics

To date, only two studies (one published journal article and one Master's thesis) have been conducted on the genetics and population structure of the oceanic whitetip shark, which provide some preliminary evidence of genetic differentiation between various populations of the species. The first study (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 ($\Phi_{ST} = 0.1039$, $P < 0.001$; 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.

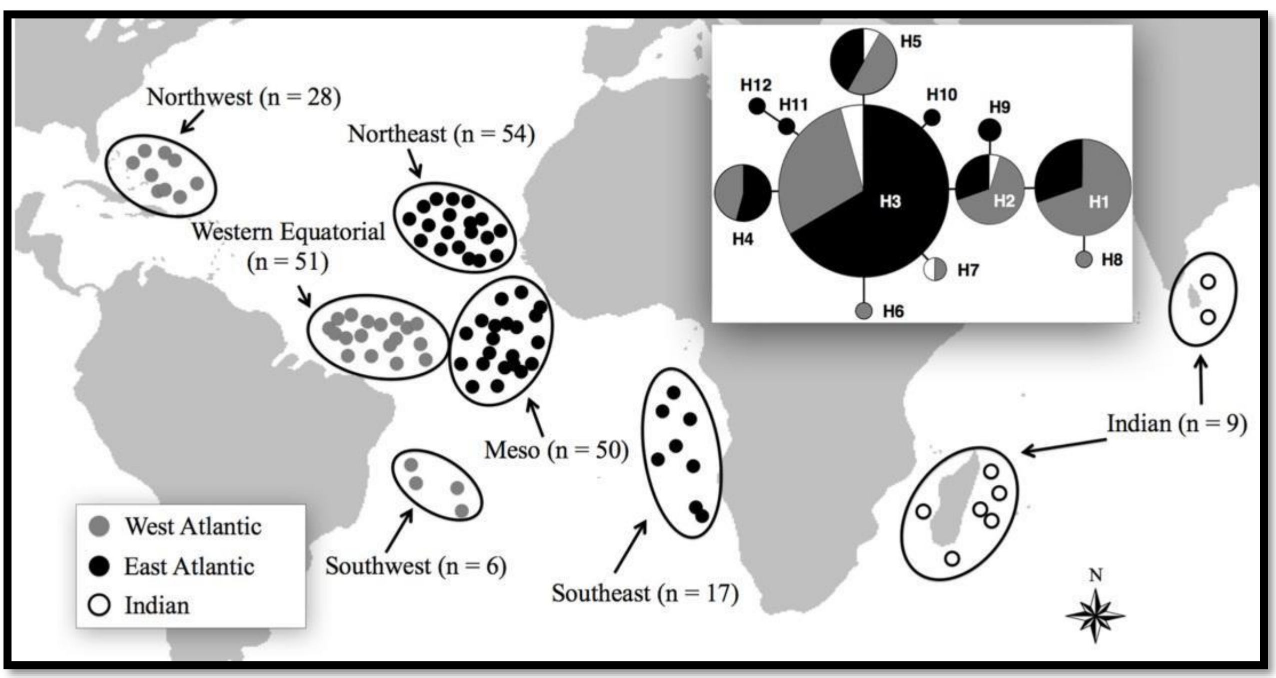

Figure 12 Geographic distribution of samples of *C. longimanus* with the network haplotypes analyzed and compiled from the sequences of the mitochondrial DNA control region. Source: Camargo *et al.* 2016.

In the second study, 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, FST, 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.

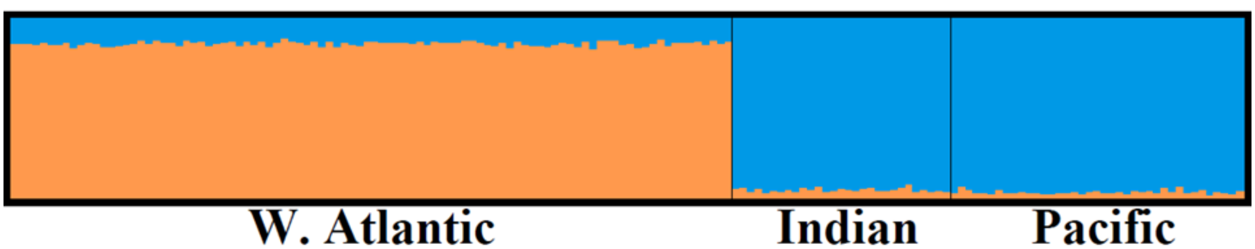

Figure 13 DISTRUCT plots summarizing STRUCTURE results of all genotyped samples: K = 2. The DISTRUCT plots clearly indicated strong sorting of two clusters: the Western Atlantic and the Indo-Pacific. Source: Ruck 2016.

Philopatry is another factor that could influence population structure within ocean basins. For example, Camargo *et al*., (2016) notes that the trans-Atlantic structure observed in their study may have developed in oceanic whitetips 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 in the tracking studies are very small 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 (refer back to Figure 4 above).

Both 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 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 mtCR genetic diversity (0.33% ± 0.19%). The oceanic whitetip 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 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 π = 0.32% ± 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. 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 (2002) also found that the oceanic whitetip ranked among the more productive species of sharks, with an annual population growth rate (λ) of 1.117 $year^{-1}$. Similar results were found in Smith *et al.* (2008), in which the oceanic whitetip shark ranked the 2nd most productive species of 11 pelagic elasmobranchs evaluated. In contrast, a recent Ecological Risk Assessment (ERA) study, determined an intrinsic rate of population increase (i.e., the rate at which a population increases in size if there are no density-dependent forces regulating the population) (*r*) of 0.094, and identified the oceanic whitetip shark as the 5th most vulnerable species of 11 pelagic shark species (Cortés *et al.*, 2010). However, in an expansion of that ERA, Cortes calculated a higher intrinsic rate of increase (r) of 0.121 (Cortés *et al.,* 2012).

Smith *et al.,* (2008) estimated a natural mortality rate of 0.203 $year^{-1}$, assuming a maximum age of 22 years. Estimated generation times range from 7 to 11.1 years (Cortés 2008b; Smith *et al.,* 2008). Finally, the oceanic whitetip shark ranked among the highest in productivity when compared with other pelagic shark species (ranking 5 out of 26 overall) in terms of its egg production, rebound potential, potential for population increase, and for its stochastic growth rate (Chapple and Botsford 2013). However, overall, the growth rate (as indexed by the von Bertalanffy K parameter), natural mortality and the intrinsic rate of population increase are all consistent with low productivity while the ages of maturity and generation times indicate moderate productivity (or low to moderate) (FAO 2012). Thus, the biology of the oceanic whitetip shark indicates that it is likely to be a species with low resilience to fishing and minimal capacity for compensation (Rice and Harley 2012). Therefore, for the purpose of this status review, we consider the oceanic whitetip shark to have low-moderate productivity.

3. GLOBAL AND REGIONAL ABUNDANCE ESTIMATES AND TRENDS

Overall, global quantitative abundance estimates and trends are lacking for the oceanic whitetip. However, there are several studies on the abundance trends for a few regions and/or populations of oceanic whitetip sharks. There is also a recent stock assessment for the oceanic whitetip shark in the Western and Central Pacific (Rice and Harley 2012). Thus, the following section provides some insight into the abundance trends of the species. It should be noted that catch records of sharks, especially non-target shark species, are often inaccurate and incomplete. 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

Worldwide catches of oceanic whitetip shark are reported in the Food and Agricultural Administration (FAO) of the United Nations (UN) 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 14). Reported worldwide catches for oceanic whitetip shark for the last 10 years of available data (2003-2013) have ranged from 150 to 468 mt per year.

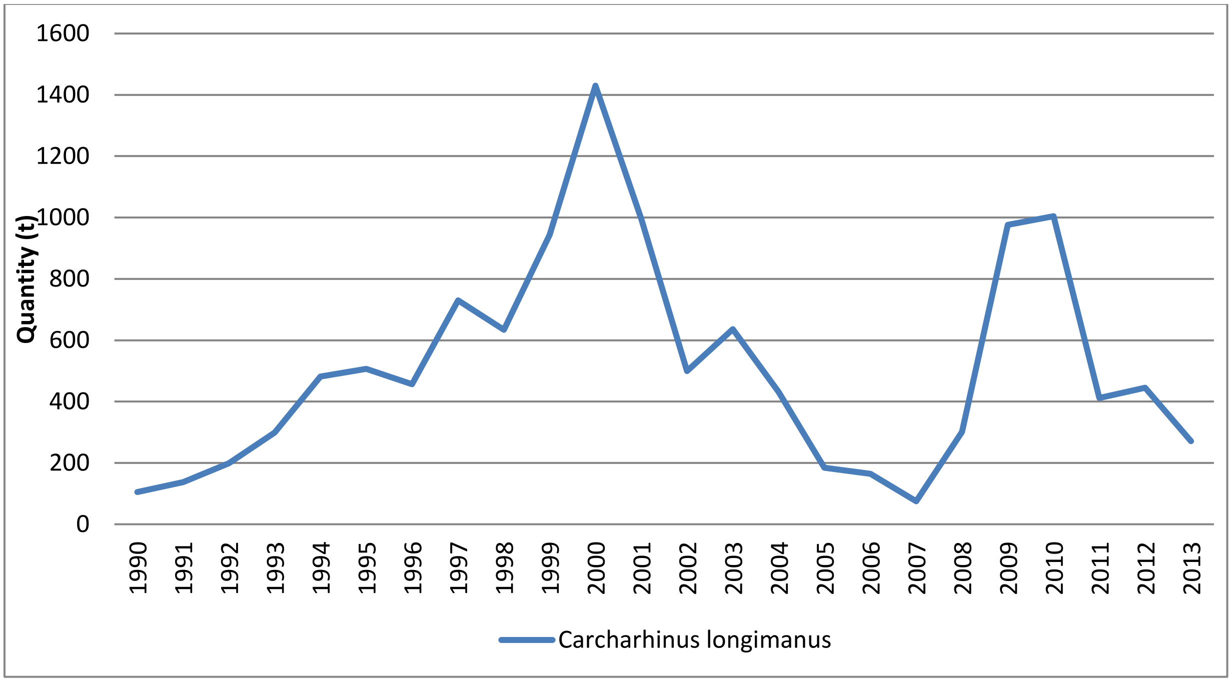

Figure 14 Global capture production for oceanic whitetip shark from 1990-2013; global capture production is production weight of the retained individuals before processing and thus may differ from landings weights. Source: FAO Global Capture Production; accessed January 28, 2016.

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 catches through time. Because FAO data are generated from fisheries agencies reports of individual countries, the data suffer from the same 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 many countries not required to report discards at all. Although more countries and Regional Fishery Management Organizations (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). Thus, given these types of data, with current estimates highly uncertain, a quantitative global population trend for the oceanic whitetip shark would not be reliable at this time.

3.2 Regional Population Trends

The following section describes the available information regarding regional catch 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 derived from the relevant RFMOs, which are international organizations that have been 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 oceanic whitetip sharks are global, highly migratory species that cross 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.

Eastern Pacific Ocean

There is a lack of quantitative abundance trends of oceanic whitetip shark in the Eastern Pacific Ocean. Historically, the oceanic whitetip shark was the third most abundant shark species after blue sharks (*Prionace glauca*) and silky sharks (*C. falciformis*). However, there is some evidence to suggest that the species has undergone significant population declines in this region. For example, in the eastern Pacific tropical tuna purse seine fisheries, unstandardized nominal catch data from the Inter-American Tropical Tuna Commission (IATTC) for the oceanic whitetip shark from purse seine sets on floating objects, unassociated sets and dolphin sets all show declining trends since 1994 (IATTC 2007). In particular, presence of oceanic whitetip sharks on sets with floating objects, which are responsible for 90% of the shark catches in Eastern Pacific purse seine fishery, has declined significantly (Hall and Román 2013). Figure 15 below shows the nominal catches per set of oceanic whitetip shark in floating object sets, and Figure 16 below shows a map describing the distribution of encounters with oceanic whitetip sharks. Both maps show four periods of time (1994-1997; 1998-2001; 2002-2005; and 2006-2009).

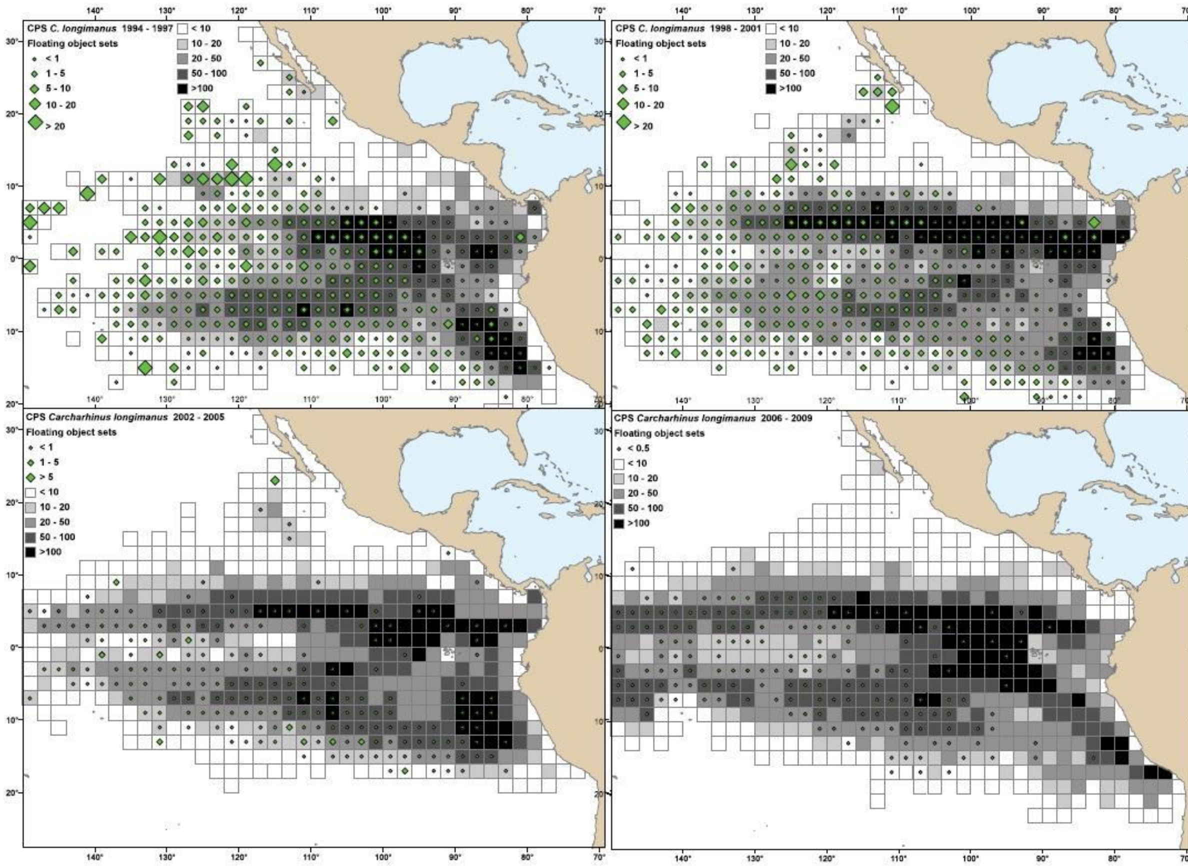

Figure 15 Numbers per set of oceanic whiteitp sharks in floating object sets in four periods (1994-1997; 1998-2001; 2002-2005; 2006-2009. The green diamonds represent numbers of oceanic whitetip shark caught; the gray shaded squares represents fishing effort (numbers of sets deployed). Source: Hall and Roman 2013.

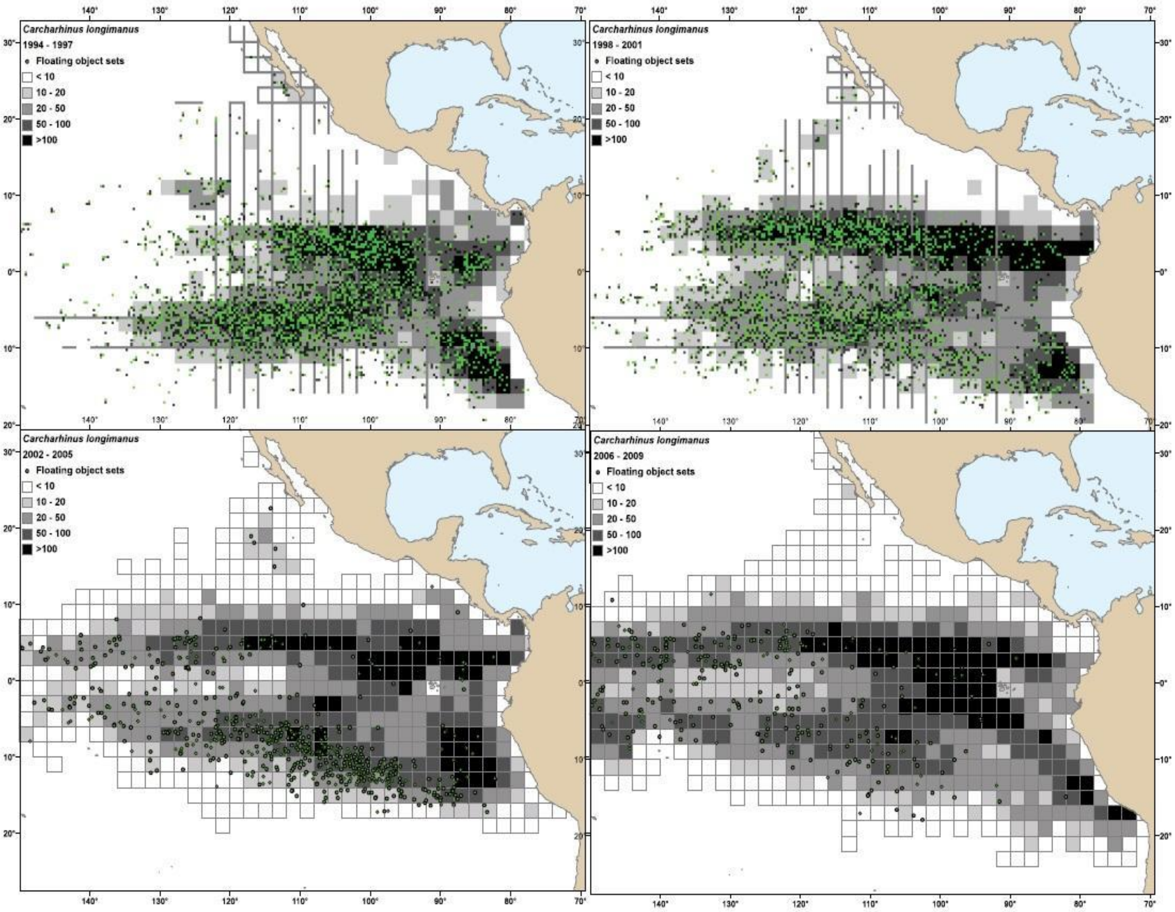

Figure 16 Encounters with oceanic whitetip sharks in floating object sets in four periods (1994-1997; 1998-2001; 2002-2005; 2006-2009). The green dots represent encounters with oceanic whitetip sharks in floating object sets (i.e., sets with oceanic whitetip sharks present); the gray shading represents fishing effort (number of sets deployed). Source: Hall and Roman 2013.

Figures 15 and 16 above provide a clear illustration of the decline in catches per set that accompanied a significant reduction in oceanic whitetip frequency (Hall and Roman 2013). Based on Figures 15 and 16 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 dolphin and school sets. These declines in nominal CPUE or the frequency of occurrence equates to an of 80–95% decline from population levels in the late 1990s (Hall and Román 2013).

Western and Central Pacific Ocean

The oceanic whitetip shark was historically considered one of the most abundant pelagic shark species throughout the Western and Central Pacific Ocean. 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 Western and Central Pacific, 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 in has suffered significant population declines throughout the region, including declining trends in standardized CPUE, biomass and size indices.

In 2011, a "status snapshot" was developed for the oceanic whitetip shark to depict its status in the Western and Central Pacific Ocean (Clarke 2011; See Figure 17 below). This status snapshot summarizes the findings from several papers based on data from the Secretariat of the Pacific Community (SPC) (Clarke *et al.*, 2011a; Lawson 2011), Japan (from both commercial longlines and research training vessels (RTV) (Clarke *et al.,* 2011b), information from an ecological risk assessment (Kirby and Hobday 2007), and catch estimates based on shark fin trade records (Clarke 2009). The downward arrows in Figure 17 depict the various CPUE trends; all available abundance, size, and catch trend indices show declining trends.

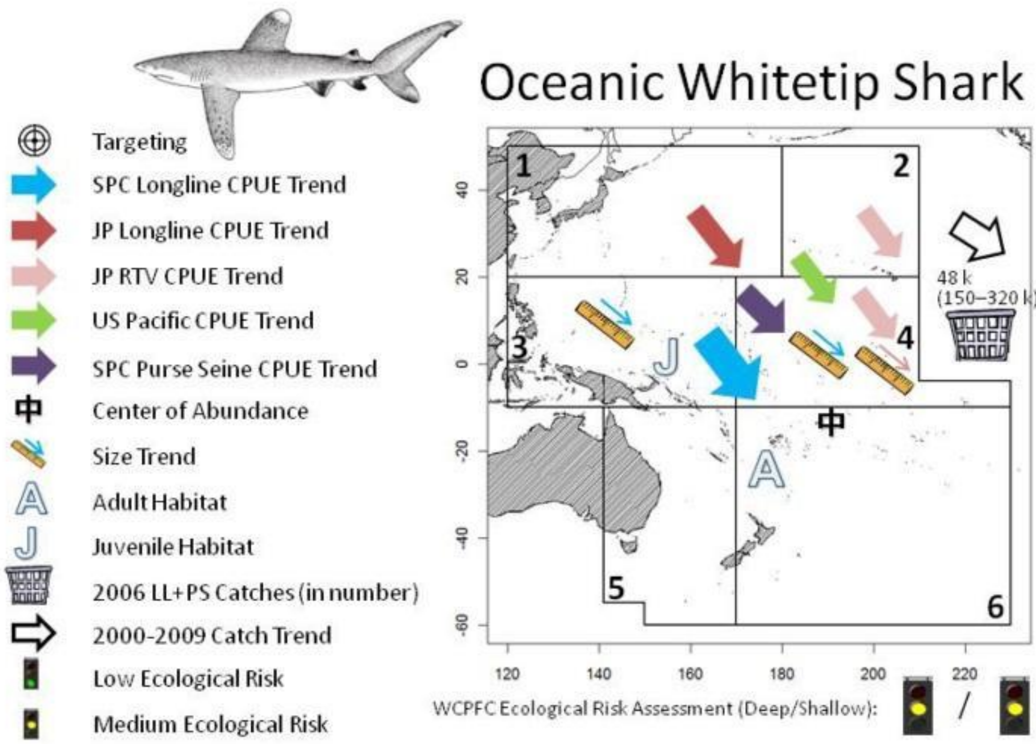

Figure 17 Status snapshot of oceanic whitetip shark in the Western and Central Pacific Fisheries Commission (WCPFC) Statistical Area. JP = Japanese; RTV – Research Training Vessels; SPC = Secretariat of the Pacific Community. Source: Clarke (2011).

In addition to the status snapshot, Rice and Harley (2012) conducted a stock assessment for the oceanic whitetip, in which standardized CPUE series were estimated in the Western and Central Pacific based on observer data from the SPC and collected from 1995-2009. Results show that the median estimate of oceanic whitetip biomass in the Western Central Pacific in 2010 was 7,295 tons (Rice and Harley 2012), which, when extrapolated, equaled a population of roughly 200,000 individuals (FAO 2012). Rice and Harley (2012) concluded that catch, CPUE, and size composition data for oceanic whitetip all show consistent declines from 1995-2009. Additionally, estimated spawning biomass, total biomass and recruitment also declined consistently throughout the time series. Specifically, current estimates of oceanic whitetip stock depletion indicate that the total biomass has been reduced to 6.6% of theoretical equilibrium virgin biomass (i.e., ~93% decline), with spawning biomass reduced by 86% since 1995 (Rice and Harley (2012); see Figures 18 and 19 below).

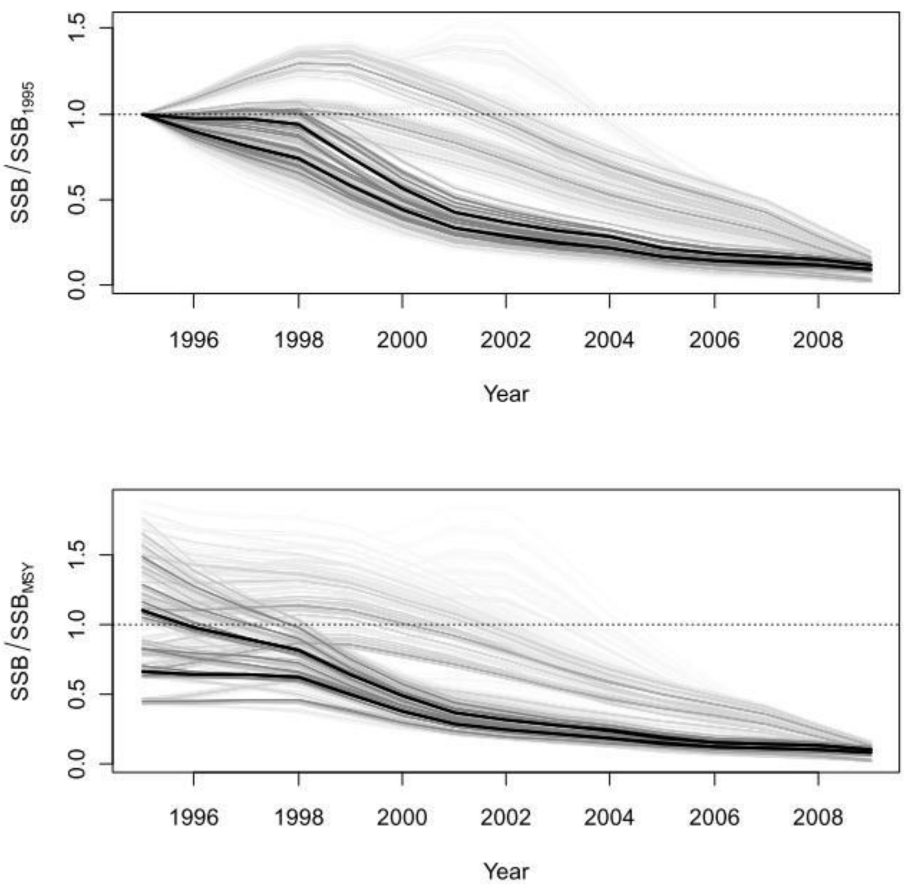

Figure 18 Changes in the spawning biomass relative to the first year of the model (1995 – top panel) and SBMSY (equilibrium spawning potential, referred to as spawning biomass at MSY; bottom panel). Each line represents one of 648 runs from the grid and the darker the line, the higher the assigned weight (plausibility) for that model run. Source: Rice and Harley 2012.

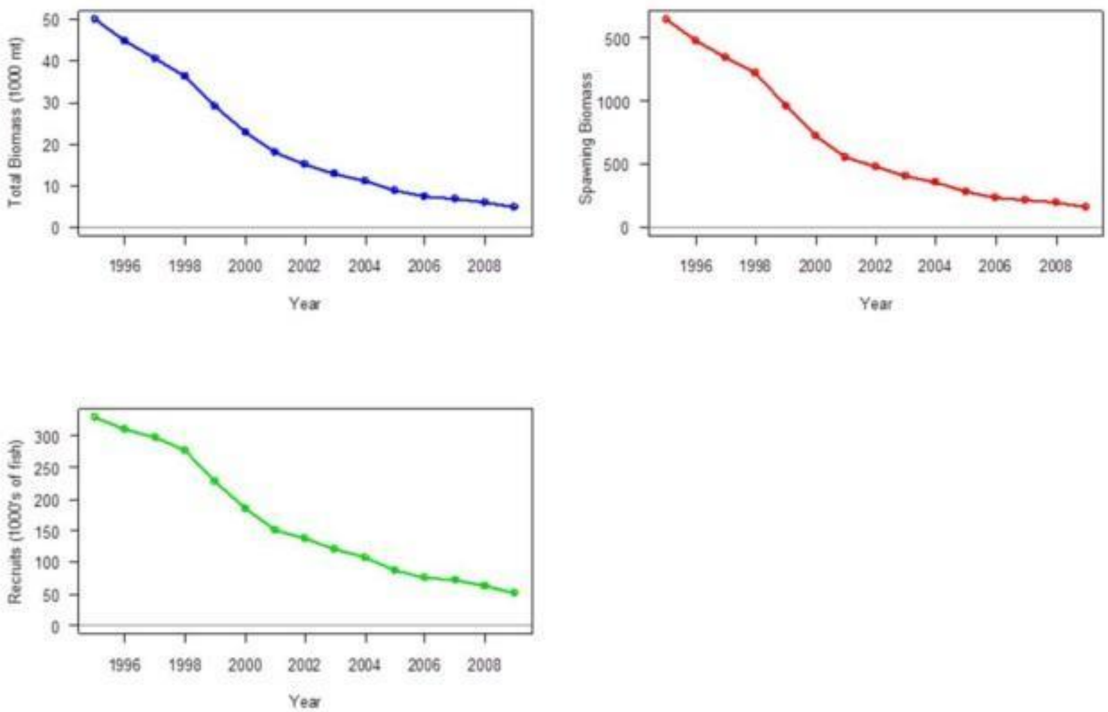

Figure 19 Estimated total biomass (top left in blue, 1000 metric tons), estimated spawning biomass (top right in red) and estimated annual recruitment (1000's of fish; bottom left in green) in the WCPO for the reference case. Source: Rice and Harley 2012.

More recently, Rice *et al.,* (2015) confirmed that population declines of oceanic whitetips have continued since the stock assessment report was completed in 2012. The proportion of positive oceanic whitetip catch in longline sets has also been steadily declining since the mid-1990s (see Figures 20 and 21 below).

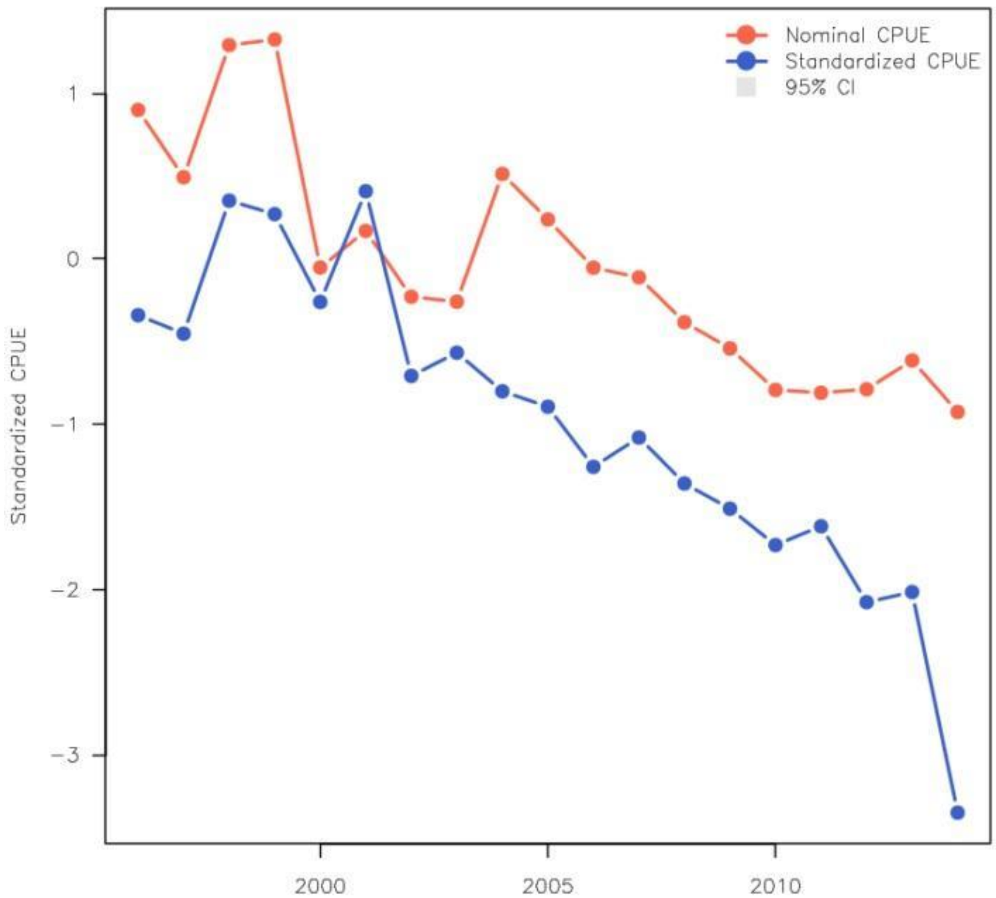

Figure 20 Nominal and Standardized CPUE trends of oceanic whitetip shark in the WCPFC. Source: Rice *et al.* 2015.

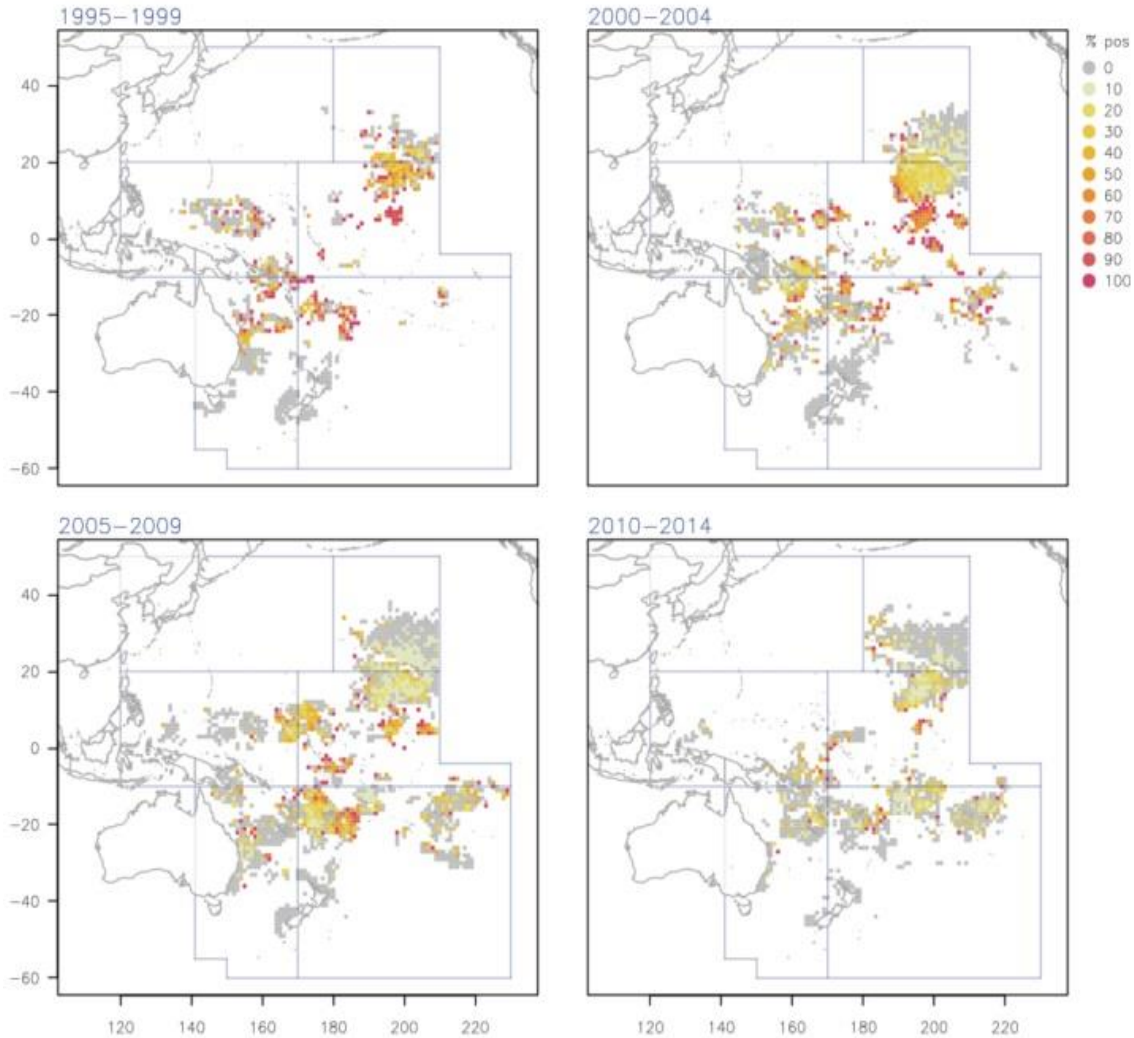

Figure 21 Spatial distribution of the proportion of longline sets for which one or more oceanic whitetip shark were caught for each five year period between 1995 and 2014. Source: Rice *et al.* 2015.

Overall, results from Rice *et al.* (2015) indicate that oceanic whitetip sharks in the Western and Central Pacific were more common prior to 2000, when the species frequently comprised >20% of the overall shark catch. However, the oceanic whitetip has not exceeded more than 20% of the total shark catch in their core tropical habitat area for over a decade, which is a significant contrast from the first ten years of the study. These results also confirm that oceanic whitetip shark abundance continues to decline throughout the tropical waters of the Western and Central Pacific Ocean (Rice *et al*., 2015). Although the trend may be exaggerated in the last year due to a lack of complete data for the last year of the dataset, the overall trend still shows a steady decline of oceanic whitetip shark abundance in the Western and Central Pacific Ocean. Additionally, while standardized CPUE data for the purse seine fishery are not available, the oceanic whitetip is one of only two species frequently caught in this fishery (the other being the silky shark) and nominal CPUE data from the purse seine fishery shows that the species has exhibited declines similar to those in the longline fishery (see Figure 22 below; Clarke *et al.,* (2012)).

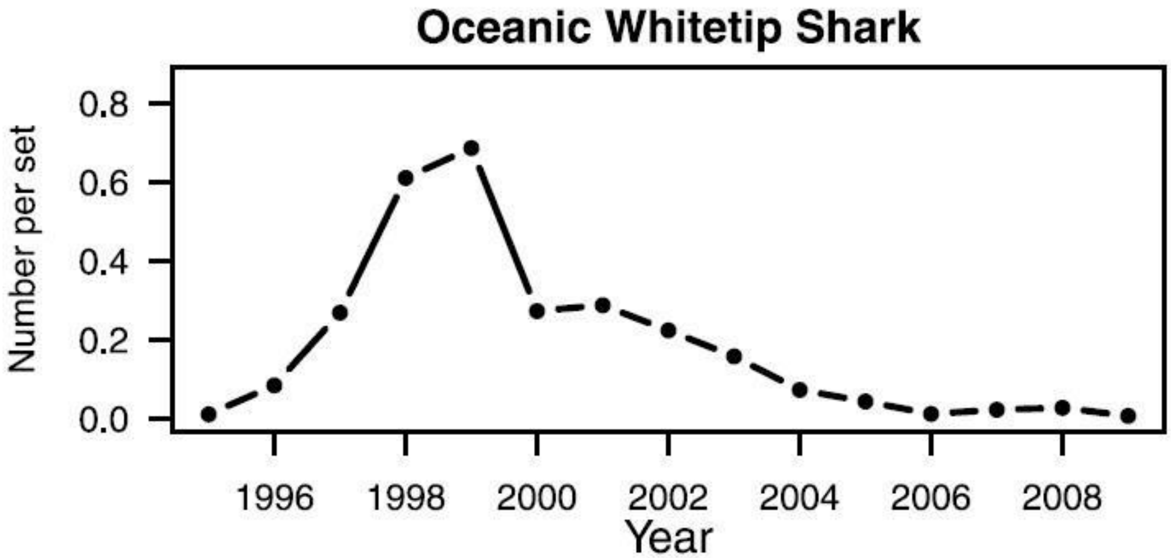

Figure 22 Nominal purse seine CPUE trend for oceanic whitetip in the western and central Pacific Ocean, 1996–2009. Source: Clarke *et al.,* (2012).

Separate analyses have also been conducted for the Hawaii-based pelagic longline fishery that found similar abundance declines (Walsh and Clarke 2011; Brodziak *et al.*, 2013). Based on observer data from the Pacific Islands Regional Observer Program (PIROP), mean annual nominal CPUE of oceanic whitetip decreased significantly from 0.428 sharks/1000 hooks in 1995 to 0.036 sharks/1000 hooks in 2010. This reflected a significant decrease in nominal CPUE on longline sets with positive catch from 1.690 sharks/1000 hooks to 0.773 sharks/1000 hooks, and a significant increase in longline sets with zero catches from 74.7% in 1995 to 95.3% in 2010. After accounting for various factors (e.g., sea surface temperature, fishery sector, and latitude), Walsh and Clarke (2011) concluded that oceanic whitetip CPUE declined by more than 90% in the Hawaii-based longline fishery since 1995.

Using the same data, Brodziak *et al*. (2013) found similar results by using several models in order to assess the species' CPUE from 1995 to 2010 in the Hawaii-based longline fisheries (both shallow and deep set). This study also found a decreasing trend in standardized CPUE from 1995 to 2010, which equates to a 90% decline in relative abundance due to increased sets with zero catches as well as decreased CPUE on sets with positive catch (Brodziak *et al.*, 2013; See Figure 23 below). The authors note that the similarity in the results from Hawaii in comparison to studies based on SPC observer data for the rest of the Western and Central Pacific suggest that declines of oceanic whitetip populations are not just local to Hawaii, but rather a Pacific-wide phenomenon. However, the authors emphasized that the closeness in alignment between the trends in Hawaii and the Western and Central Pacific Ocean may be partly due to the use of datasets that partially overlap for years prior to 2005. However, even after 2005, the trends show similar results suggesting that the patterns are fair representations of regional trends in oceanic whitetip abundance. Additionally, tuna purse seine fishery data documented a similar decrease in oceanic whitetip shark catches (79%) from 20°S to 20°N and 150°W to 130°E between 1999 and 2010 (Lawson 2011; Clarke *et al.*, 2012).

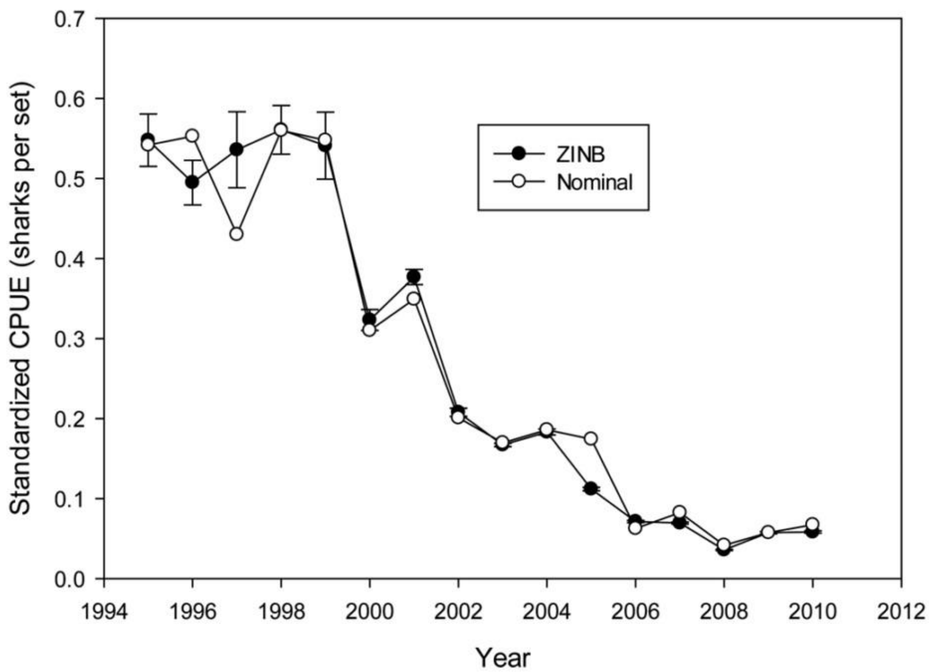

Figure 23 Comparisons of estimates of annual standardized CPUE (mean sharks per standardized longline set) for oceanic whitetip shark in the Hawaii-based pelagic longline fishery in 1995–2010 for the best-fitting model (ZINB) and the best-fitting model showing 95% confidence bars for the standard error of the mean CPUE and the nominal CPUE. Source: Brodziak *et al.* 2013.

The federally-mandated observer program accurately distinguishes the oceanic whitetip shark to species, and their occurrence in the data were examined in further detail by the ERA team, primarily to update the Brodziak *et al.,* (2013) publication with 4 additional years 2011-2014 (Figure 24 below). A standardized CPUE annual index was estimated using a generalized linear model (GLM) with a delta lognormal modeling approach in the statistical programming language R. This approach is fundamentally similar to the original study in which a zero-inflated negative binomial approach was used; both are well-suited methodologies to deal with relatively uncommon events. The delta lognormal is a 2-stage modeling approach, often termed a "hurdle" model (Cragg 1971; Maunder and Punt 2004), whereby the first model estimates the hurdle or probability of experiencing a non-zero catch. This probability is merged with the results of a second model, which estimates the magnitude of the non-zero catch. Two models are needed due to the different probability distributions associated with these two processes and the prevalence of zero catches. Using a binomial distribution for the proportion of zeros and a logarithmic Gaussian distribution for the positive catch component, the final GLM annual CPUE index is shown in Figure 39 below. The suite of variables used in the 2 modeling steps include haul quarter of the year, sea surface temperature, haul year, set type (i.e. shallow set or deep-set), hooks per float, region, vessel length, and interaction terms. The analysis presented here is not a formal stock assessment but is a preliminary exercise to glean relative abundance and trend information from a historically reliable data stream using a traditional approach, and to update the Brodziak *et al.* (2013) study with 4 additional years of information. Results show that the oceanic whitetip population in this area may have stabilized at a post-decline depressed state in recent years.

