Status Review Report: Common Thresher (*Alopias vulpinus*) and Bigeye Thresher (*Alopias superciliosus*) Sharks

2016
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

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1. INTRODUCTION

Scope and Intent of the Present Document

On August 26, 2014 and April 27, 2015, the National Marine Fisheries Service (NMFS) received two petitions to list the common[1] and bigeye thresher[2] shark, respectively, as either threatened or endangered under the U.S. Endangered Species Act (ESA). This document is a status review of both the common thresher shark (*Alopias vulpinus*) and bigeye thresher shark *(Alopias superciliosus)*. 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)). The NMFS determined the petitions presented substantial information for consideration and that a status review was warranted for both species (see following links for the Federal Register notices for common and bigeye threshers, respectively: https://federalregister.gov/a/2015-04409 and https://federalregister.gov/a/2015-19551). The ESA stipulates that listing determinations should be based on the best scientific and commercial information available. NMFS appointed an employee in the Office of Protected Resources Endangered Species 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 common and bigeye thresher sharks.

This document reports the scientific review as well as the team's conclusions regarding the biological status of common and bigeye thresher sharks. 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 January 2016.

2. LIFE HISTORY AND ECOLOGY

2.1 Taxonomy and Distinctive Characteristics

All thresher sharks belong to the family Alopiidae and are classified as mackerel sharks (Order Lamniformes). All three extant species of thresher shark belong to the genus *Alopias* and include the pelagic (*Alopias pelagicus*), bigeye (*Alopias superciliosus*) and common (*Alopias vulpinus*) thresher sharks. For purposes of this report, "thresher sharks" refers to all members of the *Alopias* genus, and individual species will be identified by either common names (e.g., pelagic, bigeye, and common thresher) or Latin names. Eitner (1995) suggested the existence of an

[1] Friends of Animals submitted to U.S. Secretary of Commerce, Acting through the National Marine Fisheries Service, an Agency within the National Oceanic and Atmospheric Administration, August 21, 2014, "Petition to list the Common Thresher shark (*Alopias vulpinus*) under the U.S. Endangered Species Act either worldwide or as one or more distinct population segments."

[2] Defenders of Wildlife submitted to U.S. Secretary of Commerce, Acting through the National Marine Fisheries Service, an Agency within the National Oceanic and Atmospheric Administration, April 27, 2015, "Petition to list the Bigeye Thresher shark (*Alopias superciliosus*) as an Endangered, or Alternatively as a Threatened, Species Pursuant to the Endangered Species Act and for the Concurrent Designation of Critical Habitat for the Species."

unrecognized fourth species of *Alopias*, but this result was based on only one specimen, and has yet to be corroborated by other genetic studies (Trejo, 2005).

Thresher sharks possess an elongated upper caudal lobe (tail fin) almost equal to its body length, which is unique to the Alopiidae family. The common thresher shark has moderately large eyes, a broad head, short snout, narrow tipped pectoral fins, and lateral teeth without distinct cusplets. The origin of the pelvic fins is well behind the insertion of the first dorsal fin. While some of the above characteristics may be shared by other thresher shark species, diagnostic features separating this species from the other two thresher shark species (bigeye and pelagic) are the presence of labial furrows, the origin of the second dorsal fin posterior to the end of the pelvic fin free rear tip, and the white color of the abdomen extending upward over the pectoral fin bases, and again rearward of the pelvic fins. The upper pectoral fin-tips may have white dots. In living specimens, dorsal coloration may vary from brown, blue slate, slate gray, blue gray, and dark lead to nearly black, with a metallic, often purplish, luster. The lower surface of the snout (forward of the nostrils) and pectoral fin bases are generally not white and may be the same color as the dorsal surface (Compagno, 1984, Goldman, 2009).

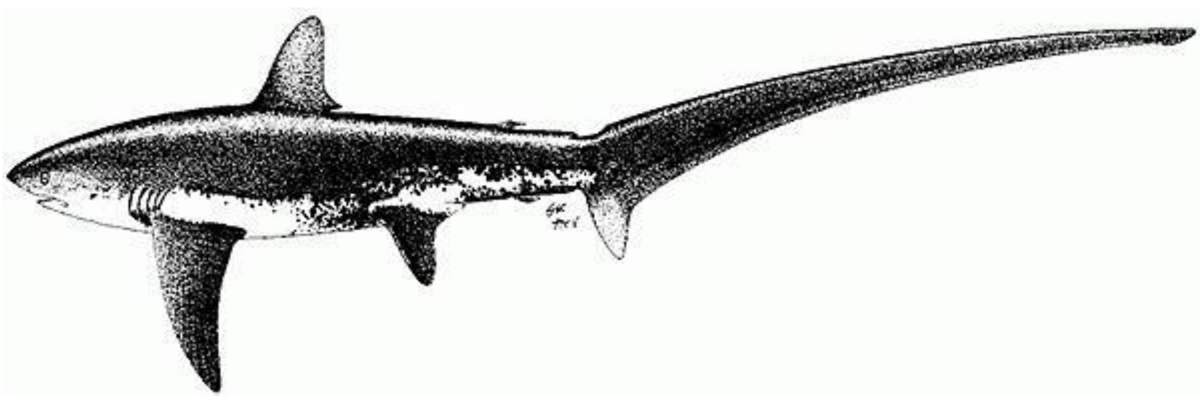

Figure 1. Common thresher shark (from FAO.org)

The bigeye thresher has a broad head, moderately long and bulbous snout, curved yet broad-tipped pectoral fins, distinctive grooves on the head above the gills, and large teeth. The first dorsal-fin midbase is closer to the pelvic-fin bases than to the pectoral-fin bases. The caudal tip is broad with a wide terminal lobe. While some of the above characteristics may be shared by other thresher shark species, diagnostic features separating this species from the other two thresher shark species (common and pelagic thresher) are their extremely large eyes, which extend onto the dorsal surface of the head, and the prominent notches that run dorso-lateral from behind the eyes to behind the gills. The body can be purplish grey or grey-brown on the upper surface and sides, with grey to white coloring on its underside; however, unlike the common thresher, the light color of the abdomen does not extend over pectoral-fin and there is no white dot on the upper pectoral-fin tips like those often seen in common threshers (Compagno, 2001).