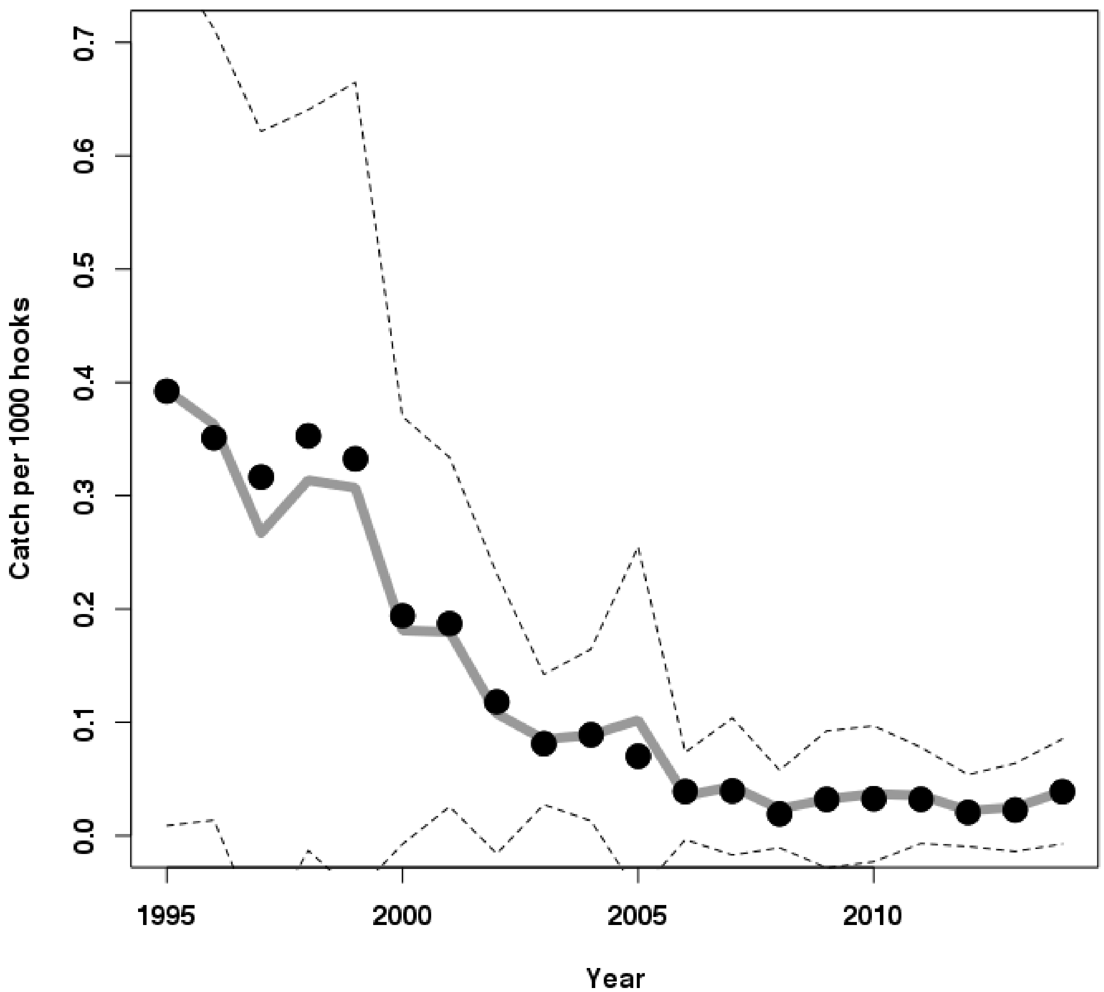

Figure 24 Comparisons of estimates of annual standardized CPUE (mean sharks per standardized longline set) for oceanic whitetip shark in the Hawaii-based pelagic longline fishery in 1995–2014. Source: NMFS PIROP Observer data; adapted from Brodziak *et al.* 2013.

Based on the foregoing information, the oceanic whitetip shark has experienced, and in most cases continues to experience, abundance declines across the Western and Central Pacific Ocean.

<u>Atlantic Ocean</u>

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 during exploratory research surveys in the western North Atlantic during the 1950s noted that several individuals often gathered at the surface around longlines, persistently investigated baited hooks, and occasionally attacked dead or dying tuna before they were hauled in (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, however, suggests the

species is now relatively rare in this region. Several studies have been conducted in this region to determine trends in abundance of various shark species, including the oceanic whitetip shark. In a study of observer data from the U.S. pelagic longline (PLL) fishery operating off the southeastern United States, Beerkircher *et al.*, (2002) showed highly variable annual mean CPUE estimates from 1992-2000, with nominal CPUE (numbers caught per 1,000 hooks) declining significantly between 1981-1983 (CPUE = 0.87; Berkeley and Campos (1988)) and 1992-2000 (CPUE = 0.48). In total, from 1992-2002, 407 oceanic whitetip sharks were caught as bycatch, and approximately 30% were discarded dead (Beerkircher *et al.*, 2004).

Baum *et al.*, (2003) analyzed logbook data for the U.S. pelagic longline fleets targeting swordfish and tunas in the Northwest Atlantic (see Figure 25 below), and reported a 70% decline in relative abundance for the oceanic whitetip shark from 1992 to 2000.

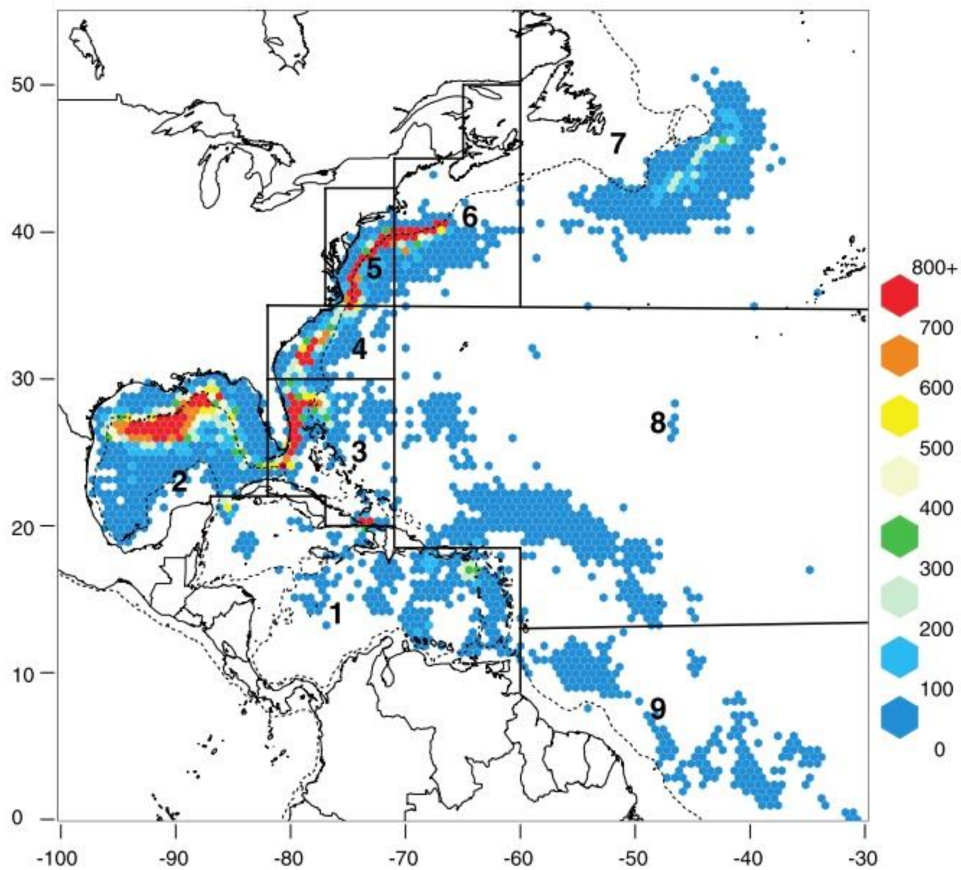

Figure 25 Map of the Northwest Atlantic showing the distribution of effort in the U.S. pelagic longline fishery between 1986 and 2000, categorized by number of sets (0 to 800), within the nine areas assessed: 1, Caribbean; 2, Gulf of Mexico; 3, Florida East Coast; 4, South Atlantic Bight; 5, Mid Atlantic Bight; 6, Northeast Coastal; 7, Northeast Distant; 8, Sargasso/North Central Atlantic; 9, Tuna North/Tuna South. Areas were modified from the U.S. National Marine Fisheries Service classification for longline fisheries. The 1000-m coastal isobath (dotted line) is given for reference. Source: Baum *et al*. 2003.

Similarly, Baum and Myers (2004) compared longline CPUE from research surveys from 1954-1957 to observed commercial longline sets from 1995-1999, and determined that the oceanic whitetip had declined by more than 150-fold, or 99.3% (95% CI: 98.3-99.8%) in the Gulf of Mexico during that time. However, the methods and results of Baum *et al*. (2003) and Baum and

Myers (2004) were challenged (see discussions in Burgess *et al.*, (2005b) and Burgess *et al.*, (2005a) on the basis of whether correct inferences were made regarding the magnitude of shark population declines in the Atlantic). More specifically, while the authors agreed that abundance of large pelagic sharks had declined, they presented arguments that the population declines were probably less severe than indicated. Of particular relevance to the oceanic whitetip, Burgess *et al.*, (2005b) noted that the change from steel to monofilament leaders between the 1950s and 1990s could have reduced the catchability of all large sharks, and the increase in the average depth of sets during the same period could have reduced the catchability of the surface-dwelling oceanic whitetip (FAO 2012). Driggers *et al.*, (2011) conducted a study on the effects of different leader materials on the CPUE of oceanic sharks and determined that with equivalent methods but using a wire leader, the catch rates of Baum and Myers (2004) for the recent period would have been 0.55 rather than 0.02 (as estimated by Baum and Myers (2004) using nylon leaders). Comparing the recent 0.55 value with the Baum *et al*. (2003) value of 4.62 for the 1950s results in an approximate decline of 88% (FAO 2012).

In a more recent re-analysis of the same U.S. pelagic longline logbook dataset using a similar methodology as Baum *et al*. (2003), Cortés *et al.*, (2007) reported a 57% decline from 1992-2005. The decline was predominantly driven by a 37% decline from 1992 to 1993 and a subsequent decline of 53% from 1997 to 2000, after which the time series remained stable (2000–2005). The number of positive observations progressively dropped after 1997. However, an analysis of the observer dataset from the same fishery showed a significantly lower decline than that of the logbook analysis, with a 9% decline in abundance from the same period of 1992-2005. It should be noted that although the authors attempted to include all areas in the analysis, in some cases, the dataset was restricted to certain areas due to insufficient or unbalanced observations by year in the remaining areas. Thus, only areas 1, 2, 3, 4, and 8 were included for oceanic whitetip sharks (refer back to Figure 25 above).

In 2010, Baum and Blanchard (2010) also analyzed observer data from 1992-2005 and reported a 50% decline (95% CI: 17–70%). However, the authors explained that although model estimates suggest significant declines in oceanic whitetip sharks between 1992 and 2005, there was a high degree of interannual variability in the individual year estimates (i.e., covariates that significantly influence catch rates of these species were not included in the models). Therefore, the catch rates were not fully standardized, limiting what can reasonably be inferred regarding the relative abundance of the species (Baum and Blanchard 2010). Finally, the Extinction Risk Analysis team conducted an updated analysis (1992-2015) using the same observer data analyzed by Cortés *et al.*, (2007) and Baum and Blanchard (2010). Similar to previous analyses, there was high variability in the initial years of the time series but overall the trend in abundance was relatively flat with about a 4% decline over the times series (Figure 26 below).

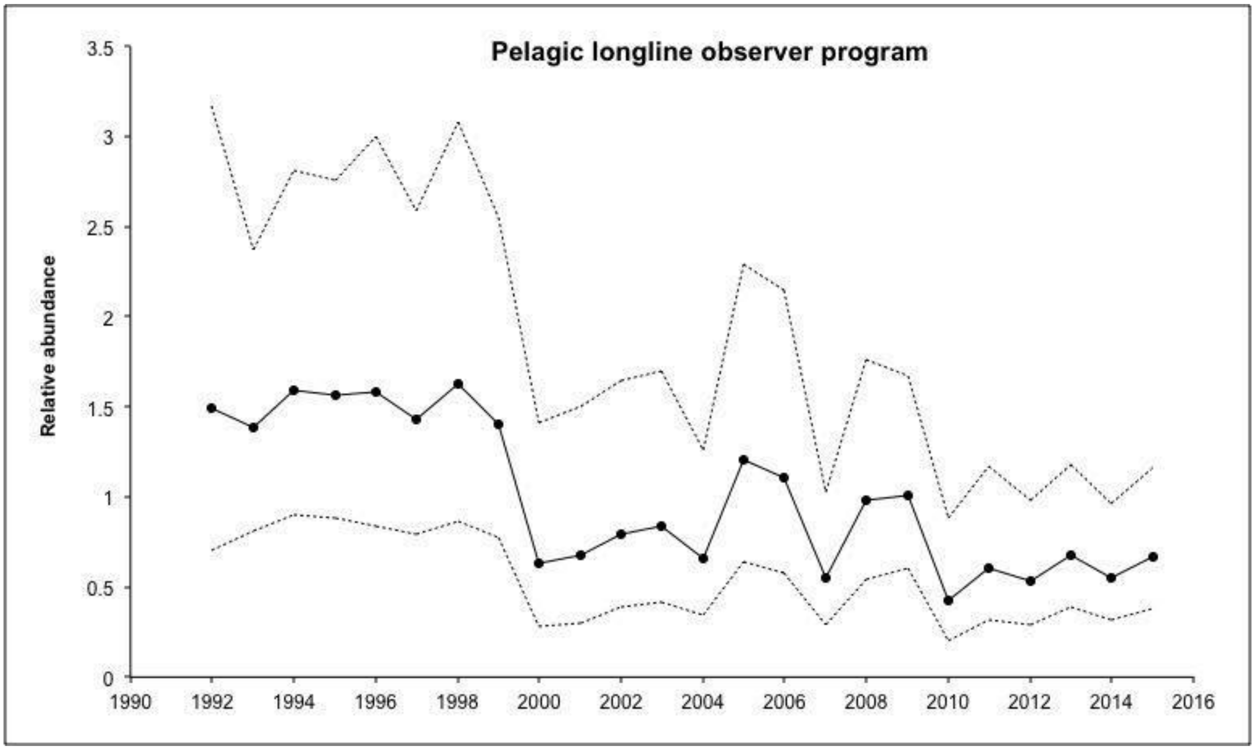

Figure 26 Estimated change in relative abundance (standardized catch per 1000 hooks) between 1992 and 2015 based on the Northwest Atlantic Pelagic Longline observer data for oceanic whitetip sharks. Relative abundance is expressed as the year's estimated mean index divided by the maximum estimated yearly mean index in each time series. Dotted lines represent upper and lower 95% confidence limits. Source: NMFS Observer Database).

Although observer data are generally regarded as more reliable than logbook data for non-target shark species (Walsh *et al.*, 2002), it should be noted that the sample size of oceanic whitetip in the observer data was substantially smaller than for other species, and thus the trends estimated should be regarded with caution. Although misreporting and species misidentification are likely to be much more prevalent in logbooks, and can obscure accurate abundance trends, species misidentification is not considered an issue for oceanic whitetip. It should also be noted that fishing pressure on the oceanic whitetip shark began decades prior to the time series covered in these studies, thus the percentage declines discussed here do not represent percentage declines from historical virgin biomass. Given all of the caveats and limitations of the studies discussed above, it appears that the oceanic whitetip shark population in the Northwest Atlantic and Gulf of Mexico suffered significant historical declines; however, relative abundance of oceanic whitetip shark may have stabilized in the Northwest Atlantic since 2000 and in the Gulf of Mexico/Caribbean since the late 1990s (Cortés *et al.*, 2007) coinciding with the first Federal Fishery Management Plan for Sharks and subsequent regulations that included trip limits and quotas.

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 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 was historically common; however, they were not included in a comprehensive species checklist of cartilaginous fishes in the Mediterranean or overview of elasmobranchs of the Mediterranean Sea (Cavanagh and Gibson 2007; Bradai *et al.*, 2012). 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

There is very little information on the abundance trends of oceanic whitetip shark in the South Atlantic Ocean. Some countries in this region still do not collect shark data while others collect it but fail to report (Frédou *et al.*, 2015). Historically, the oceanic whitetip was considered one of the most abundant species of pelagic shark 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 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 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)). In equatorial waters, 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 within the EEZ of Brazil during the 1990s, and comprised 29% of the total elasmobranch catch (Lessa *et al.*, 1999). García-Cortés and Mejuto (2002) found that the oceanic whitetip 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 (see Figure 27 below).

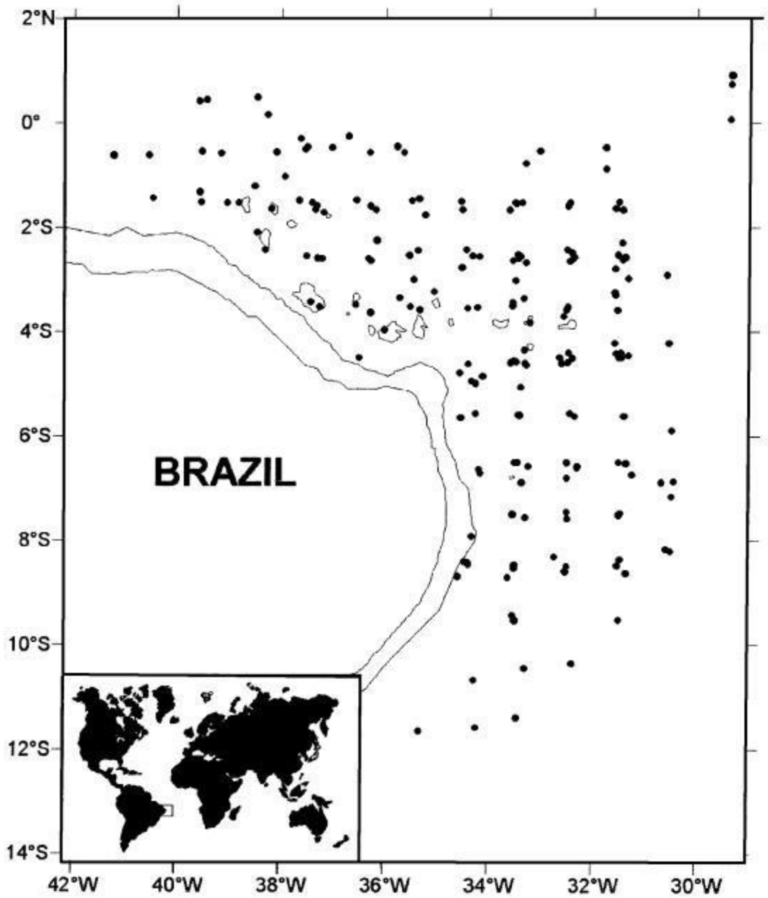

Figure 27 Location of the sampling area (small map) and station position (n = 197) performed for oceanic whitetip shark collected off northeastern Brazil (Source: Lessa *et al.* 1999).

From 1992-2002, oceanic whitetip CPUE in this area averaged 2.18 individuals/1000 hooks (Domingo *et al.*, 2007). More recently, however, average CPUE in this same area has seemingly declined to 0.1-0.3 individuals/1000 hooks (Figure 28 below). Additionally, none of the other areas within the region exhibit CPUE rates anywhere near the rates seen in the 1990s.

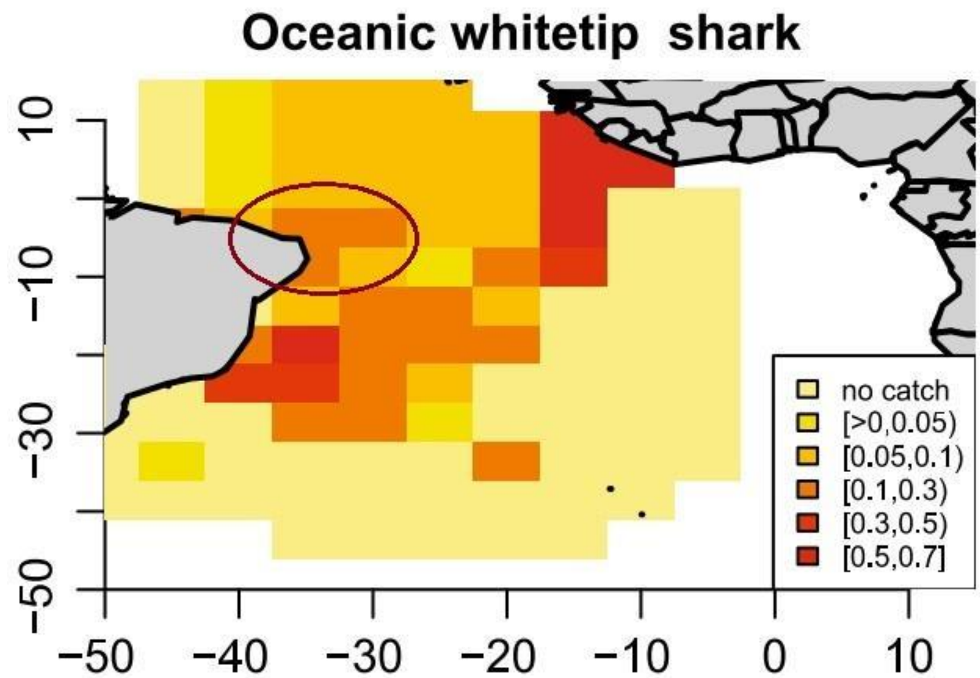

Figure 28 Longline catch per unit effort (CPUE individuals per 1,000 hooks) of the Brazilian chartered tuna longline fleet for the oceanic whitetip shark from 2004-2010 (Source: Frédou *et al.,* (2015).

Additionally, in earlier years the proportion of the oceanic whitetip shark in relation to the total catches of elasmobranches was very low at 2.7%; it showed a peak of 8.2% in 2008, and ranged from 0.8% to 3.4% in the remaining years. These values from 2004-2010 are much lower than the nearly 30% observed by Lessa *et al*. (1999) described previously. However, the results are not directly comparable due to the operational differences in the fishing gear and methods used by the experimental and the commercial operations. For example, the experimental vessels operated in much shallower layers of the water column, where encounters of oceanic whitetip shark is known to be much more frequent (Tolotti *et al.*, 2013).

More recently, 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. For example, although the Japanese fishing strategy (which typically catches fewer oceanic whitetip sharks due to deeper hook depth) accounted for the majority of hooks deployed in 2004 and 2005, the Spanish strategy (which has shown to catch more oceanic whitetip sharks due to the deployment of hooks at shallower depths) was consistently dominant from 2006 onwards. Further, in the last three years of the time series (i.e., 2008, 2009, and 2010) the Brazilian fleet consisted entirely of vessels fishing with the Spanish strategy, which may have influenced the gradual increase in CPUE over the time series. 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.

In northeastern Brazil, Santana *et al.*, (2004) conducted a demographic analysis for oceanic whitetip shark. In this analysis, the authors noted that natural mortality of oceanic whitetip shark is high, corresponding to a survival rate between birth and the first year of life of only 58.7%. From these rates, the authors analyzed various scenarios in order to observe the population's behavior based on different mortality rates. Thus, by using actual mortality rates, the authors concluded that the oceanic whitetip population of Northeast Brazil has declined approximately 7.2% per year, resulting in a rate of decline of about 50% of abundance over the course of a decade due to unsustainable fishing pressure. The authors noted that this rate of decline is within the standards known of exploited populations of oceanic whitetip shark in other parts of its range (Santana *et al*. 2004). More recently, the Government of Brazil, in its justification for listing the oceanic whitetip as Vulnerable on its List of Species of Brazilian Fauna Threatened with Extinction (MMA Ordinances No. 444/2014 and No. 445/2014) estimated that the oceanic whitetip population has potentially declined by up to 79% (ICMBio 2014)[3]. However, given the lack of historical fisheries data or a stock assessment, these estimates are uncertain.

Farther south in Uruguay, abundance of oceanic whitetip shark is seemingly low and patchy. In 6 years of observer data from the Uruguayan longline fleet (1998-2003), in which approximately 660,000 hooks were 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. It should be noted that 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 from 2003 to 2006, with the highest CPUE recorded not exceeding 0.491 individuals/1,000 hooks. In total, only 63 oceanic whitetips 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, this data does 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).

<u>Indian Ocean</u>

The status and abundance of shark species in the Indian Ocean is poorly known despite a long history of research and more than 60 years of commercial exploitation by large-scale tuna fisheries (Romanov *et al.*, 2010). De Young (2006) characterized the status of shark populations off the coasts of Egypt, India, Iran, Oman, Saudi Arabia, Sudan, United Arab Emirates, and Yemen as currently unknown. Further, the status of shark populations off the coasts of the Maldives, Kenya, Mauritius, Seychelles, South Africa, and United Republic of Tanzania is presumed to be fully over-exploited. Despite evidence for high bycatch levels of pelagic sharks

---

[3] http://www.icmbio.gov.br/portal/faunabrasileira/lista-de-especies/6526-especie-6526

in the Indian Ocean (Romanov 2002; Huang and Liu 2010), a lack of reliable data prohibits an assessment of historical changes in shark catch rate trends (Smale 2008). For oceanic whitetip sharks in particular, there is no quantitative stock assessment and only limited basic fishery indicators are available, making it difficult to determine abundance trends within this ocean basin. Therefore, the Indian Ocean Tuna Commission (IOTC) determined that the oceanic whitetip stock status in the Indian Ocean is currently uncertain (IOTC 2015a). However, historical research sampling data shows overall declines in both CPUE and mean weight of oceanic whitetip sharks (Romanov *et al.*, 2008); see Figure 29 below), and anecdotal reports suggest that oceanic whitetips have become rare throughout much of the Indian Ocean over the past 20 years (IOTC 2015a).

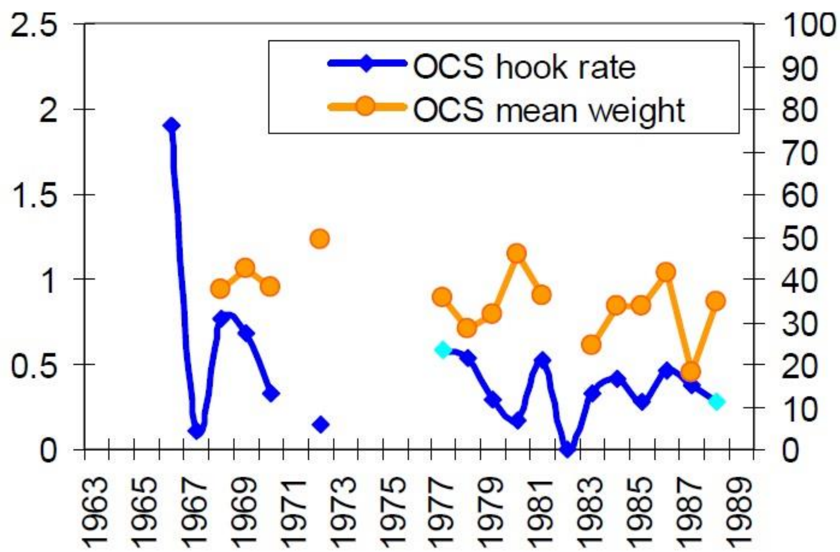

Figure 29 Historical nominal CPUE and mean weight of oceanic whitetip shark from 1963-1989 in the Indian Ocean. Left axis is CPUE; right axis is mean weight (Source: Romanov *et al.* 2008).

Additionally, some studies provide additional information on the decline of oceanic whitetip in the Indian Ocean. Data from an exploratory fishing survey for large pelagic species conducted off the eastern seaboard of the Maldives from 1987–88 indicated that oceanic whitetips represented 29% of the sharks caught by longline and 10% of the sharks caught by gillnet in all fishing zones (Anderson and Waheed 1990). In the center and north fishing zones, oceanic whitetip sharks contributed 19.9% of the total shark longline catch by numbers. During this survey, the average CPUE for all sharks was 48.7 sharks/1,000 hooks. Applying the percentage of oceanic whitetips in the catch to the total shark CPUE translates to an oceanic whitetip catch rate of approximately 1.41 individuals/100 hooks during the time period (FAO 2012). In comparison, Anderson *et al.*, (2011) conducted 4 missions to the island of Kulhudhuffushi (in the northern Haa Dhaalu atoll) from 2000-2004 to study the local shark fishery. The shark longline fishery in this region was conducted by small traditional dhonis that used an average of 141 hooks. Up until 2010, this was the most important shark fishing island in the country until the fishery closed because of a national ban on shark fishing. Anderson *et al*. (2011) estimated that the average CPUE of oceanic whitetip was 0.20 individuals per dhoni (or approximately 0.14 sharks/100 hooks), and estimated the species contributed only 3.5% of the shark landings. This is a stark contrast to the numbers reported from 1987-88, and represents a 90% decline in abundance between 1987–88 and 2000–04. This level of decline would be consistent with the decrease in the proportion of oceanic whitetip in the catch (from 29% of longline shark catch in 1987-88 to just 3.5% of landings in 2000-04) and also with anecdotal information reporting a marked decrease in sightings of oceanic whitetip sharks off northern and central Maldives (Anderson *et al.,* 2011; FAO 2012). For example, the aforementioned offshore survey conducted in 1987-88 noted that oceanic whitetips frequently approached the vessel (Anderson and Waheed, 1990), while more recent offshore surveys by divers around fish aggregating devices (FADs) reported no sightings of oceanic whitetips off the north or center of the Maldives (Anderson *et al.,* 2011). Ultimately, Anderson *et al*. (2011) determined that the shark stocks that supported the shark fishery were sequentially overfished, with the decline in oceanic shark catches the result of high (and likely unsustainable) levels of fishing by overseas fisheries. The IOTC Working Party on Ecosystems and Bycatch (WPEB) noted the following on the aforementioned studies:

> "Data collected on shark abundance represents a consistent time series for the periods 1987–1988 and 2000–2004, collected with similar longline gear, and that the data was showing a declining trend in oceanic whitetip shark abundance, which is a potential indicator of overall stock depletion."

The WPEB further noted that it could be related to localized effects, although this was deemed unlikely as oceanic whitetip sharks are wide-ranging and abundance trends from long-term research conducted by the former Soviet Union between the 1960s and 1980s indicate a similar decline of oceanic whitetip sharks, and that "sightings of this species in Maldives and Réunion islands is now quite uncommon" (IOTC 2011a).

Other studies on the abundance trends of oceanic whitetip shark, including analyses of standardized CPUE indices from Japanese and Spanish longline fisheries indicate potential population declines ranging from 25-40%, although trends are conflicting. Standardized CPUE for oceanic whitetip shark has been estimated for the Japanese longline fleet operating in the Indian Ocean (Semba and Yokawa 2011; Yokawa and Semba 2012). In the first study, CPUE reached its peak in 2003 and then showed a gradual decline thereafter. (Figure 30 below; Semba and Yokawa (2011)). Prior to 2003, the authors attribute large fluctuations in oceanic whitetip CPUE to changes in reporting requirements as opposed to the actual population trend, as the initial years of the time series reflect the introduction phase of a new records system. The data showed low values in 2000 and 2001 (attributed to extremely low catches), and a gradual decreasing trend from 2003 to 2009. The authors interpreted the 40% decline in CPUE as an indication of a decrease in population abundance (FAO 2012; Semba and Yokawa 2011). In an update of the 2011 study, Yokawa and Semba (2012) used a modified data filtering method, and produced a rather similar and somewhat flattened trend when compared to the results of the 2011 study.

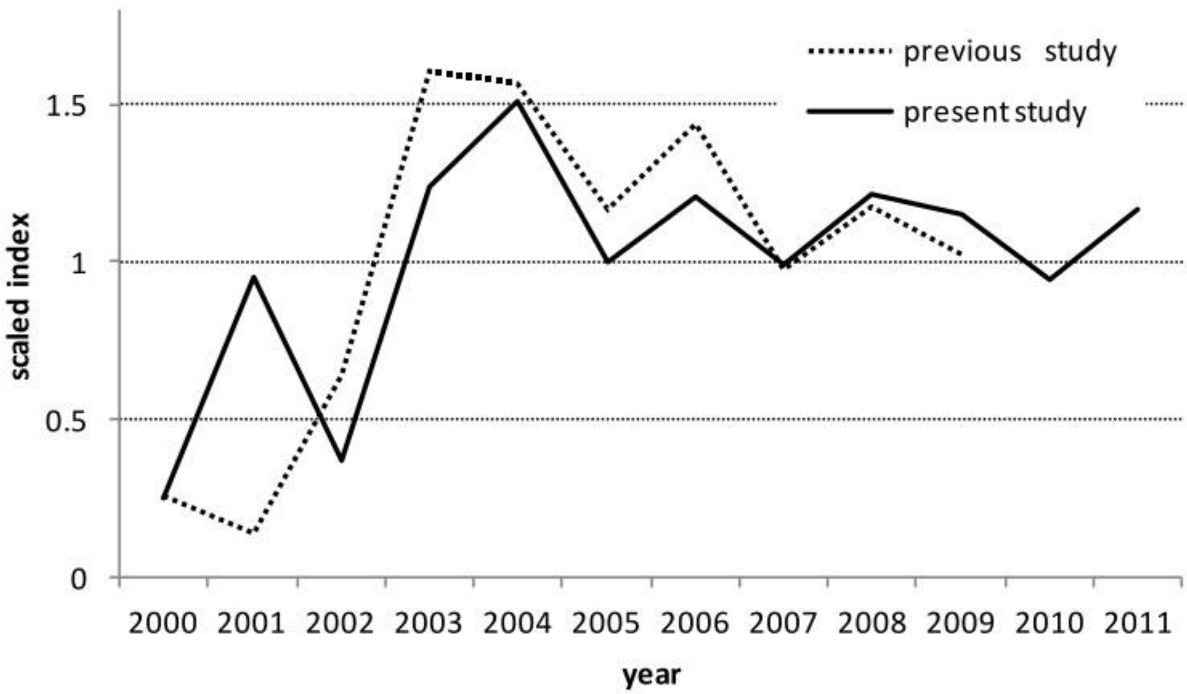

Figure 30 Trends of standardized CPUE of oceanic whitetip shark in the Japanese longline fleet operating in the Indian Ocean (Source: Yokawa and Semba 2012).

Ramos-Cartelle *et al*. (2012) used a General Linear Mixed Model to determine standardized CPUE rates of oceanic whitetip shark in the Spanish longline fishery from 1998-2011 based on 2,806 set records. Results showed large historical fluctuations and a general decreasing trend from 1998-2007, followed by an increase thereafter (Figure 31 below). Overall, the magnitude of decline in this study was estimated to be about 25-30% (Ramos-Cartelle *et al.*, 2012). However, the authors noted that this index may not be a reliable indicator of the species' stock abundance as a whole due to high variability of the standardized catch rates between consecutive years and scarce numbers of specimens in some years (Ramos-Cartelle *et al.*, 2012). However, the data does reaffirm the oceanic whitetip's relatively low prevalence in the surface longline commercial fishery targeting swordfish in waters with lower temperatures than those generally preferred by the species (García-Cortés *et al.*, 2012; Ramos-Cartelle *et al.*, 2012).

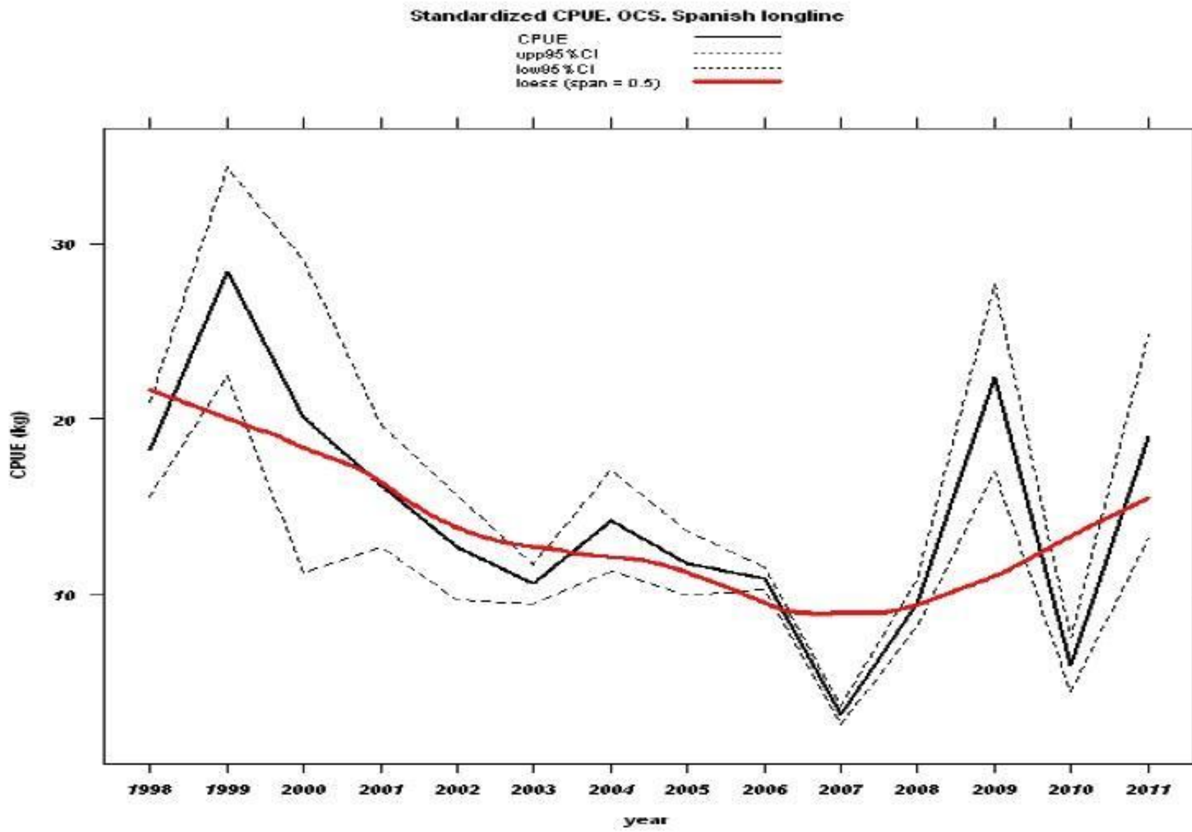

Figure 31 Estimated standardized catch rates of the Spanish longline fleet (kg dressed weight), corresponding 95% confidence limits (bootstrap percentile method) and loess fit (red line) of the oceanic whitetip shark in the Indian Ocean during the 1998-2011 period (Source: Ramos-Cartelle *et al.* 2012).

Finally, Tolotti *et al.*, (2015b) analyzed data from 3,339 purse seine sets conducted by the French tuna fleet in the Indian Ocean. The time series includes data from the mid-1990s (1995 and 1996) and from 2005-2014. Sets covered a large area of the Indian Ocean, from approximately 5°N to 20°S latitude and 70°E to 40°E longitude. Additional historical data from the Soviet Union (USSR) were also incorporated into the analyses in order to examine possible changes in population trends. Interactions between oceanic whitetip sharks and the tropical purse seine fisheries were analyzed in terms of occurrence per set, but did not account for the number of individuals caught per set. Results showed a marked change in the proportion of FAD sets with oceanic whitetips present, fluctuating around 20% in the mid-1980s and 1990s, and then dropping to less than 10% from 2005 onwards (Tolotti *et al*., 2015b; See Figure 32 below).

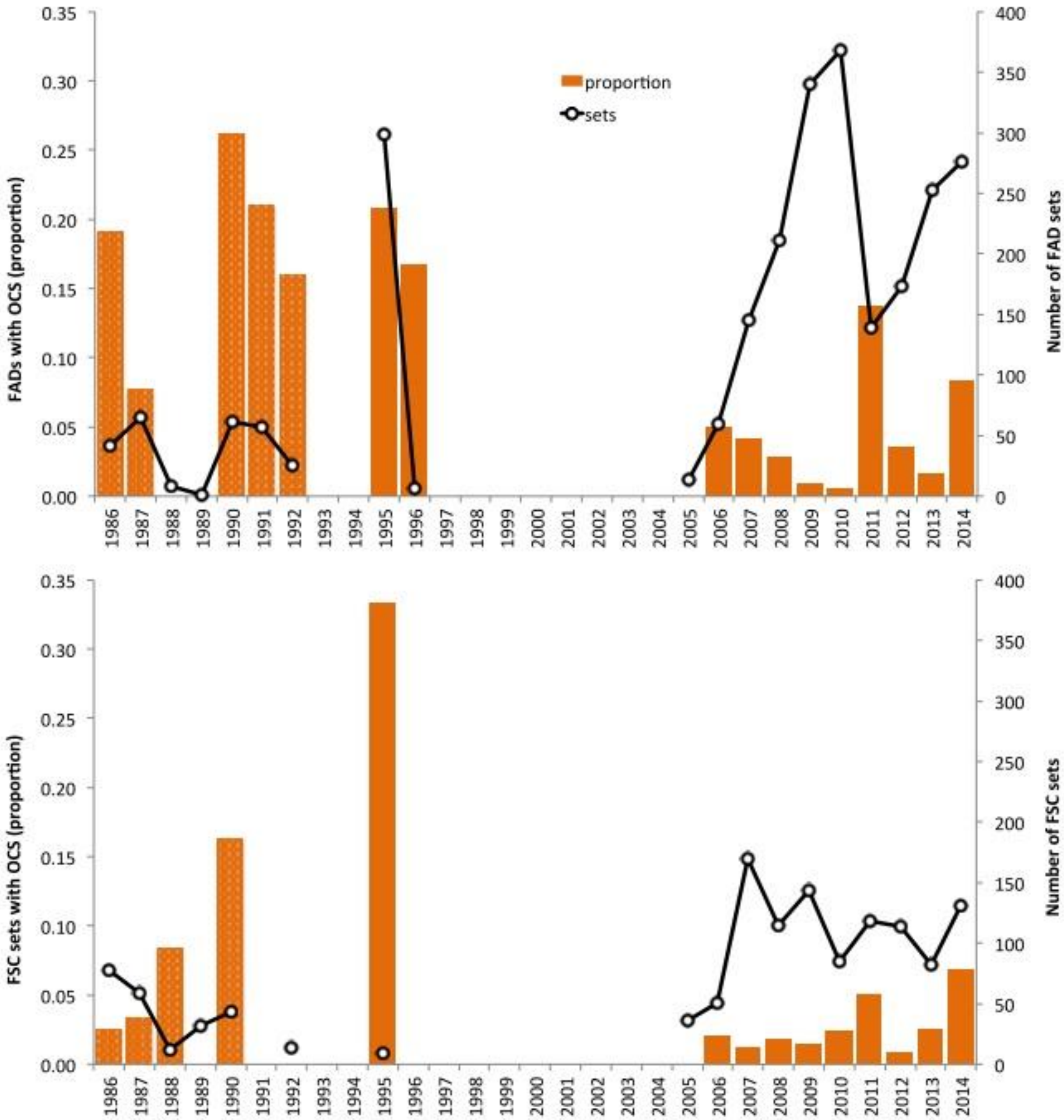

Figure 32 Proportion between sets with the presence of oceanic whitetip sharks (bars) and the total number of sets (points). Top panel shows the proportion on FAD sets and bottom panel on FSC. The shaded bars represent the historic database from USSR. Source: Tolotti *et al.* 2015b.

Considering that the number of FADs has greatly increased since the 1990s (Dagorn *et al.*, 2013; Maufroy *et al.*, 2015; Tolotti *et al.*, 2015b), the authors concluded that the percent change in the proportion of FADs with oceanic whitetip sharks by more than 50% could indicate a population decline (Tolotti *et al.*, 2015b). Alternatively, the authors considered that the decline of oceanic whitetip shark occurrence per FAD could be the result of a sharp increase on FAD densities combined with a small and stable population size. Although it is unclear which scenario is more plausible based on the available data, given the declines indicated in other studies throughout the

Indian Ocean, it seems more likely that the marked decline observed in Tolotti *et al.*, (2015b) is indicative of a declining abundance trend rather than a small, stable population. Overall, while it is likely that the oceanic whitetip shark has experienced some level of decline in the Indian Ocean, there is considerable uncertainty regarding current population abundance and the exact magnitude of decline in this region.

Regional Population Trends Summary

Overall, evidence (both quantitative and qualitative) suggests that while the oceanic whitetip shark was 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 magnitudes throughout its global range. Where more robust information is available, declines in oceanic whitetip shark abundance range from 86 to greater than 90% in some areas of the Pacific Ocean (with declines observed across the entire basin), and between 57-88% in the Atlantic and Gulf of Mexico. Although information from the Indian Ocean is highly uncertain and much less reliable, the best available information points to varying magnitudes of decline, with the species becoming rare across the basin over the last 20 years. The only population that currently shows a stable trend, based on standardized CPUE observer data, is the Northwest Atlantic. The trend of oceanic whitetip catches in the Hawaii-based pelagic longline fishery may have also potentially stabilized at a post-decline depressed state in recent years. In addition to CPUE trends, which can often be misleading and unreliable due to uncertainties in standardization, stock structure and other factors, other abundance indices such as trends in occurrence and composition of the species in catch data, as well as biological indicators (e.g., mean length or weight, etc.) also indicate significant and continuing declines of oceanic whitetip in a large portion of its range.

4. ESA SECTION 4(a)(1) FACTORS

The ESA requires NMFS to determine whether a species is endangered or threatened due to any one of the five factors specified in section 4(a)(1) of the ESA. The following provides information on each of these five factors as they relate to the current status of the oceanic whitetip shark.

4.1 (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.

Habitat in United States

In the U.S. EEZ, the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires NMFS to identify and describe Essential Fish Habitat (EFH), minimize the adverse effects of fishing on EFH, and identify actions to encourage the conservation and enhancement of EFH. The MSA defines EFH as as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity” (16 U.S.C. 1802(10)) and requires the identification of EFH in Fishery Management Plans (FMPs).

Atlantic

Essential fish habitat has been designated for the oceanic whitetip in localized areas in the Atlantic and Gulf of Mexico, as well as the U.S. Caribbean. Insufficient data is available to differentiate EFH between nenonates/juveniles and adults; therefore, the following description of EFH is for all life stages. Currently, designated EFH includes waters greater than 200 m in depth from offshore of the North Carolina/Virginia border to the Blake Plateau. Designated EFH in the Gulf of Mexico includes offshore habitats of the northern Gulf of Mexico at the Alabama/Florida border 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 to be EFH for the oceanic whitetip (see Figure 33 below; NMFS 2017). However, while we can confirm that the geographical areas occupied by the oceanic whitetip include U.S. waters, there is no information regarding habitat use of oceanic whitetip sharks in any of these areas (J. Carlson, personal communication, 2017), and nurseries and pupping grounds have not been identified (NMFS 2017; CITES 2013).

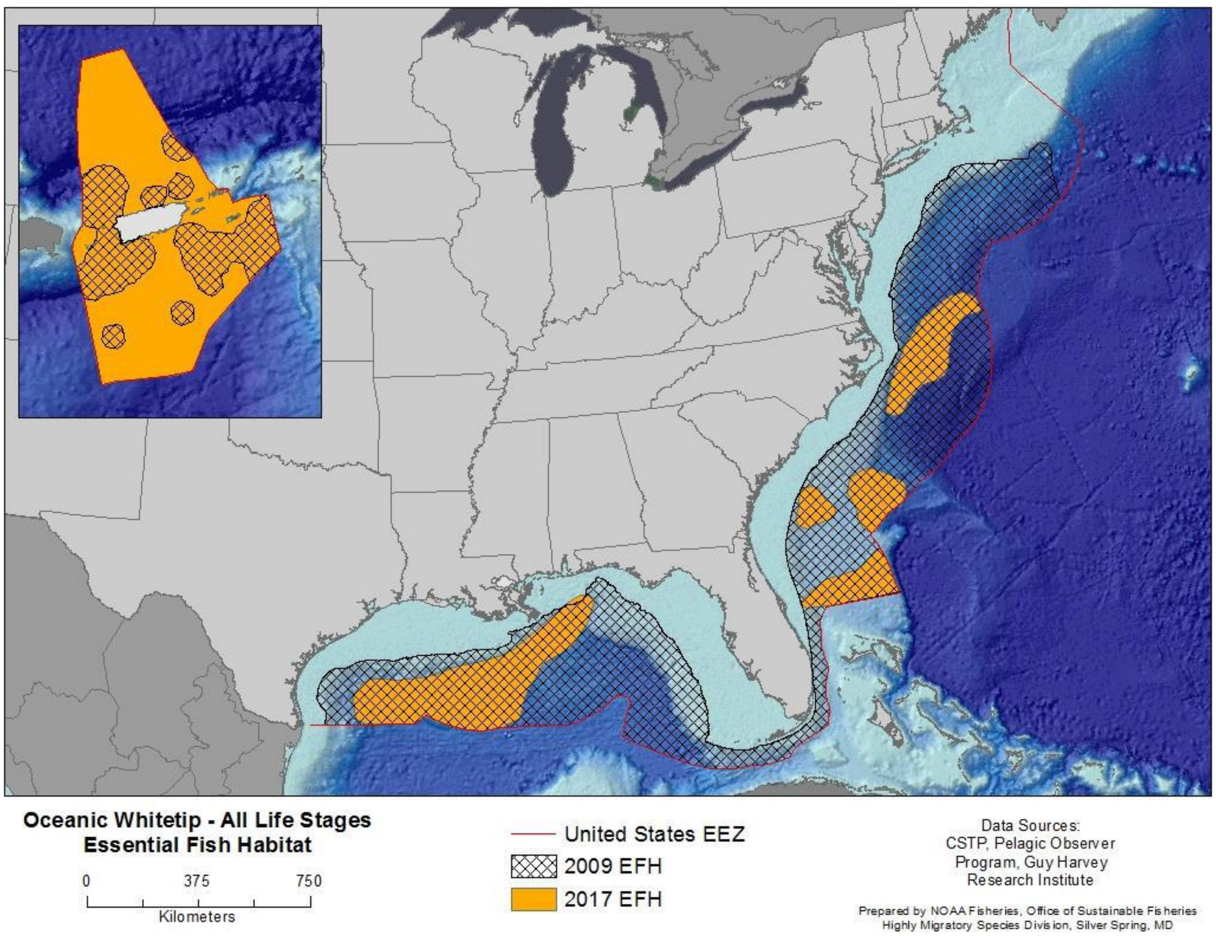

Figure 33 EFH for oceanic whitetip shark in the Northwest Atlantic (Source: NMFS (2009a).

Pacific

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 (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). Since EFH is defined for the oceanic whitetip as the water column or attributes to the water column, cumulative impacts from HMS and non-HMS fishing gears 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 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 not available.

Climate Change

Studies on the impacts of climate change specific to the oceanic whitetip have not been conducted. 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 impact these species. As a proxy, below is a description of available climate change studies on other pelagic shark species that occur in the range of oceanic whitetip sharks. However, without any species-specific studies, climate change impacts to oceanic whitetip sharks are highly uncertain.

In a study to assess the vulnerability of sharks and rays on Australia's Great Barrier Reef (GBR) to climate change, Chin *et al.*, (2010) conducted an Integrated Risk Assessment for Climate Change. The assessment examined individual species but also lumped species together in ecological groups (such as freshwater and estuarine, coastal and inshore, reef, shelf, etc.) to determine which groups may be most vulnerable to climate change. Pelagic shark species (e.g., oceanic whitetip and blue sharks) were considered in the "pelagic" ecological group. The assessment took into account the *in situ* changes and effects that are predicted to occur over the next 100 years in the GBR and assessed each species' exposure, sensitivity, and adaptive capacity to a number of climate change factors. The resulting vulnerability rankings for each species were then collated to calculate the relative vulnerability of the ecological groups.

The climate change factors that were considered in the assessment included water and air temperature, ocean acidification, freshwater input, ocean circulation, sea level rise, severe weather, light, and ultraviolet radiation. Results from the assessment showed that freshwater/estuarine sharks and rays are at highest risk from climate change, with high exposure to the climate change factors. The pelagic ecological group showed relatively low risk, with moderate to high exposure to only a couple of the climate change factors (e.g., oceanographic changes and rising temperatures could affect productivity, migration patterns, and phenology, as well as the physiochemical environment, respectively). Additionally, all of the species within the pelagic group (except the plankton-feeders) had low sensitivity and rigidity (i.e., assessments that considered species' rarity, habitat and trophic specificity, physical-chemical intolerance, immobility, and latitudinal range), which lowered their individual vulnerability to climate change factors.

In another study on potential effects of climate change to sharks, Hazen *et al.*, (2012) used data derived from an electronic tagging project (Tagging of Pacific Predators Project) and output from 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 34).

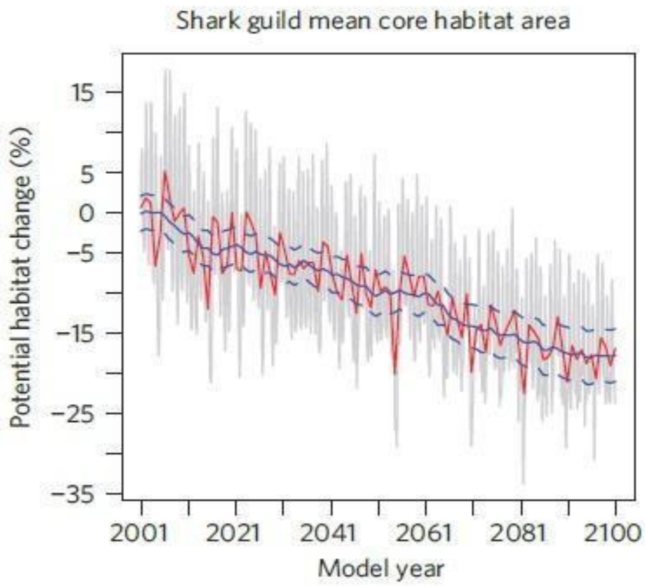

Figure 34 Core habitat area for sharks from the year 2000 to 2100 shown as monthly (grey), yearly (red) and 5-year filtered (blue) time series with 1 standard deviation marked by dashed lines (Source: Hazen *et al.* 2012).

Overall, the model predictions in Hazen *et al.*, (2012) and the vulnerability assessment in Chin *et al.*, (2010) represent only two very broad analyses of how climate change may affect pelagic sharks, and do not account for factors such as species interactions, food web dynamics, and fine-scale habitat use patterns that need to be considered to more comprehensively assess the effects of climate change on the pelagic ecosystem. Further, results of these studies 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, but given their broad distribution in various habitat types, these species can move to areas that suit their biological and ecological needs. Therefore, while effects from climate change have the potential to pose a threat to sharks in general, including habitat changes such as changes in currents and ocean circulation and potential impacts to prey species, species-specific impacts to oceanic whitetip sharks and their habitat are currently unknown, but likely minimal.

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 demand of the international shark fin trade, bycatch-related mortality, and illegal, unreported, and unregulated (IUU) fishing. The oceanic whitetip shark is not generally targeted, but the species is regularly caught and taken as bycatch in numerous fisheries around the world. This species is commonly caught with pelagic longlines, purse seines, handlines, troll and occasionally pelagic and even bottom trawls (Compagno 1984). Although thought to be of low commercial value, oceanic whitetip shark meat is utilized fresh, smoked, and dried and salted for human consumption (Compagno 1984). Additionally, oceanic whitetip meat from longline bycatch has been marketed 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 fins are highly prized in the international shark fin market and sell for USD $45 to USD $85 per kg (CITES 2013).

In addition to mortality caused by retention and finning in commercial fisheries, oceanic whitetip sharks likely experience some level of fishing mortality upon being discarded or released. While several studies throughout the oceanic whitetip shark's range indicate relatively high at-vessel survivorship rates in longline fisheries relative to other pelagic sharks (up to 88% in longline fisheries using circle hooks; Beerkircher *et al.,* (2002); Bromhead *et al.,* (2012); Fernandez-Carvalho *et al.,* (2015)), these numbers can vary among fleets and do not account for potential post-release mortality. These data suggest that oceanic whitetips could benefit from live release as mandated in the shark resolutions passed by most RFMOs (Camhi *et al.*, 2009) if they are fully implemented and enforced; however, this may not always be the case. See *Inadequacy of Existing Regulatory Mechanisms* section for more details. For the purposes of this status review, population dynamic characteristics, such as current population size, abundance trends by regions, and the effects of fisheries and the shark fin trade on the species were considered when evaluating whether the oceanic whitetip shark is currently experiencing overutilization throughout its global range. Much of the data come from localized study sites and over short time periods and thus is difficult to extrapolate to the global population. 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.

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 in the Eastern Pacific is noted as extending as far north as southern California waters, 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. 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[4]).

Oceanic whitetip sharks are commonly caught as bycatch in the tropical tuna purse seine fishery. From 1993-2009, oceanic whitetip 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 Eastern Pacific. However, much of this data is aggregated under the category of "sharks," especially data collected prior to 2005. 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, upon which 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 (See Figure 35 below).

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

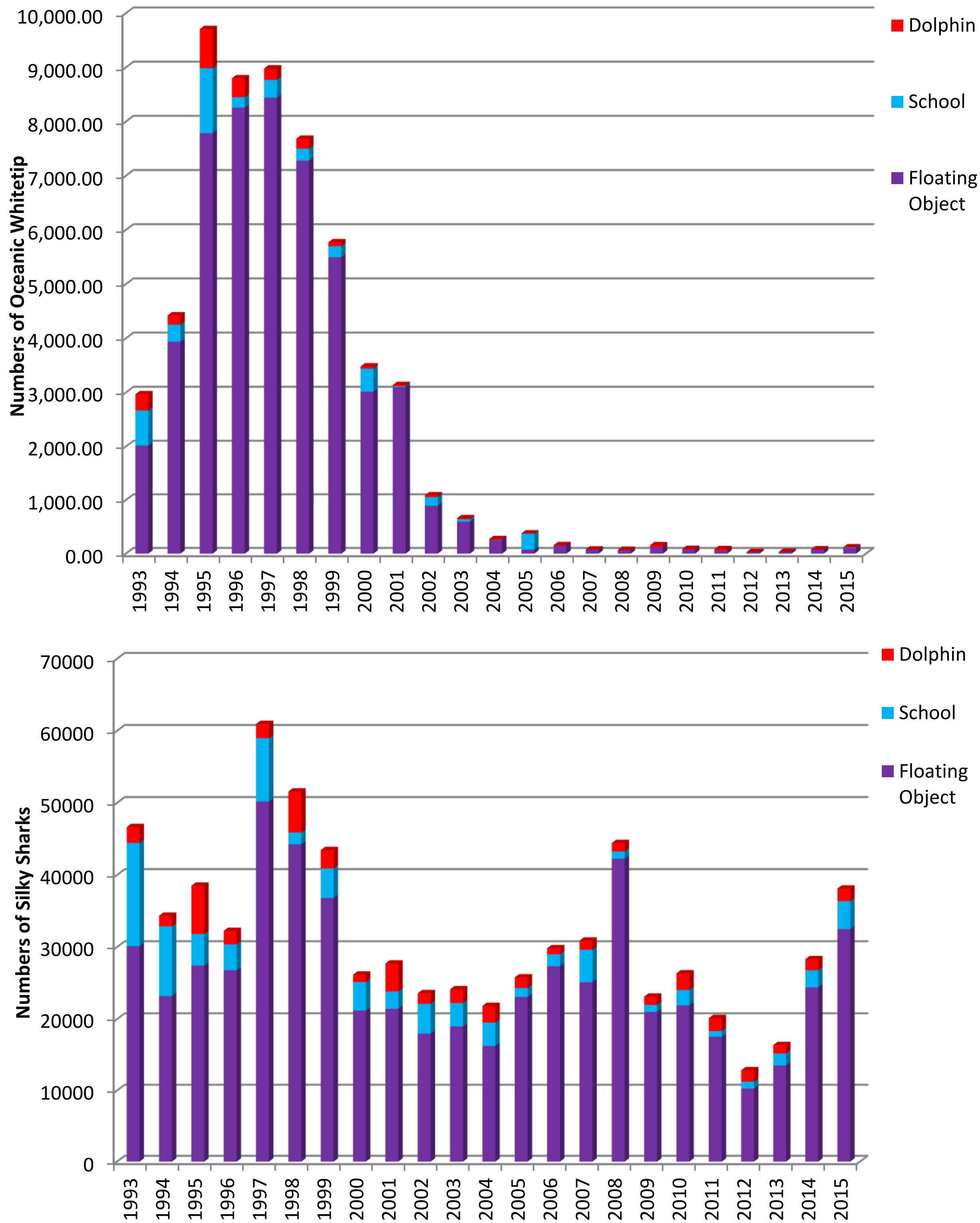

Figure 35 Annual estimated numbers of oceanic whitetip and silky sharks caught as bycatch in the tropical tuna purse seine fishery of the Eastern Pacific Ocean. *Note the differences in scales for the species. Source: IATTC Observer Database.

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 catches of oceanic whitetip shark peaked in 1995, with approximately 9,709 individuals caught in all sets. Within 10 years, catches dropped dramatically to only 379 oceanic whitetip sharks caught, with catches continuing to decline thereafter, with only 120 individuals caught in 2015. This is in drastic contrast to catches of the closely related silky shark, which has remained relatively constant over the same time period. 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 whitetips captured in 1993, have been virtually eliminated from the population, indicating the possibility of recruitment failure in the population (see Figure 36 below).

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 36 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 time 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 record observed (Hall and Román 2016). The total number of sets has also continued increasing, with 2015 being the highest record observed.

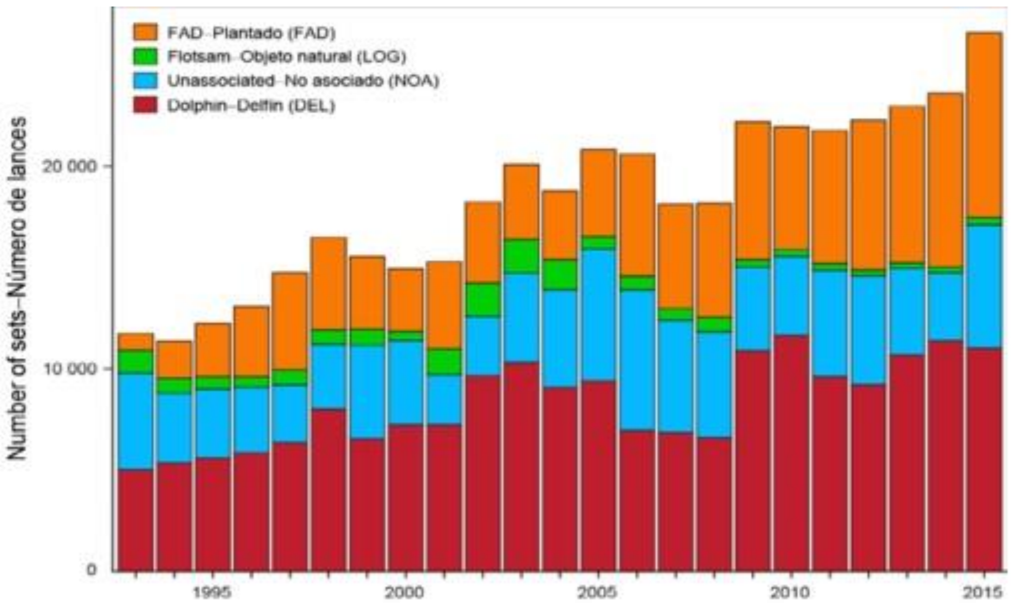

Figure 37 Number of sets, by type, in the Eastern Pacific Ocean. Source: Hall and Roman 2016.

Thus, given that fishing effort in the Eastern Pacific continues to increase, fishing pressure and associated mortality of oceanic whitetip sharks is expected to continue. Though mortality rates of oceanic whitetip in purse seine fisheries are not available, it is likely that oceanic whitetip sharks experience high mortality rates similar to congener *C. falciformis* (silky shark; >85% in Western and Central Pacific and Indian Ocean purse seine fisheries; Poisson *et al.*, (2014); Hutchinson *et al.*, (2015)) during and after interactions with purse seine fisheries. Although management measures are now in place that prohibit retention of oceanic whitetip shark in the Eastern Pacific Ocean (IATTC 2011), this will not likely be sufficient to prevent further population declines due to the 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, given the significant decline in catches and virtual disappearance of oceanic whitetip sharks from purse seine fishing grounds in the Eastern Pacific, it appears that these declines are likely the result of overutilization of the species.

Not only are oceanic whitetip sharks commonly encountered in purse seine fisheries, they are sometimes a significant component of the bycatch in longline fisheries and are likely taken in artisanal fisheries in several countries around the Eastern Pacific Ocean (IATTC 2007). While information regarding catch rates of oceanic whitetip shark in these fisheries is not readily available, some limited information is available from various countries that fish in these waters. For example, 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. The oceanic whitetip shark has 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.

Western and Central Pacific Ocean

The Western and Central Pacific Ocean 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 Western and Central Pacific Ocean are available from the Western and Central Pacific Fisheries Commission (WCPFC[5]). The WCPFC is the RFMO that seeks the conservation and sustainable use of highly migratory fish stocks in the Western and Central Pacific Ocean. 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. Currently, under CMM 2010-07 (which replaced CMM 2009-04 and was revised in 2014), reporting is only required south of 20°S until biological data shows this or another geographic limit to be appropriate[6]. Despite this requirement, recent catches of key shark species have not been provided to the WCPFC for a number of longline fleets, including Indonesia, which is the top shark fishing nation in the world (Dent and Clarke 2015).

Despite the lack of data, shark catches in this region can be estimated from limited observer data and it is clear that the majority of pelagic sharks are captured by longlines (Lawson 2011). Lawson (2011) describes the longline fishery in the Western and Central Pacific as "comprised of vessels that specifically target sharks, engage in 'mixed targeting' (in which vessels use methods that aim to catch shark and tuna species simultaneously), and target tuna and other non-shark species and take sharks solely as bycatch." Even when sharks are caught as bycatch, survival is often low due to the practice of finning or rough handling during gear retrieval. Although total shark catch in this region is highly uncertain due to caveats related to under-reporting and non-reporting of sharks, estimates form 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). Overall, with the exception of 2014, total effort in the longline fleet has increased from1995-2014 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 (i.e., regions 3 and 4 shown in Figure 40 below) (Rice *et al.,* 2015).

[5] http://www.wcpfc.int/wcpfc-data-catalogue-0

[6] http://www.wcpfc.int/doc/data-01/scientific-data-be-provided-commission-revised-wcpfc4-6-7-and-9

Oceanic whitetip sharks commonly interact with the longline fisheries throughout the Pacific, with at least 20 member nations of the WCPFC recording the species in their fisheries. In this region, where sharks represent 25% of the longline fishery catch, a study from 2007 based on observer data showed that the oceanic whitetip shark was the 5th most common species of shark caught as bycatch out of a total 49 species reported by observers, and represents approximately 3% of the total shark catch (Molony 2007). 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). Longline observer coverage data is also lacking for the distant-water fleets of Japan, South Korea, and Chinese Taipei, which comprise a significant proportion of longline effort in the Western and Central Pacific Ocean (SPC 2010). Since 2009, total observer coverage in the longline fishery remains below 2% (Clarke 2013) despite the requirement for a 5% coverage minimum. However, the WCPFC requirement for 5% observer coverage in the longline fishery (established in 2012) has resulted in increased submission of observer longline data in recent years (Williams *et al*. 2015).

The WCPFC also manages the active tuna purse seine fleet in this region, which has expanded significantly since the 1980s and experienced a sharp increase in recent years. Available data suggest oceanic whitetip sharks are frequently encountered by the purse seine fleets (though not as frequently as the longline fishery), with the oceanic whitetip 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).

Catches of oceanic whitetip shark have declined significantly in both longline and purse seine fisheries. Lawson (2011) conducted statistical analyses to estimate catches of key shark species in the Western Central Pacific Ocean. In this study, oceanic whitetip shark catches in Western and Central Pacific Ocean longline and purse seine fisheries were estimated based on SPC data for longline and purse seine fleets collected by observers onboard fishing vessels (Figures 38 and 39 below).

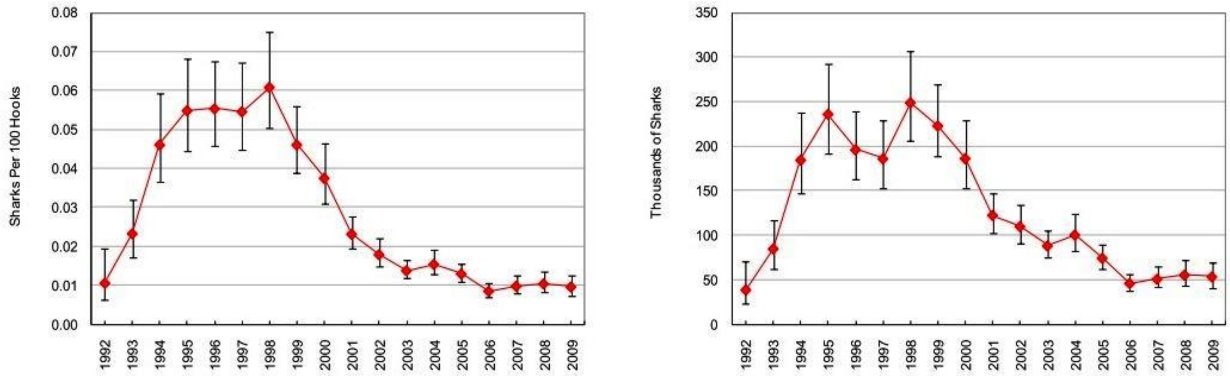

Figure 38 Estimates of longline catch rates (left) and catches (right) of oceanic whitetip sharks in the WCPFC Statistical Area east of 130°E. Source: Lawson 2011.

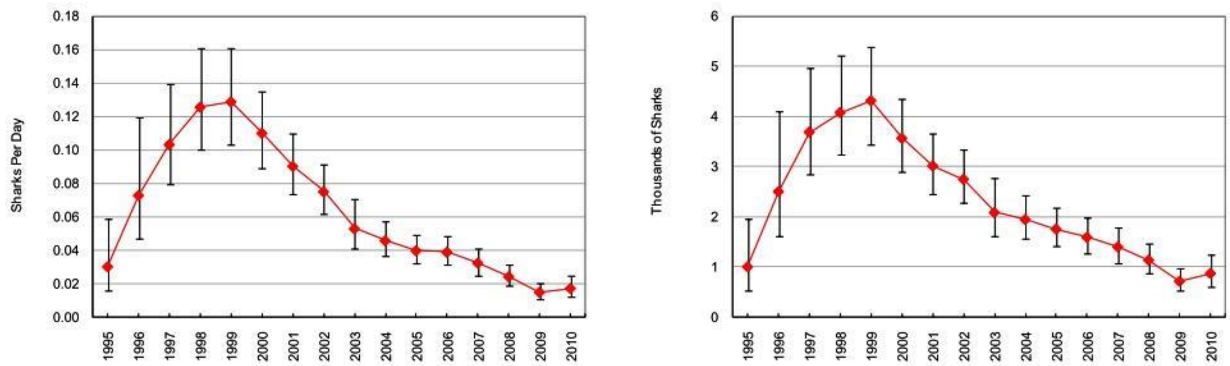

Figure 39 Estimates of purse seine catch rates (left) and catches (right) of oceanic whitetip sharks in the area from 20°S to 20°N and 130°E to 210°W. Source: Lawson 2011.

Oceanic whitetip sharks comprised 6.34% of longline shark catches and the trends in oceanic whitetip catch rates and catches by purse seiners are similar to those for longlines, and show declines from the late 1990s onwards (Lawson 2011). For example, estimated catches of oceanic whitetip shark in the WCPO longline fishery suggest that catches peaked in 1998 at ~249,000 individuals and declined to only ~53,000 individuals in 2009. However, Lawson (2011) notes that the accuracy of the estimates of catch rates shown in Figures 38 and 39 above may be affected by reporting errors early in the time series, and possibly by the targeting of sharks. It should also be noted that catches by the fleets of Indonesia and the Philippines were not included because neither observer nor effort data are available for these fleets. Further, Lawson (2011) notes the following operation changes in longline fishing that likely affected shark catch rates in the region:

- Japan longline fishing in the Australia Fishing Zone ceased in 1997.
- A trip limit for sharks was imposed in Australia in 2000.
- Shark finning was banned in Hawaii in 2000.
- The shallow set longline fishery in Hawaii was closed from 2001 to 2004.
- The use of wire traces generally has declined since 2004.
- Wire traces were banned in Australia in 2005.

Additionally, and as discussed previously, observer coverage in the Western and Central Pacific has been highly variable, ranging from negligible to moderate. Large areas in the WCPFC Statistical Area (including to the west of 130°E, the northwest and the southeast) have not been covered by observer data, which complicates catches and catch rate estimates of sharks and other non-target species. Nonetheless, longline catch estimates of oceanic whitetip sharks in the WCPFC Statistical Area east of 130°E indicate removals have been variable, with estimates fluctuating widely from ~39,000 to ~249,000 individuals, and an overall average of ~127,000 individuals from 1992-2009 (Lawson 2011). Purse seine fishery catch estimates of oceanic whitetip sharks in the WCPFC Statistical Area from 20°S to 20°N and 130°E to 210° averaged 2,267 individuals from 1995-2010 (Lawson 2011). As noted previously (and shown in Figures 38 and 39 above), both fisheries show significant declining trends in catches of oceanic whitetip shark.

Clarke *et al.*, (2011b) conducted a separate analysis of shark data from the North Pacific provided by Japan, including two comprehensive datasets: the North Pacific longline operational data from research training vessel (RTV) surveys (1992-2009; n = 32,053 sets) and commercial longline logbook (LLL) records (1993-2009; n = 1,215,299 sets). In total, 258,824 sharks were recorded in the RTV dataset of which 9,591 individuals (2-4%) were oceanic whitetip sharks (75% were blue sharks). In the LLL dataset, nearly 9.8 million sharks were recorded, with oceanic whitetip sharks comprising less than 1% of the total (Clarke *et al.*, 2011b). As oceanic whitetip sharks are found more frequently in Region 4 than in Regions 1 and 2 (see Figure 40 below), the catch rates for Region 4 are likely the most reliable. Catch rate trends from both filtered and unfiltered RTV datasets show a decline of approximately 75% from 1994-2004 (~0.4 oceanic whitetips sharks per 1,000 hooks in 1994 to ~0.1 sharks per 1,000 hooks in 2004). In contrast, filtered LLL catch rates do not show a clear trend with catch rates near zero in most years and peaks of ~0.1-0.2 oceanic whitetips per 1,000 hooks in some years (Clarke *et al.*, 2011b). Overall, catches of this species were most frequently observed in the central North Pacific south of 20^{o} N latitude, but the authors note that this species also occurs in more northerly locations. Oceanic whitetips were rarely recorded after 2005, which may be indicative of a substantial decline in abundance because of overutilization. Catch rates based on RTV data showed substantial declines both north and south of 20^{o} N latitude (Regions 2 and 4) and there was some evidence for a trend of decreasing size of both males and females in recent years (Clarke *et al.*, 2011b).

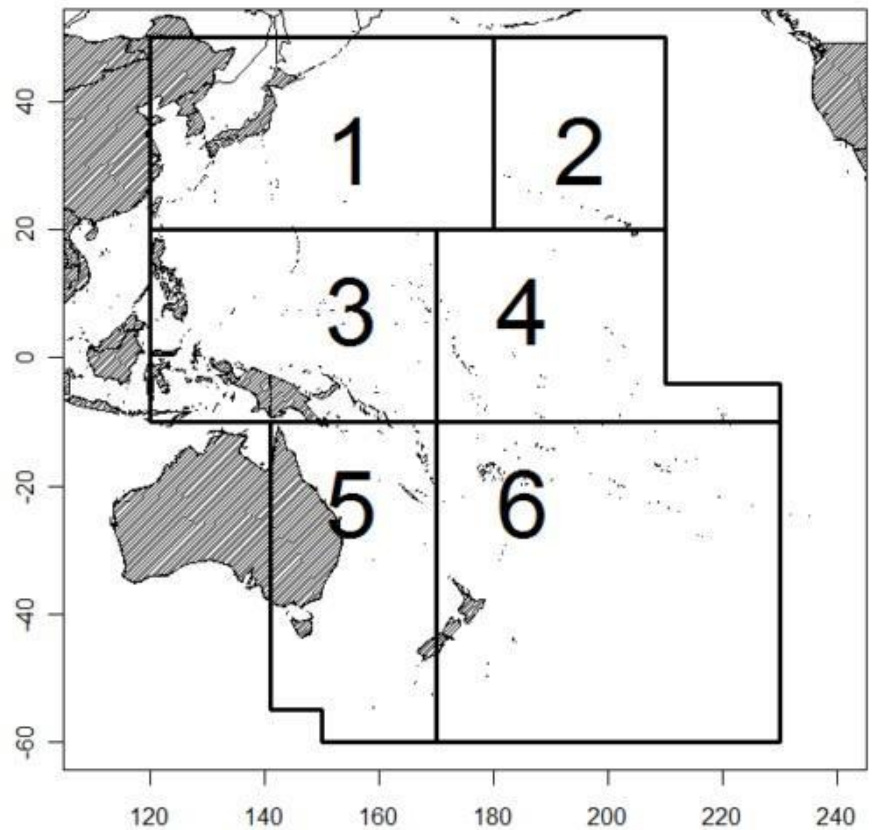

Figure 40 Regional boundaries based on analysis of coverage patterns in the RTV and LLL data sets. Source: Clarke *et al.* 2011b.

Clarke *et al.*, (2011a) conducted an indicator-based analysis to determine the stock status of key shark species in the Western and Central Pacific Ocean by examining data from the SPC–Oceanic Fisheries Programme for sharks taken in longline and purse seine fisheries. However, the authors listed several caveats related to the datasets used in this indicator-based analysis. For example, longline logsheet data only cover ≤35% of the fishery, with major gaps in coverage for certain areas. Non-reporting, under-reporting, and/or lack of species-specific reporting also hinders the data. Further, low levels of observer data coverage (i.e., typically <1%) are not representative of the entire WCPO longline fishery as a whole;

Given the major limitations of logsheet data, the indicator analyses relied primarily on observer data. These data formed the basis for an assessment of a number of shark status indicators in four main classes: range based on fishery interactions, catch composition, catch rates and biological indicators of fishing pressure (e.g., median size, sex ratio). Based on fishery interaction maps (see Figure 41 below; Clarke *et al.*, 2011a), the oceanic whitetip shark is found throughout WCPO between 30^{o} N and S latitude, and, as noted previously, is also commonly encountered in the purse seine fishery, particularly in areas just south of the equator.

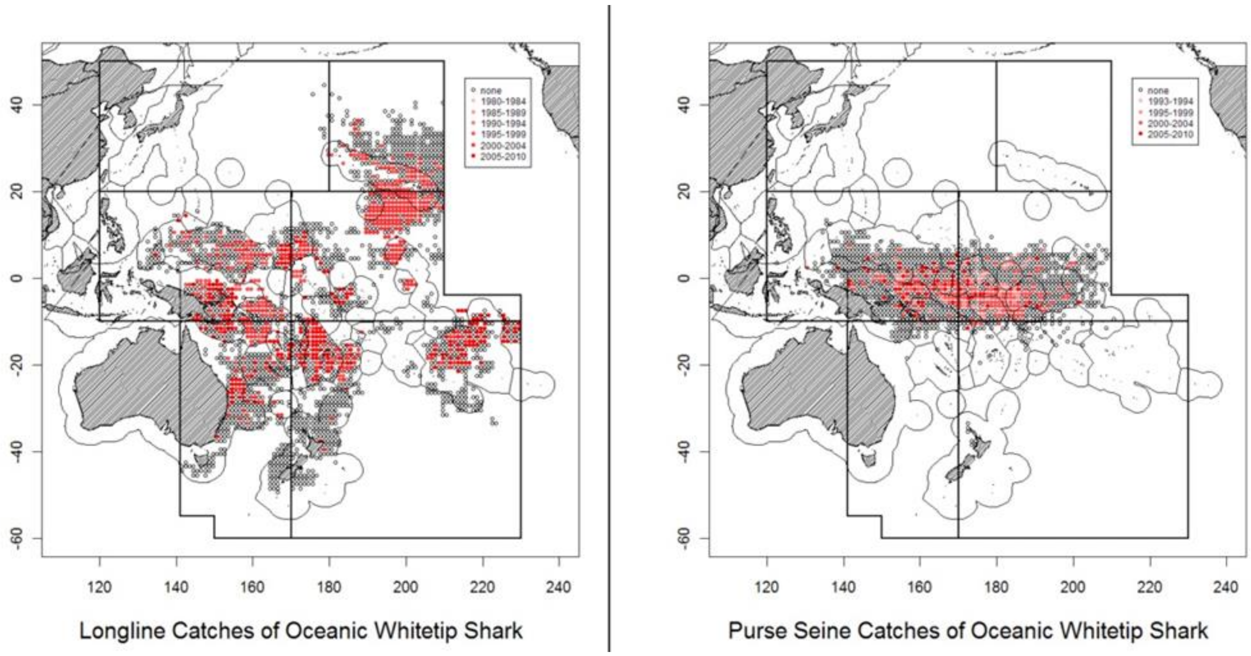

Figure 41 Fishery interaction maps for oceanic whitetip sharks based on observer records from the WCPO longline (1980-2010) and purse seine fisheries (1993-2010). Colored circles represent positive catches (points are shaded by year with more recent catches in the darkest shades) and empty circles represent zero catch. Source: Clarke *et al.* 2011a.

Based on nominal and standardized catch rates for longline and purse seine fisheries, records of oceanic whitetip sharks in both fisheries have become increasingly rare over time. In fact, standardized catch rates for longline observer data shows a clear, steep decline in abundance. Median size showed a declining trend for both sexes in both fisheries and in all regions until samples became too rare for analysis. These trends were significant in the core tropical habitat areas (Clarke *et al*., 2011a; see Figure 42 below).

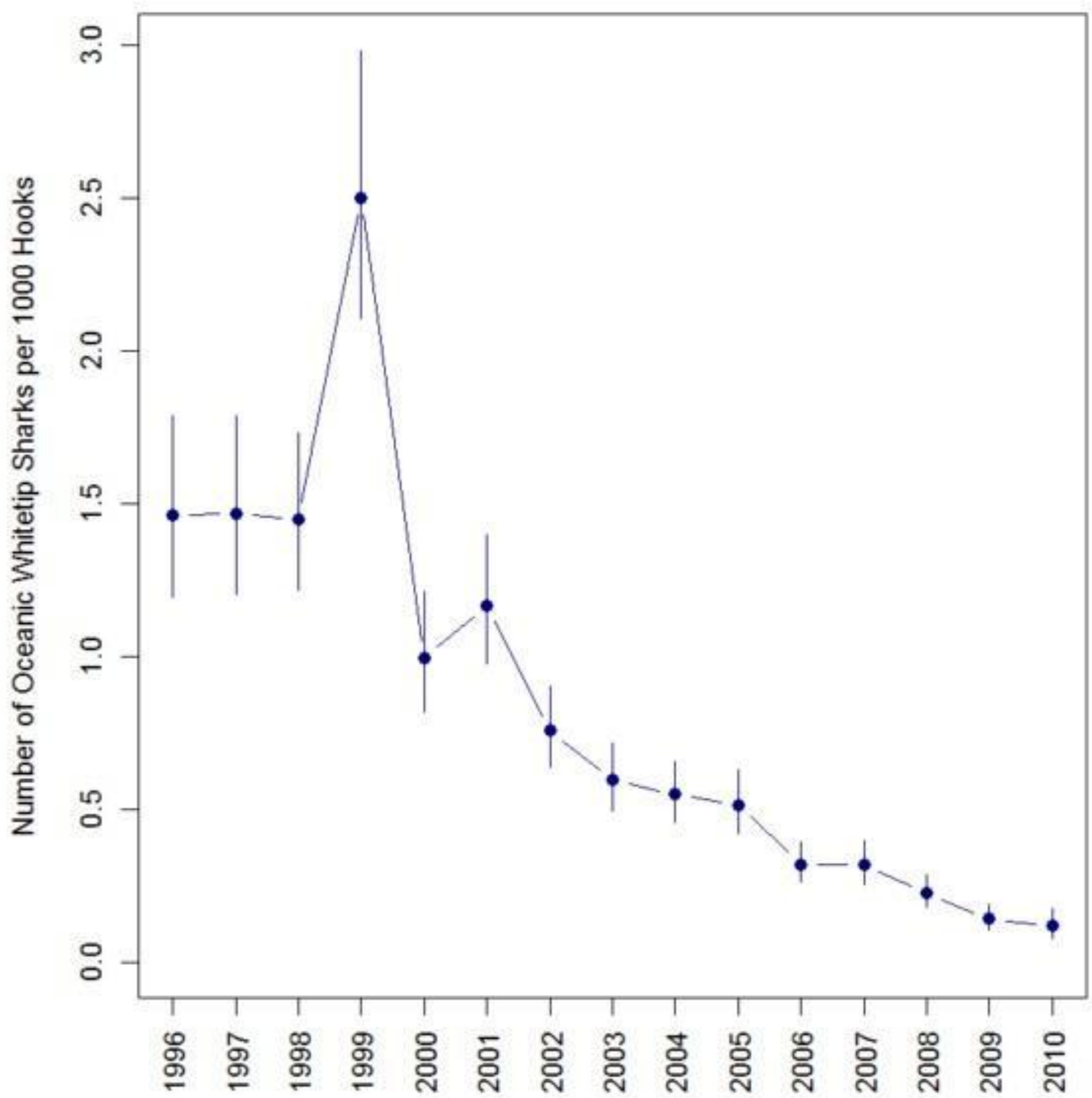

Figure 42 Catch rates for oceanic whitetip sharks in the WCPO standardized using a quasi-Poisson formulation of a generalized linear model. Source: Clarke *et al.,* (2011a).

In fact, annual values in recent years have decreased to one-tenth of those observed in 1996-1998 with minimal uncertainty in the estimates (Clarke *et al.*, 2012). Similar patterns are suggested by nominal catch rates in the purse seine fishery and standardized purse seine catch rates in Lawson (2011); refer back to Figure 39 above).

Finally, the previously discussed stock assessment of oceanic whitetip shark in the Western and Central Pacific (which used the same data as discussed previously in Clarke *et al.*, (2011a) and Clarke *et al*. 2012) analyzed fisheries data from 1995-2009, and determined that the greatest impact on the species is attributed to bycatch from the longline fishery, with less significant impacts from target longline activities and purse-seining (Rice and Harley 2012). From 1995 to 2009, rates of fishing mortality increased consistently, which was driven mainly by increased effort in the longline fleet over the same time period, and remained substantially above the maximum sustainable yield (MSY) (i.e., the point at which there would be an equilibrium) for the species (Rice and Harley 2012). In fact, the stock assessment concluded that fishing mortality on oceanic whitetip sharks in the Western and Central Pacific has increased to levels 6.5 times what is sustainable, thus concluding that overfishing is still occurring. Given that fishing pressure began well before the start of this time series, the authors of the stock assessment noted that it was not assumed that the oceanic whitetip population was at an unfished state of equilibrium at the start of the model (i.e., 1995). Thus, the reported declines (i.e., 86% since 1995) do not reflect total historical population declines for the species in this region. Further, this study does not include removals of oceanic whitetip sharks from Indonesia and the Philippines, which are two major shark catching nations in this region. As previously discussed, a recent study concluded that oceanic whitetip not only continue to decline throughout the tropical waters of the Western and Central Pacific Ocean, but even if the population doubled since the stock assessment, it would still be considered overfished (Rice *et al.,* 2015).

Due to continued and increasing fishing pressure in the Western and Central Pacific, size trends for oceanic whitetip 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 fishery (in Regions 3 and 4), and for the purse seine fishery (in Region 3), which represents 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, since 2000, 100% of oceanic whitetips sampled in the purse seine fisheries have been 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) fishery and comprised approximately 3% of the total shark catch from 1995-2006 (Brodziak *et al.,* 2013). This fishery began around 1917, and underwent significant expansion in the late 1980s to become the largest fishery in the state (Boggs and Ito 1993). This fishery currently targets tunas and billfishes and is managed under the auspices of the Western Pacific Fishery Management Council (WPFMC). Of all fisheries managed under the Fishery Ecosystem Plan (FEP) for Pelagic Fisheries of the Western Pacific Region Ecosystem Plan, the Hawaii-based longline fishery is the largest, accounting for the majority of Hawaii's commercial pelagic landings, with 26 million lbs (~12 million kg) resulting in revenue exceeding $92 million in 2012 (WPFMC 2012). 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 pelagic longline fishery is a limited entry fishery with a maximum of 164 permits available. Current participation is about 125 vessels which target a range of pelagic species.

Catch data compiled from the Hawaii-based logbook annual summary reports also show a declining trend for oceanic whitetip sharks since 2000, with an uptick in the last year (oceanic whitetip sharks were not tallied separately in fisheries logbooks prior to 2000; see Figure 43 below).

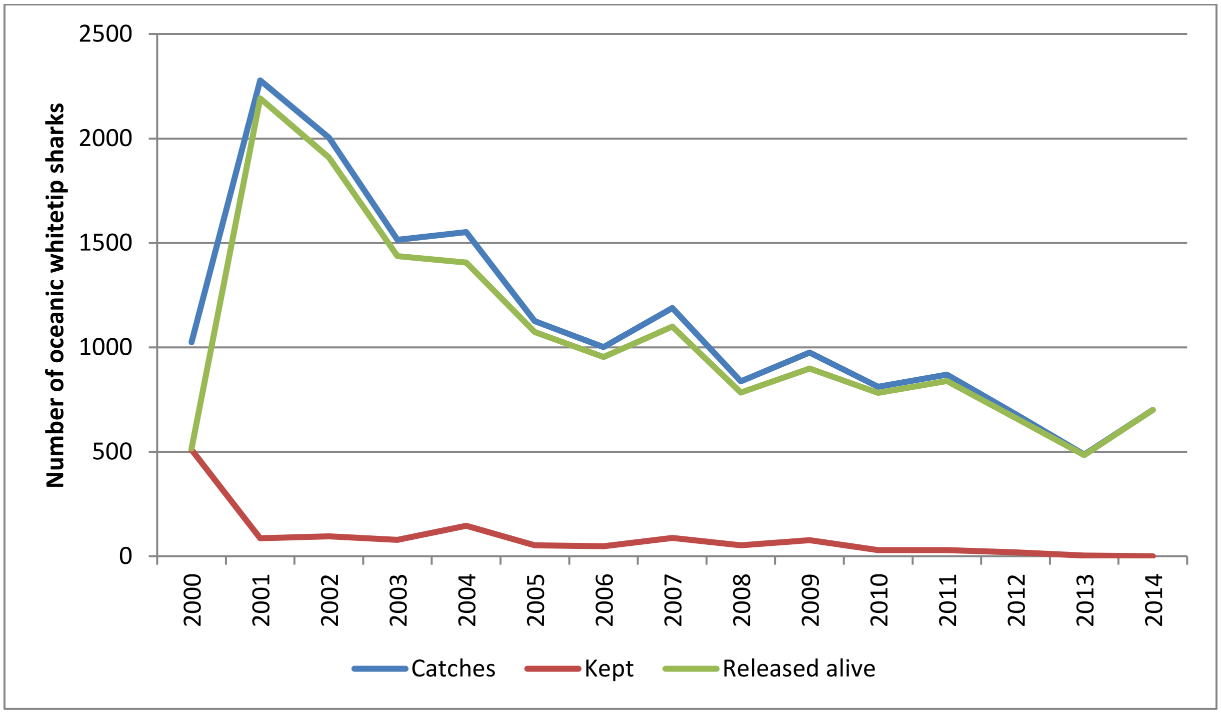

Figure 43 Summary of Pacific Islands Fishery Science Center (PIFSC) fishery logbook reports of oceanic whitetip catches from 2000-2014. Source: NMFS PIFSC[7].

Annual bycatch of approximately 58,402lbs (26.5 mt) and 38,640.lbs (17.5 mt) of oceanic whitetip were estimated for the Hawaii-based deep-set and shallow-set longline fisheries, respectively, based on data from 2005 (NMFS 2011a). Overall, oceanic whitetip sharks were generally not landed or rarely landed in the Pacific Islands region. In the updated report (NMFS 2013), total annual bycatch estimates included 47,553 lbs (21.6 mt) of oceanic whitetip, based on data from 2010. Thus, it appears that overall bycatch estimates have decreased for oceanic whitetip sharks in 2010 compared to 2005, which also coincides with the declines in relative abundance over this same time period. Brodziak *et al*. (2013) concluded that the relative abundance of oceanic whitetip (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 within this portion of its range. It should be noted that the majority of oceanic whitetip sharks are now released alive in this fishery, with the number of individuals kept on a declining trend. 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[8] estimated 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

---

[7] http://www.pifsc.noaa.gov/fmb/reports.php

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

sharks survived after being released. Nonetheless, this particular fishery may be less of a threat to the oceanic whitetip shark in the foreseeable future.

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 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. Based on logbook longline summary reports from American Samoa, unstandardized (i.e., nominal) CPUE and catches of oceanic whitetip sharks have trended downward until about 2009, at which point the trend appears to have potentially stabilized (Figure 44). It should be noted that this data is based on nominal catches recorded in fisheries logbooks and may not be reliable.

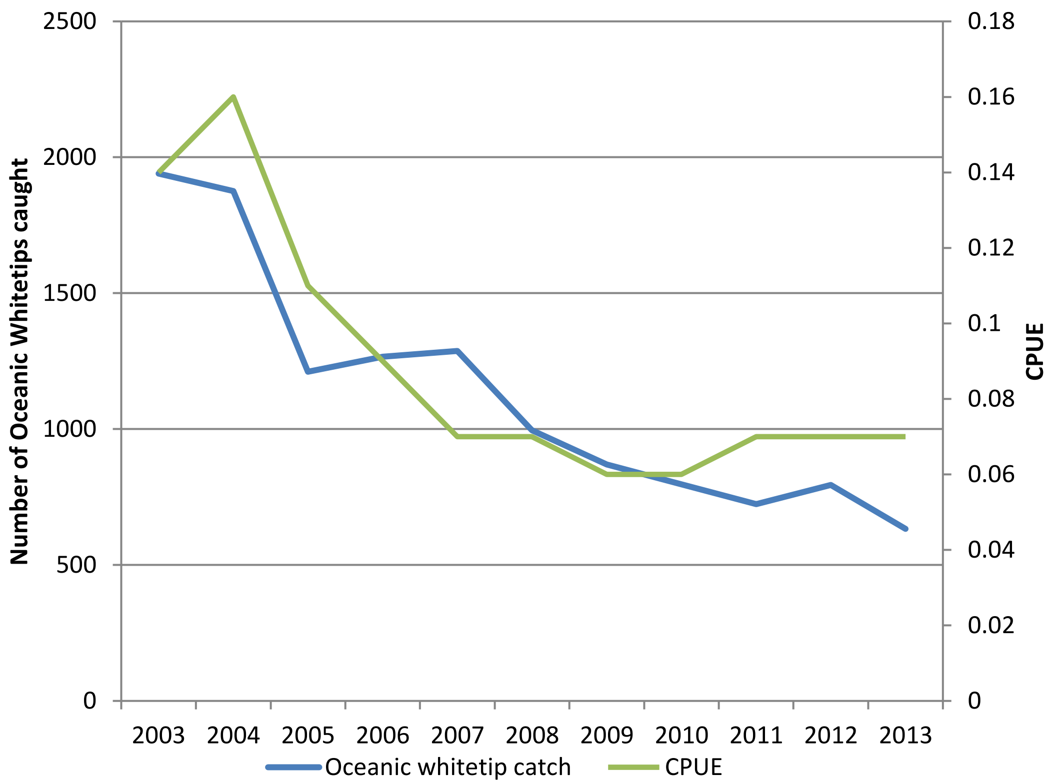

Figure 44 Summary report of unstandardized fishing effort and catch statistics for U.S. longline vessels landing in American Samoa from 2003-2013, compiled from PIFSC Annual Summary Reports as derived from NMFS Western Pacific Daily Longline Fishing Log records. Source: PIFSC American Samoa Longline fishery logbook summary reports[9].

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 2011c).

Australia

Several studies have been conducted to assess the ecological risk of species in various fisheries throughout Australia. While oceanic whitetip sharks are known from Australian waters and are

[9] http://www.pifsc.noaa.gov/fmb/reports/american_samoa/longline_logbook_summary.php

known bycatch in two major fisheries (the Eastern and Western Tuna and Billfish fisheries), they have only been assessed in the Eastern Tuna and Billfish fishery (ETBF). The oceanic whitetip shark is listed as a bycatch species in the ETBF, which 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 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 oceanic whitetip is a prominent 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 oceanic whitetip in the ETBF. In the ERA, average annual logbook catch of oceanic whitetip 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, oceanic whitetip 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 45 below).

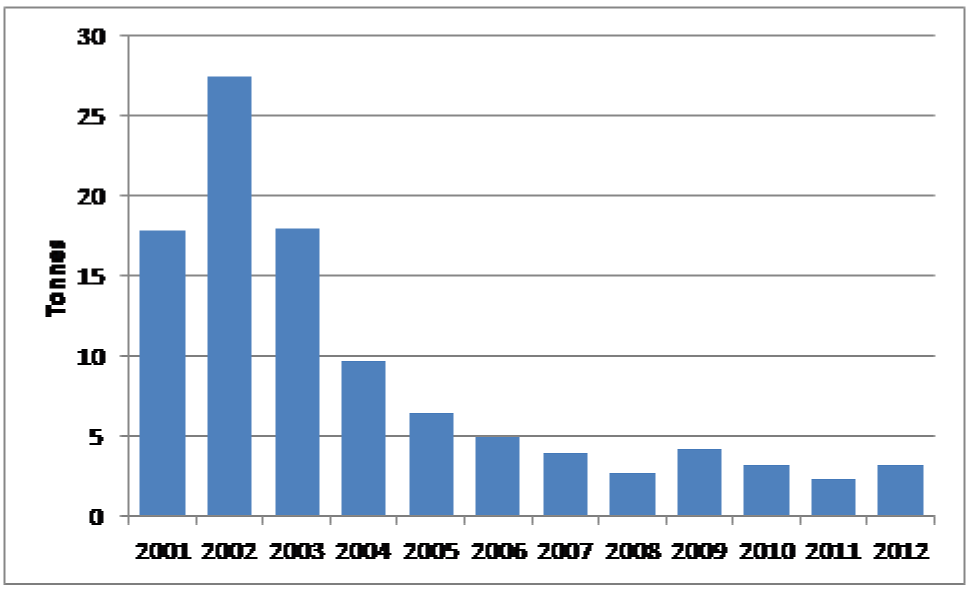

Figure 45 Annual catches (t) of oceanic whitetip shark in Australia from 2001 to 2012. Source: Koopman and Knuckey 2014.

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 the Western Tuna and Billfish Fishery (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 shark are possibly caught in state managed fisheries operating far offshore, the total Australian catch of oceanic whitetip shark is estimated to be less than 5 t per year (Koopman and Knuckey 2014). There is also reported take in IUU fishing in Australian waters, with the oceanic whitetip 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, 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 whitetips is substantially underestimated. Nevertheless, the study concluded that oceanic whitetips 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 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.

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 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 oceanic whitetip of 0.2904 in RMI longline fisheries. In these fisheries, oceanic whitetip exhibits a relatively high at-vessel survival rate of approximately 70% (n = 917). However, 97.4% of oceanic whitetips 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.

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 whitetips were captured and discarded after finning (Piovano and Gilman 2016). In 2013, 62 oceanic whitetips 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.

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).

Western and Central Pacific Summary

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 whitetips as a result of fishing mortality in both longline and purse seine fisheries indicate that overutilization of the species is likely 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, it is likely that the oceanic whitetip shark is experiencing overutilization in this portion of its range.

ATLANTIC OCEAN

Northwest and Western Central Atlantic and Gulf of Mexico

Like 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 was conducted in 2008 by the ICCAT Standing Committee on Research and Statistics (SCRS) for shark and ray species typically taken in Atlantic pelagic longline fisheries. This ERA categorized the relative risk of overexploitation of the 11 major species of pelagic sharks, including oceanic whitetip sharks, and derived an overall vulnerability ranking for each of the species, defined as "a measure of the extent to which the impact of a fishery on a species will exceed its biological ability to renew itself." The oceanic whitetip shark ranked 5th most susceptible to pelagic fisheries among 11 other Atlantic Ocean species (Cortés 2008a; Cortés *et al.,* 2010). In an update and expansion of the SCRS ERA, the oceanic whitetip shark was found to be a moderately productive species that shows varying levels of susceptibility to the combined pelagic longline fisheries in the Atlantic Ocean, and ranked 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 8.8-8.9 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 whitetips were caught historically as bycatch in PLL fisheries targeting tuna and swordfish in this region. Although an estimated 8,526 individuals were recorded as captured in U.S. fisheries logbooks from 1992 to 2000 (Baum *et al.,* 2003), pelagic longlining for Atlantic Highly Migratory Species (HMS) began on the East Coast of the U.S. 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. Secondary target species include dolphin fish, albacore tuna, and to a lesser degree, sharks. The U.S. PLL fishery has been historically comprised of five relatively distinct segments with various fishing practices and strategies. These segments are: 1) the Gulf of Mexico yellowfin tuna fishery; 2) the South Atlantic-Florida east coast to Cape Hatteras swordfish fishery; 3) the Mid-Atlantic and New England swordfish and bigeye tuna fishery; 4) the U.S. distant water swordfish fishery; and 5) the Caribbean Islands tuna and swordfish fishery (NMFS 2008). There are many PLL gear and area restrictions and the fishery is strictly monitored.

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 the International Commission for the Conservation of Atlantic Tunas (ICCAT). Overall, very few oceanic whitetip sharks have been landed by the commercial fishery, except for two peaks of about 1,250 and 1,800 fish in 1983 and 1998, respectively. Otherwise, total catches never exceeded 450 fish (NMFS 2009b). From 1992-2000, elasmobranchs represented 15% of the total catch in numbers by the PLL fishery, with oceanic whitetip comprising 2.8% of the shark bycatch (Beerkircher *et al.*, 2002). Observer data from the NMFS Pelagic Observer Program recorded 912 oceanic whitetip sharks caught on U.S. PLL gear between 1992 and 2015. The following table (Table 2) shows Atlantic domestic commercial landings of oceanic whitetip sharks, which were compiled from the most recent stock assessment documents.

Table 2 Commercial landings of Atlantic oceanic whitetip sharks (lbs, dressed weight) from 2003-2013. Source: (NMFS 2012; 2014; 2017)

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2,559	1,082	713	354	787	1,899	933	769	2,435	258	62	22	0

*Consistent with ICCAT Recommendation 10-07, retention of oceanic whitetip 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 have been variable, but averaged approximately 1,077.4 lbs (488.7 kg; 0.4887 mt) per year from 2003-2013. Although oceanic whitetip sharks have been prohibited in fisheries with pelagic longline gear onboard since 2011, they can still be caught as bycatch, caught with other gears, and are occasionally landed. However, since the ICCAT retention prohibition was implemented in 2011, estimated commercial landings of oceanic whitetip declined from 1.1 mt in 2011 to only 0.03 mt in 2013 (NMFS 2012; 2014). In 2013, NMFS reported a total of 33 oceanic whitetip interactions to ICCAT, with 88% released alive. Oceanic whitetips are also infrequently caught in buoy gear for swordfish; however, these interactions are relatively minimal, with 11 individuals caught from 2009-2015 (NMFS 2017).

In addition to information from the United States, international fisheries information and catch data for the Atlantic are available from ICCAT. The 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 46 and 47 (Figure 46 is the same as Figure 47 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.

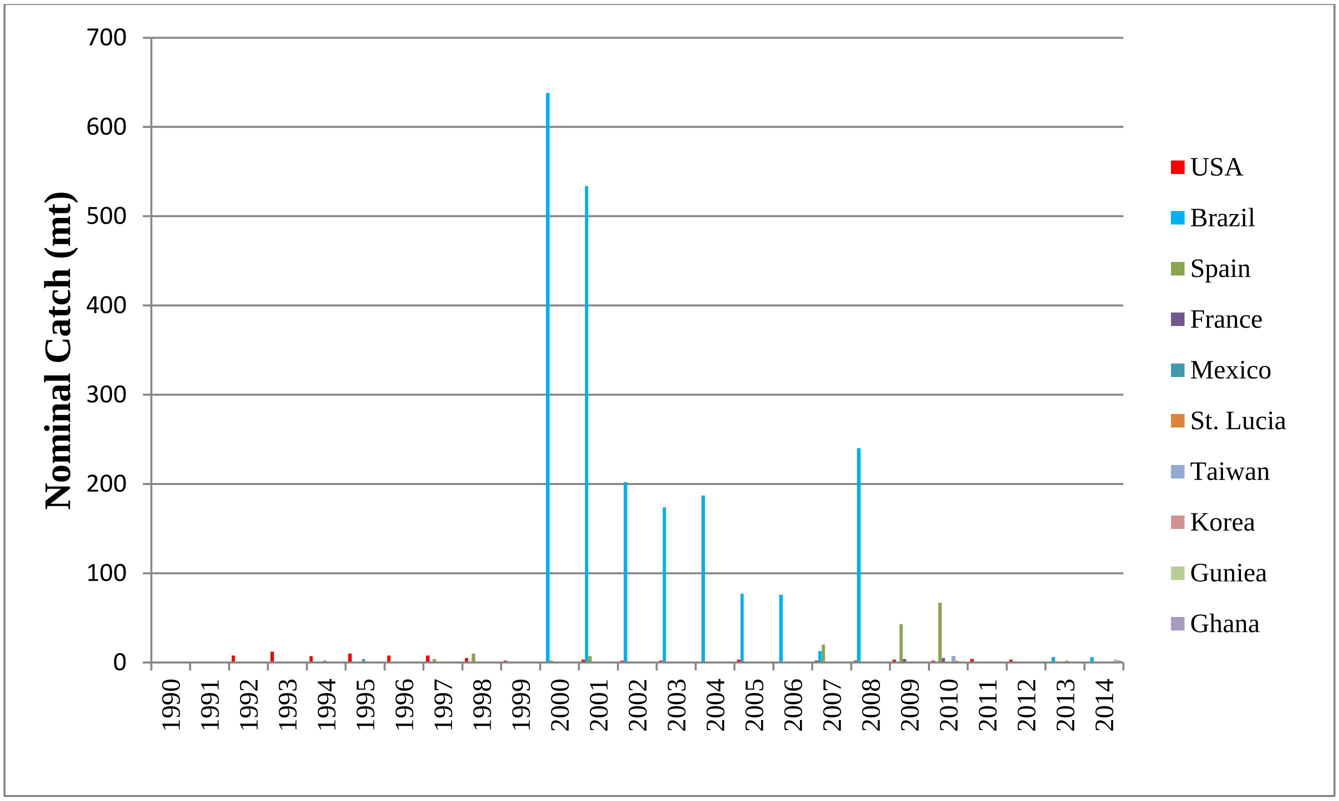

Figure 46 Nominal catches (mt) of oceanic whitetip reported to ICCAT by CPC vessel flag from 1990-2014. Source: ICCAT nominal catch information: Task I web-based application; accessed January 28, 2016.

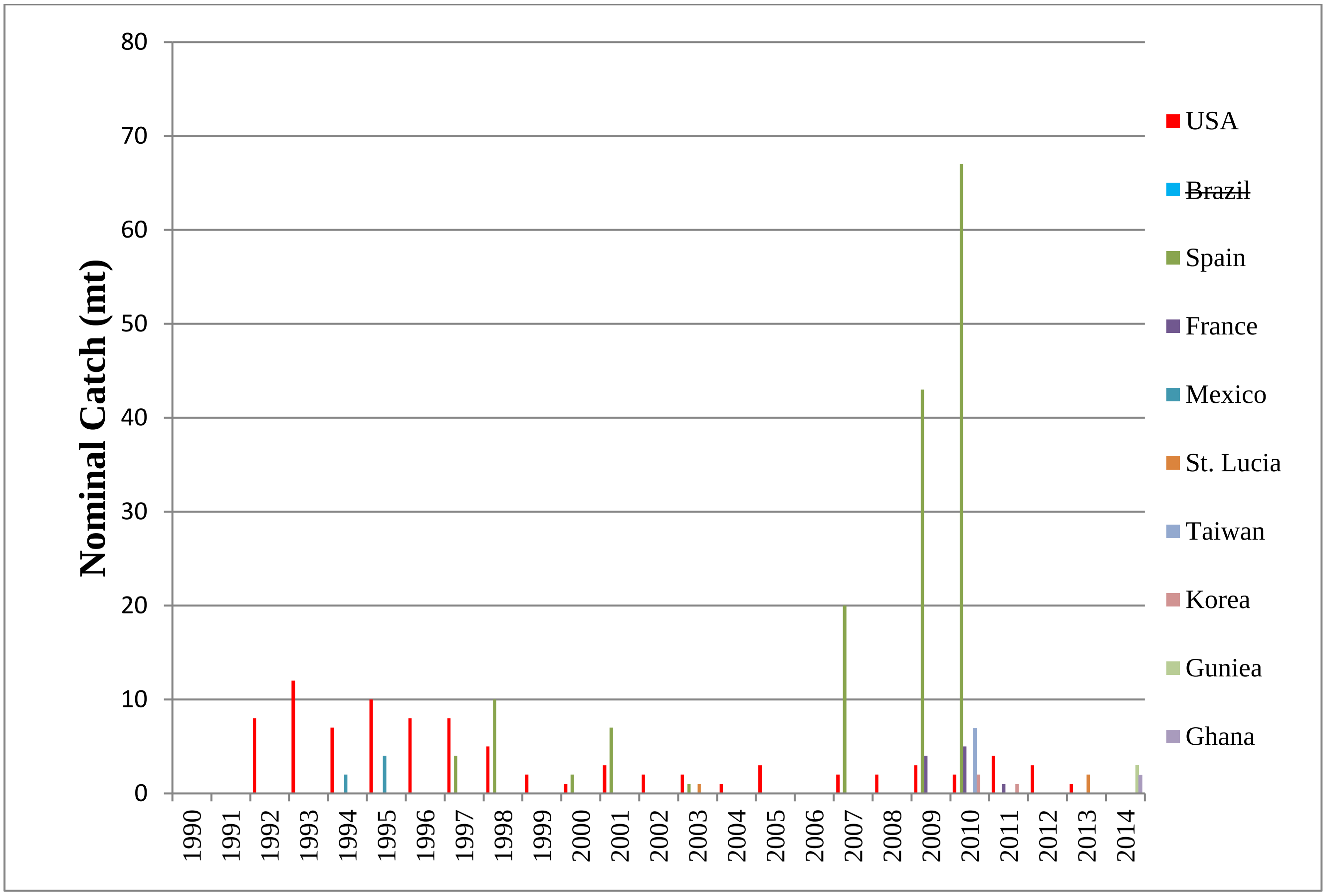

Figure 47 Nominal catches (mt) of oceanic whitetip reported to ICCAT by CPC vessel flag (except Brazil) from 1990-2014. Source: ICCAT nominal catch information: Task I web-based application; accessed January 28, 2016.

In total, approximately 2,430 mt of oceanic whitetip 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 for years 2011-2014, which is after the prohibition was implemented. Only 3 countries reported catching oceanic whitetip sharks in 2014 (Brazil, Guinea and Ghana).

Cuba

Although shark fishing in Cuba most likely commenced at the beginning of the 20th Century, the first official records were not made until 1959 (Cuba NPOA-Sharks 2015). A historical time series on shark production in Cuban waters from 1959–2014 shows a period of growth between 1959 and 1981, with peak production occurring in 1981 of 2,644t (CUBA NPOA-Sharks 2015). In general, shark fishing reached its maximum levels during the first half of the 1980s, with average production of 2,482t from 1980-1985, after which catches showed an unstable but consistently declining trend to a minimal level of 869t in 1993. After another peak of 1,918t produced in 1997, production once again declined to 546t and 541t in 2004 and 2005, respectively. Finally, following a peak of 900t in 2008, production contracted to 469.5t and 487.5t in 2012 and 2013, respectively, and slightly increased in 2014 to 533.6t (Cuba NPOA-Sharks 2015).

According to data from the 1960s, the oceanic whitetip once represented the highest percentage of shark catches in northwestern Cuba by weight (25.4%; Guitart 1975 cited in Cuba Department of Fisheries, 2016). As previously noted, shark catches in Cuba increased until 1981 and have been variable since. Since 1985, a substantial decline was observed in some species, including oceanic whitetip. 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 can't 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 abundance 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." 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.

<u>Northwest and Central Atlantic Summary</u>

As previously discussed in the *Regional Population Trends* section of this status review, abundance trend estimates derived from standardized catch rate indices of the U.S. PLL fishery suggest that the oceanic whitetip shark has undergone significant historical declines in abundance in the Northwest Atlantic, likely due to of fishing mortality. Logbook data indicates that the oceanic whitetip population declined sharply from 1986-2000 by approximately 70% in the Northwest and Central Atlantic, and up to 88% in the Gulf of Mexico; however, the claim of such drastic declines was criticized for a lack of understanding of logbook data (Burgess *et al.,* 2005b; Burgess *et al.,* 2005a), and a less pronounced trend (i.e., 9%) in observer data was found, indicating uncertainty in the magnitude of decline of the Atlantic oceanic whitetip population. Given that observer data are generally considered a more reliable indicator of population abundance trends for bycatch species such as sharks, oceanic whitetip abundance may have stabilized in the Northwest Atlantic since 2000 and in the Gulf of Mexico and Caribbean since the late 1990s. Despite historical abundance declines, 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 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 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 region, including Brazilian, Uruguayan, Taiwanese, Japanese, Venezuelan, Spanish and Portuguese longline fisheries; however, the largest oceanic whitetip catching country in this region is Brazil.

As previously discussed in this report, oceanic whitetips were historically reported as the second-most abundant shark, outnumbered only by blue shark, in research surveys from northeastern Brazil between 1992 and 1997 (Lessa *et al*., 1999; FAO 2012). In fact, those research surveys showed that oceanic whitetip shark comprised nearly 30% of total elasmobranch catches (Lessa *et al*. 1999) and averaged a CPUE rate of 2.18 individuals per 1,000 hooks (Domingo *et al.,* 2007). However, recent information indicates that the oceanic whitetip may be experiencing overutilization in this part of its range because of unsustainable fishing mortality. The oceanic whitetip 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 and utilizes two distinct fishing strategies referred to as the “Japanese” strategy (JAP; targets tuna down to >200 m) and “Spanish” strategy (SPA; targets swordfish down to 100 m). Oceanic whitetip CPUE is higher with the SPA strategy than the JAP strategy due to shallower hook depth; in fact, the depth range of the gear used in the SPA fishing strategy corresponds exactly to the oceanic whitetip’s preferred vertical distribution

(Tolotti *et al.*, 2013). Additionally, from 1999-2011, the area with the highest effort concentration was bound by the 5°N and the 15°S parallels and by the 040°W and 035°W meridians. Thus, despite the wide distribution of fishing sets, the area of highest effort is clearly 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 oceanic whitetip shark 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 48 and 49 below).

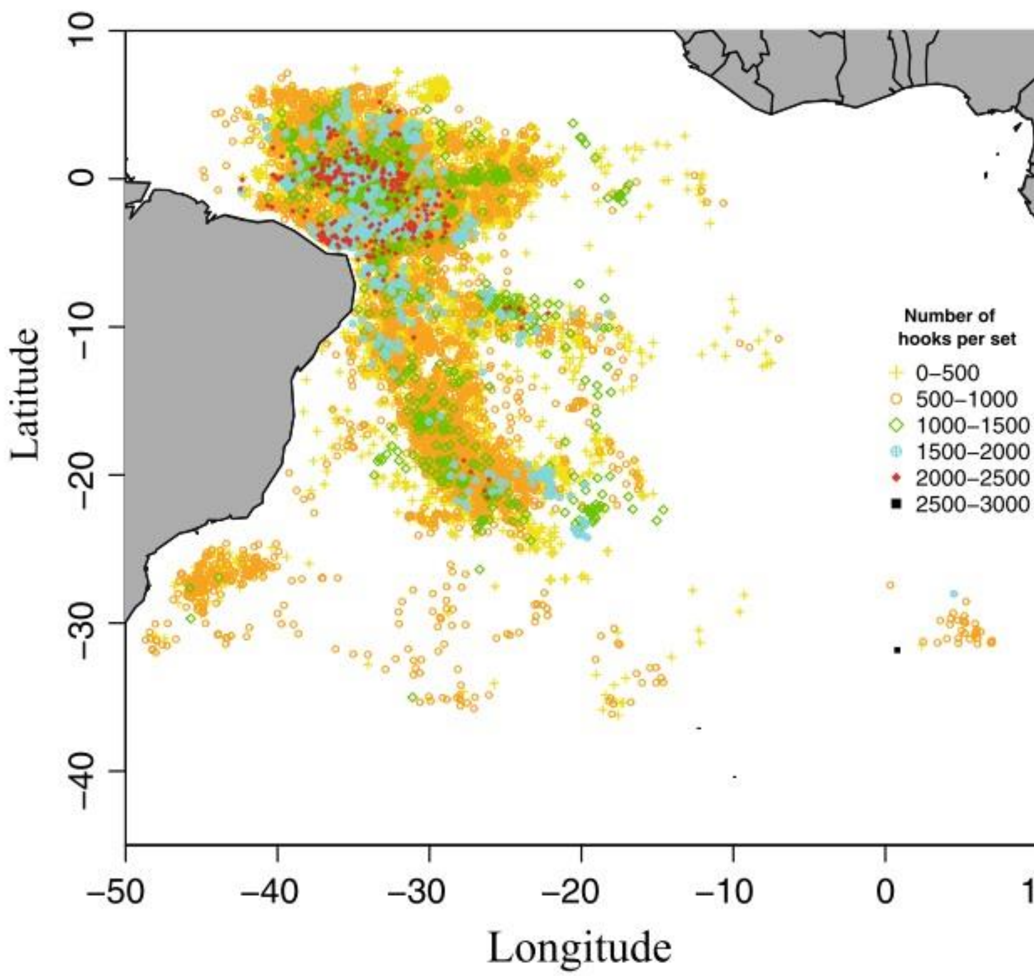

Figure 48 Distribution of fishing effort (number of hooks per set) by the Brazilian chartered tuna longline fleet in the Atlantic Ocean, from 2004 to 2010. Source: Frédou *et al.* 2015.

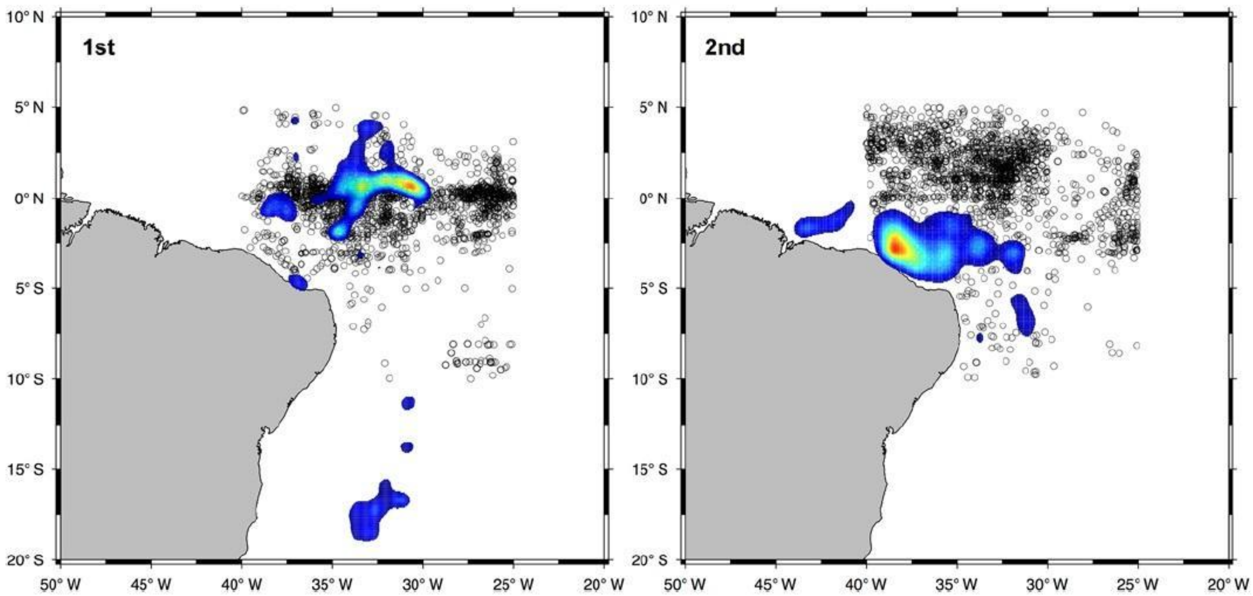

Figure 49 Kernel density estimation of post-processed tracks showing the areas of high utilization by oceanic whitetip sharks tagged in the western Atlantic Ocean between 2010 and 2012. The left panel represents the 1st quarter of the year and the right represents the 2nd. Small circles are fishing set locations from foreign tuna longline vessels chartered by Brazil operating from 2004 to 2010. Source: Tolotti *et al.* 2015a.

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 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 nursery habitat, suggesting that these areas are at a direct risk from the industrial longline fishery (Frédou *et al.*, 2015).

It also appears that the percentage of immature sharks has increased in recent years compared to surveys conducted in the 1990s (See Figures 50 and 51 below).

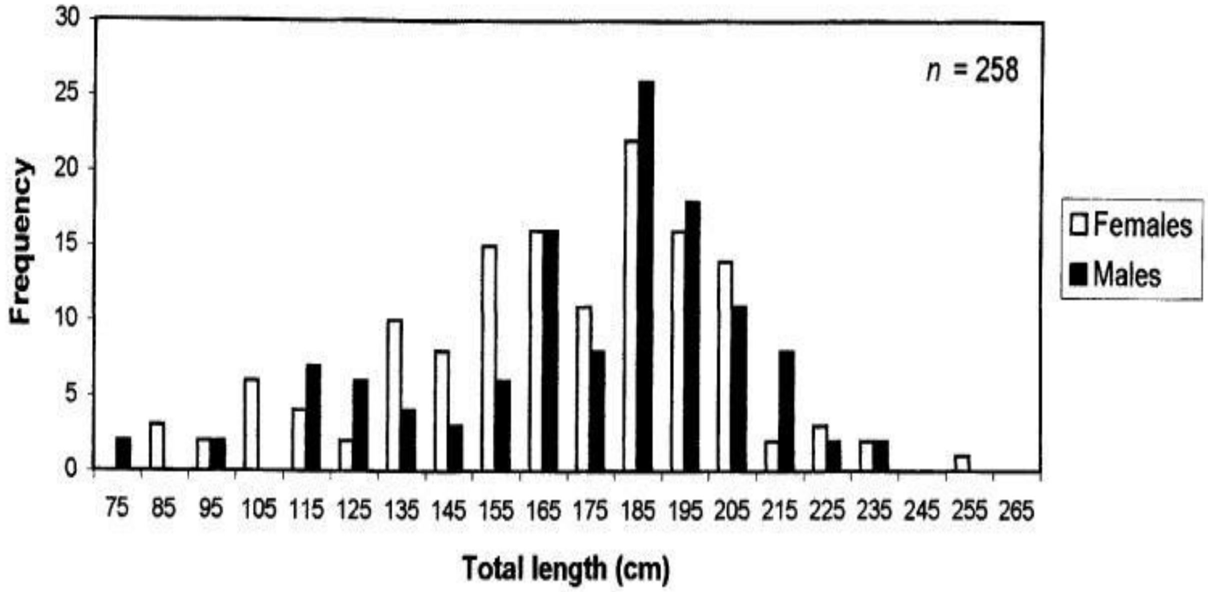

Figure 50 Length-frequency distribution for male and female whitetip shark, *C. longimanus*, caught off northeastern Brazil between 1992 and 1997. Source: Lessa *et al.* 1999.

.

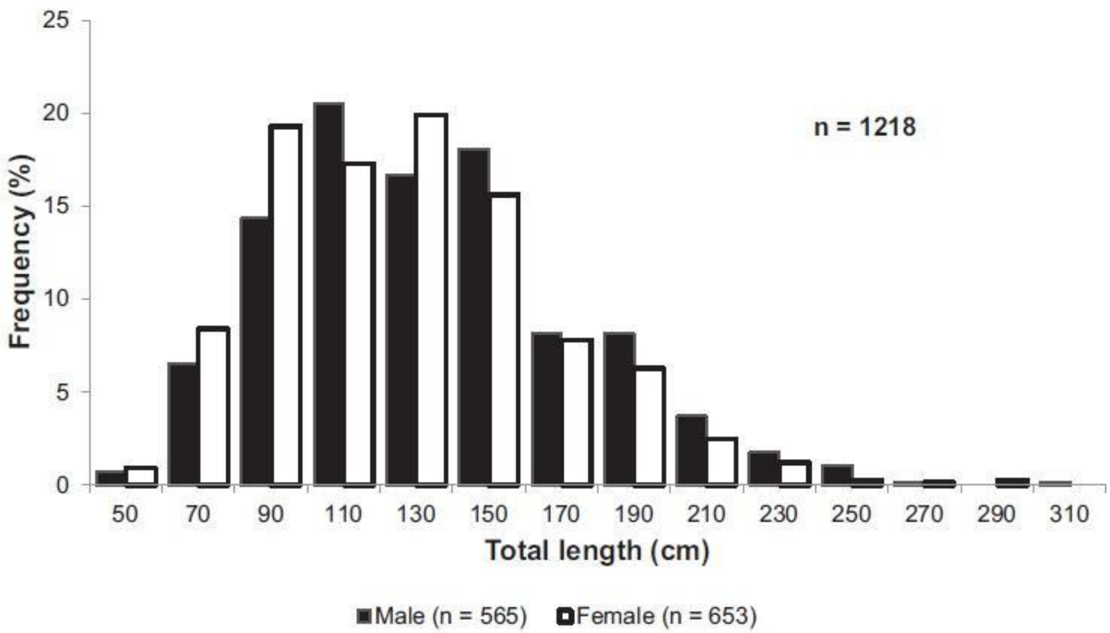

Figure 51 Length–frequency distribution of oceanic whitetip shark, *C. longimanus*, caught in the southwestern equatorial Atlantic Ocean between 2005 and 2009. Source: Tolotti *et al.* 2013.

It should be noted that Figure 50 from Tolotti *et al*. 2013 represents a much larger area of the southwestern and equatorial Atlantic and has a much larger sample size than the results shown in Figure 51 from Lessa *et al*. 1999. However, the two study areas do overlap and provide some indication that the size composition of oceanic whitetip sharks in the southwestern Atlantic is potentially shifting downwards. 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.

As discussed previously in the *Regional Population Trends* section, a demographic analysis of oceanic whitetip sharks off Brazil estimated that fishing mortality of oceanic whitetip is 14 times higher than required for maintaining equilibrium, resulting in an annual decline of 7.2% (Santana *et al.*, 2004). This rate of decline results in a reduction of about 50% of abundance in the course of approximately a decade, which is within the standards known of exploited oceanic whitetip populations in other regions (Santana *et al.*, 2004). The authors concluded that conservation and management are necessary for the species because the high value of initial mortality is accentuated by an excess of fishing effort, such that that these factors contribute to the population reduction of oceanic whitetip shark in northeastern Brazil (Santana *et al*., 2004). Catches of oceanic whitetip 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 46 above). This decline in reported landings also coincides with the previously discussed demographic analysis that reported a 50% population decline in Brazil. 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).

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 of oceanic whitetip across its preferred vertical and horizontal habitat areas in Brazilian waters is negatively impacting oceanic whitetip sharks at all life stages. Given the demographic analysis discussed previously indicating a 50% population decline in these waters as a result of unsustainable rates of fishing mortality, combined with the species' relatively low-moderate productivity, it is likely that the oceanic whitetip is experiencing overutilization in this portion of its range.

As discussed previously in the *Regional Population Trends* section, elsewhere across the southern and equatorial Atlantic, the oceanic whitetip shark exhibits extremely low CPUE values and comprises a very small percentage of catches in various fisheries. For example, farther north 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 FL (Arocha *et al.*, 2002), which is well below the size of maturity estimated for this region (i.e., 180-190 cm).

Similarly, observer data from the Uruguayan longline fleet operating farther south in this region reported low CPUE values for oceanic whitetip from 2003 to 2006, with the highest CPUE recorded not exceeding 0.491 individuals/1,000 hooks. In total, only 63 oceanic whitetips were caught on 2,279,169 hooks and 63% were juveniles (see Figure 52 below; Domingo *et al*. 2007). Based on the catches and relative abundance, three zones were determined for the oceanic whitetip, including: Zone 1: Western South Atlantic and southern Brazil; 2: International waters on the Chain of Montes Vitoria- Trindade near the Bank Davis; Zone 3: Northeast Atlantic in the Gulf of Guinea. Average length and CPUE values were analyzed for *C. longimanus* 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 whitetips caught in only 4 months. Though these data do not indicate whether a decline in the oceanic whitetip population has occurred, they clearly show that this species is currently not abundant in these areas (FAO 2012). However, it is possible that the species has always been uncommon in this area of the South Atlantic, especially given the preference of this species to remain in warm, tropical waters.

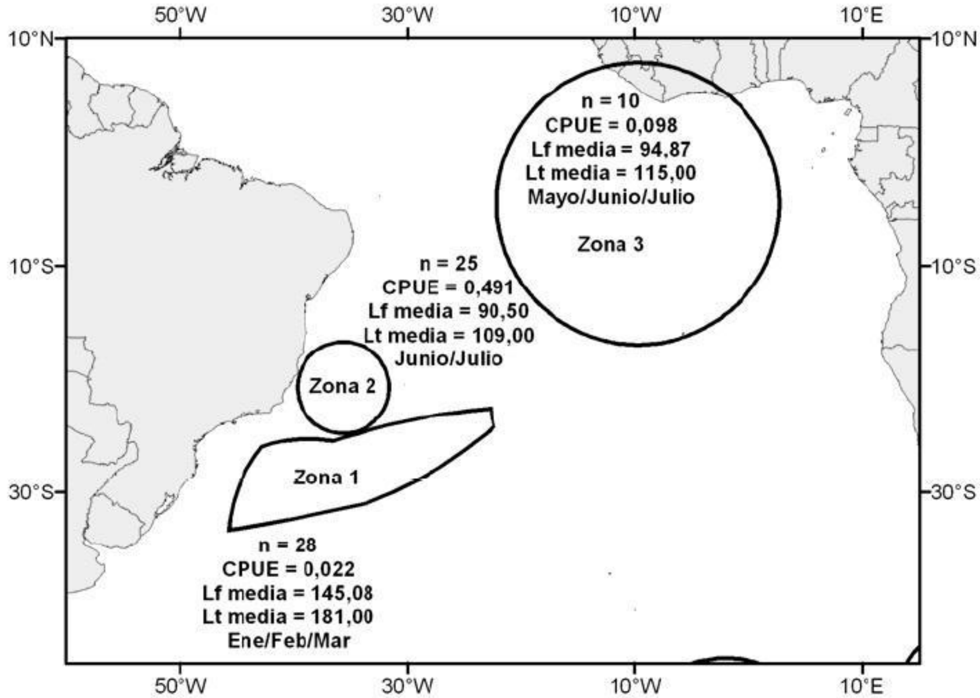

Figure 52 Areas (Zones 1-3), number (n), CPUEs, Lf and Lt media (average lengths) and times of observed oceanic whitetip sharks by the Uruguay National Observer Program from 2003-2006. Source: Domingo *et al.* 2007.

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 oceanic whitetip was the least caught shark species from 5°N-15°S, with only 3 individuals caught, comprising 0.1% in number and 0.1% in weight of total shark catches. However, oceanic whitetip was not found from 15°S-40°S, which are more southern and temperate waters (Joung *et al.*, 2005). Species-specific CPUE for oceanic whitetip 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 53 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).

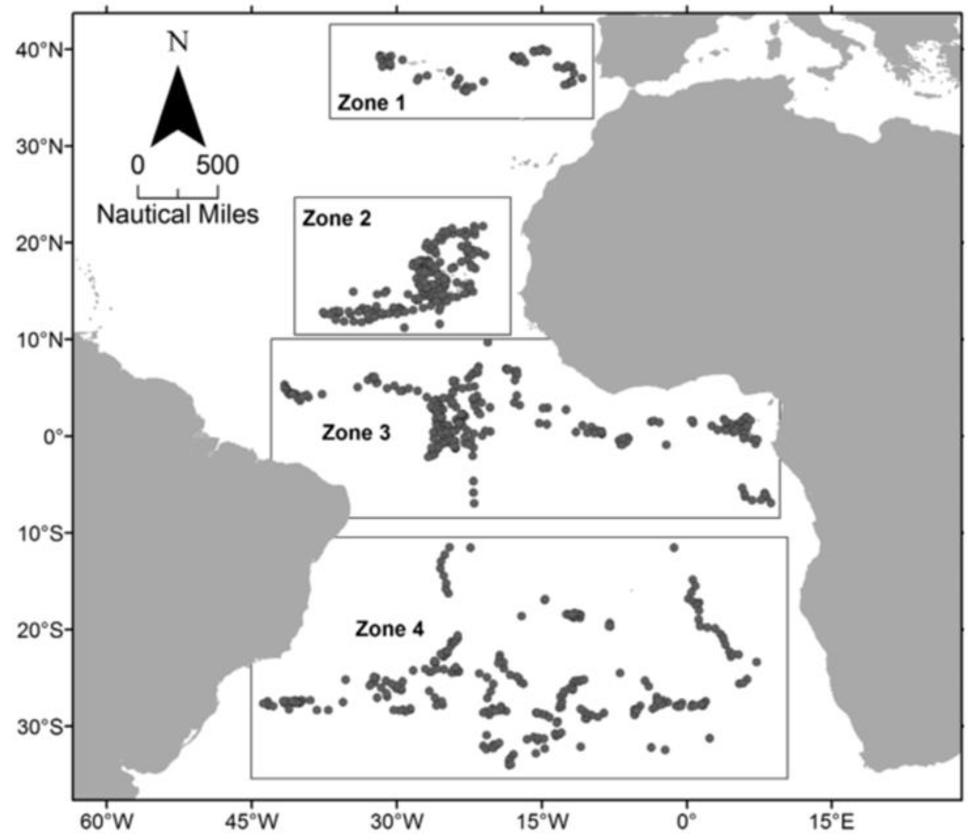

Figure 53 Locations of observed Portuguese longline operations in the Atlantic Ocean from 2008 to 2011. Source: Coelho *et al.* 2012.

Over the same time period (2008-2011), a total of 202 experimental pelagic longline sets were carried out in the Tropical Northeast Atlantic Ocean (corresponding to Zone 2 in Figure 53 above). Fernandez-Carvalho *et al.*, (2015) noted that this area has become a major fishing ground for the European pelagic longline fleets (i.e. Spanish and Portuguese) in recent years. The study compared mortality rates between hook and bait type to determine potential bycatch mitigation methods. Over the course of the study, 152 oceanic whitetip sharks were caught, with higher catch rates observed with the use of circle Gt hooks. The species presented relatively low at-vessel mortality rates (11-28%) compared to other shark species, which ranged from a low of 4-8% for the crocodile shark and a high 61-64% for the smooth hammerhead shark (Fernandez-Carvalho *et al*., 2015).

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 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.

Finally, 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 oceanic whitetip, have declined precipitously from considerable fishing pressure and absence 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, 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 declined by 14%, but overall conclusions regarding the status of oceanic whitetip were inconclusive. Figure 54 below shows trends in standardized catch rates for oceanic whitetip for each of the three phases.

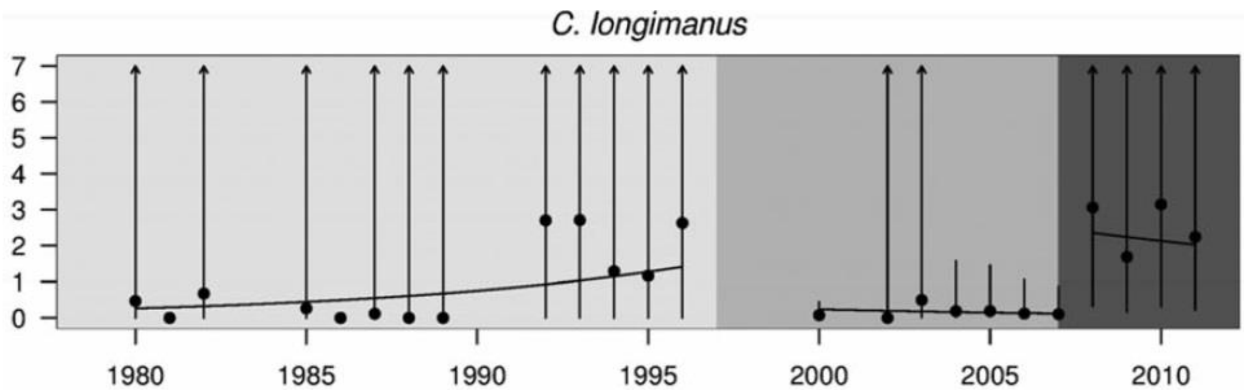

Figure 54 Trends in standardized catch rates of oceanic whitetip sharks (estimated from generalized linear models with a zero truncated negative binomial distribution) in 3 fishing phases (shadings); solid lines, overall trends with year as continuous variable; dots, individual year estimates with year as factor; vertical lines, 95% 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, the ERA team exhibited lower confidence in the results of this study.

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, the species' current abundance and trends in this region are uncertain.

Indian Ocean

Despite evidence for high bycatch levels of pelagic sharks in the Indian Ocean (Romanov 2002, Huang and Liu 2010), there is a paucity of reliable data to facilitate assessing historical changes in shark catch rate trends (Smale 2008). In an analysis of long-term trends from research and fisheries data collected in the Indian Ocean from 1961-2009, the oceanic whitetip was recorded in catches from each time series (e.g., 1961-1970; 1971-1980; 1981-1989; 2002-2009) (Romanov *et al.*, 2010). According to the IOTC, the RFMO that manages tuna and tuna-like species in the Indian Ocean and adjacent waters, 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 the oceanic whitetip shark comprises 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 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 are theoretically supposed to deploy nets of 2.5 miles in length, 6,000 miles of nets may be deployed on a daily basis (Fontenau 2011; Figure 55 below).

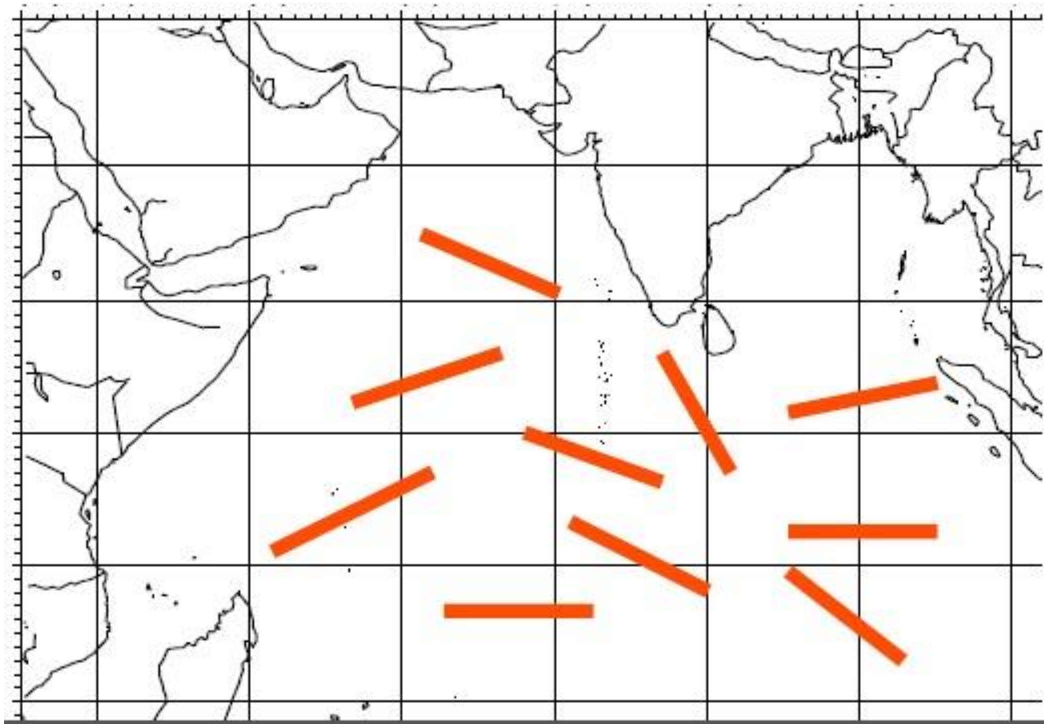

Figure 55 Schematic conceptual view of the total length of drifting nets that may be deployed daily by a fleet of 3,000 vessels using 2.5 miles long nets. Source: Fontenau 2011.

The main fleets catching oceanic whitetip 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 CPCs to annually report oceanic whitetip 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 become 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 2015a). 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 incidental catches and discards to the IOTC was implemented in 2013, estimated catches skyrocketed 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 56 and 57 below).

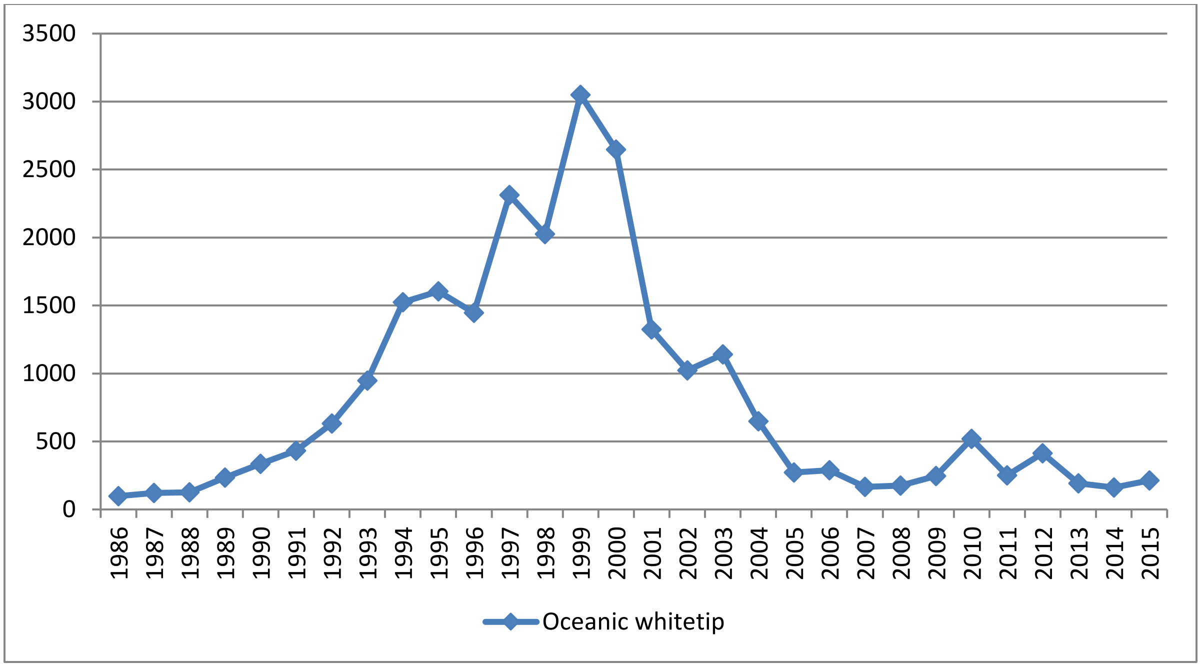

Figure 56 Total catches (mt) (all gears) of oceanic whitetip as reported to the IOTC from 1986-2009. Source: Murua *et al.* 2013(b) and IOTC nominal catch database.

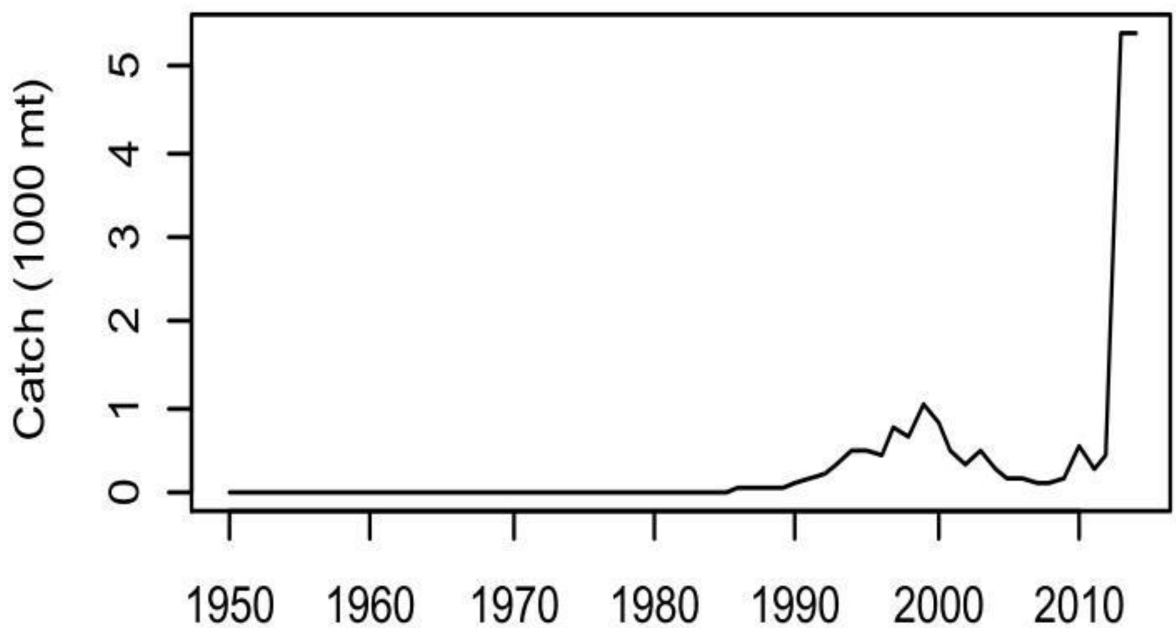

Figure 57 Total nominal catches of oceanic whitetip for all fleets operating in the Indian Ocean (1950-2014). Source: IOTC (2015b).

Only 6 countries reported catches of oceanic whitetip in 2014: Tanzania, Sri Lanka, Maldives, Islamic Republic of Iran, India and Seychelles. The reporting of catches of oceanic whitetip sharks (shown in Figure 57 above) shows an unusual trend dominated by the Sri Lankan combination longline-gillnet fisheries with the addition of proportionately very large catches by India in the last years (2013-2014) (IOTC 2015b). Overall, prior to the unusual trend in 2013 and 2014,the trend in catch 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 3,050 mt in 1999, followed by a sharp and continued decline in the 2000s. The IOTC's Working Group on Ecosystems and Bycatch stated that at current catch levels (i.e., average of 347 mt prior to 2013) the Indian Ocean stock of oceanic whitetip was at considerable risk. Given the high level of fishing pressure on oceanic whitetip in the Indian Ocean, and the species' low-moderate productivity, it is therefore likely that the substantially high catches of oceanic whitetip sharks in the Indian Ocean (5,000+ mt estimated for 2013 and 2014) are in excess of what is sustainable and may be contributing to overutilization of the species in the Indian Ocean. Additionally, oceanic whitetip sharks appear to have higher mortality rates on longlines in the Indian Ocean (e.g., 58% mortality in longline fisheries that fish for swordfish (IOTC 2015a) compared to mortality rates observed in other portions of its range (e.g., ~23% in NW Atlantic (Beerkricher *et al*. 2002; Gallagher *et al*. 2014); 11-28% in the South Atlantic (Fernandez-Carvalho *et al*. 2015); 30% in RMI (Bromhead *et al*. 2012)). 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 shark in the Indian Ocean is provided below where available.

<u>Indonesia</u>

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 specimens landed are mostly 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 sharks can be estimated from the size of its fins, and the shark fins found at fin collectors in east Indonesia indicate that most of the oceanic whitetips 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[10]). The oceanic whitetip is a protected species in Indonesia and banned from export. Thus, based on the genetic results of shark fins from numerous fish markets throughout Indonesia and the evidence of illegal trade of oceanic whitetip 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 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 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 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 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 oceanic whitetip 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.

Sri Lanka

Although sharks were dominant in the historical large pelagic fish landings in Sri Lanka, their current production is low, with catches mostly a result of bycatch. 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

---

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

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 (*C.longimanus*), 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 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 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.

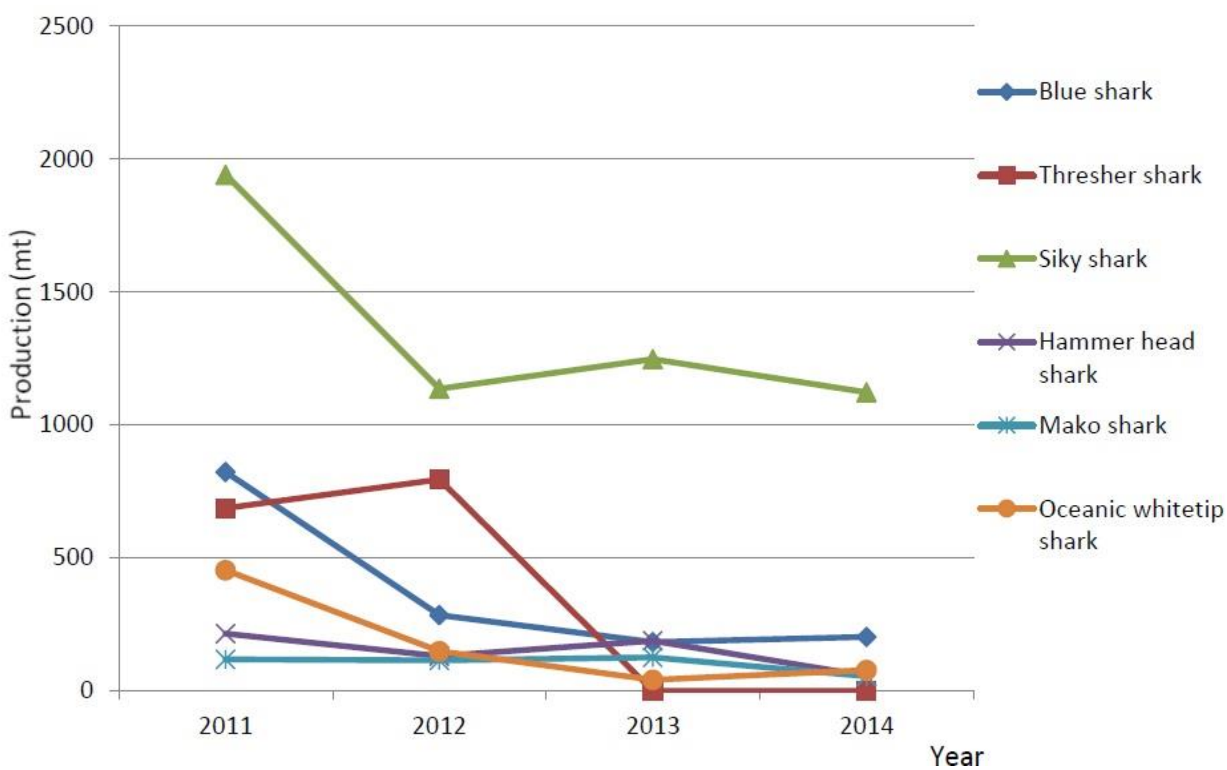

Figure 58 Sri Lanka shark landings by major species 2011-2014. Source: Jayathilaka and Maldeniya 2015.

<u>Taiwan</u>

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 10˚N and 10˚S, where the species would likely be most prevalent (see Figure 59 below). During the study, the average discard rate for sharks was 54.2% (Huang and Liu 2010).

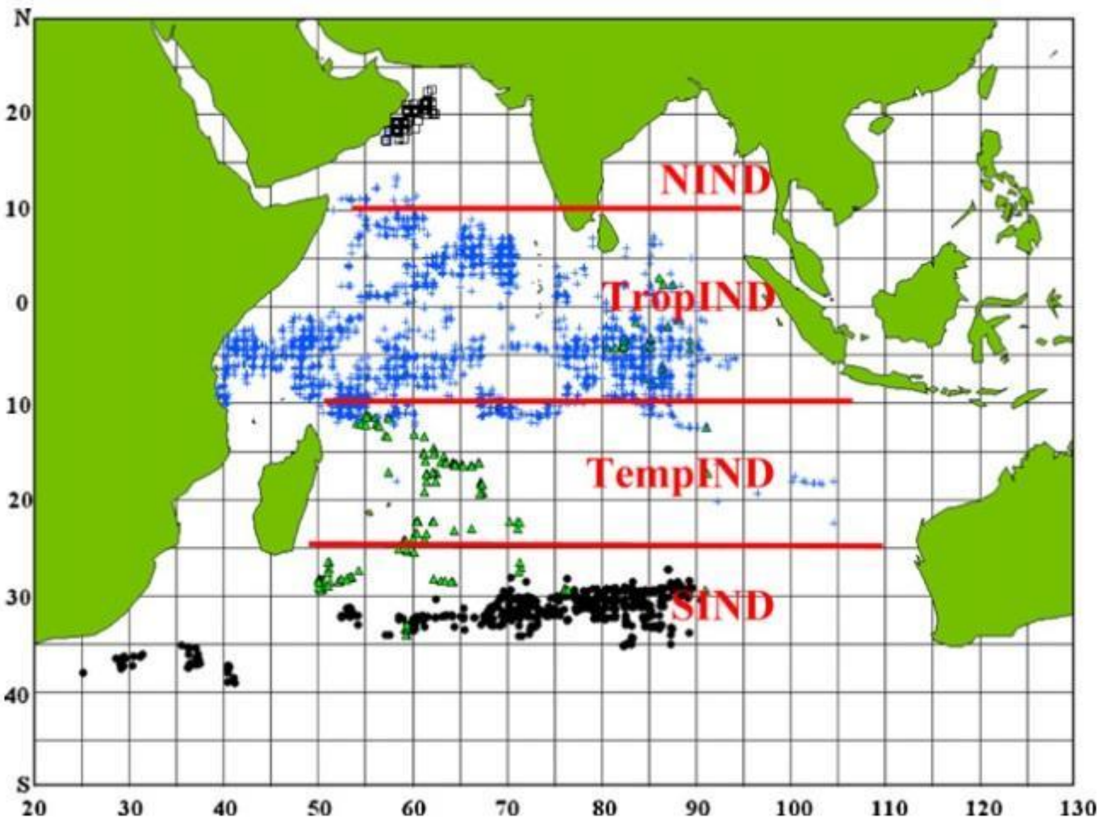

Figure 59 Areas and observed effort distributions of the Taiwanese longline fishery in the Indian Ocean. Black squares, yellowfin tuna fleet; blue crosses, bigeye fleet; green triangles, albacore fleet; black circles, bluefin tuna fleet. Source: Huang and Liu 2010.

<u>African semi-industrial fleet</u>

The African semi-industrial fleet (including Madagascar, Mauritus, 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. (IOTC Secretariat) 2013).

<u>Indian Ocean Summary</u>

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, comprises an estimated 11% of the total shark catch (Murua *et al*. 2013), and is impacted by all three major fisheries in the region, including longlines, gillnets, and purse seine fisheries. As discussed previously in the *Regional Population Trends* section of this 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.

Shark Trade

A demand for shark products has existed since the early 1900s, including liver oil, hides, fins, meat, teeth and jaws. Since the 1980s, much of the demand for shark products 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 USD377.9 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 USD379.8 million and 121,641 tonnes for value and volume, respectively (Dent and Clarke 2015). Dent and Clarke (2015) emphasized that: "the significant difference between the unit values of trade in both commodity categories reflects the much higher value of shark fins, which retail as some of the most expensive seafood items in the world." Historically, this disparity in value has sometimes led fishers to remove fins from captured sharks before discarding the less valuable remainder in order to maximize the value of the contents of their limited hold space (Dent and Clarke 2015).

Shark finning makes monitoring catch levels difficult because shark carcasses are not available to be counted or weighed, and these figures are challenging to estimate based solely on the quantity of fins landed. The resulting lack of accurate catch data makes effective shark fishery management on an international scale troublesome, because international fishing pressure on sharks may not be well understood and is therefore commonly underestimated (Jacquet *et al.*, 2008). 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). This biomass estimate is almost three times higher than the maximum calculated using FAO global shark capture production statistics (0.60 million t/year). In a similar vein, a recent study by Jacquet *et al*. (2008) found that Ecuadorian landings of sharks have also been grossly underestimated compared to what is reported to the FAO. For the period of 1991-2004, reconstructed estimates from government reports and grey literature were 3.6 times greater than what was reported to the FAO. Further, because some countries, such as Spain, do not report shark fins as a separate commodity in the FAO database, but lump them into general "shark" categories, the FAO shark fin export data may not be a good indicator of the global trade in shark fins. These studies indicate that the FAO database, the only source for current international catch statistics, may be drastically under-representing global shark catches. However, this issue is changing as the World Customs Organization now requires countries to create fin-specific commodity codes (Dent and Clarke 2015), though this does not necessarily remedy the under-reporting of sharks that are caught.

Demand from international shark fin trade is the main economic force driving the retention and subsequent finning of oceanic whitetip sharks taken as bycatch, as their large, morphologically distinct fins command high prices on the international market of US $45–85/kg (CITES 2013). Thus, the oceanic whitetip shark is considered a "preferred" species for its fins and make up part of the "first choice" category in the China, Hong Kong SAR fin market (Vannuccini 1999). 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 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.

In more recent years, genetic testing conducted in various fish markets provides additional confirmation of the species-specific utilization of oceanic whitetip shark 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 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 United Arab Emirates, oceanic whitetip shark comprised 0.45% of fins tested (Jabado *et al.*, 2015). 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.

From 2000 to 2011, China, Hong Kong Special Administrative Region (SAR) maintained its position as the world's largest trader of shark fins, controlling 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 value terms (62% of total volume). According to Dent and Clarke (2015), China, Hong Kong SAR reported imports of 3,319 t ($154.9 million) of "dried, unprocessed" fins, 188 tonnes ($1.9 million) of "frozen, unprocessed" fins, and 14 tonnes ($840,000) of dried, processed fins in 2012. In the same year, China, Hong Kong SAR reported a total of 4,959 t of high-valued "frozen shark meat" imports, worth $64.3 million. 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 reliable gauge of the global trade for many years, rose by 10%

in 2011 but fell by 22% in 2012. Dent and Clarke (2015) identified a number of factors that may have contributed to the downturn in the trade of fins through China, Hong Kong SAR, 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 (see Figure 60 below), 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).

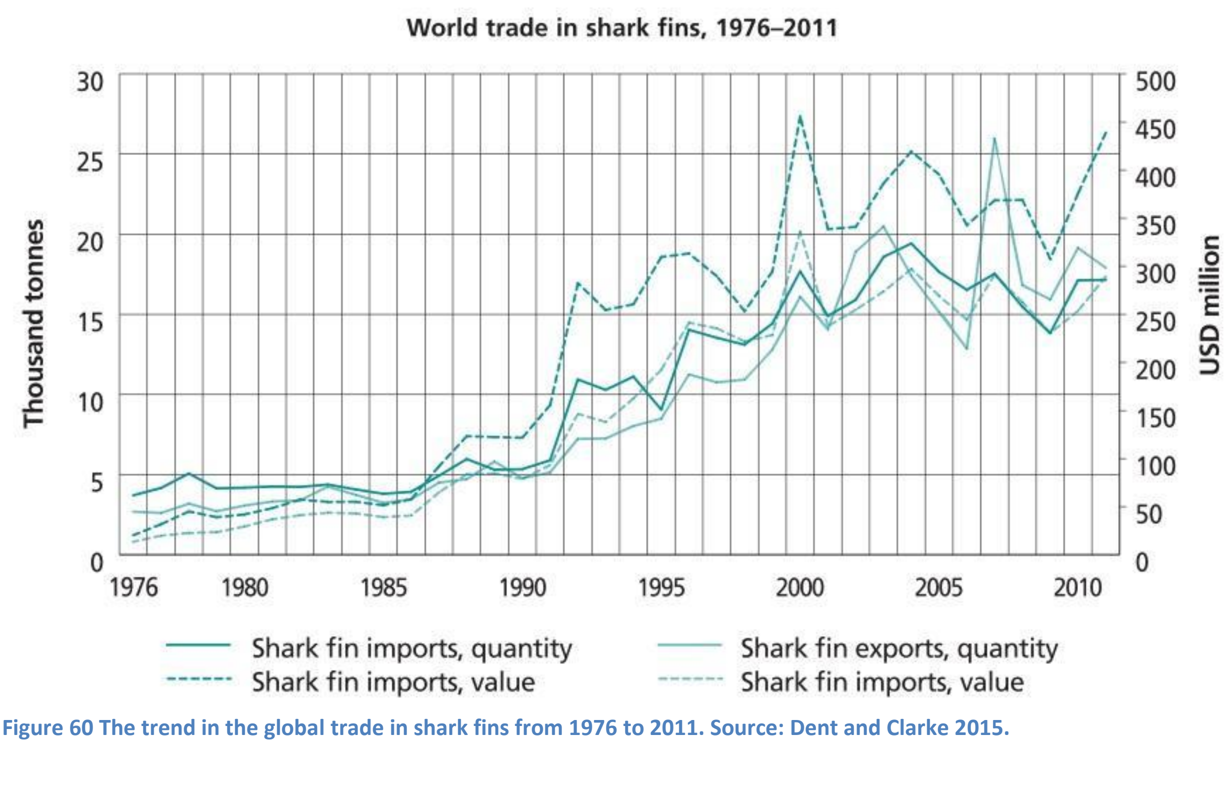

Figure 60 The trend in the global trade in shark fins from 1976 to 2011. Source: Dent and Clarke 2015.

Global data from FAO's Fishery Commodities and Trade Database also reflects a recent decrease in shark fin exports. The export of all shark products has substantially increased since the early 1990s, but appears to have leveled off in the last few years (See Figure 61 below). It should be noted that not all fins in the market originate from shark finning, and there is growing pressure from many countries to stop finning and instead require all fins remain naturally attached to the carcass, which has likely had some effect on the recent surge in the shark meat trade (see section 4.4 on *Inadequacy of Existing Regulatory Mechanisms*).

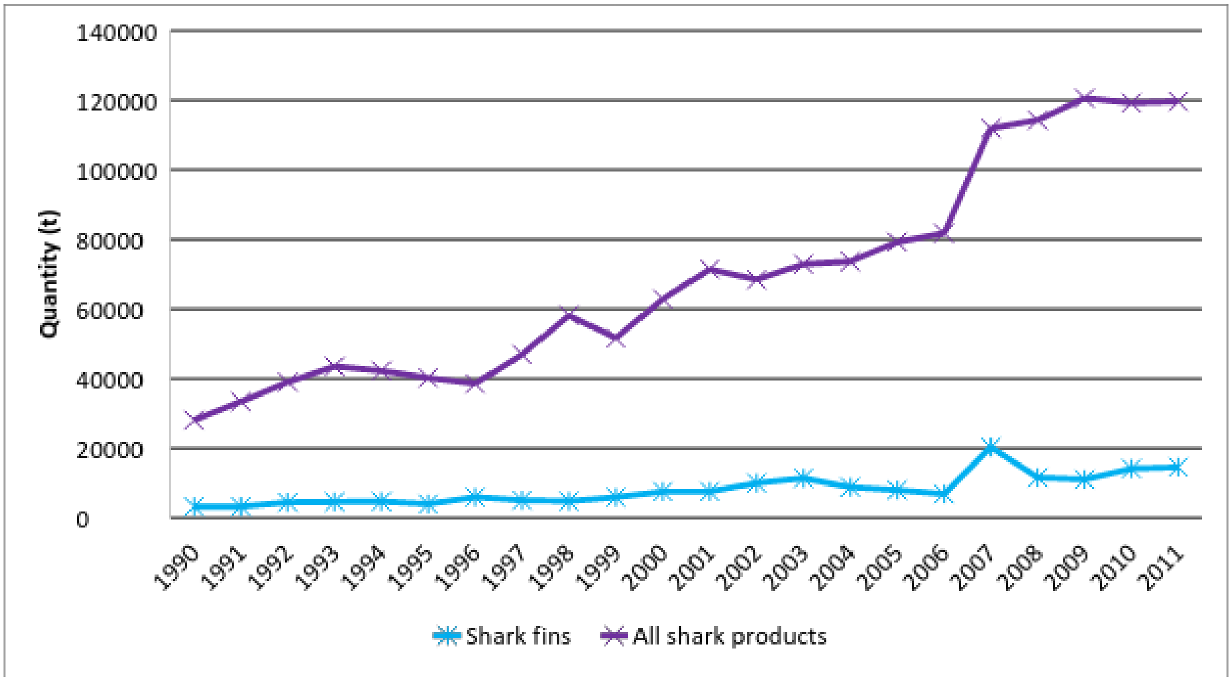

Figure 61 Global exports of shark products from 1990-2011, as reported in the FAO Fishery Commodities and Trade Database. Shark fins include: shark fins dried, salted; shark fins dried, unsalted; shark fins in brine but not dried or smoked; shark fins frozen; and shark fins prepared or preserved. Shark products include: all shark fins (described above); sharks nei, frozen; sharks, rays nei, frozen; shark fillets nei. frozen; sharks, rays, chimaeras nei fillets, frozen; sharks nei, fresh or chilled; sharks rays, skates, fresh or chilled; shark fillets, fresh or chilled; sharks, rays, chimaeras fillets, fresh or chilled; sharks, dried, salted or in brine; sharks, rays, etc., dried, salted or in brine; shark oil; shark liver oil ("nei" = not elsewhere included).

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 preferred species for their fins and obtain a high price in the international market. 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 a main economic driver for 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, existing fishing pressure will not (Dent and Clarke 2015). However, given that oceanic whitetip shark 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 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 Eastern Pacific, 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%. However, the reliability of these estimates may be somewhat uncertain as they are derived from nominal catch rates and are not standardized to account for other factors that may affect catch rates not related to changes in abundance (e.g., climate related factors). Nonetheless, based on the known condition of the species, there is no evidence to suggest that other factors besides overutilization have caused the significant observed decline, as the species has seemingly disappeared from fishing grounds here and 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 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 4% since 1992. However, fishing pressure on oceanic whitetip sharks began over two decades prior to the start of this time series; thus the estimated declines are not from historical virgin 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. Therefore, 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 Western and Central Pacific, 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%. In particular, the first and only stock assessment of oceanic whitetip shark determined that the species is experiencing overfishing and the stock is in an overfished state (Rice and Harley 2012). 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 shark 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, combined with their relatively low-moderate productivity, it is likely that the impact to oceanic whitetip is significant in the Indian Ocean.

Shark trade

Studies found that oceanic whitetip shark represents approximately 2% of the Hong Kong shark-fin market, which has been used as an indicator of the global trade for many years. 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 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 monetary value in the Hong Kong market. This is evidenced by the fact that as recently as October 2015, Indonesian authorities conducted a seizure of 3,000 illegal fins from oceanic whitetip sharks taken from Indonesian waters, despite national and international regulations to protect the species. Additionally, since 2014, several shipments of oceanic whitetip 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[11]. 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 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 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 numerous regulatory mechanisms that may impact the status of sharks in general, as well as

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

species-specific regulations for oceanic whitetip 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 Magnuson-Stevens Act 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*. The 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 Western and Central Pacific Ocean 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. To aid in enforcement and reduce confusion among fishers, the Atlantic States Marine Fisheries Commission (ASMFC), which regulates fisheries in state waters from Maine to Florida, implemented a Coastal Shark FMP that mostly mirrors the federal regulations for sharks (See Appendix 1). 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 Magnuson-Stevens Act, 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 recently proposed to allow federally-permitted U.S. longline vessels 50 ft and longer to fish in certain portions of the LVPA (80 FR 51527). Specifically, the proposed action would allow 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 higher at-vessel survivorship of oceanic whitetip sharks, adequate implementation of these regulations has the potential to be beneficial for the species. 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 Magnuson-Stevens Act 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 fishers, 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[12] 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 all 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[13] (71 FR 58058, NMFS 2006). Since 2006, this FMP has been amended ten times. 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 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 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

---

[12] http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/index.html

[13] http://www.fisheries.noaa.gov/sfa/hms/documents/fmp/consolidated/index.html

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 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 ◦ 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 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 62 below).

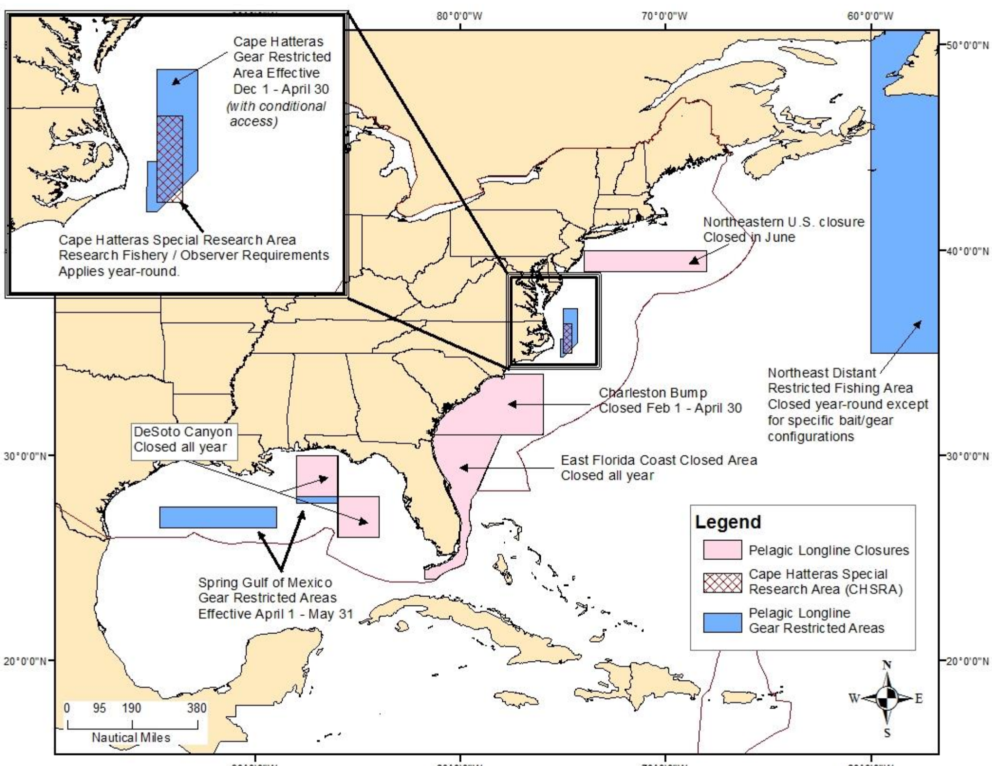

Figure 62 Time/area closures and gear restricted areas in the Atlantic, Gulf of Mexico, and Caribbean Sea that limit use of pelagic longline gear (NMFS 2016).

Although there has been so 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 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 all; and may not be held in combination with any other Atlantic HMS vessel permits. However, at this time, fishermen who hold the CCSB permit are prohibited from retaining Atlantic sharks, and 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 International Commission for the Conservation of Atlantic Tuna (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 in this region despite its prohibited status in ICCAT associated fisheries (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, an analysis of the 2005-2009 HMS logbook data indicated that, on average, a total of 50 oceanic whitetip sharks were kept per year, with an additional 147 oceanic whitetip sharks caught per year and subsequently discarded (133 released alive and 14 discarded dead). Thus, without the prohibition, approximately 197 oceanic whitetip sharks could be caught and 64 oceanic whitetip sharks (32%) could die from being discarded dead or retained each year (NMFS 2011b). However, since the prohibition was implemented in 2011, estimated commercial landings of oceanic whitetip declined from only 1.1 mt in 2011 to only 0.03 mt in 2013 (NMFS 2012;

2014). While the retention ban for oceanic whitetip does not prevent incidental catch or subsequent at-vessel and post-release mortality, it is likely somewhat effective in reducing overall fishing mortality on the species in the Atlantic PLL fishery. In fact, in 2013, NMFS reported a total of 33 oceanic whitetip interactions, with 88% (i.e., 29 individuals) released alive and only 4 discarded dead. It also appears that the relative abundance of oceanic whitetip shark may have stabilized in the region concomitant with pelagic shark management in the early 1990s.

Overall, it's possible 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 ERA team's analysis of observer data from the fishery, but there's no way to confirm this assertion. Overall, we do agree that 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 regulations 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 Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) 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 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 (Figure 63), which was expected. With the passage of the U.S. Shark Conservation Act in 2011, exports of dried shark fins dropped again by 58% to 15 mt, which represented the second lowest export amount since 2001. This is in contrast to the price per kg of shark fin, which was at its highest price of ~$100/kg, and suggests that existing regulations have likely been effective at discouraging fishing for sharks solely for the purpose of the fin trade. Thus, although the international shark fin trade is likely a driving force behind the overutilization of many global shark species, the U.S. participation in this trade appears to be diminishing (Miller *et al.* 2014). In 2012, the value of fins also decreased suggesting that the worldwide demand for fins may be on a decline. 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).

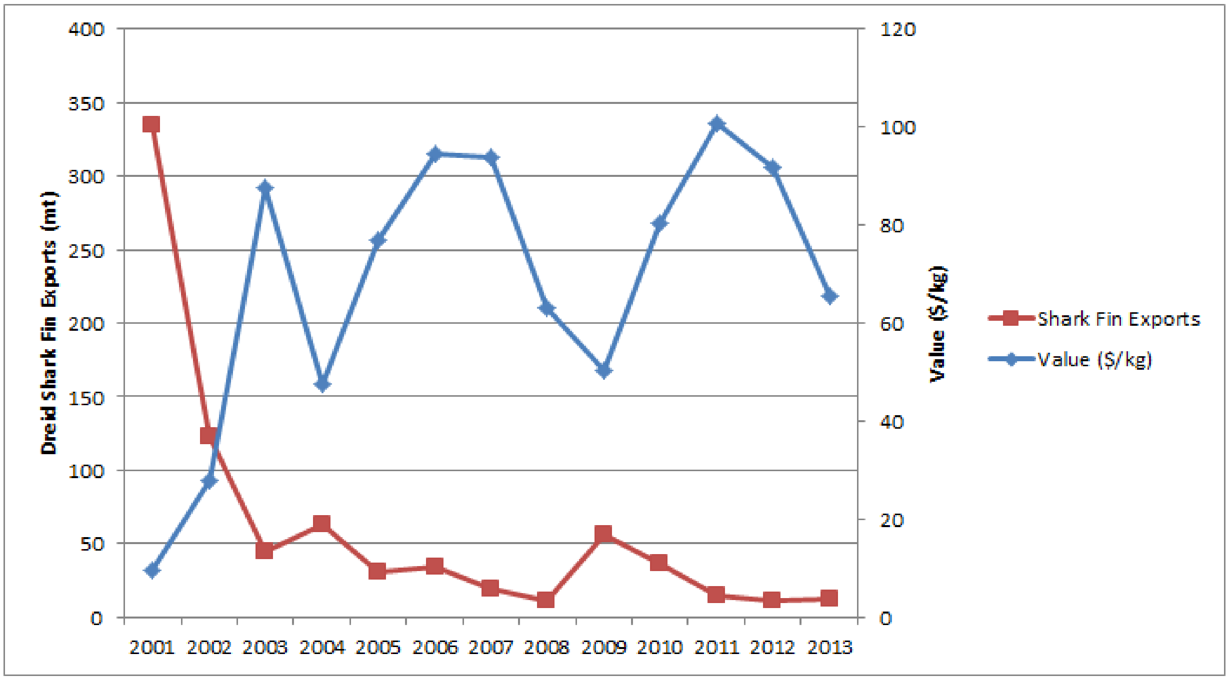

Figure 63 Amount and value of U.S. shark fin exports from 2001 to 2012. Source: Adapted from Miller *et al.* 2014 and NMFS (2012); NMFS (2013a)).

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 led to a subsequent decline of 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 the state in 2000, the shark fin imports from the U.S. into Hong Kong declined significantly (54% decrease, from 374 to 171 t) as Hawaii could no longer be used as a fin trading center for the international fisheries operating and finning in the Central Pacific (Figure 64) (Clarke *et al.*, 2007).

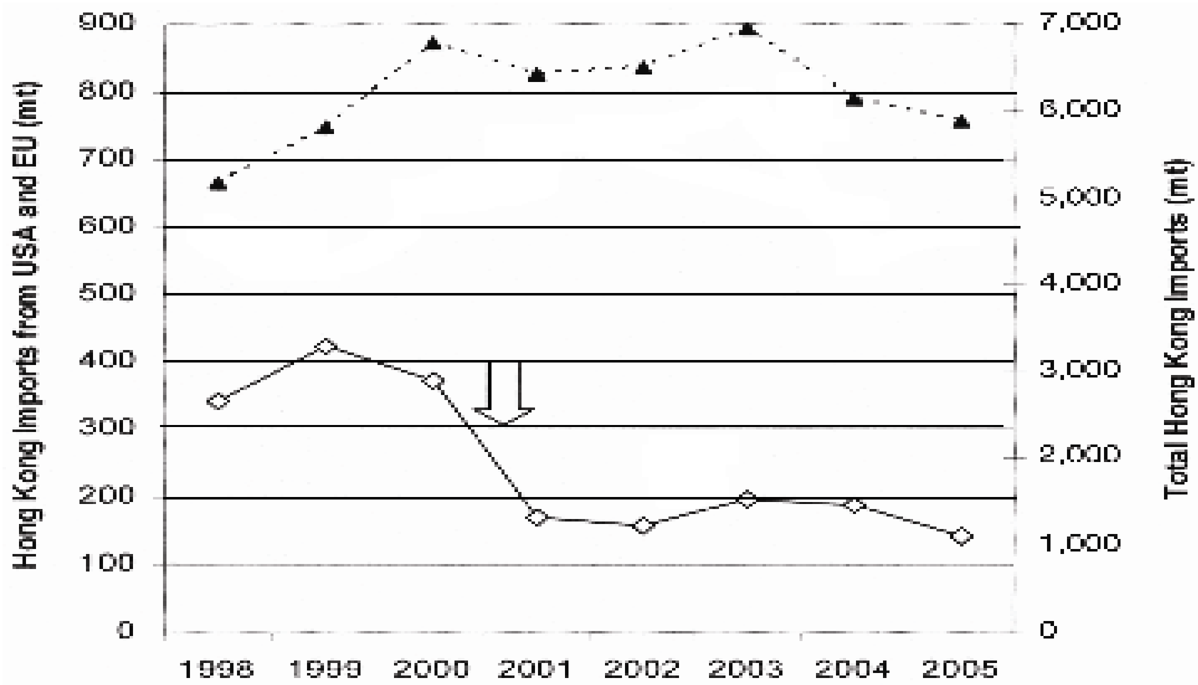

Figure 64 Annual imports of shark fin to Hong Kong from the U.S. (◊) and total Hong Kong imports (▲) from 1998-2005. The large arrow indicates the implementation of finning regulations in the state of Hawaii. Source: Adapted from Clarke *et al.* 2007.

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 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, with compliance likely variable among other countries and regions. In other parts of the world, finning and retention bans may not be adequate for oceanic whitetip 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 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)[14]

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

CITES is an international agreement between governments, 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 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 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 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 fins from most RFMO member countries should not be occurring. However, recent data from Hong Kong's Agriculture Fisheries Conservation Department (AFCD) suggests this is not the case. Since the listing of oceanic whitetip sharks under CITES Appendix II went into effect in 2014, approximately 1,263 kg (2,784 lbs) of oceanic whitetip fins have been confiscated upon entry into Hong Kong because the country of origin did not include the required CITES permits. Since 2014, confiscated oceanic whitetip fin shipments included 940.46 kg from Colombia, 10.96 kg from the Seychelles, and 272.49 kg from the United Arab Emirates (AFCD, Unpublished data). Additionally, 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[15].

Convention on the Conservation of Migratory Species of Wild Animals[16]

The Convention of Migratory Species (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. However, despite being a highly migratory species in need of international cooperation for its management and conservation, the oceanic whitetip shark is not listed under the Convention.

2009 FAO Port State Measures Agreement (PSMA)

The PSMA was adopted in 2009 as a tool to combat illegal, unreported and unregulated (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

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

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

for port entry, countries will conduct regular inspections in accordance 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 European Union (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.

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 Colombia: Abbotsford, Coquitlam, Nanaimo, Port Moody, North Vancouver, and Maple Ridge, have all passed bans on the sale of shark fins.
- CNMI
- American Samoa
- Cook Islands
- Egypt
- French Polynesia
- Guam (with an exception for subsistence fishing)
- Republic of the Marshall Islands
- Sabah, Malaysia

FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-SHARKS)

Developed in 1998, IPOA-SHARKS aims to ensure the conservation and management of sharks and their long-term sustainable use. Consequently, the FAO recommends that RFMOs carry out regular shark population assessments and that member States cooperate on joint and regional shark management plans, and develop National Plans of Action for sharks (NPOA-Sharks). The FAO reports on implementation of the IPOA-Sharks at each meeting of its Committee on Fisheries. In 2009 and 2011, significant implementation progress of the IPOA-Sharks was observed, indicating that international attention given to conservation and management of sharks positively influenced the motivation of governments to take action (Fischer *et al*. 2012). The most recent comprehensive review of implementation progress was conducted in 2012. Overall, 143 countries, areas, territories and entities report shark catches to FAO; however the 2012 review focused on the top 26 shark catching nations, as they represent approximately 84% of the global shark catches reported to the FAO from 2000-2009[17]. The development of NPOAs provides some indication of the level of commitment of a catching country to manage its shark fisheries; of the 26 key shark catching countries in the world, 18 are known to have developed NPOA-Sharks, and an additional five are in the process of adopting or developing such a plan (three[18] have completed a draft NPOA that is awaiting adoption by parliament and two[19] have initiated drafting of their NPOA). However, three countries (12% of the top shark fishing countries, areas and territories) have not yet addressed an NPOA-Sharks (Fischer *et al*. 2012). See Appendix 5 for a table that describes the current status of development of NPOAs by the top 26 shark-catching countries and territories.

Despite the improvements in development and implementation of IPOA-Sharks in recent years, successful implementation of these plans continues to be hampered by a number of problems and issues. Because of slow progress in the initial implementation of IPOA-Sharks among member countries, the FAO convened an Expert Consultation on the Implementation of the IPOA-Sharks

[17] http://www.fao.org/fishery/topic/18123/en

[18] Brazil, Peru and Thailand

[19] India and Sri Lanka

in 2005, which focused on the challenges encountered by FAO Members with regard to the conservation and management of sharks. According to Fischer *et al*. (2012), nine areas of particular concern were identified by the Expert Consultation, including:

- lack of appropriate taxonomic guides to identify species;
- lack or insufficient information on the population biology of elasmobranch species, both targeted and bycatch species;
- lack of funds for management;
- lack of human resources;
- competition from other management imperatives;
- lack of effective policy and institutional practices;
- scarce or lacking data, particularly for catch and fishing effort, to inform management decision making;
- weak or non-existent capacity of many developing countries; and
- low political priority for elasmobranch fisheries.

Despite progress achieved since 2005, the main findings of the Expert Consultation were still valid as of 2012, evidenced by pertinent issues raised by respondents in the most recent IPOA-Sharks implementation review questionnaire (Fischer *et al.*, 2012). Overall, the majority of problems encountered regarding conservation and management of sharks were related to problems with fisheries management in general (e.g., institutional weaknesses, lack of trained personnel, inadequate fisheries research, and inadequate monitoring, control and surveillance (MCS)). Further, inadequate data pertaining to shark biological characteristics and fisheries were noted by almost half of the respondents, particularly in developing countries. In addition, many countries need more trained officers for fisheries monitoring and control, and, in some countries, there is also a need for institutional strengthening. In addition, many of the top shark-fishing countries, areas and territories also have difficulties with shark species identification, which considerably affects the reporting of shark catches and discards (Fischer *et al*. 2012). Finally, the quality of the existing NPOA-Sharks varies, and there are no reporting mechanisms on implementation of the NPOAs; thus, it remains uncertain whether a particular plan is being implemented or what impact the plan has had on conservation and management of sharks. Further, while the IPOA-Sharks indicates that NPOAs should be reviewed every five years, and some NPOAs have now been in place for five years or longer, evaluations of progress and revised Plans are lacking (Lack and Sant 2009), though a few revised Plans have been submitted (see Appendix 5 for more details).

Regional Analysis

Pacific

In the Eastern Pacific, the IATTC is the RFMO responsible for the conservation and management of tuna and tuna-like species. As noted previously, the IATTC has passed a no-retention measure for oceanic whitetip sharks by implementing Resolution C-11-10 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 status review, this measure is not likely adequate to prevent capture and mortality in one of the main fisheries that catches oceanic whitetip sharks in this region (i.e., the tropical tuna purse seine fishery). Though mortality rates of oceanic whitetip in purse seine fisheries are not available, it is likely that oceanic whitetip sharks experience high mortality rates similar to congener *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)) during and after interactions with purse seine fisheries. Given that they are captured in a net 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. In fact, when oceanic whitetip sharks are released alive in the fishery, they are considered to be dead by the IATTC observer program because there is no evidence of post-release survival (Martín Hall, Pers. Comm. 2016). Some of these issues (i.e., the high level of stress that oceanic whitetip sharks experience when caught in purse seine nets) may be addressed by the 2016 Resolution C-16-05 for the Management of Shark Species. This Resolution will require 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. Considering safety precautions, 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. However, Resolution C-16-05 does not come into force until January 2018. Additionally, given the depleted status of the population in this region, it is unclear as to how effective these measures will be.

In the Western and Central Pacific, 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. Clarke (2013) attributes this ineffectiveness to a lack of outcome-focused objectives of the CMM requirements, resulting in increased difficulty and challenges associated with verifying compliance and data monitoring and review. 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 is. Clarke (2013) reviewed the potential efficacy of the oceanic whitetip retention prohibition measure as follows:

> "With regard to the expected effectiveness of the no-retention measure for oceanic whitetip sharks, a previous analysis of longline observer data from 1995-2010 suggested that without a no-retention measure the mortality rate for oceanic whitetip shark catches would be 87%. Assuming full implementation of no-retention and prompt release

unharmed requirements for this species the mortality rate was estimated to fall to 31%[20] (Clarke 2011). The recent oceanic whitetip shark stock assessment found that overfishing is occurring (Fcurrent/FMSY = 6.5) and the stock is in an overfished state (SBcurrent/SBMSY = 0.153). Given the severely depleted state of the oceanic whitetip shark population, even if no-retention measures reduced mortality by more than 50% (i.e. from 87% to 31%), it is not clear how quickly and to what extent these conditions would allow the oceanic whitetip shark population to recover because model projections were not conducted (Rice and Harley 2012). Compounding this uncertainty, less-than-full implementation will erode the benefits of any mitigation measure."

Additionally, and as previously noted, finning bans and ratios do not address incidental catch of oceanic whitetip sharks and the subsequent mortality that may result after release; thus, these management measures may not necessarily prevent mortality of oceanic whitetip sharks. Although it is possible that a reduction in finning would coincide with an increase in the percentage of sharks released alive, this is not necessarily the case. In a study of longline fisheries of the Western and Central Pacific, Rice *et al*. (2015) showed a reduction in the percentage of key shark species that were finned from 2010-2013, with the last year of the study showing an increase in finning and a decrease in the number of sharks retained. The reduction in finning from 2010-2013 paralleled a rise in retention, which would be expected if fishers were beginning to retain the carcass to comply with CMM 2010-07 (the 5% fin to carcass rule; Rice *et al*. 2015). However, this could also be due to the growing demand for meat and a waning interest in shark fins, as discussed earlier (see Dent and Clarke (2015) and Eriksson and Clarke (2015) for more details). With respect to oceanic whitetip sharks, Rice *et al*. (2015) concluded that observations of the species in the longline fishery have generally indicated a reduction in the proportion finned since the mid-2000s (See Figure 66 below). For example, data collected by on-board observers from the Fijan longline fishery show that even though the fishery has not fully complied with the measure, a clear improvement was detected from 2011 to 2014; the percentage of oceanic whitetips released alive increased from 0% in 2011 to 63% in 2014 (See Figure 65 below). Also, while 100% of oceanic whitetips were finned in 2011 and 2012, and 60% were finned in 2013, only 3% were finned in 2014 (Piovano and Gilman 2016), though there is no information regarding how many of these sharks survived after their release.

[20] This lower estimate assumes that mortality only occurs during haulback, not during handling. Any rough handling, e.g. to retrieve the terminal tackle, would tend to increase the mortality rate (Clarke 2013).

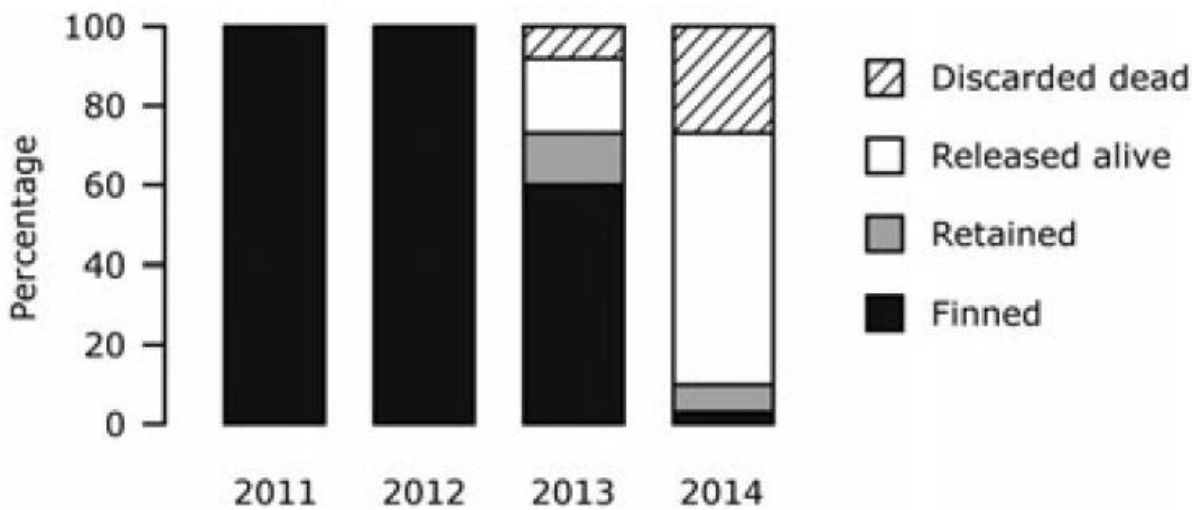

Figure 65 Fate of oceanic whitetip sharks after capture in the longline gear (expressed as percentage per year, N = 109). Source: Poviano and Gilman 2016.

However, in the first year of the CMM (2013) proportionally more oceanic whitetip sharks were retained and, with respect to CMM 2011-04, observations from the longline fishery have shown that the CMM is not being strictly adhered to, with non-negligible proportions of oceanic whitetips retained or finned. More oceanic whitetip sharks were retained in 2013 (the first year of the CMM) both in numbers and proportionally than in 2012 in the longline fishery. Due to recent change 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 in recent years is complicated (Rice *et al*., 2015).

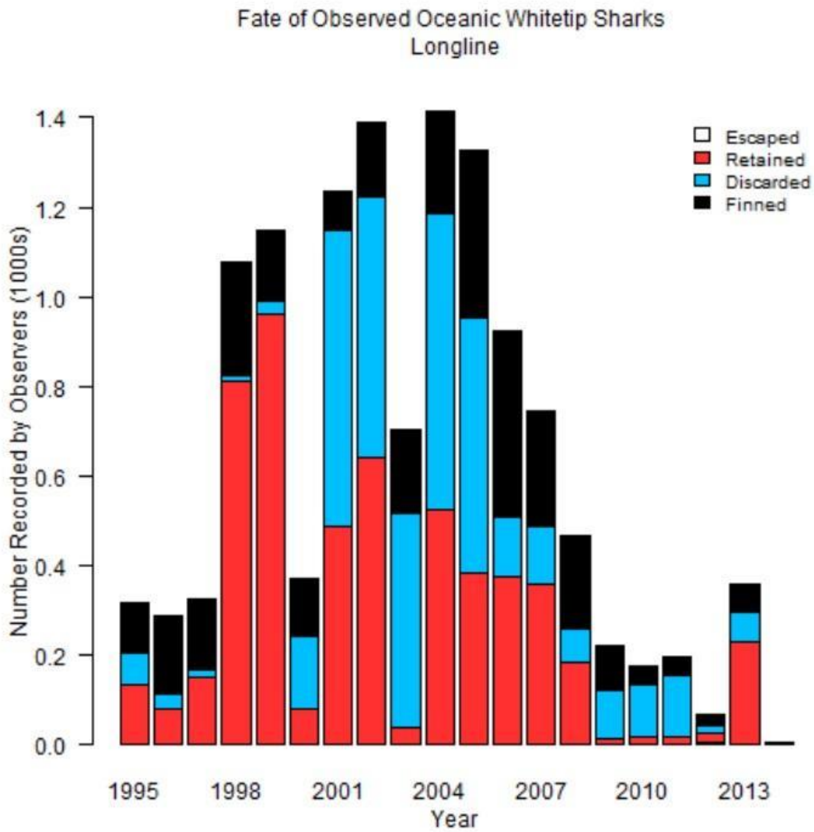

Figure 66 Fate of observed oceanic whitetip sharks caught by longline in the WCPO from 1995-2013. Source: Rice *et al.* 2015.

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 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 higher 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 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. However, while it is predicated that oceanic whitetip shark mortality may be reduced by up to 37% if both measures are used, this CMM allows flag-states to choose which fishing technique they exclude. 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 under CMM 2014-05 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. It is therefore unlikely that the options under CMM 2014-05 of either banning shark lines or wire traces will result in sufficient reductions in fishing mortality (Harley *et al.*, 2015). 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

Oceanic whitetip catches have been reported by ICCAT vessels since the 1980s by the United States, but not by other countries 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 higher at-vessel survivorship 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 46, 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. In Brazil, which is one of the top 26 shark-catching countries in the world and the largest oceanic whitetip catching country in the region, the significant decline in reported catches by the Brazilian fleet (as discussed in the *Overutilization* section of this status review) occurred prior to any management recommendations by ICCAT to prohibit retention of oceanic whitetip sharks in ICCAT-associated fisheries. In any case, despite the retention prohibition, Brazil reported 6 mt of oceanic whitetip in 2014, which indicates the species is still being caught and continues to experience fisheries-related mortality in this portion of its range. In addition to ICCAT regulations, sharks in Brazil must be landed with corresponding fins and a 5% fin-carcass weight ratio is required. In addition, all carcasses and fins must be unloaded and weighed and the weights reported to authorities. Pelagic gillnets and trawls are prohibited in waters less than 3 nmi (5.6 km) from the coast; however, given that the oceanic whitetip is pelagic species, a gillnet ban within 3 nmi of the coast is not likely going to be beneficial. Further, implementation and enforcement of these regulations have been noted as difficult and likely poor (Chiaramonte and Vooren 2007).

In December, 2014, the Brazilian Government's Chico Mendes Institute for Biodiversity Conservation approved the NPOA for the Conservation of Elasmobranchs of Brazil (No 125). However, this plan will not be fully implemented for another five years. In addition, this plan focuses on 12 priority species and does not include specific regulations to manage or protect the oceanic whitetip shark, despite the declining population off Brazil's coast. 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 "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 cancelled, 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). 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). 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 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 05/05, 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 encourages 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. 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 2014, only 12 of the 35 CPCs had developed NPOAs for sharks (IOTC 2014).

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. This latter vessel 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. Thus, it appears that the retention ban of oceanic whitetip in the Indian Ocean is limited in scope relative to other RFMO no-retention measures, and only partially protective depending on whether the measure is adequately implemented and enforced. Finally, as an interim pilot measure, it is highly uncertain as to whether this measure will be ongoing into the foreseeable future.

In Indonesia, which is the top shark fishing nation in the world, 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. In fact, 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 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)[21].

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, unregulated and unreported (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 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)

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

and an estimated value of $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 $10 billion and $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). 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)[22]. 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 US $72,000 in Indonesia, but would reportedly earn several times that amount in Hong Kong (South China Morning Post, 2015)[23]. In February 2013, oceanic whitetip fins were found in a large seizure of fins from a Taiwanese vessel fishing in the Marshall Islands[24]. 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)[25]. Recreational fishermen 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[26]. While these reports provide just a few examples of recent illegal fishing activities, more evidence and additional reports of specific IUU fishing activities throughout the world can be found in Miller *et al.,* (2014).

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 some improvement in combatting IUU fishing. In the most recent 2015 Biennial Report to Congress, which highlights U.S. findings and analyses of foreign IUU fishing activities, NMFS reports that all 10 nations that were previously identified in the 2013 Biennial Report for IUU activities took appropriate actions to address the violations (e.g., through adoption of new laws and regulations or by amending existing ones, sanctioning vessels, and improving monitoring

---

[22] http://www.ticotimes.net/2014/11/25/illegal-shark-fins-destined-for-hong-kong-seized-at-costa-rica-airport#comments-53192
[23] http://www.scmp.com/news/asia/southeast-asia/article/1864948/indonesia-seizes-3000-shark-fins-destined-hong-kong
[24] http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11119560
[25] http://www.msn.com/en-us/news/world/taiwan-boat-caught-with-huge-illegal-shark-fin-haul/ar-AAeuKhd
[26] http://www.abc.net.au/news/2015-06-12/fishers-caught-with-shark-fin/6541278

and enforcement) (NMFS 2015). In the current report, 6 countries were identified for having vessels engaged in IUU fishing activities; however, no countries were identified for engaging in protected living marine resources bycatch or for catching sharks on the high seas (although NMFS caveats this by noting the inability to identify nations due primarily to the restrictive time frames and other limitations in the statute) (NMFS 2015).

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, if adequately implemented and enforced, could reduce the overall bycatch mortality of oceanic whitetip 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 several times, no-retention measures do not entirely mitigate for any potential post-release mortality that may occur. Thus, these measures may only be partially effective. As an additional caveat, the rarity of a particular species could be capitalized upon. Due to their large rounded shape and distinctive white markings, the fins of the oceanic whitetip shark are among the easiest to identify (Clarke *et al.*, 2006a); this means its vulnerability could increase to dangerous levels should their rarity become an attractive quality (Tolotti *et al*., 2015c). Additionally, in light of the numerous conservation regulations set forth for this species of late, awareness regarding its threatened status has clearly increased. Although future scenarios are difficult to predict and highly uncertain, it seems that many of the rarity-associated black market factors described above are possible for the oceanic whitetip, especially given the global ban on its retention in pelagic fisheries under tuna RFMO management (Tolotti *et al.*, 2015c). 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 whitetips 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 after the shark is released.

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 *C. longimanus* fins is evident by the recent incidents of illegal finning and trafficking of oceanic whitetip in places like Indonesia and Costa Rica. 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 are seemingly adequate in achieving their intended purpose, with the Northwest Atlantic population of oceanic whitetip 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 environmental pollutants and toxins and their potential impacts to oceanic whitetip sharks.

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 brevotoxins, 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 species, 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 species, 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 that 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, although 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, the effects of these pollutants in oceanic whitetip shark populations and potential risk to the viability of the species remain unknown. In fact, there is no information on the lethal concentration limits of toxins or metals in oceanic whitetip sharks or evidence to suggest that current concentrations of environmental pollutants are causing detrimental physiological effects to the point where the species may be at an increased risk of extinction. As such, the best available information does not indicate that the present bioaccumulation rates and concentrations of environmental pollutants in the tissues of oceanic whitetip sharks are significant threats to the species, such that it substantially increases the species' risk of extinction throughout its global range.

5. EXTINCTION RISK ANLAYSIS

5.1 Introduction

The Endangered Species Act (ESA) (Section 3) defines endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range." Threatened species is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Neither the National Marine Fisheries Service (NMFS) nor the U.S. Fish and Wildlife Service (USFWS) have developed any formal policy guidance about how to interpret the definitions of threatened or endangered species in the ESA. In many previous NMFS status reviews, a team has been convened, often referred to as a "Biological Review Team," in order to compile the best available information on the species and conduct a risk assessment through evaluation of the demographic risks, threats, and extinction risk facing the species or distinct population segment (DPS). This information is ultimately used by the NMFS Office of Protected Resources, after consideration of the legal and policy dimensions of the ESA standards and benefits of ongoing conservation efforts, to make a listing determination. For purposes of this risk assessment, an Extinction Risk Analysis (ERA) team, comprised of fishery biologists, managers, and shark experts, was convened to review the best available information in this Status Review document and evaluate the overall risk of extinction facing the oceanic whitetip shark.

5.2 Distinct Population Segments

Criteria for Identification of Distinct Population Segments

Under the ESA, a listing determination may address a "species," which is defined to also include subspecies and, for any vertebrate species, any DPS that interbreeds when mature (16 U.S.C. 1532(16)). The joint policy of the USFWS and NMFS provides guidelines for defining DPSs below the taxonomic level of species (61 FR 4722; February 7, 1996). The policy identifies two elements to consider in a decision regarding whether a population qualifies as a DPS: discreteness and significance of the population segment to the species.

<u>Discreteness</u>
A DPS may be considered discrete if it is markedly separate from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors, or if it is delimited by international governmental boundaries. Genetic differences between the population segments being considered may be used to evaluate discreteness.

<u>Significance</u>
If a population segment is considered discrete, its biological and ecological significance must then be evaluated. Significance is evaluated in terms of the importance of the population segment to the overall welfare of the species. Some of the considerations that can be used to determine a discrete population segment's significance to the taxon as a whole include:

1) Persistence of the population segment in an unusual or unique ecological setting;
2) Evidence that loss of the population segment would result in a significant gap in the range of the taxon; and
3) Evidence that the population segment differs markedly from other populations of the

species in its genetic characteristics.

However, NMFS determined at the 90-day finding stage that the petition to list the oceanic whitetip shark was warranted for the global species. As such, we (the ERA team) conducted the extinction risk analysis on the global oceanic whitetip shark population.

5.3 Extinction Risk Analysis

The ability to measure or document risk factors to a marine species is often limited, where quantitative estimates of abundance and life history information are often lacking altogether. Therefore, in assessing extinction risk of a data limited species, it is important to include both qualitative and quantitative information. In previous NMFS status reviews, Biological Review Teams have used a risk matrix method to organize and summarize the professional judgment of a panel of knowledgeable scientists. This approach is described in detail by Wainright and Kope (1999) and has been used in Pacific salmonid status reviews as well as in reviews of Pacific hake, walleye pollock, Pacific cod, Puget Sound rockfishes, Pacific herring, and black abalone (see http://www.nmfs.noaa.gov/pr/species/ for links to these reviews). In the risk matrix approach, the condition of the species is summarized according to four demographic risk criteria: abundance, growth rate/productivity, spatial structure/connectivity, and diversity. These viability criteria, outlined in McElhany *et al*. (2000), reflect concepts that are well-founded in conservation biology and that individually and collectively provide strong indicators of extinction risk. Using these concepts, the ERA team estimated the extinction risk of the oceanic whitetip shark after conducting a demographic risk analysis. Likewise, the ERA team performed a threats assessment for the species by scoring the severity of current threats to the species and their impact on the species through the foreseeable future. The summary of the demographic risks and threats obtained by this approach was then considered by the ERA team in determining the species' overall level of extinction risk. Specifics on each analysis for the species are provided below.

Foreseeable future – ERA team discussion

For the purpose of this extinction risk analysis, the term "Foreseeable future" was defined as the timeframe over which threats can be predicted reliably to impact the biological status of the species. In determining an appropriate "foreseeable future" timeframe, we first considered the life history of the oceanic whitetip shark. The most recent longevity estimate for the oceanic whitetip is approximately 20 years (Rodrigues *et al*. 2015). Generation time, which is defined as the time it takes, on average, for a sexually mature female oceanic whitetip shark to be replaced by offspring with the same spawning capacity, is estimated to be around 11 years (Smith *et al*. 2008). As a long-lived species that matures relatively late, has relatively slow growth rates and low to moderate productivity, it would likely take several generation times for any conservative management action to be realized and reflected in population abundance indices. Thus, we determined that 30 years would reflect the species' life history and encompass 3 generation times. We then discussed whether we could confidently predict the impact of threats on the species out to 30 years and agreed that since the main threats to the species were likely fisheries and the regulatory measures that manage these fisheries, we had the background knowledge and expertise to confidently predict the impact of these threats on the biological status of the species within this timeframe. For the foregoing reasons, we agreed that a biologically reasonable foreseeable future timeframe would be 30 years for the oceanic whitetip.

Methods

Demographic Risks Analysis

After reviewing all relevant biological and commercial information for the species, including: current abundance of the species in relation to historical abundance and trends in abundance based on indices such as catch statistics; the species growth rate and productivity in relation to other species and its potential effect on survival rates; its spatial and temporal distribution; natural and human-influenced factors that cause variability in survival and abundance; and possible threats to genetic integrity; each ERA team member assigned a risk score to each of the four demographic criteria (abundance, growth rate/productivity, spatial structure/connectivity, diversity). Risks for each demographic criterion were ranked on a scale of 0 (unknown risk) to 3 (high risk). Below are the definitions that the team used for each ranking:

> 0 = Unknown: The current level of information is either unavailable or unknown for this demographic factor, such that the contribution of this factor to the extinction risk of the species cannot be determined.
>
> 1 = Low risk: It is unlikely that the particular factor contributes or will contribute significantly to the species' risk of extinction.
>
> 2 = Moderate risk: It is likely that the particular factor contributes or will contribute significantly to the species' risk of extinction.
>
> 3 = High risk: It is highly likely that the particular factor contributes or will contribute significantly to the species' risk of extinction.

The team members were given a template to fill out and asked to rank the risk of each demographic factor. After scores were provided, the team discussed the range of perspectives for each of the demographic risks and the supporting data on which they were based, and was given the opportunity to revise scores if desired after the discussion. The scores were reviewed by the ERA team and considered in making the overall risk determination, which is presented at the end of this section. Although this process helps to integrate and summarize a large amount of diverse information, there is no simple way to translate the risk matrix scores directly into a determination of overall extinction risk. Thus, it should be emphasized that this exercise was used simply as a tool to help the ERA team members organize the information and assist in their thought processes for determining overall risk of extinction for the species. Other descriptive statistics, such as mean, variance, and standard deviation, were not calculated as the ERA team felt these metrics would add artificial precision or accuracy to the results.

Table 3 Template for the Demographics Risk Analysis Worksheet used in ERA team deliberations. The matrix is divided into four sections that correspond to the parameters for assessing population viability (McElhany *et al.* 2000).

Name	*Abundance*	Notes	*Growth/ Productivity*	Notes	*Spatial Structure/ Connectivity*	Notes	*Diversity*	Notes

<u>Threats Assessment</u>

Section 4(a)(1) of the ESA requires the agency to determine whether the species is endangered or threatened because of any of the following factors:

1) destruction or modification of habitat;
2) overutilization for commercial, recreational, scientific, or educational purposes;
3) disease or predation;
4) inadequacy of existing regulatory mechanisms; or
5) other natural or human factors

Similar to the demographics risk analysis, the ERA team members were given a template to fill out and asked first to determine the relative importance of each identified potential threat in terms of whether that threat rose to the level of having any impact on the extinction risk of the species. Below are the relative importance levels of the threats.

0 = It is unknown whether this is a threat to the species
1 = It is unlikely that this is a threat to the species
2 = It is likely that this is a threat to the species
3 = It is highly likely that this is a threat to the species

The ERA team members were then asked to rank each threat in terms of the magnitude of impact each threat has on the extinction risk of the species. Below are the specific definitions of the threat effect levels:

0 = Unknown: The current level of information is either unavailable or unknown for this particular threat, such that the contribution of this threat to the extinction risk of the species cannot be determined.
1 = Low: It is unlikely that this factor contributes significantly to risk of extinction.
2 = Moderate: This factor contributes significantly to long-term risk of extinction, but does not in itself constitute a danger of extinction in the near future.
3 = High: This factor contributes significantly to long-term risk of extinction and is likely to significantly contribute to short-term risk of extinction.

After scores were provided, the team discussed the range of perspectives for each of the threats, and the supporting data on which they were based, and was given the opportunity to revise scores if desired after the discussion. The scores were then reviewed by the ERA team and considered in making the overall risk determination that is presented at the end of this section. Again, it should be emphasized that this exercise was used simply as a tool to help the ERA team members organize the information and assist in their thought processes for determining the overall risk of extinction for the oceanic whitetip shark.

Table 4 Template for the threats assessment used in ERA team deliberations.

ESA Factor 4(a)	Threat	Relative importance of threat	Likelihood of impact on trajectory of species	Rationale
Habitat destruction, modification or curtailment	Loss or degradation of habitat			
Overutilization	Bycatch (incl. at-vessel and post-release mortality) Shark trade			
Disease, predation				
Inadequacy of existing regulatory mechanisms	Current regulations			
Other natural or manmade factors	Climate change			

Overall Level of Extinction Risk Analysis

Guided by the results from the demographics risk analyses as well as the threats assessments, the ERA team members used their informed professional judgment to make an overall extinction risk determination for both species. For these analyses, the ERA team defined three levels of extinction risk:

> 1 = Low risk: A species or DPS is at low risk of extinction if it is not at moderate or high level of extinction risk (see "Moderate risk" and "High risk" above). A species or DPS may be at low risk of extinction if it is not facing threats that result in declining trends in abundance, productivity, spatial structure, or diversity. A species or DPS at low risk of extinction is likely to show stable or increasing trends in abundance and productivity with connected, diverse populations.
>
> 2 = Moderate risk: A species or DPS is at moderate risk of extinction if it is on a trajectory that puts it at a high level of extinction risk in the foreseeable future (see description of "High risk" above). A species or DPS may be at moderate risk of extinction due to projected threats or declining trends in abundance, productivity, spatial structure, or diversity. The appropriate time horizon for evaluating whether a species or DPS is more likely than not to be at high risk in the foreseeable future depends on various case- and species-specific factors.
>
> 3 = High risk: A species or DPS with a high risk of extinction is at or near a level of abundance, productivity, spatial structure, and/or diversity that places its continued persistence in question. The demographics of a species or DPS at such a high level of risk may be highly uncertain and strongly influenced by stochastic or depensatory processes. Similarly, a species or DPS may be at high risk of extinction if it faces clear and present threats (e.g., confinement to a small geographic area; imminent destruction, modification, or curtailment of its habitat; or disease epidemic) that are likely to create present and substantial demographic risks.

To allow individuals to express uncertainty in determining the overall level of extinction risk facing the oceanic whitetip, the ERA team adopted the "likelihood point" (FEMAT) method (see Table 3 below for template). This approach has been used in previous status reviews (e.g., Pacific salmon, Southern Resident Killer Whale, Puget Sound Rockfish, Pacific herring, and black abalone) to structure the team's thinking and express levels of uncertainty in assigning threat risk categories. For this approach, each team member distributed 10 'likelihood points' among the three extinction risk levels. After scores were provided, the team discussed the range of perspectives for the species, and the supporting data on which it was based, and was given the opportunity to revise scores if desired after the discussion.

Finally, the ERA team did not make recommendations as to whether the oceanic whitetip shark should be listed as threatened or endangered. Rather, the ERA team drew scientific conclusions about the overall risk of extinction faced by the species under present conditions and in the foreseeable future based on an evaluation of the species' demographic risks and assessment of threats.

Table 5 Template for the overall level of extinction risk analysis used in ERA team deliberations.

	1 = Low risk	2 = Moderate Risk	3= High Risk	Rationale
Number of likelihood points				

ERA Team's Extinction Risk Results and Conclusion for the Oceanic Whitetip Shark

Evaluation of Demographic Risks

Out of the four demographic factors analyzed in this ERA, we identified abundance as most concerning in terms of demographic risks that may contribute to the extinction risk of the oceanic whitetip shark. The other demographic factors, including growth rate/productivity, spatial structure/connectivity, and diversity also garnered some concern by the ERA team. Below is a brief discussion of the rationale for our ERA team's conclusions regarding the demographic risk assessment for the oceanic whitetip shark.

Abundance

While there is currently no reliable global population size estimate for the oceanic whitetip shark, the ERA team evaluated numerous sources of information, including the results of a recent stock assessment and several other abundance indices including: trends in occurrence and composition in fisheries catch data, CPUE, and biological indicators to assess current abundance and trends. The ERA team agreed that while the oceanic whitetip shark was historically one of the most abundant and ubiquitous shark species in tropical seas around the world, numerous lines of evidence suggest the species has not only undergone significant historical declines throughout its range, but likely continues to experience declines in abundance globally.

In the Eastern Pacific, oceanic whitetip sharks were historically the third most abundant shark species after blue sharks (*P. glauca*) and silky sharks (*C. falciformis*), and comprised approximately 20% of the total shark catch in the tropical tuna purse seine fishery. However, both nominal catches and encounters with oceanic whitetip sharks in all set types in the purse seine fishery have declined significantly since 1994. In fact, these declines are compatible with an 80-95% population decline compared to the late 1990s, and the species has virtually disappeared from the fishing grounds (Hall and Roman 2013). Similar levels of decline have also been observed throughout the Western and Central Pacific Ocean. Like the Eastern Pacific, the oceanic whitetip shark was once one of the most abundant pelagic shark species throughout the Western and Central Pacific Ocean, comprising up to 28% of the shark catch during the 1950s (Strasburg 1958). A recent stock assessment conducted in the Western and Central Pacific estimated an 86% decline in spawning biomass from 1995 to 2009, with total biomass reduced to just 6.6% of the theoretical equilibrium virgin biomass (Rice and Harley 2012). An updated assessment analyzing various abundance indices, including standardized CPUE, concluded that the oceanic whitetip shark continues to decline throughout the tropical waters of the Western and Central Pacific (Rice *et al*. 2015), indicating a severely depleted population of oceanic whitetip across the region with observations of the species becoming increasingly rare. Similar results were found in analyses of CPUE data from the Hawaii-based pelagic longline fishery, where oceanic whitetip shark showed a decline in relative abundance on the order of 90% (Clarke *et al.*, 2012; Brodziak *et al.*, 2013). An update of this time series conducted by the ERA team in this report indicates a relative stability in the population size at the post-decline depressed state with no signs of recovery. The ERA team agreed that the levels of significant population decline observed in these studies indicate that these declines are not just local or regional, but rather a Pacific-wide phenomenon, with no significant indication that these trends have reversed.

Similar levels of historical decline have been observed for oceanic whitetip sharks in the Atlantic Ocean. While there is some debate regarding the exact magnitude of decline in the Northwest Atlantic, the best available data indicates that the oceanic whitetip experienced a significant historical decline ranging from 50-88% (Baum *et al.*, 2003; Baum and Myers 2004; Cortés *et al.*, 2007). In order to discern the species' current abundance trend in this area, we conducted an analysis of the most recent observer data from the U.S. Northwest Atlantic Pelagic Longline Fishery from 1992-2015. We determined that the population experienced a small decline of 4% over the time series, with the overall trend indicative that the population may have stabilized. An earlier analysis of the same data series from 1992-2005 showed a 9% decline in abundance (Cortés *et al.*, 2007). Farther south, while robust abundance data is lacking in the South Atlantic, the best available information, including analyses of fisheries data from 1980-2011, indicate the oceanic whitetip shark has undergone at least an 85% decline (Santana *et al.*, 2004; ICMBio; Barreto *et al.*, 2015). In addition, demographic analyses from the largest oceanic whitetip shark catching country in the South Atlantic (i.e., Brazil) indicate declines similar to the Northwest Atlantic of 50-79% in recent decades, though some of this decline may be attributed to a shift in effort distribution to more temperate waters since 2006. Elsewhere across the South Atlantic, the oceanic whitetip shark appears to be relatively rare, with low patchy abundance. Overall, the ERA team determined that while the Northwest Atlantic population of oceanic whitetip shark has likely begun to stabilize, it is at a significantly diminished abundance. Elsewhere in the Atlantic, the ERA team agreed that declines of oceanic whitetip shark are likely ongoing, although we acknowledge some uncertainty regarding the available data from this region.

Abundance information from the Indian Ocean is relatively deficient and unreliable. However, 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). In addition, the IOTC reports that despite limited data, oceanic whitetip shark abundance has likely declined significantly over recent decades. Quantitative studies on various fisheries operating in the Indian Ocean indicate population declines ranging from 25-90%. Despite the varying magnitudes of reported declines, the ERA team agreed that given the high fishing pressure and catches of oceanic whitetip shark in the Indian Ocean (which are likely severely underreported), combined with the species' high at-vessel mortality rates in longlines in this area and the species' low-moderate productivity, it is likely that the species will continue to experience population declines in this region into the foreseeable future.

Overall, in areas where oceanic whitetip shark data are available, trends from throughout the species' global range show large historical declines in abundance (e.g., Eastern Pacific, Western and Central Pacific, Atlantic and Indian Oceans). Recent evidence suggests that most populations are still experiencing various levels of decline due to continued fishing pressure and associated mortality. The potential stabilization of the abundance trends at depleted levels seen in pelagic longline observer data from the Northwest Atlantic and Hawaiian pelagic longline fisheries represents a small contingent of the global population and has not shown any signs of recovery. Thus, the best available data included in this Status Review document suggest that the global population of oceanic whitetip continues to experience various levels of decline throughout the majority of its range.

Growth rate/productivity

The ERA team noted that this species has some life history parameters that are typically advantageous, and some that are likely detrimental to the species' resilience to excessive levels of exploitation. For example, in comparison to other shark species, the oceanic whitetip is relatively productive, with an intrinsic rate of population increase (*r*) of 0.121 per year (Cortés *et al*. 2012). The oceanic whitetip also ranked among the highest in productivity when compared with other pelagic shark species in terms of its pup production, rebound potential, potential for population increase, and for its stochastic growth rate (Chapple and Botsford 2013). However, although the oceanic whitetip shark has a relatively high productivity rate relative to other sharks, it is still considered low for a fish species (r <0.14). Additionally, the species has a fairly late age of maturity (~6-9 years for females depending on the location), has a lengthy gestation period of 9-12 months, and only produces an average of 5-6 pups every two years. Thus, while this species may generally be able to withstand low to moderate levels of exploitation, given the high level of fishing mortality this species has and continues to experience throughout the majority of its range, its life history characteristics may only provide the species with a limited ability to compensate. Therefore, based on the best available information, the ERA team concluded that these life history characteristics likely pose a risk to this species in combination with threats that reduce its abundance, such as overutilization.

Spatial structure/connectivity

The oceanic whitetip shark is a relatively widespread species that may be comprised of distinct stocks in the Pacific, Indian, and Atlantic oceans. The population exchange between these stocks is unknown; however, based on genetic information, telemetry data, and temperature preferences it is unlikely that there is much exchange between populations in the Atlantic and Indo-Pacific Oceans. However, recent genetic data suggests potentially significant population structure within the Atlantic, which may be underpinned by the fact that this species exhibits a high degree of philopatry in some locations (i.e., the species returns to the same site for purposes of breeding or feeding, etc). For example, the population structure observed in the Atlantic, despite no physical or oceanographic barrier, could result in localized depletions in areas where fishing pressure is high. However, habitat characteristics that are important to this species are unknown. The species is highly mobile, and there is little known about specific migration routes. It is also unknown if there are source-sink dynamics at work that may affect population growth or species' decline. There is no information on critical source populations to suggest spatial structure and/or loss of connectivity are presently posing demographic risks to the species. Thus, based on the best available information, there is insufficient information to support the conclusion that spatial structure and connectivity currently pose a significant demographic risk to this species.

Diversity

Preliminary research suggests the oceanic whitetip has low genetic diversity (0.33% ± 0.19%; Ruck 2016; Camargo *et al*. 2016), which is about half that of silky sharks (0.61% ± 0.32%; Clarke *et al.*, (2015a)). The ERA team noted that the relatively low mtDNA genetic diversity of the oceanic whitetip raises potential concern for the future genetic health of this species, particularly in concert with steep global declines in abundance. Based on the fact that exploitation of the oceanic whitetip shark began with the onset of industrial fishing in the 1950s, only 5-7 generations of oceanic whitetip have passed since the beginning of this exploitation. Thus, the low genetic diversity of oceanic whitetip shark likely reflects historical levels, and the significant global declines are not yet reflected genetically (Ruck 2016). The ERA team noted that this may be a cause for concern in the foreseeable future, since a species with already relatively low genetic diversity undergoing significant levels of exploitation may increase the species' risk in terms of evolutionary adaptability to a rapidly changing oceanic environment as well as potential extirpations (Camargo *et al*., 2016). However, the ERA team also noted that low genetic diversity does not necessarily equate to a risk of extinction in and of itself for all species; but, in combination with low levels of abundance and continued exploitation, low genetic diversity may pose a viable risk to the species in the foreseeable future.

Threats Assessment

Out of the five ESA section 4(a)(1) factors, based on the best available information, we identified overutilization and inadequate regulatory mechanisms as most concerning in terms of threats that may contribute to the extinction risk of the species. The other factors, including habitat destruction, modification, or curtailment; disease and predation; and other natural or manmade factors were not identified as threats to the species. Below is a brief discussion of the rationale for our ERA team's conclusions regarding the threats assessment for the oceanic whitetip shark.

Habitat Destruction, Modification, or Curtailment

The ERA team did not identify habitat destruction, modification, or curtailment as a threat that contributes significantly to the species' risk of extinction. The ERA team emphasized that the oceanic whitetip shark is a highly migratory, pelagic species of shark that likely spends much of its lifecycle in the open ocean. As such, the oceanic whitetip shark is likely more confined by temperature and prey distributions, and is not reliant on any particular habitat type that would be affected by threats such as climate change or physical destruction, etc. Additionally, due to their highly migratory nature, they can modify their distributional range to remain in an environment conducive to their physiological and ecological needs. The oceanic whitetip shark is also an extremely opportunistic feeder. It is therefore very unlikely that the loss or degradation of any particular habitat type would have a substantial effect on the oceanic whitetip population. As a result, and given the best available information, the ERA team concluded that habitat destruction, modification, or curtailment is not a threat that contributes to the species' extinction risk, now or in the foreseeable future.

<u>Overutilization</u>

The ERA team concluded that overutilization is the single most important threat contributing to the extinction risk of the oceanic whitetip shark globally. The ERA team assessed various factors that may contribute to the overutilization of the oceanic whitetip shark, including incidental bycatch in commercial fisheries (considering impacts of at-vessel and post-release mortality), retention and finning for purposes of the international fin trade, and impacts of IUU fishing. The oceanic whitetip shark is generally not a targeted species, but because of its tendency to remain in surface waters (0-152 m depth) and in tropical latitudes where fishing pressure is often most concentrated for target species such as tuna, the species is frequently encountered and suffers high mortality rates in numerous fisheries throughout its global range. Although the ERA team recognized that the oceanic whitetip shark has relatively lower at-vessel mortality rates in longlines than other shark species, the species still exhibits a range of mortality from 11-28% in the Atlantic to upwards of 60% in the Indian Ocean (Fernandez-Carvalho *et al*. 2015; IOTC 2015b), and these rates do not account for post-release mortality. In addition to bycatch-related mortality, the oceanic whitetip shark is a preferred species for retention because its large fins obtain a high price per kg in the Asian fin market, and comprises approximately 2% of the global fin trade (Clarke *et al.,* 2006a). This high value and demand for oceanic whitetip fins incentivizes the retention and subsequent finning of oceanic whitetip sharks when caught, and thus represents the main economic driver of mortality of this species in commercial fisheries throughout its global range. In fact, growth in demand from the fin trade during the 1990s coincided with a pattern of soaring catches of oceanic whitetip sharks in numerous fisheries across the globe. Catches generally peaked between 1995 to 2000 followed by precipitous declines over the next 10 years due to severe overfishing (Hazin *et al.,* 2007; Lawson 2011; Clarke *et al.,* 2012; Hasarangi *et al.,* 2012; Brodziak *et al.,* 2013; Hall and Román 2013).

The ERA team concluded that overutilization is likely a significant threat to the oceanic whitetip shark throughout the Pacific Ocean basin. In the Eastern Pacific, the oceanic whitetip shark was historically caught in large numbers in the tropical tuna purse seine fishery. However, in recent years, oceanic whitetip shark catches declined dramatically despite a generally increasing trend in fishing effort (both in geographic scope and number of sets). In total, oceanic whitetip catches declined drastically from a peak of 9,000+ individuals caught in 1995 to only 120 individuals in 2015 (refer back to Figure 35). In addition, their capture probability in floating object purse seine sets (the set type responsible for 90% of catches) has decreased from a high of 30% capture rate per set between 1994 and 1998, to less than 5% from 2004 to 2008 (Morgan 2014). This is in stark contrast to catches of the closely related silky shark, which have remained relatively constant over the same time period (Hall and Roman 2013). This indicates that the large decline in catches of oceanic whitetip shark in the purse seine fishery has largely been driven by unsustainable fishing mortality. Thus, given the increase in fishing effort in the Eastern Pacific over time, combined with the decline in catches and virtual disappearance of oceanic whitetip sharks from purse seine fishing grounds in the Eastern Pacific, the ERA team agreed that the oceanic whitetip shark population in the Eastern Pacific is likely experiencing overutilization.

In the Western and Central Pacific Ocean, numerous analyses indicate that the oceanic whitetip shark is experiencing overutilization across the region. The ERA team concluded that the once ubiquitous oceanic whitetip shark has experienced significant and ongoing declines in the Western and Central Pacific Ocean as a direct result of unsustainable fishing mortality in both longline and purse seine fisheries operating in the species' core tropical habitat area. The ERA team accepted the results of a recent stock assessment report that determined fishing mortality of oceanic whitetip throughout the Western and Central Pacific has increased to levels that are 6.5 times what is sustainable. Because of this fishing mortality, oceanic whitetip biomass declined by 86% (Rice and Harley 2012). Currently, the population is overfished and overfishing is still occurring. As a result, catch trends of oceanic whitetip shark in both longline and purse seine fisheries have significantly declined, with declining trends also detected in some biological indicators, such as biomass and size indices. Similar results between analyses of SPC observer data from the larger Western and Central Pacific 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 region-wide phenomenon across the Pacific Ocean basin. Updated analyses of the Hawaii observer data indicate a stabilized trend at depleted levels in recent years. The significant declining trends observed in all available abundance indices (e.g., standardized CPUE, biomass and median size) of oceanic whitetips occurred as a result of increased fishing effort in the longline fishery, with lesser impacts from targeted longline fishing and purse-seining. Because of the significant fishing mortality in both longline and purse seine fisheries that has contributed to large abundance declines of the species, the ERA team concluded that overutilization of the species is likely occurring throughout the Western and Central Pacific.

As discussed in the *Abundance* section above, there has been debate in the literature regarding the exact magnitude of decline of oceanic whitetip shark in the Northwest Atlantic and Gulf of Mexico (with estimates of up to 50-70% in the Northwest Atlantic from 1986-2005 and estimates of up to 88% in the Gulf of Mexico from the 1950s to the late 1990s). Nonetheless, the ERA team agreed that the oceanic whitetip shark suffered significant historical declines in abundance as a result of overexploitation since the onset of industrial fishing in the 1950s. Because these data are largely based on fisheries logbooks and have been openly criticized in the scientific literature, the ERA team conducted its own species-specific analysis of observer data from the Northwest Atlantic, which were deemed more reliable and accurate by the ERA team than fisheries logbook data. Based on this updated analysis, the Northwest Atlantic population of oceanic whitetip shark has declined by 4% since 1992, but has likely begun to stabilize (albeit at a significantly diminished abundance). Reported landings for oceanic whitetip in the Northwest Atlantic have been variable over the last 10 years of available data, with a decrease since the implementation of ICCAT Recommendation 10-07 in 2011. This indicates that these regulatory mechanisms may be effective in reducing retention in the region. Furthermore, the Northwest Atlantic population of oceanic whitetip shark may have stabilized since the 1990s, which coincides with the first Federal Fishery Management Plan for Sharks in the Northwest Atlantic Ocean and Gulf of Mexico. The plan directly manages oceanic whitetip shark under the pelagic shark group, and includes regulations on trip limits and quotas; therefore, under current management measures, including the implementation of ICCAT Recommendation 10-07, the ERA team concluded that the threat of overutilization is not likely as significant in this area relative to other portions of the species' range.

In contrast, the ERA team agreed that overutilization is likely a significant threat to oceanic whitetip sharks in the South Atlantic, and in particular, the population that appears to show site fidelity to a specific area off the northeastern coast of Brazil. While robust quantitative studies regarding catch trends of oceanic whitetip sharks are limited, the oceanic whitetip was once one of the most abundant shark species encountered in longline fisheries in the southern and equatorial Atlantic; however, this species is now seemingly rare with low, patchy abundance across the region. Additionally, the large majority of catches across the region are comprised of immature individuals. The team considered trends in several indicators, including average CPUE, commercial catches, and size composition of oceanic whitetip that show significant declines in recent decades that are indicative of overutilization of the species. The high fishing pressure across the South Atlantic that occurred concomitantly with a lack of regulations to control fishing from the mid-1990s through the mid-2000s likely led to the overutilization of oceanic whitetip shark. The team agreed that overutilization is likely still occurring given that the highest levels of fishing effort in this region overlap significantly with the preferred vertical and horizontal habitat of the species, including potential nursery grounds and areas where the species shows a high degree of site fidelity.

Finally, the ERA team agreed that overutilization of oceanic whitetip is likely occurring in the Indian Ocean. This species is caught as bycatch in all three major commercial fisheries in the Indian Ocean, including pelagic longline, purse seine and gillnet fisheries. Although information from this region is limited and catch data are severely underreported, the IOTC reports that catches of oceanic whitetip shark are high, and comprise a significant proportion of the total estimated shark catch in this region at 11% (Murua *et al*. 2013). The oceanic whitetip also suffers from a relatively high at-vessel mortality rate in longlines in this region (i.e., 58%). In 2013, the IOTC reported average catches of ~347 t over the previous 5 years and noted that this level of catch put the oceanic whitetip population at considerable risk. The IOTC also noted that maintaining or increasing this level of catch would likely result in further declines of the species. The ERA team noted that these conclusions were made before improved species-specific reporting of incidental catches and discards of oceanic whitetip to the IOTC was required. Once the IOTC Resolution for the conservation of oceanic whitetip shark was implemented, catch estimates for the species skyrocketed, with 5,000+ mt of oceanic whitetip shark catches estimated for 2013 and 2014. While the ERA team acknowledges a level of uncertainty with these estimates, given the significantly high level of fishing pressure in this region, the species' relatively high mortality in longline and purse seine fisheries in this region (with unknown levels of mortality in the region's gillnet fisheries), combined with the species' low-moderate productivity, the ERA team concluded that the oceanic whitetip shark is likely experiencing ongoing threats of overutilization that may contribute to continued population declines in this region into the foreseeable future.

As described in this Status Review, the main economic driver for overutilization of the oceanic whitetip shark throughout its global range has been its high value and demand in the international shark fin trade. The oceanic whitetip shark has been reported as a preferred species for the international fin trade and is a species often categorized as "first choice" in the China Hong Kong SAR fin market. The morphologically distinct oceanic whitetip fins are sold under the name "*Liu Qiu*," fetching a high price of $45-85/kg and comprising approximately 2% (by weight) of the global shark fin trade based on data from 2000. Although 2% may seem like a relatively small portion of the trade, this equated to an estimated 220,000 -1.2 million oceanic whitetip sharks traded globally in 2000. Clarke (2008) estimated 80-210,000 oceanic whitetip sharks were sourced from the Atlantic Ocean alone to supply the Hong Kong fin market in 2003. At this rate, a species with life history characteristics like the oceanic whitetip would not likely be able to sustain continued pressure of that magnitude. Recent genetic analyses of fins in markets of major shark fin exporting countries throughout the range of the species, including Taiwan, Indonesia, and UAE, confirm the continued presence of oceanic whitetip shark fins in various markets throughout its range. Although the ERA team recognizes that the situation regarding the fin trade may be improving, as evidenced by an overall decline in the fin trade and increased regulations, the recent incidents of illegal trafficking and exports of oceanic whitetip fins from places like Costa Rica, Egypt, India, Indonesia, and other locations as recently as 2017 indicate that oceanic whitetip sharks are still sought after for their fins and continue to experience pressure from demands of the fin trade. Thus, the ERA team concluded that based on the best available information, the incentive to take oceanic whitetip sharks for their fins remains high and is an ongoing threat contributing to the overutilization of the species. The ERA team also considered whether the recent shift in demand away from shark fins to shark meat would have any considerable impact on the oceanic whitetip shark. Although there are markets for low-value shark meat such as oceanic whitetip, the retention bans for the species in all relevant RFMOs will likely dampen this threat. Thus, the ERA team did not think this shift in demand from shark fins to meat would create a significant new threat to the species.

<u>Disease or Predation</u>
We could find no information linking disease to declines in oceanic whitetip shark populations.

Predation also does not appear to be increasing this species' risk of extinction, as the oceanic whitetip is a large shark with limited numbers of predators. Therefore, based on the best available information, we concluded that neither disease nor predation is contributing to the species' risk of extinction, now or in the foreseeable future.

Inadequacy of Existing Regulatory Mechanisms

In discussions regarding existing regulatory mechanisms for the oceanic whitetip, the ERA team noted that the most influential regulations currently in place are likely the species-specific retention prohibition measures recently implemented by all RFMOs throughout the species' range. In fact, the oceanic whitetip shark is currently the only shark species protected by RFMO's in all oceans, which underscores the conservation needs of the species. In addition, the oceanic whitetip was also recently added to Appendix II of CITES, which went into effect in 2014. However, the team emphasized the difficulty in analyzing the efficacy of these regulations, as many have been in place for only a couple of years and implementation and enforcement across international boundaries are likely highly variable and/or lacking altogether. Despite this difficulty, the ERA team largely agreed that these prohibition measures may only be partially effective and thus inadequate for significantly reducing the threat of overutilization to the species.

For all of the retention prohibitions enacted by RFMOs, the ERA team acknowledged that these measures do not prevent oceanic whitetip sharks from being caught or any at-vessel and post-release mortality that may result. For example, the ERA team agreed that the retention prohibition enacted for oceanic whitetip sharks in the Eastern Pacific would not likely be effective for the tropical tuna purse seine fishery (the main fishery that catches this species in this region), as individuals probably suffer from high mortality rates in this fishery, even if they are released. In the Western and Central Pacific, observations from the longline fishery have shown that CMM 2011-04 for the retention prohibition of oceanic whitetip is not being strictly followed (or not yet fully implemented), with non-negligible proportions of oceanic whitetips still being retained or finned. In fact, more oceanic whitetip sharks were retained in 2013 (the first year of the CMM) than 2012 in the longline fishery (Rice *et al*., 2015). The ERA team agreed that despite the increasing management measures in this region, given the severely depleted state of the oceanic whitetip population, less-than-full implementation erodes the benefits of any mitigation measures. In the Indian Ocean, the ERA team expressed significant concern regarding the inadequacy of management measures. In particular, the IOTC's Resolution 13-06 on the retention prohibition of oceanic whitetip shark is limited in terms of its scope and effectiveness. This is because the IOTC Resolution 13-06 is not binding on India (one of the main oceanic whitetip shark catching countries identified by the IOTC), does not apply to artisanal fisheries operating within their EEZs for the purposes of local consumption, and does not explicitly prohibit selling or offering for sale any oceanic whitetip products.

We noted that in some locations, regulatory measures may be effective for reducing the threat of overutilization. For example, in the U.S. Northwest Atlantic and Pacific Island States and

Territories, oceanic whitetip sharks are managed under comprehensive management plans and regulations. In Hawaii for example, finning regulations have resulted in a significant decline in the number of oceanic whitetip sharks finned and an increase in the number of sharks released alive. In the Northwest Atlantic, oceanic whitetip sharks are managed under the pelagic species complex of the Atlantic HMS FMP, with commercial quotas imposed that restrict the overall level of oceanic whitetip sharks taken in this part of its range. Pelagic longline gear is heavily managed and strictly monitored. The use of pelagic longline gear (targeting swordfish, tuna and/or shark) also requires specific permits, with all required permits administered under a limited access program. Presently, no new permits are being issued; thus, persons wishing to enter the fishery may only obtain these permits by transferring the permit from a permit holder who is leaving the fishery, and are currently subject to vessel upgrading restrictions. These national regulations, as detailed in the 2006 Consolidated HMS FMP and described in this Status Review Report, combined with ICCAT's Recommendation 10-07 on the retention prohibition of oceanic whitetip shark have likely led to the recent stabilization of the Northwest Atlantic population. In contrast, the ERA team had significant concerns regarding the inadequacy of regulatory mechanisms in the South Atlantic, and in particular, the most significant oceanic whitetip shark catching country in the region (i.e., Brazil). Specifically, the ERA team expressed concern regarding the end of systematic data collection in 2012 from fleets fishing over Brazilian jurisdiction, and the cancellation of onboard observer programs, which renders any further monitoring of South Atlantic shark populations difficult or impossible.

The ERA team also deemed inadequate regulations to control for overutilization via the shark fin trade a concern, because the shark fin trade has and continues to be the main economic driver for retention and mortality of oceanic whitetip shark in commercial fisheries throughout the globe. As noted previously in the *Overutilization* section above, the ERA team recognized that the situation regarding the fin trade is showing a general improvement, with recent studies indicating a decline in the shark fin market due to a waning interest in fins and an increase in regulations to curb shark finning. For example, many countries and RFMOs have implemented shark finning bans or have prohibited the sale or trade of shark fins or products (as described in detail in this Status Review document), with declining trends in finning and catches of oceanic whitetip sharks evident in some locations as a result of these regulations (e.g., Fiji, Australia and the United States). In fact, the trade in shark fins through China, Hong Kong Special Administrative Region (SAR), which has served as an indicator of the global trade for many years, rose by 10% in 2011 but fell by 22% in 2012. Additionally, current indications are that the shark fin trade through Hong Kong SAR and China will continue to contract (Dent and Clarke 2015). However, despite the slight improvement regarding the decline of the shark fin trade, the ERA team expressed concern that the high demand for oceanic whitetip fins is ongoing, as evidenced by recent genetic studies that confirm the presence of oceanic whitetip shark fins in several markets throughout its range, as well as several incidents of illegal finning and trafficking of oceanic whitetip fins in places like Indonesia and Costa Rica. Additionally, while the species was listed under Appendix II of CITES in 2014, there have since been several shipments of oceanic whitetip fins confiscated upon entry into Hong Kong due to a lack of proper permitting paperwork from the countries of origin. Based on the foregoing information, the ERA team concluded that despite national and international protections for oceanic whitetip, illegal finning and exportation activities are ongoing. As such, and based on the best available information, existing regulatory mechanisms to control for overutilization by the shark fin trade are likely inadequate to significantly reduce this threat to the oceanic whitetip shark at this time.

Other Natural or Manmade Threats

The ERA team did not identify any other natural or manmade threats that may affect the continued existence of the oceanic whitetip shark. As described in this Status Review, although 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, the effects of these pollutants in oceanic whitetip shark populations and potential risk to the viability of the species remain unknown. In fact, there is no information on the lethal concentration limits of toxins or metals in oceanic whitetip sharks or evidence to suggest that current concentrations of environmental pollutants are causing detrimental physiological effects to the point where the species may be at an increased risk of extinction. As such, the best available information does not indicate that the present bioaccumulation rates and concentrations of environmental pollutants in the tissues of oceanic whitetip sharks are significant threats to the species, such that it substantially increases the species' risk of extinction throughout its global range.

Overall Risk Summary

Guided by the results and discussions from the demographics risk analysis and threats assessment, we analyzed the overall risk of extinction to the global oceanic whitetip shark population. In this process, the ERA team considered the best available scientific and commercial information regarding the oceanic whitetip shark from all regions of the species' global range, and analyzed the collective condition of these populations to assess the species' global extinction risk. The following table gives the results of our likelihood point distributions. Likelihood points were tallied and the totals (n = 60) are presented for the overall level of extinction risk.

Table 6 Results of the ERA team's overall extinction risk analysis

Overall Level of Extinction Risk for the Oceanic Whitetip Shark			
	1 = Low risk	2 = Moderate risk	3= High risk
# of Likelihood Points	20	34	6

The ERA team was fairly confident in determining the overall level of extinction risk for the oceanic whitetip shark, placing the majority of our likelihood points in the "moderate risk" category. Due to some uncertainty regarding abundance trends and catch data for populations in certain areas (e.g., South Atlantic and Indian Ocean), as well as stabilizing trends observed in two areas (e.g., Northwest Atlantic and Hawaii), the team expressed uncertainty by placing some of their likelihood points in the "low risk" and "high risk" categories as well.

During discussions, the ERA team reiterated that the once abundant and ubiquitous oceanic whitetip shark has likely experienced significant historical population declines throughout its global range, with multiple data sources and analyses, including a stock assessment and trends in relative abundance, suggesting declines in excess of 80% in most areas. The ERA team concluded that declining abundance trends of varying magnitudes are likely ongoing in all three ocean basins. The ERA team noted that the species' ability to avoid extirpation in the Northwest Atlantic and Hawaii after significant declines and persist at a low population size, likely precludes the species from a current high risk of extinction. However, the ERA team noted that the most significant threat to the continued existence of the oceanic whitetip shark in the foreseeable future is ongoing and significantly high rates of fishing mortality driven by demands of the international trade in shark fins and meat, as well as impacts related to incidental bycatch and IUU fishing. The team emphasized that the oceanic whitetip shark's vertical and horizontal distribution significantly increases its exposure to industrial fisheries, including pelagic longline and purse seine fisheries operating within the species' core tropical habitat throughout its global range. In addition to declines in oceanic whitetip catches throughout its range, there is also evidence of declining average size over time in some areas, which is particularly concerning given that litter size has been shown to be correlated with maternal length. With such extensive declines in the species' global abundance and the ongoing threat of overutilization, the species' slow growth and low fecundity may limit its ability for compensation. Related to this, the low genetic diversity of oceanic whitetip is also cause for concern and a viable risk over the foreseeable future for this species. This is particularly concerning since it is possible (though uncertain) that a reduction in genetic diversity following the large reduction in population size due to overutilization has not yet manifested in the species. Loss of genetic diversity can lead to reduced fitness and a limited ability to adapt to a rapidly changing environment, thus increasing the species' overall risk of extinction.

Finally, the species' extensive distribution, ranging across entire oceans and across multiple international boundaries complicates management of the species. The ERA team agreed that implementation and enforcement of management measures that could reduce the threat of overutilization to the species are likely highly variable and/or lacking altogether across the species' range. The ERA team acknowledged a significant increase in species-specific management measures to control for overutilization of oceanic whitetip shark across its range; however, the ERA team also noted that most of these regulations, particularly the retention prohibitions enacted by all relevant RFMOs throughout the range of the species, are too new to truly determine their efficacy in reducing mortality of oceanic whitetip shark. Despite this limitation, and with the exception of the Northwest Atlantic and Pacific Island States and Territories, the ERA team was not confident in the adequacy of these regulations to reduce the threat of overutilization and prevent further abundance declines in the foreseeable future. First, the ERA team discussed the fact that retention prohibitions do not prevent at-vessel and post-release mortality, which is likely high in some fisheries. In addition, the biggest concern to the ERA team with regard to these regulatory mechanisms going forward is the lack of full implementation and enforcement. The ERA team noted that proper implementation and enforcement of these regulations would likely result in a reduction in overall mortality of the species over time. However, the best available information suggests that this may not currently be the case. Given the species' depleted state throughout its range, the ERA team agreed that less than full implementation and enforcement of current regulations is likely undermining any conservation benefit to the species.

Based on all of the foregoing information, which represents the best scientific and commercial data available regarding current demographic risks and threats to the species, the ERA team concluded that the oceanic whitetip shark currently has a moderate risk of extinction. We concluded that the species does not currently have a high risk of extinction because of the following: (1) the species has a significantly broad distribution and does not seem to have been extirpated in any region, even in areas where there is heavy harvest bycatch and utilization of the species' high-value fins; (2) there appears to be a potential for relative stability in population sizes on the order of 5-10 years at the post-decline depressed state. This suggests that this species is potentially capable of persisting at a low population size; (3) two populations seem to have stabilized, which reduces the global population's overall extinction risk; (4) the overall reduction of the fin trade as well as increasing management regulations will likely reduce overall mortality to some extent, and thus reduces the species' current risk of extinction. However, given the species' significant historical and ongoing abundance declines in all three ocean basins, slow growth, low fecundity, and low genetic diversity, combined with ongoing threats of overutilization and largely inadequate regulatory mechanisms, we concluded that over the next 30 years, the oceanic whitetip shark has a moderate risk of extinction throughout its global range.

Appendix 1

Current and relevant shark regulations by U.S. state and territory in the Atlantic and Pacific (Source: Adapted from Miller *et al*. 2014; NMFS (2011a); NMFS (2013a); HMSMT Report 2008).

U.S. Atlantic States	Shark Regulations
Maine New Hampshire	Although part of the Atlantic States Marine Fisheries Commission (ASMFC), both Maine and New Hampshire were granted de minimis status for the Interstate FMP for Atlantic Coastal Sharks (see further details below) that was adopted by the ASFMC in 2008 (ASFMC 2008). These states implement the following rules that uphold the goals and objectives of the FMP: require federal dealer permits for all dealers purchasing Coastal Sharks; prohibit the take or landings of prohibited species in the plan; close the fishery for porbeagle sharks when the NMFS quota has been harvest; prohibit the commercial harvest of porbeagle sharks in State waters; require that head, fins and tails remain attached to the carcass of all shark species, except smooth dogfish, through landing.
Massachusetts	Also a part of the ASMFC, and was granted de minimis status for the Interstate FMP for Atlantic Coastal Sharks. Granted an exemption from the possession limit for non-sandbar large coastal sharks and closures of the non-sandbar large coastal shark fisheries.
Rhode Island Connecticut New York New Jersey Delaware Maryland Virginia	Fishers must abide by the Interstate FMP for Atlantic Coastal Sharks adopted by the ASMFC (ASFMC 2008). This FMP requires that all sharks harvested by commercial or recreational fishers within state waters have the tail and fins attached naturally to the carcass. While there are no set quotas for the pelagic group, ASFMC opens and closes the fishery when NMFS opens and closes the corresponding federal fisheries. Sharks caught in the recreational fishery must have a fork length of at least 4.5 feet (54 inches) and they must be caught using a handline or rod and reel. Each recreational shore-angler is allowed a maximum harvest of one shark from the federal recreationally permitted species per calendar day. Recreational fishing vessels are allowed a maximum harvest of one shark from the federal recreationally permitted species per trip, regardless of the number of people on board the vessel. An annual recreational seasonal closure is imposed in state waters of Virginia, Maryland, Delaware and New Jersey from May 15 through July 15 during which time fishers are prohibited from possessing certain species - regardless of where the shark was caught. Fishers who catch any of these species in federal waters may not transport them through the state waters of Virginia, Maryland, Delaware, and New

U.S. Atlantic States	Shark Regulations
	Jersey during the seasonal closure. New York amended its Environmental Conservation Law to prohibit sharks (excluding spiny dogfish) from being taken for commercial or recreational purposes by baited hooking except with the use of non-stainless steel non-offset circle hooks. New York, Maryland, and Delaware have shark fin laws that ban the possession, sale, or distribution of shark fins. All three laws in these states exempt Spiny dogfish and Smooth dogfish fins from the ban. Each state law also includes other exceptions including for education, research, and other situations.
North Carolina	Adopted the ASMFC Coastal Shark Interstate FMP. Additionally, the Director may impose restrictions for size, seasons, areas, quantity, etc. via proclamation. The longline in the shark fishery shall not exceed 500 yds or have more than 50 hooks. Requires reporting of all recreationally landed sharks through state administered HMS catch card program.
South Carolina	Adopted the ASMFC Coastal Shark Interstate FMP. Additionally, defers to federal regulations. Gillnets may not be used in the shark fishery in state waters.
Georgia	Adopted the ASMFC Coastal Shark Interstate FMP. Additionally, commercial/recreational regulations: 2 sharks/person or boat, whichever is less, with a minimum size of 48” FL (122 cm). It is unlawful to have in possession more than one shark greater than 84" TL (213 cm). All sharks must be landed with the head and fins intact. Sharks may not be landed in Georgia if harvested using gillnets.
Florida	Adopted the ASMFC Coastal Shark Interstate FMP.
Alabama	Recreational and commercial: bag limit – 1 shark/person/day with a minimum size of 54” FL (137 cm) or 30” dressed (76 cm). State waters close when federal season closes and no shark fishing on weekends, Memorial Day, Independence Day, or Labor Day. Restrictions on chumming and shore-based angling if creating unsafe bathing conditions. Regardless of open or closed season, gillnet fishers targeting other fish may retain sharks with a dressed weight not exceeding 10% of total catch.

U.S. Atlantic States	Shark Regulations
Louisiana	Recreational: bag limit 1 shark/person/day with a minimum size of 54" FL (137 cm). Commercial: 33 sharks/vessel/day limit and no minimum size. Commercial and recreational harvest of sharks prohibited from April 1st through June 30th. Fins must remain naturally attached to carcass through off-loading. Owners/operators of vessels other than those taking sharks in compliance with state or federal commercial permits are restricted to no more than one shark from either the large coastal, small coastal, or pelagic group per vessel per trip within or without Louisiana waters.
Mississippi	Recreational: bag limit - LCS/Pelagics 1 shark/person (possession limit) up to 3 sharks/vessel (possession limit) with a minimum size of 37" TL (94 cm). Finning is prohibited.
Texas	Commercial/recreational: bag limit – 1 shark/person/day; Commercial/recreational possession limit is twice the daily bag limit (i.e., 2 sharks/person/day)
Illinois	Bans the possession, sale, or distribution of detached shark fins.
U.S. Atlantic and Caribbean Territories:	
U.S. Virgin Islands	Federal regulations and federal permit requirements apply in territorial waters.
Puerto Rico	Federal regulations and federal permit requirements apply in territorial waters.

U.S. Pacific States	
California	California's Shark Fin Prohibition law prohibits the sale, purchase, or possession of detached shark fins. The law exempts licensed shark fishers that land sharks in California from the possession ban. Includes an education and research exemption. Sharks may not be taken with drift gillnets of mesh size eight inches (20 cm) or greater except under a revocable permit issued by the California Department of Fish and Game.
Hawaii	It is unlawful to possess, sell, offer for sale, trade, or distribute shark fins. Includes exemptions for education and research.
U.S. Pacific	

Territories:	
American Samoa	Prohibits the possession, delivery, or transportation of any shark species or shark body part. Includes an exemption for research. Shark fishing and possession of sharks within 3 nmi of shoreline was banned in Nov 2012.
Guam	Bans the possession, sale, offer for sale, take, purchase, barter, transport, export, import, trade or distribution of shark fins. Includes exemptions for research and subsistence fishing.
CNMI	Bans the possession, sale, offer for sale, trade, or distribution of shark fins. Includes exemptions for research and subsistence fishing.

Appendix 2

Summary of Global Shark Fishing Regulations (excluding the United States)

Country	Date	Prohibited Shark Fishing
Bahamas	2011	Commercial shark fishing in the approximately 630,000 square kilometers (243,244 square miles) of the country's waters is prohibited.
British Virgin Islands	2014	No commercial fishing of sharks or rays
Brunei	2013	No harvest or importation of shark products
Colombia	1995	Shark fishing is prohibited in the Malpelo Wildlife Sanctuary
Cook Islands	2012	Commercial shark fishing banned. Created a sanctuary in its waters, contiguous with the sanctuary in French Polynesia and bans the possession or sale of shark products.
Congo-Brazzaville	2001	Shark fishing is prohibited.
Costa Rica	1978	Shark fishing is prohibited in Cocos Island National Park.
Ecuador	2004	Directed fishing for sharks is banned in all Ecuadorian waters, but sharks caught in "continental" (i.e., not Galapagos) fisheries may be landed if bycaught (finning is banned).
Egypt	2005	Shark fishing is prohibited throughout the Egyptian Red Sea territorial waters to 12 miles from the shore, as is the commercial sale of sharks.
French Polynesia	2012	All shark fishing banned. Created shark sanctuary in its waters contiguous with the sanctuary in Cook Islands, and banned trade in all sharks.

Country	Date	Prohibited Shark Fishing
Guinea-Bissau	2009	Ban on shark fishing in Marine Protected Areas (two parks covering 2,077 km^2).
Honduras	2010	No shark fishing
Indonesia	2010	No shark fishing in Raja Ampat
Israel	1980	No shark fishing
Kiribati	2015	No commercial shark fishing in the Phoenix Islands Protected Area and Southern Line Islands
Maldives	2010	Bans fishing, trade and export of sharks and shark products in the country, effectively converting its 35,000-square-mile (90,000-square-kilometer) EEZ into a sanctuary for sharks, a swath of the Indian Ocean about the size of the U.S. State of Maine.
Marshall Islands	2011	No commercial shark fishing or sale of shark products
Mauritania	2003	Created a 6000 km^2 coastal sanctuary for sharks and rays (Banc d'Arguin National Park - PNBA). Targeted shark fishing is prohibited.
Micronesia Region	2015	Established the Micronesia Regional Shark Sanctuary, which prohibits the commercial fishing and trade of sharks and rays and their parts. The sanctuary includes the waters of the Republic of Marshall Islands, Republic of Palau, Guam, CNMI, Federated States of Micronesia and its four member states, Yap, Chuuk, Pohnpei, and Kosrae.
Micronesia	2015	Passed Public Law No. 18-108 in early 2015 to implement the Micronesia Regional Shark Sanctuary, which prohibits the commercial fishing and trade of sharks and rays and their parts.
New Caledonia	2013	Passed regulations to prohibit all shark fishing in its EEZ. Regulations also ban the taking, possession, sale or export of all species of sharks. The Pacific waters of this French overseas territory are roughly the size of South Africa and can protect upwards of 50 species of sharks.

Country	Date	Prohibited Shark Fishing
Palau	2009	Created a shark sanctuary that encompasses 240,000 square miles (621,600 square kilometers, roughly size of France) of protected waters. Prohibits the commercial fishing of sharks.
Republic of the Marshall Islands	2011	Bans commercial fishing of sharks in all 1,990,530 square kilometers (768,547 square miles) in the country's waters, an ocean area four times the landmass of California. A complete prohibition on the commercial fishing of sharks as well as the sale of any sharks or shark products. Any shark caught accidentally by fishing vessels must be set free. A ban on the use of wire leaders, a longline fishing gear which is among the most lethal to sharks.
Sabah, Malaysia	2011	Prohibits shark fishing.
Spain	2011	Prohibits the capture, injury, trade, import and export of specific shark species, and requires periodic evaluations of their conservation status.
Tokelau (an island territory of New Zealand in the South Pacific)	2011	Created a shark sanctuary which encompasses all 319,031 square kilometers (123,178 square miles) of Tokelau's exclusive economic zone; however, dead sharks may be retained.
Venezuela	2012	Commercial shark fishing is prohibited throughout the 3,730 square kilometers (1,440 square miles) of the Caribbean Sea that make up the Los Roques and Las Aves archipelagos.

Appendix 3

Summary of Global Shark Finning Regulations (excluding U.S.)

Country	Date	Prohibited Shark Finning
Argentina	2009	Ban on shark finning.
Australia	Various	States and Territories govern their own waters. Central government regulates 'Commonwealth' or Federal waters, from 3 to 200 nautical miles offshore. Sharks must be landed with fins naturally attached in Commonwealth, NSW and Victorian waters, and must be landed with corresponding fins in a set fin to carcass ratio in Tasmanian, Western Australian, Northern Territory and Queensland waters.
Brazil	1998	Sharks must be landed with corresponding fins. Fins must not weigh more than 5% of the total weight of the carcass.

Country	Date	Prohibited Shark Finning
		All carcasses and fins must be unloaded and weighed and the weights reported to authorities. Pelagic gillnets and trawls are prohibited in waters less than 3 nautical miles (5.6 km) from the coast.
Canada	1994	Finning in Canadian waters and by any Canadian licensed vessel fishing outside of the EEZ is prohibited.When landed, fins must not weigh more than 5% of the dressed weight of the shark.
Cape Verde	2005	Finning prohibited throughout the EEZ.
Chile	2011	Bans shark finning in Chilean waters. Sharks must be landed with fins naturally attached.
Colombia	2007	Sharks must be landed with fins naturally attached to their bodies.
Costa Rica	2006	Ban on shark finning.
El Salvador	2006	Shark finning is prohibited. Sharks must be landed with at least 25% of each fin still attached naturally. The sale or export of fins is prohibited without the corresponding carcass.
England and Wales	2009	Ban on shark finning.
European Union	2003 (finning) 2013 (fins-attached)	Shark finning is prohibited by all vessels fishing in EU waters and on all EU vessels fishing in oceans worldwide since 2003. Sharks must be landed with fins naturally attached since 2013.
Gambia	2004	Ban on finning in all territorial waters. Mandatory to land sharks caught in Gambian waters on Gambian soil.
Guinea	2009	Ban on finning in all territorial waters.
India	2013	Bans removal of shark fins on board a vessel in the sea.
Japan	2008	Ban on shark finning by Japanese vessels; however, Japanese vessels operating and landing outside Japanese waters are exempt.
Mexico	2007	Shark finning is prohibited. Shark fins must not be landed unless the bodies are on board the vessel. In 2011, Mexico banned shark fishing from May 1 to July 31 in Pacific Ocean and from May 1 to June 30 in Gulf of Mexico and Caribbean Seas.
Namibia	2003	Generally prohibits the discards of harvested or bycaught marine resources. Prohibits shark finning.

Country	Date	Prohibited Shark Finning
New Zealand	2009/2016	Finning of live sharks (and disposing of carcasses at sea) is prohibited. By 2016, all species of sharks must be released alive or brought to shore with fins naturally attached (with the exception of some species that may be landed in accordance with a gazette fin to "greenweight" ratio)[27].
Nicaragua	2004	Fins must not weigh more than 5% of the total weight of the carcass. Export of fins allowed only after proof that carcass has been sold as the capture of sharks for the single use of their fins is prohibited.
Oman	1999	Prohibits the throwing of any shark part or shark waste in the sea or on shore. It is also prohibited to separate shark fins and tails unless this is done according to the conditions set by the competent authority.
Pakistan		Require that all parts of the shark are used and fins be landed naturally attached.
Panama	2006	Shark finning is prohibited. Industrial fishers must land sharks with fins naturally attached. Artisanal fishers may separate fins from the carcass but fins must not weigh more than 5% of the total weight of the carcass.
Seychelles	2006	Fins may not be removed onboard a vessel unless authorized. Must produce evidence that they have the capacity to utilize all parts or the shark. Fins may not be transshipped. Fins must not weigh more than 5% of the total weight of the carcass (after evisceration) or 7% (after evisceration and beheading).
Sierra Leone	2008	Ban on shark finning.
South Africa	1998	Sharks must be landed, transported, sold, or disposed of whole (they can be headed and gutted). Sharks from international waters may be landed in South Africa with fins detached.
Sri Lanka	2001	Ban on shark finning.
Taiwan	2012	Enacted a shark finning ban with the exception of vessels not landing in Taiwan.
Venezuela	2012	Sharks caught in Venezuelan waters must be brought to port with fins naturally attached.

[27] http://www.fish.govt.nz/en-nz/Environmental/Sharks/Eliminating+shark+finning+in+New+Zealand.htm

Appendix 4

Summary of RFMO Shark Regulations pertinent to the oceanic whitetip shark

RFMO	Date	Shark Regulations
International Commission for the Conservation of Atlantic Tunas (ICCAT)[28]	2010	Recommendation 10-07 specifically prohibits the retention, transshipping, landing, storing, selling, or offering for sale any part or whole carcass of oceanic whitetip sharks (*C. longimanus*) in any fishery.
Inter-American-Tropical-Tuna-Commission (IATTC)[29]	2011	Resolution C-11-10 on the conservation of oceanic whitetip sharks caught in association with fisheries in the Antigua Convention Area prohibits 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.
Western and Central Pacific Fisheries Commission (WCPFC)[30]	2013	Conservation Management Measure (CMM) 2011-04 prohibits vessels flying their flag and vessels under charter arrangements to the CCM 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. WCPFC also adopted a CMM 2014-05 (effective July 2015) that requires each national fleet to choose either banning wire leaders or banning the use of shark lines.
Indian Ocean Tuna Commission (IOTC)[31]	2013	Resolution 13/06 prohibits, as an interim pilot measure, all fishing vessels flying their flag and on the IOTC Record of Authorized Vessels, or authorized to fish for tuna or tuna-like species managed by the IOTC on the high seas to retain onboard, transship, land or store any part or whole carcass of oceanic whitetip sharks with the exception of scientific observers collecting biological samples. The provisions of this measure do not apply to artisanal fisheries operating exclusively in their respective Exclusive Economic Zone (EEZ) for the purpose of local

[28] https://www.iccat.int/en/RecsRegs.asp
[29] https://www.iattc.org/ResolutionsActiveENG.htm
[30] https://www.wcpfc.int/conservation-and-management-measures
[31] http://www.iotc.org/cmms/basic

RFMO	Date	Shark Regulations
		consumption. This measure is also not binding on India.
Indian Ocean Tuna Commission (IOTC)	2005	Requires that fishers fully utilize any retained catches of sharks. 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. Onboard fins cannot weigh more than 5% of the weight of sharks onboard, up to the first point of landing (HSI 2014).
Inter-American Tropical Tuna Commission (IATTC)	2005	
North Atlantic Fisheries Organization (NAFO)	2005	
Southeast Atlantic Fisheries Commission (SEAFO)	2006	
Western and Central Pacific Fisheries Commission (WCPFC)	2008	
North East Atlantic Fisheries Commission (NEAFC)	2007	

Appendix 5

Status and Development of National Plans of Action-Sharks by top 26 shark-catching countries/territories and regulatory mechanisms in each country (Source: Adapted by Fischer *et al*. (2012) and updated via http://www.fao.org/fishery/ipoa-sharks/npoa/en).

Rank and Country/Territory	NPOA-Sharks
1. Indonesia	Yes, released in 2010
2. India	No, under development as at October 2004; current status unknown
3. Spain	Yes, European Community (EC) Action Plan on the Conservation and Management of Sharks
4. Taiwan	Yes, released in 2006
5. Argentina	Yes, released in 2004
6. Mexico	Yes, released in 2004
7. USA	Yes, released in 2001
8. Pakistan	No; status unknown
9. Malaysia	Yes, released in 2006; revised in 2014
10. Japan	Yes, released in 2001; revised in 2009
11. France	Yes, see EC Action Plan

Rank and Country/Territory	**NPOA-Sharks**
12. Thailand	No, drafted in 2005, but current status unknown
13. Brazil	No, draft available but not approved
14. Sri Lanka	Yes, released in 2013
15. New Zealand	Yes, released in 2008; revised in 2013
16. Portugal	Yes, see EC Action Plan
17. Nigeria	No
18. Iran	Yes, but unavailable
19. United Kingdom	Yes, see EC Action Plan
20. Republic of Korea	Yes, released in 2011
21. Canada	Yes, released in 2007
22. Peru	No, drafted in 2005, but awaiting adoption
23. Yemen	No
24. Australia	Yes, released in 2004; revised in 2012
25. Senegal	Yes, released in 2005
26. Venezuela	Yes, released in 2006

References

Agnew, D.J., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J.R. and Pitcher, T.J. (2009) Estimating the Worldwide Extent of Illegal Fishing. *PloS one,* **4,** e4570-e4570.

Aguilar, C., González-Sansón, G., Hueter, R.E., Rojas, E., Cabrera, Y., Briones, A., Borroto, R., Hernández, A. and Baker, P. (2014) Captura de tiburones en la región noroccidental de Cuba. *Lat. Am. J. Aquat. Res.,* **42,** 477-487.

Amorim, A.F. (1998) Elasmobranchs caught by longlines off Brazil. *Marine and Freshwater Research,* **49,** 621-632.

Anderson, R.C. and Waheed, A. (1990) Exploratory fishing for large pelagic species in the Maldives. *Ministry of Fisheries and Agriculture. Republic of Maldives Bay of Bengal Programme For Fisheries Development.***,** 17 pp.

Anderson, R.C., Adam, M.S. and Saleem, M.R. (2011) Shark longline fishery in the northern Maldives. IOTC-2011-WPEB07-27 Rev_1.

Arauz, R. (2017) Report: oceanic whitetip shark (Carcharhinus longimanus) landing information from Costa Rica, inadequacy of existing domestic and regional regulatory regimes, and recommendations for oceanic whitetip shark protective regulations. Fins Attached Marine Research and Conservation. 16pp.

Ardill, D., Itano, D. and Gillett, R. (2011) A review of bycatch and discard issues in Indian Ocean tuna fisheries. *SmartFish Working Papers No. 00X. Indian Ocean Commission-SmartFish Programme.***,** 48 pp.

Arocha, F., Arocha, O. and Marcano, L.A. (2002) Observed shark bycatch from the Venezuelan tuna and swordfish fishery from 1994 through 2000. *Col. Vol. Sci. Pap. ICCAT,* **54,** 1123-1131.

Asano-Filho, M., Fonteles Holanda, F.C.A., da Silva Santos, F.J., Lucena, F. and de Sousa Lima Pantaleão, G. (2004) A short note on the catch composition and weight-length relationship of tunas, billfishes and sharks of North Brazil. *Brazilian Journal of Oceanography,* **52,** 249-253.

Austin, B. and Zhang, X.H. (2006) Vibrio harveyi: a significant pathogen of marine vertebrates and invertebrates. *Lett. Appl. Microbiol.,* **43,** 119-124.

Australia Department of the Environment (2014) Non-Detriment finding for the export of shark species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and harvested from Australian waters: *Sphyrna lewini* - scalloped hammerhead shark, *Sphyrna mokarran* -great hammerhead shark, *Sphyrna zygaena* -smooth hammerhead shark, *Lamna nasus* -porbeagle shark, *Carcharhinus longimanus* - oceanic whitetip shark. p. 56.

Backus, R.H., Springer, S. and Arnold Jr., E.L. (1956) A contribution to the natural history of the white-tip shark, *Pterolamiops longimanus* (Poey). *Deep-sea Research,* **3,** 178-188.

Barreto, R., Ferretti, F., Mills, J., Amorim, A., Andrade, H., Worm, B. and Lessa, R. (2015) Trends in the exploitation of South Atlantic shark populations. *Conservation Biology,* **30,** 792-804.

Bass, A.J., D' Aubrey, J.D. and Kistnasamy, N. (1973) *Sharks of the east coast of southern Africa. I. The genus Carcharhinus (Carcharhinidae).* Durban, Republic of South Africa: South African Association for Marine Biological Research, The Oceanographic Institute, 168pp.

Baum, J., Medina, E., Musick, J.A. and Smale, M. (2006) *Carcharhinus longimanus*. The IUCN Red List of Threatened Species. Version 2015.2. Downloaded on 24 June 2015.: IUCN.

Baum, J.K., Myers, R.A., Kehler, D.G., Worm, B., Harley, S.J. and Doherty, P.A. (2003) Collapse and conservation of shark populations in the Northwest Atlantic. *Science,* **299,** 389-392.

Baum, J.K. and Myers, R.A. (2004) Shifting baselines and the decline of pelagic sharks in the Gulf of Mexico. *Ecol. Lett.,* **7,** 135-145.

Baum, J.K. and Blanchard, W. (2010) Inferring shark population trends from generalized linear mixed models of pelagic longline catch and effort data. *Fisheries Research,* **102,** 229-239.

Beerkircher, L.R., Cortés, E. and Shivji, M. (2002) Characteristics of shark bycatch observed on pelagic longlines off the Southeastern United States, 1992–2000. *Marine Fisheries Review,* **64,** 40-49.

Beerkircher, L.R., Brown, C.J., Abercrombie, D.L. and Lee, D.W. (2004) SEFSC Pelagic observer program data summary for 1992-2002. *NOAA Technical Memorandum NMFS-SEFSC-522***,** 25.

Bensley, N., Woodhams, J., Patterson, H., Rodgers, M., McLoughlin K, Stobutzki, I. and Begg, G. (2010) 2009 Shark Assessment Report for the Australian National Plan of Action for the Conservation and Management of sharks, Final Report to the Department of Agriculture, Fisheries and Forestry, Bureau of Rural Sciences. Canberra, Australia.

Berkeley, S.A. and Campos, W.L. (1988) Relative abundance and fishery potential of pelagic sharks along Florida's East Coast. *Marine Fisheries Review,* **50.**

Blaber, S.J.M., Dichmont, C.M., White, W., Buckworth, R., Sadiyah, L., Iskandar, B., Nurhakim, S., Pillans, R., Andamari, R., Dharmadi and Fahmi (2009) Elasmobranchs in southern Indonesian fisheries: the fisheries, the status of the stocks and management options. *Rev. Fish Biol. Fish.,* **19,** 367-391.

Boggs, C.H. and Ito, R.Y. (1993) Hawaii's pelagic fisheries. *Marine Fisheries Review,* **55,** 69-82.

Bonfil, R., Clarke, S. and Nakano, H. (2008) The biology and ecology of the oceanic whitetip shark, *Carcharhinus longimanus*. In: *Sharks of the Open Ocean: Biology, Fisheries, and Conservation.* M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds): Blackwell Publishing. pp. 128-139.

Bradai, M.N., Saidi, B. and Enajjar, S. (2012) Elasmobranchs of the Mediterranean and Black Sea: status, ecology and biology bibliographic analysis. *General Fisheries Commission for the Mediterranean Studies and Reviews,* **91,** 116.

Branstetter, S. (1990) Early life-history implications of selected carcharhinoid and lamnoid sharks of the Northwest Atlantic. In: *Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of the fisheries. NOAA Tech. Rep. NMFS 90.* J. Pratt, Harold L. , S.H. Gruber and T. Taniuchi (eds): U.S. Dep. Commer., NOAA NMFS. pp. 17-28.

Brodziak, J., Walsh, W.A. and Hilborn, R. (2013) Model selection and multimodel inference for standardizing catch rates of bycatch species: a case study of oceanic whitetip shark in the Hawaii-based longline fishery. *Canadian Journal of Fisheries and Aquatic Sciences,* **70,** 1723-1740.

Bromhead, D., Clarke, S., Hoyle, S., Muller, B., Sharples, P. and Harley, S. (2012) Identification of factors influencing shark catch and mortality in the Marshall Islands tuna longline fishery and management implications. *Journal of fish biology,* **80,** 1870-1894.

Burgess, G.H., Beerkircher, L.R., Cailliet, G.M., Carlson, J.K., Cortés, E., Goldman, K.J., Grubbs, R.D., Musick, J.A., Musyl, M.K. and Simpfendorfer, C.A. (2005a) Reply to "Robust estimates of decline for pelagic shark populations in the Northwest Atlantic and Gulf of Mexico". *Fisheries,* **30,** 30-31.

Burgess, G.H., Beerkircher, L.R., Cailliet, G.M., Carlson, J.K., Cortés, E., Goldman, K.J., Grubbs, R.D., Musick, J.A., Musyl, M.K. and Simpfendorfer, C.A. (2005b) Is the collapse of shark populations in the Northwest Atlantic Ocean and Gulf of Mexico real? *Fisheries,* **30,** 19-26.

Camara, M.B. (2008) Quelle gestion des peches artisanales en Afrique de l'Ouest ? Etude de la complexite de l'espace halieutique en zone littoral senegalaise., Universite Cheikh Anta Diop Dakar.

Camargo, S.M., Coelho, R., Chapman, D., Howey-Jordan, L., Brooks, E.J., Fernando, D., Mendes, N.J., Hazin, F.H., Oliveira, C., Santos, M.N., Foresti, F. and Mendonca, F.F. (2016) Structure and genetic variability of the oceanic whitetip shark, *Carcharhinus longimanus*, determined using mitochondrial DNA. *PloS one,* **11,** 1-11.

Camhi, M.D., Pikitch, E.K. and Babcock, E.A. (2008) *Sharks of Open Ocean: Biology, Fisheries and Conservation.* Blackwell Publishing, 536pp.

Camhi, M.D., Valenti, S.V., Fordham, S.V., Fowler, S.L. and Gibson, C. (2009) The conservation status of pelagic sharks and rays: report of the IUCN Shark Specialist Group Pelagic Shark Red List Workshop. Newbury, UK., IUCN Species Survival Commission’s Shark Specialist Group. 78pp.

Carlson, J.K. and Gulak, S.J.B. (2012) Habitat use and movements patterns of oceanic whitetip, bigeye thresher, and dusky sharks based on archival satellite tags. *Collect. Vol. Sci. Pap. ICCAT,* **68,** 1922-1932.

Castro, A.L., Stewart, B.S., Wilson, S.G., Hueter, R.E., Meekan, M.G., Motta, P.J., Bowen, B.W. and Karl, S.A. (2007) Population genetic structure of Earth's largest fish, the whale shark (Rhincodon typus). *Mol. Ecol.,* **16,** 5183-5192.

Castro, J.A. and Mejuto, J. (1995) Reproductive parameters of blue shark, *Prionace glauca*, and other sharks in the Gulf of Guinea. *Marine Freshwater Research,* **46,** 967-973.

Cavanagh, R.D. and Gibson, C. (2007) Overview of the conservation stuats of cartilaginous fishes (Chondrichthyans) in the Mediterranean Sea. The World Conservation Union (IUCN). vi + 42.pp.

Chapple, T.K. and Botsford, L.W. (2013) A comparison of linear demographic models and fraction of lifetime egg production for assessing sustainability in sharks. *Conservation biology : the journal of the Society for Conservation Biology,* **27,** 560-568.

Chiaramonte, C. and Vooren, C.M. (2007) Squatina guggenheim, Hidden Angelshark. The IUCN Red List of Threatened Species 2007: e.T39330A10202558. http://dx.doi.org/10.2305/IUCN.UK.2007.RLTS.T39330A10202558.en.

Chin, A., Kyne, P.M., Walker, T.I. and McAuley, R.B. (2010) An integrated risk assessment for climate change: analysing the vulnerability of sharks and rays on Australia's Great Barrier Reef. *Glob. Chang. Biol.,* **16,** 1936-1953.

Chin, A., Simpfendorfer, C., Tobin, A. and Heupel, M. (2013) Validated age, growth and reproductive biology of Carcharhinus melanopterus, a widely distributed and exploited reef shark. *Marine and Freshwater Research,* **64**.

CITES (2013) Convention on International Trade in Endangered Species of Wild Fauna and Flora consideration of proposals for amendment of Appendices I and II. Sixteenth meeting of the Conference of the Parties Bangkok (Thailand), 3-14 March 2013.

Clarke, C.R., Karl, S.A., Horn, R.L., Bernard, A.M., Lea, J.S., Hazin, F.H., Prodöhl, P.A. and Shivji, M.S. (2015a) Global mitochondrial DNA phylogeography and population structure of the silky shark, *Carcharhinus falciformis*. *Marine Biology,* **162,** 945-955.

Clarke, S., Milner-Gullande, J. and Bjorndal, T. (2007) Perspectives social, economic, and regulatory drivers of the shark fin trade. *Marine Resource Economics,* **22,** 305-327.

Clarke, S. (2008) Use of shark fin trade data to estimate historic total shark removals in the Atlantic Ocean. *Aquatic Living Resources,* **21,** 373-381.

Clarke, S. (2009) An alternative estimate of catches of five species of sharks in the Western and Central Pacific Ocean based on shark fin trade data. Western and Central Pacific Fisheries Commission Scientific Committee Fifth Regular Session. WCPFC-SC5-2005/EB-WP-02. 31 pp.

Clarke, S. (2011) A status snapshot of key shark species in the Western and Central Pacific and potential management options. Western and Central Pacific Fisheries Commission Scientific Committee Seventh Regular Session. WCPFC-SC7-2011/EB-WP-04. 36 pp.

Clarke, S., Harley, S., Hoyle, S. and Rice, J. (2011a) An indicator-based analysis of key shark species based on data held by SPC-OFP. Western and Central Pacific Fisheries Commission Scientific Committee Seventh Regular Session. WCPFC-SC7-2011/EB-WP-01. 1-88.

Clarke, S., Yokawa, K., Matsunaga, H. and Nakano, H. (2011b) Analysis of North Pacific shark data from Japanese commercial longline and research/training vessel records. Western and Central Pacific Fisheries Commission Scientific Committee Seventh Regular Session. WCPFC-SC7-2011/EB-WP-02. 87 pp.

Clarke, S. (2013) Towards an Integrated Shark Conservation and Management Measure for the Western and Central Pacific Ocean. Western and Central Pacific Fisheries Commission Scientific Committee Ninth Regular Session. WCPFC-SC9-2013/ EB-WP-08. 36 pp.

Clarke, S., Rui, C., Francis, M., Kai, M., Kohin, S., Liu, K.-M., Simpfendorfer, C., Tovar-Avila, J., Rigby, C. and Smart, J. (2015b) Report of the Pacific Shark Life History Expert Panel Workshop 28-30 April 2015. Western and Central Pacific Fisheries Commission Scientific Committee Eleventh Regular Session. 116pp.

Clarke, S.C., Magnussen, J.E., Abercrombie, D.L., Mcallister, M.K. and Shivji, M.S. (2006a) Identification of shark species composition and proportion in the Hong Kong shark fin market based on molecular genetics and trade records. *Conservation Biology,* **20,** 201-211.

Clarke, S.C., McAllister, M.K., Milner-Gulland, E.J., Kirkwood, G.P., Michielsens, C.G., Agnew, D.J., Pikitch, E.K., Nakano, H. and Shivji, M.S. (2006b) Global estimates of shark catches using trade records from commercial markets. *Ecol. Lett.,* **9,** 1115-1126.

Clarke, S.C., Harley, S.J., Hoyle, S.D. and Rice, J.S. (2012) Population trends in Pacific Oceanic sharks and the utility of regulations on shark finning. *Conservation Biology,* **27,** 197-209.

Claro, R., Baisre, J.A., Lindeman, K.C. and García-Arteaga, J.P. (2001) Cuban fisheries: historical trends and current status. In: *Ecology of the Marine Fishes of Cuba.* R. Claro, K.C. Lindeman and L.R. Parenti (eds): Washington DC: Smithsonian Institution Press. pp. 194-218.

Coelho, R., Hazin, F.H.V., Rego, M., Tambourgi, M., Oliveira, P., Travassos, P., Carvalho, F. and Burgess, G. (2009) Notes of the reproduction of the oceanic whitetip shark, Carcharhinus longimanus, in the southwestern equatorial Atlantic Ocean. *Collect. Vol. Sci. Pap. ICCAT,* **64,** 1734-1740.

Coelho, R., Fernandez-Carvalho, J., Lino, P.G. and Santos, M.N. (2012) An overview of the hooking mortality of elasmobranchs caught in a swordfish pelagic longline fishery in the Atlantic Ocean. *Aquatic Living Resources,* **25,** 311-319.

Compagno, L.J.V. (1984) FAO Species Catalogue. Vol 4. Sharks of the world: an annotated and illustrated catalogue of shark species known to date. Parts 1 and 2. FAO Fisheries Synopsis No. 125. FAO, Rome, Italy. p. 655.

Correia, J.P.S. and Smith, M.F.L. (2001) Elasmobranch landings for the Portuguese Commercial Fishery from 1986 to 2001. *Marine Fisheries Review***,** 32-40.

Cortés, E. (1999) Standardized diet compositions and trophic levels of sharks. *ICES Journal of Marine Science,* **56,** 707-717.

Cortés, E. (2002) Incorporating uncertainty into demographic modeling: application to shark populations and their conservation. *Conservation biology : the journal of the Society for Conservation Biology,* **16,** 1048-1062.

Cortés, E., Brown, C.A. and Beerkircher, L.R. (2007) Relative abundance of pelagic sharks in the western and north Atlantic ocean, including the Gulf of Mexico and Caribbean Sea. *Gulf and Caribbean Research,* **19,** 37-52.

Cortés, E. (2008a) Catches of pelagic sharks from the Western North Atlantic Ocean, including the Gulf of Mexico and Caribbean Sea. *SCRS/2007/072 Collect. Vol. Sci. Pap. ICCAT,* **62,** 1434-1446.

Cortés, E. (2008b) Comparative life history and demography of pelagic sharks. In: *Sharks of the open ocean: biology, fisheries and conservation.* M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds): Blackwell Publishing Ltd. pp. 309-320.

Cortés, E., Arocha, F., Beerkircher, L., Carvalho, F., Domingo, A., Heupel, M., Holtzhausen, H., Santos, M.N., Ribera, M. and Simpfendorfer, C. (2010) Ecological risk assessment of pelagic sharks caught in Atlantic pelagic longline fisheries. *Aquatic Living Resources,* **23,** 25-34.

Cortés, E., Domingo, A., Miller, P., Forselledo, R., Mas, F., Arocha, F., Campana, S., Coelho, R., DaSilva, C., Hazin, F.H.V., Holtzhausen, H., Keene, K., Lucena, F., Ramirez, K., Santos, M.N., Semba-Murakami, Y. and Yokawa, K. (2012) Expanded ecological risk assessment of pelagic sharks caught in Atlantic pelagic longline fisheries. *SCRS/2012/167***,** 1-56.

Cragg, J.G. (1971) Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica,* **39,** 829-844.

Cruz-Nuñez, G., Palmadóttir, H., Jónsdóttir, R. and García- Rodríguez, E. (2009) Quality of Cuban shark liver oil. Comparison with Icelandic cod liver oil. *REDVET. Revista electrónica de Veterinaria,* **10,** 1-10.

Cuba Department of Fisheries (2016) Analysis of catches of Oceanic Whitetip sharks Carcharhinus longimanus in Cuba. Cuba Department of Fisheries Fisheries Research Center.

Cuba NPOA-Sharks (2015) National plan of action for the conservation and management of Chondrichthyes in the Republic of Cuba. Havana, Cuba: Ministry of the Food Industry. p. 51.

D'Alberto, B.M., Chin, A., Smart, J.J., Baje, L., White, W.T. and Simpfendorfer, C.A. (2017) Age, growth and maturity of oceanic whitetip shark (Carcharhinus longimanus) from Papua New Guinea. *Marine and Freshwater Research,* **68**.

Dagorn, L., Holland, K.N., Restrepo, V. and Moreno, G. (2013) Is it good or bad to fish with FADs? What are the real impacts of the use of drifting FADs on pelagic marine ecosystems? *Fish and Fisheries,* **14,** 391-415.

Dapp, D., Arauz, R., Spotila, J.R. and O'Connor, M.P. (2013) Impact of Costa Rican longline fishery on its bycatch of sharks, stingrays, bony fish and olive ridley turtles (Lepidochelys olivacea). *Journal of Experimental Marine Biology and Ecology,* **448,** 228-239.

De Young, C. (2006) Review of the state of world marine capture fisheries management: Indian Ocean. Rome, FAO. 458pp.

Dent, F. and Clarke, S. (2015) State of the global market for shark products. FAO Fisheries and Aquaculture Technical Paper No. 590. Rome, FAO. 187pp.

Dermawan, A., Sadili, D., Suharsono and Kasasiah, A. (2013) A review of the status of shark fisheries and shark conservation in Indonesia. Directorate of Marine and Aquatic Resources Conservation Directorate General of Marine, Coasts and Small Islands Ministry of Marine Affairs and Fisheries. p. 94.

Di Dario, F., Alves, C.B.M., Boos, H., Frédou, F.L., Lessa, R.P.T., Mincarone, M.M., Pinheiro, M.A.A., Polaz, C.N.M., Reis, R.E., Rocha, L.A., Santana, F.M., Santos, R.A., Santos, S.B., Vianna, M. and Fábio, V. (2014) A better way forward for Brazil's fisheries. *Sci. Transl. Med.,* **347**.

Diop, M. and Dossa, J. (2011) 30 years of shark fishing in West Africa. In: *Development of fisheries, catch trends, and their conservation status in Sub-Regional Fishing Commission member countries* Corlet/Condé-sur-Noireau, France.

Domingo, A. (2004) ¿Adonde fue el longimanus? In: *Elasmovisor*: Sociedade Brasileira para o Estudo de Elasmobrânquios.

Domingo, A., Miller, P., Forselledo, R., Pons, M. and Berrondo, L. (2007) Abundancia del tiburon loco (Carcharhinus longimanus) el el Atlantico Sur. *Col. Vol. Sci. Pap. ICCAT,* **60,** 561-565.

Driggers, W.B., Carlson, J.K., Cullum, B., Dean, J.M., Oakley, D. and Ulrich, G. (2004) Age and growth of the blacknose shark, Carcharhinus acronotus, in the western North Atlantic Ocean with comments on regional variation in growth rates. *Environmental Biology of Fishes,* **71,** 171-178.

Driggers, W.B., Carlson, J.K., Cortés, E. and Ingram Jr., G.W. (2011) Effects of wire leader use and species-specific distributions on shark catch rates off the southeastern United States. *IOTC-2011-SC14 – INF08.* [www.iotc.org/files/proceedings/2011/sc/IOTC-2011-SC14-INF08[E].pdf](www.iotc.org/files/proceedings/2011/sc/IOTC-2011-SC14-INF08[E].pdf).

Eddy, C., Brill, R. and Bernal, D. (2016) Rates of at-vessel mortality and post-release survival of pelagic sharks captured with tuna purse seines around drifting fish aggregating devices (FADs) in the equatorial eastern Pacific Ocean. *Fisheries Research,* **174,** 109-117.

Eriksson, H. and Clarke, S. (2015) Chinese market responses to overexploitation of sharks and sea cucumbers. *Biological Conservation,* **184,** 163-173.

Escobar-Sanchez, O., Galvan-Magana, F. and Rosiles-Martinez, R. (2010) Mercury and selenium bioaccumulation in the smooth hammerhead shark, Sphyrna zygaena Linnaeus, from the Mexican Pacific Ocean. *Bull. Environ. Contam. Toxicol.,* **84,** 488-491.

FAO (2012) Report of the fourth FAO expert advisory panel for the assessment of proposals to amend Appendices I and II of CITES concerning commercially-exploited aquatic species. In: *FAO Fisheries and Aquaculture Report No. 1032* Rome. p. 169.

Fernandez-Carvalho, J., Coelho, R., Santos, M.N. and Amorim, S. (2015) Effects of hook and bait in a tropical northeast Atlantic pelagic longline fishery: Part II—Target, bycatch and discard fishes. *Fisheries Research,* **164,** 312-321.

Fiedler, F.N., Port, D., Giffoni, B.B., Sales, G. and Fisch, F. (2017) Pelagic longline fisheries in southeastern/south Brazil. Who cares about the law? *Marine Policy,* **77,** 56-64.

Filmalter, J., Forget, F., Poisson, F., Vernet, A.L., Bach, P. and Dagorn, L. (2012) Vertical and horizontal behaviour of silky, oceanic white tip and blue sharks in the western Indian Ocean. *IOTC–2012–WPEB08–23.*

Fischer, J., Erikstein, K., D'Offay, B., Guggisberg, S. and Barone, M. (2012) Review of the implementation of the Internatinoal Plan of Action for the Conservation and Mangement of Sharks. Rome, Food and Agricultural Organization of the United Nations.

Flewelling, L.J., Adams, D.H., Naar, J.P., Atwood, K.E., Granholm, A.A., O'Dea, S.N. and Landsberg, J.H. (2010) Brevetoxins in sharks and rays (Chondrichthyes, Elasmobranchii) from Florida coastal waters. *Marine Biology,* **157,** 1937-1953.

Fong, Q.S.W. and Anderson, J.L. (2000) Assessment of the Hong Kong shark fin trade. *INFOFISH International,* **1,** 28-32.

Fontenau, A. (2011) Potential impact of gillnets fisheries on Indian ocean ecosystems? Indian Ocean Tuna Commission. IOTC-2011-WPEB07-INF32.

Francis, M.P. and Lyon, W.S. (2014) Review of commercial fishery interactions and population information for the oceanic whitetip shark, a protected New Zealand species. National Institute of Water & Atmospheric Research Ltd.

Frédou, F.L., Tolotti, M.T., Frédou, T., Carvalho, F., Hazin, H., Burgess, G., Coelho, R., Waters, J.D., Travassos, P. and Hazin, F.H.V. (2015) Sharks caught by the Brazilian tuna longline fleet: an overview. *Rev. Fish Biol. Fish.,* **25,** 365-377.

Gaither, M.R., Bowen, B.W., Rocha, L.A. and Briggs, J.C. (2015) Fishes that rule the world: circumtropical distributions revisited. *Fish and Fisheries***,** n/a-n/a.

Gallagher, A.J., Orbesen, E.S., Hammerschlag, N. and Serafy, J.E. (2014) Vulnerability of oceanic sharks as pelagic longline bycatch. *Global Ecology and Conservation,* **1,** 50-59.

García-Cortés, B. and Mejuto, J. (2002) Size-weight relationships of the swordfish (Xiphias gladius) and several pelagic shark species caught in the Spanish surface longline fishery in the Atlantic, Indian, and Pacific Oceans. *Col. Vol. Sci. Pap. ICCAT,* **54,** 1132-1149.

García-Cortés, B., Ramos-Cartelle, A., González-González, I. and Mejuto, J. (2012) Biological observations of oceanic whitetip shark (Carcharhinus longimanus) on Spanish surface longline fishery targeting swordfish in the Indian Ocean over the period 1993-2011. *IOTC-2012-WPEB08-25*.

García-Hernández, J., Cadena-Cárdenas, L., Betancourt-Lozano, M., García-De-La-Parra, L.M., García-Rico, L. and Márquez-Farías, F. (2007) Total mercury content found in edible tissues of top predator fish from the Gulf of California, Mexico. *Toxicol. Environ. Chem.,* **89,** 507-522.

Gelsleichter, J. and Walker, C.J. (2010) Pollutant exposure and effects in sharks and their relatives. Taylor and Francis Group, LLC. p. 37.

Goldman, K. and Cailliet, G. (2004) Age Determination and Validation in Chondrichthyan Fishes. In: *Biology of Sharks and Their Relatives*. pp. 399-447.

Gonzalez-Pestana, A., Kouri J, C. and Velez-Zuazo, X. (2014) Shark fisheries in the Southeast Pacific: A 61-year analysis from Peru. *F1000 Research,* **3,** 19.

Hall, M. and Román, M. (2013) Bycatch and non-tuna catch in the tropical tuna purse seine fisheries of the world. *Food and Agricultural Organizaiton of the United Nations, Rome 2013,* **568,** 262.

Hall, M. and Román, M.H. (2016) The fishery on fish-aggregating devices (FADS) in the Eastern Pacific Ocean - Update. Inter-American Tropical Tuna Commission Scientific Advisory Committee, Seventh Meeting, La Jolla, California (USA, 09-13 May 2016. DOCUMENT SAC-07-03e.

Harley, S., Caneco, B., Donovan, C., Tremblay-Boyer, L. and Brouwer, S. (2015) Monte Carlo simulation modelling of possiblemeasures to reduce impacts of longlining on oceanic whitetip and silky sharks. Western and Central Pacific Fisheries Commission Scientific Committee Eleventh Regular Session. WCPFC-SC11-2015/EB-WP-02.

Harley, S. and Pilling, G. (2016) Potential implications of the choice of longline mitigation approach allowed within CMM 2014-05. Western and Central Pacific Fisheries Commission Scientific Committee Twelfth Regular Session. WCPFC-SC12-2016/EB-WP-06.

Hasarangi, D.G.N., Maldeniya, R. and Haputhantri, S.S.K. (2012) A Review on shark fishery resources in Sri Lanka. *IOTC–2012–WPEB08–15 Rev_1*, 15 p.

Hazen, E.L., Jorgensen, S., Rykaczewski, R.R., Bograd, S.J., Foley, D.G., Jonsen, I.D., Shaffer, S.A., Dunne, J.P., Costa, D.P., Crowder, L.B. and Block, B.A. (2012) Predicted habitat shifts of Pacific top predators in a changing climate. *Nature Climate Change,* **3,** 234-238.

Hazin, F.H.V., Hazin, H.G. and Travassos, P. (2007) CPUE and catch trends of shark species caught by Brazilian longliners in the Southwestern Atlantic Ocean. *Col. Vol. Sci. Pap. ICCAT,* **60,** 636-647.

Herrera, M. and Pierre, L. (2011) Review of the statistical data available for the bycatch species. IOTC–2011–WPEB07–08.

Hoelzel, A.R., Shivji, M.S., Magnussen, J. and Francis, M.P. (2006) Low worldwide genetic diversity in the basking shark (Cetorhinus maximus). *Biol. Lett.,* **2,** 639-642.

Howey-Jordan, L.A., Brooks, E.J., Abercrombie, D.L., Jordan, L.K.B., Brooks, A., Williams, S., Gospodarczyk, E. and Chapman, D.D. (2013) Complex Movements, philopatry and expanded depth range of a severely threatened pelagic shark, the oceanic whitetip (Carcharhinus longimanus) in the western North Atlantic. *PloS one,* **8,** 1-12.

Howey, L.A., Tolentino, E.R., Papastamatiou, Y.P., Brooks, E.J., Abercrombie, D.L., Watanabe, Y.Y., Williams, S., Brooks, A., Chapman, D.D. and Jordan, L.K.B. (2016) Into the deep: the functionality of mesopelagic excursions by an oceanic apex predator. *Ecol. Evol.*

Huang, H.-W. and Liu, K.-M. (2010) Bycatch and discards by Taiwanese large-scale tuna longline fleets in the Indian Ocean. *Fisheries Research,* **106,** 261-270.

Hutchinson, M.R., Itano, D.G., Muir, J.A. and Holland, K.N. (2015) Post-release survival of juvenile silky sharks captured in a tropical tuna purse seine fishery. *Marine Ecology Progress Series,* **521,** 143-154.

IATTC (2007) Proposal for a comprehensive assessment of key shark species caught in assocaition with fisheries in the eastern Pacific Ocean. Document SAR-8-15. Inter-American Tropical Tuna Commission Working Group to Review Stock Assessments. La Jolla, California.

IATTC (2011) Resolution C-11-10 - Resolution on the conservatino of oceanic whitetip sharks caught in association with fisheries in the Antigua Convention Area. Inter-American Tropical Tuna Commission 82nd Meeting, La Jolla, California (USA).

ICES (2014) Report of the Working Group on Elasmobranch Fishes (WGEF). Lisbon, Portugal. 681pp.

ICMBio (2014) Lista de Especies Ameacadas - Peixes Carcharhinus longimanus (Poey, 1861) - Tubarão-galha-branca. Ministerio do Meio Ambiente Instituto Chico Mendes de Conservacao de Biodiversidade. Accessed: http://www.icmbio.gov.br/portal/faunabrasileira/lista-de-especies/6526-especie-6526.

IOTC (2011a) Report of the seventh session of the IOTC Working Party on Ecosystems and Bycatch. Lankanfinolhu, North Malé Atoll, Republic of Maldives, IOTC–2011–WPEB07–R[E]. p. 99.

IOTC (2011b) Report of the 14th Session of the IOTC Scientific Committee. Mahé, Seychelles, Indian Ocean Tuna Commission. 259pp.

IOTC (2014) Report of the Seventeenth Session of the IOTC Scientific Committee. IOTC–2014–SC17–R[E]. 357.

IOTC (2015a) Status of the Indian Ocean oceanic whitetip shark (OCS: Carcharhinus longimanus). *IOTC–2015–SC18–ES18[E]*.

IOTC (2015b) Review of the statistical data available for bycatch species. Indian Ocean Tuna Commission. IOTC–2015–WPEB11–07. 39pp.

Jabado, R.W., Al Ghais, S.M., Hamza, W., Henderson, A.C., Spaet, J.L.Y., Shivji, M.S. and Hanner, R.H. (2015) The trade in sharks and their products in the United Arab Emirates. *Biological Conservation,* **181,** 190-198.

Jacquet, J., Alava, J.J., Ganapathiraju, P., Henderson, S. and Zeller, D. (2008) In hot soup: sharks captured in Ecuador's waters. *Environ. Sci.,* **5**.

Jayathilaka, R.A.M. and Maldeniya, R. (2015) Impact of policies on the conservation of sharks in the large pelagic fishery. IOTC–2015–WPEB11–18 Rev_1. National Aquatic Resources Research and Development Agency (NARA), Crow Island, Colombo 15, Sri Lanka.

John, M.E. and Varghese, B.C. (2009) Decline in CPUE of oceanic sharks in the Indian EEZ : urgent need for precautionary approach. Mobasa, Kenya, IOTC Working Party on Ecosystems and Bycatch.

Joung, S.-J., Liu, K.-M., Liao, Y.-Y. and Hsu, H.-H. (2005) Observed by-catch of Taiwanese tuna longline fishery in the South Atlantic Ocean. *J. Fish. Soc. Taiwan,* **32,** 69-77.

Joung, S.-J., Chen, N.-F., Hsu, H.-H. and Liu, K.-M. (2016) Estimates of life history parameters of the oceanic whitetip shark,Carcharhinus longimanus, in the Western North Pacific Ocean. *Mar. Biol. Res.*, 1-11.

Kannan, K., Blankenship, A.L., Jones, P.D. and Giesy, J.P. (2000) Toxicity reference values for the toxic effects of Polychlorinated Biphenyls to aquatic mammals. *Hum. Ecol. Risk Assess.,* **6,** 181-201.

Kirby and Hobday (2007) Ecological risk assessment for the effects of fishing in the Western & Central Pacific Ocean: productivity-susceptibility anlysis. Western and Central Pacific Fisheries Commission, Scientific Committee Third Regular Session. 20pp.

Kohler, N.E., Casey, J.G. and Turner, P.A. (1998) NMFS cooperative shark tagging program, 1962-1993: an atlas of shark tag and recapture data. *Marine Fisheries Review,* **60,** 1-87.

Koopman, M. and Knuckey, I. (2014) Advice on CITES Appendix II Shark Listings. Fishwell Consulting Pty Ltd 2014.

Kyne, P.M., Carlson, J.K., Ebert, D.A., Fordham, S.V., Bizzarro, J.J., Graham, R.T., Kulka, D.W., Tewes, E.E., Harrison, L.R. and Dulvy, N.K. (2012) The conservation status of North American, Central American, and Caribbean Chondrichthyans. Vancouver, Canada, IUCN Species Survival Commission Shark Specialist Group.

Lack, M. and Meere, F. (2009) Pacific Islands Regional Plan of Action for sharks: guidance for Pacific Island countries and territories on the conservation and management of sharks. 123 pp.

Lack, M. and Sant, G. (2012) An overview of shark utilisation in the Coral Triangle region. TRAFFIC and WWF.

Lawson, T. (2011) Estimation of catch rates and catches of key shark species in tuna fisheries of the Western and Central Pacific Ocean using observer data. Western and Central Pacific Fisheries Commission, Scientific Committee Seventh Regular Session.

Lee, H.K., Kim, S.J., Jeong, Y., Lee, S., Jeong, W., Lee, W.C., Choy, E.J., Kang, C.K. and Moon, H.B. (2015) Polybrominated diphenyl ethers in thirteen shark species from offshore and coastal waters of Korea. *Mar. Pollut. Bull.,* **95,** 374-379.

Lessa, R., Santana, F.M. and Paglerani, R. (1999) Age, growth and stock structure of the oceanic whitetip shark, Carcharhinus longimanus, from the southwestern equatorial Atlantic. *Fisheries Research,* **42,** 21-30.

Liu, K.-M. and Tsai, W.-P. (2011) Catch and life history parameters of pelagic sharks in the Northwestern Pacific. Keelung, Chinese Taipei, ISC Shark Working Group Workshop. 12pp.

Liu, S.Y., Chan, C.L., Lin, O., Hu, C.S. and Chen, C.A. (2013) DNA barcoding of shark meats identify species composition and CITES-listed species from the markets in Taiwan. *PloS one,* **8,** e79373.

Lombardi-Carlson, L.A., Cortés, E., Parsons, G.R. and Manire, C.A. (2003) Latitudinal variation in life-history traits of bonnethead sharks, Sphyrna tiburo, (Carcharhiniformes:Sphyrnidae) from the eastern Gulf of Mexico. *Marine and Freshwater Research,* **54,** 875-883.

Madigan, D.J., Brooks, E.J., Bond, M.E., Gelsleichter, J., Howey, L.A., Abercrombie, D.L., Brooks, A. and Chapman, D.D. (2015) Diet shift and site-fidelity of oceanic whitetip sharks Carcharhinus longimanus along the Great Bahama Bank. *Marine Ecology Progress Series,* **529,** 185-197.

Martinez-Ortiz, J., Aires-da-Silva, A.M., Lennert-Cody, C.E. and Maunder, M.N. (2015) The Ecuadorian Artisanal Fishery for Large Pelagics: Species Composition and Spatio-Temporal Dynamics. *PloS one,* **10,** e0135136.

Mather, F.J. and Day, C.G. (1954) Observations of pelagic fishes of the tropical Atlantic. *Copeia,* **1954, No. 3,** 179-188.

Maufroy, A., Chassot, E., Joo, R. and Kaplan, D.M. (2015) Large-Scale Examination of Spatio-Temporal Patterns of Drifting Fish Aggregating Devices (dFADs) from Tropical Tuna Fisheries of the Indian and Atlantic Oceans. *PloS one,* **10,** e0128023.

Maunder, M.N. and Punt, A.E. (2004) Standardizing catch and effort data: a review of recent approaches. *Fisheries Research,* **70,** 141-159.

Mazzoleni, R.C. and Schwingel, P.R. (1999) Elasmobranch species landed in Itajaí Harbor, southern Brazil. *Notas TÉC. Facimar,* **3,** 111-118.

Megalofonu, P., Yannopoulos, C., Damalas, D., De Metrio, G., Deflorio, M., se la Serna, J.M. and Macias, D. (2005) Incidental catch and estimated discards of pelagic sharks from the swordfish and tuna fisheries in the Mediterranean Sea. *Fishery Bulletin,* **103,** 620-634.

Mejuto, J., García-Cortés, B. and Ramos-Cartelle, A. (2005) Tagging-recapture activities of large pelagic sharks carried out by Spain or in collaboration with the tagging programs of other countries. *Col. Vol. Sci. Pap. ICCAT,* **58,** 974-1000.

Miller, M.H., Carlson, J., Hogan, L. and Kobayashi, D. (2014) Status Review Report: Great Hammerhead Shark (Sphyrna mokarran). Final Report to National Marine Fisheries Service, Office of Protected Resources. June 2014. 116.

Molony, B. (2007) Commonly captured sharks and rays for consideration of the ecosystem and bycatch SWG at SC3. Western and Central Pacific Fisheries Commission Scientific Committee Third Regular Session. WCPFC-SC3-EB SWG/IP-19.

Moreno, G. and Herrera M. (IOTC Secretariat) (2013) Estimation of fishing capacity by tuna fishing fleets in the Indian Ocean. *Report presented at the 16th Session of the Scientific Committee of the Indian Ocean Tuna Commission. Busan, Republic of Korea, 2–6 December 2013. IOTC–2013–SC16–INF04.*

MRAG Asia Pacific (2016) Towards the quantification of illegal, unreported and unregulated (IUU) fishing in the Pacific Islands region. p. 101.

Mundy-Taylor, V. and Crook, V. (2013) Into the deep: Implementing CITES measures for commercially-valuable sharks and manta rays. Report prepared for the European Commission.

Murua, H., Coelho, R., Santos, M.N., Arrizabalaga, H., Yokawa, K., Romanov, E., Zhu, J.F., Kim, Z.G., Bach, P., Chavance, P., Delgado de Molina, A. and Ruiz, J. (2012) Preliminary Ecological Risk Assessment (ERA) for shark species caught in fisheries managed by the Indian Ocean Tuna Commission (IOTC). IOTC-2012-WPEB08-31 Rev_2. 16pp.

Murua, H., Abascal, F.J., Amande, J., Ariz, J., Bach, P., Chavance, P., Coelho, R., Korta, M., Poisson, F., Santos, M.N. and Seret, B. (2013a) Provision of scientific advice for the purpose of the implementation of the EUPOA sharks. Final Report. European Commission, Studies for Carrying out the Common Fisheries Policy (MARE/2010/11 -LOT 2).

Murua, H., Santos, M.N., Chavance, P., Amande, J., Abascal, F.J., Ariz, J., Bach, P., Korta, M., Poisson, F., Coelho, R. and Seret, B. (2013b) EU project for the provision of scientific advice for the purpose of the implementation of the EUPOA sharks: a brief overview of the results for Indian Ocean. *IOTC–2013–WPEB09–19 Rev_1***,** 21 pp.

Musyl, M.K., Brill, R.W., Curran, D.S., Fragoso, N.M., McNaughton, L.M., Nielsen, A., Kikkawa, B.S. and Moyes, C.D. (2011) Postrelease survival, vertical and horizontal movements, and thermal habitats of five species of pelagic sharks in the central Pacific Ocean. *Fishery Bulletin,* **109,** 341-368.

NMFS (2006) Final Consolidated Atlantic Highly Migratory Species Fishery Management Plan. Highly Migratory Species Management Division, Office of Sustainable Fisheries. NOAA Fisheries. U.S. Department of Commerce.

NMFS (2008) Final Amendment 2 to the Consolidated Atlantic Highly Migratory Species Fishery Managment Plan. Silver Spring, MD: Office of Sustainable Fisheries, Highly Migratory Species Management Division. NOAA Fisheries. U.S. Department of Commerce. p. 726.

NMFS (2009a) Amendment 1 to the Consolidated HMS FMP. Essential Fish Habitat. Chapter 5. 59-263pp.

NMFS (2009b) Annual Report of the United States of America. U.S. Department of Commerce, NOAA Fisheries. 62pp.

NMFS (2011a) U.S. National Bycatch Report First Edition. U.S. Dep. Comm., NOAA Tech. Memo. NMFS-F/SPO-117C. 528pp.

NMFS (2011b) Final environmental assessment, regulatory impact review, and final regulatory flexibility analysis for a final rule to implement the 2010 International Commission for the Conservation of Atlantic Tunas recommendations on Sharks. United States Department of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service Office of Sustainable Fisheries Highly Migratory Species Management Division.

NMFS (2011c) Shark finning report to Congress purusant to the Shark Finning Prohibition Act (Public Law 106-557). *U.S. Department of Commerce National Oceanic and Atmospheric Administration*, 112 pp.

NMFS (2012) 2012 Stock Assessment and Fishery Evaluation report (SAFE) for Atlantic Highly Migratory Species. *Atlantic Highly Migratory Species Management Division. NOAA Fisheries. U.S. Department of Commerce*.

NMFS (2013) U.S. National Bycatch Report First Edition Update 1. L.R. Benaka, C. Rilling, E.E. Seney and H. Winarsoo (eds) U.S. Dep. of Commerce. p. 57.

NMFS (2014) 2014 Stock Assessment and Fishery Evaluation (SAFE) Report for Atlantic Highly Migratory Species. *Atlantic Highly Migratory Species Management Division. NOAA Fisheries. U.S. Department of Commerce*, 195 pp.

NMFS (2015) Improving international fisheries management: Report to Congress pursuant to section 403(a) of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006. U.S. Department of Commerce. p. 107.

NMFS (2016) HMS commercial compliance guide: guide for complying with the Atlantic tunas, swordfish, shark, and billfish regulations. Office of Sustainable Fisheries, Highly Migratory Species Management Division: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service p. 77.

NMFS (2017) 2016 Stock Assessment and Fishery Evaluation (SAFE) Report for Atlantic Highly Migratory Species. Silver Spring, MD, Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Atlantic Highly Migratory Species Management Division. 203pp.

Novianto, D., Rochman, F. and Nugraha, B. (2014) Species composition, CPUE and length frequency of oceanic sharks based on observer data from the Indonesian longline fishery in the Indian Ocean.

O'Meara, D., Harper, S., Perera, N. and Zeller, D. (2011) Reconstruction of Sri Lanka's fisheries catches 1950-2008. In: *Fisheries Centre Research Reports Fisheries Catch Reconstructions: Islands Part II.* S. Harper and D. Zeller (eds) British Columbia, Canada: Fisheries Centre, University of British Columbia.

Petersen, S., Nel, D. and Omardien, A. (2007) Towards an ecomsystem approach to longline fisheries in the Benguela: an assessment of impcats on seabirds, sea turtles, and sharks. WWF South Africa Report Series – 2007/Marine/001. World Wildlife Fund.

Piovano, S. and Gilman, E. (2016) Elasmobranch captures in the Fijian pelagic longline fishery. *Aquatic Conservation: Marine and Freshwater Ecosystems,* **2016,** 13.

PIRO (2015) Compliance guide: Fishing restrictions related to the oceanic whitetip shark, the silky shark and the whale shark. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Pacific Islands Regional Office. p. 7.

Poisson, F., Filmalter, J.D., Vernet, A.-L., Dagorn, L. and Jech, J.M. (2014) Mortality rate of silky sharks (*Carcharhinus falciformis*) caught in the tropical tuna purse seine fishery in the Indian Ocean. *Canadian Journal of Fisheries and Aquatic Sciences,* **71,** 795-798.

Ramos-Cartelle, A., García-Cortés, B., Ortíz de Urbina, J., Fernández-Costa, J., González-González, I. and Mejuto, J. (2012) Standardized catch rates of the oceanic whitetip shark (*Carcharhinus longimanus*) from observations of the Spanish longline fishery targeting swordfish in the Indian Ocean during the 1998-2011 period. IOTC-2012-WPEB08-27. 15pp.

Rice, J. and Harley, S. (2012) Stock assessment of oceanic whitetip sharks in the western and central Pacific Ocean. Western and Central Pacific Fisheries Commission Scientific Committee Eighth Regular Session. WCPFC-SC8-2012/SA-WP-06 Rev 1. 53pp.

Rice, J., Tremblay-Boyer, L., Scott, R., Hare, S. and Tidd, A. (2015) Analysis of stock status and related indicators for key shark species of the Western Central Pacific Fisheries Commission. *Western and Central Pacific Fisheries Commission, Scientific Committee Eleventh Regular Session. WCPFC-SC11-2015/EB-WP-04-Rev 1*, 146 pp.

Rodrigues, J., Freitas, D., Fernandes, Í. and Lessa, R. (2015) Estrutura populacional do tubarao estrangeiro (*Carcharhinus longimanus*) no Atlantico Sul. 3.

Roman-Verdesoto, M. and Orozco-Zoller, M. (2005) Bycatches of sharks in the tuna purse-seine fishery of th eastern Pacific ocean reported by observers of the Inter-American Tropical Tuna Commission, 1993-2004. La Jolla, California, Inter-American Tropical Tuna Commission.

Romanov, E. (2002) Bycatch in the tuna purse-seine fisheries of the western Indian Ocean. *Fishery Bulletin,* **100,** 90-105.

Romanov, E., Bach, P. and Romanova, N.y. (2008) Preliminary estimates of bycatches in the western equatorial Indian Ocean in the traditional multifilament longline gears (1961-1989). Bangkok, Thailand: IOTC Working Party on Environment and Bycatch (WPEB). IOTC-2008-WPEB-10.

Romanov, E. and Romanova, N. (2009) Size distribution and length-weight relationships for some large pelagic sharks in the Indian Ocean. IOTC Working Party on Ecosystems and Bycatch (WPEB). Mombasa, Kenya. IOTC-2009-WPEB-06.

Romanov, E., Bach, P., Rabearisoa, N., Rabehagasoa, N., Filippi, T. and Romanova, N. (2010) Pelagic elasmobranch diversity and abundance in the Indian Ocean: an analysis of long-term trends from research and fisheries longline data. IOTC-2010-WPEB-16. 19pp.

Rose, D.A. (1996) An overview of world trade in sharks and other cartilaginous fishes. A TRAFFIC Network Report. 112pp.

Ruck, C. (2016) Global genetic connectivity and diversity in a shark of high conservation concern, the oceanic whitetip, *Carcharhinus longimanus*. Master of Science, Nova Southeastern University, 64pp.

Santana, F.M., Duarte-Neto, P.J. and Lessa, R.P. (2004) *Carcharhinus longimanus*. In: *Dinâmica de Populações e Avaliação de Estoques dos Recursos Pesqueiros da Região Nordeste. Vol II.* R.P. Lessa, M.F. de Nóbrega and J.L. Bezerra Jr. (eds): Universidade Federal Rural de Pernambuco Deoartanebti de Pesca. Laboratório de Dinâmica de Populações Marinhas - DIMAR.

Satria, F., Nugroho, W., Sadiyah, D., Nugraha, L., Barata, B. and Suryanto, A. (2011) National report Indonesia southern bluefin tuna fisheries. Bali, Benoa 19 - 28th July 2011. CCSBT – ESC/1107/SBT FISHERIES – Indonesia (revised).

Seki, T., Taniuchi, T., Nakano, H. and Shimizu, M. (1998) Age, growth and reproduction of the oceanic whitetip Shark from the Pacific Ocean. *Fisheries Science,* **64,** 14-20.

Semba, Y. and Yokawa, K. (2011) Trend of standardized CPUE of oceanic whitetip shark (*Carcharhinus longimanus*) caught by Japanese longline fishery in the Indian Ocean. IOTC–2011–WPEB07–35.

Sembiring, A., Pertiwi, N.P.D., Mahardini, A., Wulandari, R., Kurniasih, E.M., Kuncoro, A.W., Cahyani, N.K.D., Anggoro, A.W., Ulfa, M., Madduppa, H., Carpenter, K.E., Barber, P.H. and Mahardika, G.N. (2015) DNA barcoding reveals targeted fisheries for endangered sharks in Indonesia. *Fisheries Research,* **164,** 130-134.

Simpfendorfer, C. (2014) Information for the development of Non Detriment Findings for CITES listed sharks. Report to Department of the Environment. Centre for Sustainable Tropical Fisheries and Aquaculture & School of Earth and Environmental Sciences, James Cook University, Queensland, Australia. 39pp.

Smale, M.J. (2008) Pelagic shark fisheries in the Indian Ocean. In: *Sharks of the Open Ocean.* M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds) Oxford, U.K.: Blackwell Publishing Ltd. pp. 247-259.

Smith, S.E., Au, D.W. and Show, C. (1998) Intrinsic rebound potentials of 26 species of Pacific sharks. *Marine and Freshwater Research,* **49,** 663-678.

Smith, S.E., Au, D.W. and Show, C. (2008) Intrinsic rates of increase in pelagic elasmobranchs. In: *Sharks of the open ocean: biology, fisheries and conservation.* M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds): Blackwell Publishing Ltd.

Sosa-Nishizaki, O., Marquez-Farias, J.F. and Villavincencio-Garayzar, C.J. (2008) Case study: pelagic shark fisheries along the west coast of Mexico. In: *Sharks of the open ocean: biology, fisheries, and conservation.* M. Camhi, E.K. Pikitch and E.A. Babcock (eds): Blackwell Publishing. pp. 60-68.

SPC (2010) Non-target species interactions with the tuna fisheries of the Western and Central Pacific Ocean. In: *Scientific Committee Sixth Annual Session* Nuku'alofa Tonga: Western and Central Pacific Fisheries Commission. p. 59.

Storelli, M.M., Ceci, E., Storelli, A. and Marcotrigiano, G.O. (2003) Polychlorinated biphenyl, heavy metal and methylmercury residues in hammerhead sharks: contaminant status and assessment. *Marine Pollution Bulletin,* **46,** 1035-1039.

Strasburg, D. (1958) Distribution, abundance, and habits of pelagic sharks in the Central Pacific ocean. . *Fishery Bulletin 138 Washington, U.S. Govt. Print. Off.,* **58,** 335-361.

Tambourgi, M.R.d.S., Hazin, F.H.V., Oliveira, P.G.V., Coelho, R., Burgess, G. and Roque, P.C.G. (2013) Reproductive aspects of the oceanic whitetip shark, *Carcharhinus longimanus* (Elasmobranchii: Carcharhinidae), in the equatorial and southwestern Atlantic Ocean. *Brazilian Journal of Oceanography,* **61,** 161-168.

Taniuchi, T. (1990) The role of elasmobranchs in Japanese fisheries. In: *Elasmobranchs as living resources: advances in the biology, ecology, systematics, and the status of the fisheries.* J. Pratt, Harold L., S.H. Gruber and T. Taniuchi (eds): NOAA Dept. of Commerce. p. 12.

Testerman, C. (2014) Molecular ecology of globally distributed sharks. Doctoral Dissertation. Nova Southeastern University. Retrieved from NSUWorks, Oceanographic Center. (6) http://nsuworks.nova.edu/occ_stuetd/6.

Tolotti, M.T., Travassos, P., Frédou, F.L., Wor, C., Andrade, H.A. and Hazin, F. (2013) Size, distribution and catch rates of the oceanic whitetip shark caught by the Brazilian tuna longline fleet. *Fisheries Research,* **143,** 136-142.

Tolotti, M.T., Bach, P., Hazin, F., Travassos, P. and Dagorn, L. (2015a) Vulnerability of the Oceanic Whitetip Shark to Pelagic Longline Fisheries. *PloS one,* **10,** e0141396.

Tolotti, M.T., Bach, P., Romanov, E. and Dagorn, L. (2015b) Interactions of oceanic whitetip sharks with the tuna purse seine fishery in the Indian Ocean. *IOTC-2015-WPEB11-29.*

Tolotti, M.T., Filmalter, J.D., Bach, P., Travassos, P., Seret, B. and Dagorn, L. (2015c) Banning is not enough: The complexities of oceanic shark management by tuna regional fisheries management organizations. *Global Ecology and Conservation,* **4,** 1-7.

Valdés, J.A., Abierno, A.R. and Hueter, R.E. (2016) Catches of oceanic whitetip sharks (Carcharhinus longimanus) off the Northwest Coast of Cuba. Center for Marine Research, University of Havana, Cuba and Mote Marine Laboratory, Sarasota, Florida USA.

Vannuccini, S. (1999) Shark utilization, marketing, and trade. *FAO Fisheries Technical Paper 389,* **Accessed online: http://www.fao.org/docrep/005/x3690e/x3690e00.htm**.

Varghese, S.P., Vijayakumaran, K., Tiburtius, A. and Mhatre, V.D. (2015) Diversity, abundance and size structure of pelagic sharks caught in tuna longline survey in the Indian seas. *Indian Journal of Geo-Marine Science,* **44,** 11.

Varghese, S.P., Unnikrishnan, N., Gulati, D.K. and Ayoob, A.E. (2016) Size, sex and reproductive biology of seven pelagic sharks in the eastern Arabian Sea. *Journal of the Marine Biological Association of the United Kingdom,* **97,** 181-196.

Varkey, D.A., Ainsworth, C.H., Pitcher, T.J., Goram, Y. and Sumaila, R. (2010) Illegal, unreported and unregulated fisheries catch in Raja Ampat Regency, Eastern Indonesia. *Marine Policy,* **34,** 228-236.

Walsh, W., Bigelow, K. and Sender, K. (2009) Decreases in shark catches and mortality in the Hawaii-based longline fishery as documented by fishery observers. In: *Western and Central Pacific Fisheries Commission Scientific Committee Fifth Regular Session. WCPFC-SC5-2009/EB- IP-8.* Port Vila, Vanuatu. p. 36.

Walsh, W.A., Kleiber, P. and McCracken, M. (2002) Comparison of logbook reports of incidental blue shark catch rates by Hawaii-based longline vessels to fishery observer data by application of a generalized additive model. *Fisheries Research,* **58,** 79-94.

Walsh, W.A. and Clarke, S.C. (2011) Analyses of catch data for oceanic whitetip and silky sharks reported by fishery observers in the Hawaii-based longline fishery in 1995−2010. Pacific Islands Fisheries Science Center Administrative Report H-11-10. 76pp.

Ward-Paige, C.A. (2017) A global overview of shark sanctuary regulations and their impact on shark fisheries. *Marine Policy,* **82,** 87-97.

Ward-Paige, C.A. and Worm, B. (2017) Global evaluation of shark sanctuaries. *Global Environmental Change,* **47,** 174-189.

Webb, H., Hobday, A., Dowdney, J., Bulman, C., Sporcic, M., Smith, T., Furlani, D., Fuller, M., Williams, A. and Stobutzki, I. (2007) Ecological Risk Assessment for the Effects of Fishing: Eastern Tuna & Billfish Fishery: Longline Sub-fishery. Report for the Australian Fisheries Management Authority.

White, W.T. (2007) Biological observations on lamnoid sharks (Lamniformes) caught by fisheries in eastern Indonesia. *Journal of the Marine Biological Association of the UK,* **87,** 781.

Williams, P., Tuiloma, I. and Falasi, C. (2015) Status of ROP Data Management with tables on ROP longline coverage. Western and Central Pacific Fisheries Commission Scinetific Committee Eleventh Regular Session. Pohnpei, Federated States of Micronesia. p. 18.

WPFMC (2009) Fishery ecosystem plan for Pacific pelagic fisheries of the Western Pacific Region. Honolulu, Hawaii., Western Pacific Regional Fishery Management Council.

WPFMC (2012) Pelagic Fisheries of the Western Pacific 2012 Annual Report. Honolulu, Hawaii, Western Pacific Regional Fishery Management Council. 292pp.

Yokawa, K. and Semba, Y. (2012) Update of the standardized CPUE of oceanic whitetip shark (Carcharhinus longimanus) caught by Japanese longline fishery in the Indian Ocean. IOTC–2012–WPEB08–26.