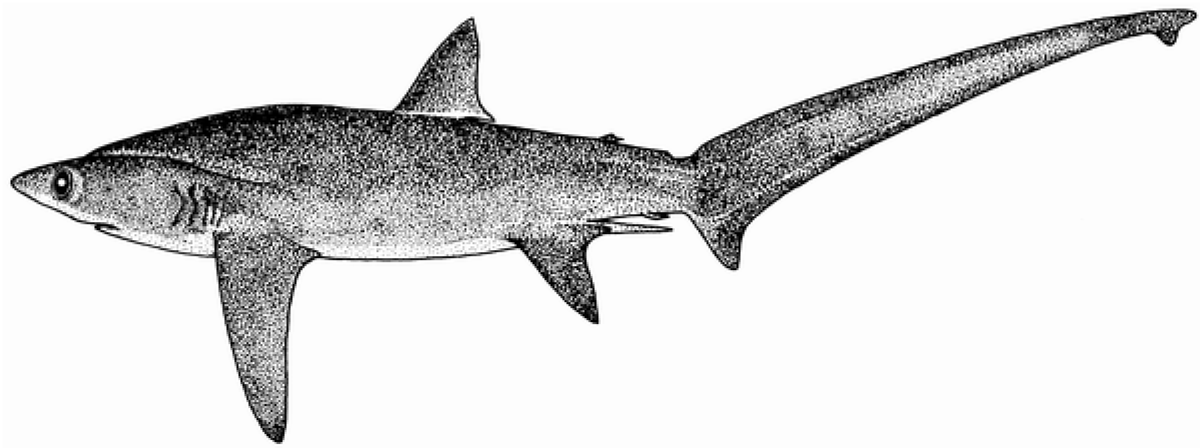

Figure 2. Bigeye thresher shark (from FAO.org)

Both common and bigeye threshers have shown evidence of physiological adaptations for tolerating cold waters, particularly during their daily migrations up and down the water column. The common thresher's internal anatomy of the swimming musculature closely resembles that of the endothermic sharks in the Lamnidae family. Bernal and Sepulveda (2005) confirmed that *A. vulpinus* is capable of significantly elevating the temperature of its aerobic red myotomal musculature (RM) above that of the sea surface temperature (SST). However, there is some conflicting information regarding whether the bigeye thresher is warm-bodied like the common thresher. While the bigeye thresher possesses the same aerobic red muscles responsible for generating heat in the common thresher, these muscles are arranged along the flanks of the body just beneath the skin, as opposed to near the core of the body. Further, there is no blood vessel countercurrent exchange system (i.e., the rete mirabile) in the trunk to limit the loss of metabolic heat to the surrounding water. Thus, the bigeye thresher differs from common thresher in that it does not possess the medial and anterior RM arrangement that would likely facilitate metabolic heat conservation (RM endothermy) (Sepulveda et al., 2005). However, the bigeye thresher does possess a highly developed rete system around its brain and eyes, which may buffer those sensitive organs against temperature changes during the shark's daily migrations up and down the water column, which can be as much as 15–16 °C (27–29 °F) (Weng and Block, 2004).

Information on thresher sharks is often reported as a thresher shark complex (*Alopias* spp.) without species-specific information. Even with species-specific information, misidentification is known to occur. Although this document does not review the pelagic thresher shark, the pelagic thresher shark has been misidentified as common thresher shark in fisheries data and scientific reports (e.g., Velez-Zuazo et al. (2015)). Therefore, some information in this report from published fisheries data and scientific literature may have the wrong thresher shark species associated with it. The common thresher shark has higher concentrations in temperate, coastal waters in all the world's oceans, while the pelagic thresher shark is typically distributed in warmer waters (pelagic thresher sharks are not known to occur in the Atlantic Ocean). Therefore, information on common thresher sharks in temperate waters is more likely to be from common threshers than information from tropical waters, which is likely to be from misidentified pelagic thresher sharks. There is also potential for misidentifications between bigeye threshers and other thresher species, although due to its distinctive physical characteristics described previously, these misidentifications are less likely less prevalent.

2.2 Distribution and Habitat Use

Common thresher

The common thresher shark is a large highly migratory pelagic species of shark found throughout the world in temperate and tropical seas, with a noted tolerance for cold waters as well; however, highest concentrations tend to occur in coastal, temperate waters (Moreno et al., 1989, Goldman, 2009). Genetic studies and comparisons of biological characteristics (e.g., fecundity and length at maturity) of specimens from different regions of the world show that although migratory, *A. vulpinus* appears to exhibit little to no immigration and emigration between geographic areas; namely between the Pacific and northwest Atlantic populations (Gubanov, 1972, Moreno et al., 1989, Bedford, 1992, Trejo, 2005). In the North Atlantic, common thresher sharks occur from Newfoundland, Canada, to Cuba in the west and from Norway and the British Isles to the African coast in the east (Gervelis and Natanson, 2013). Landings along the South Atlantic coast of the United States and in the Gulf of Mexico are rare. Common thresher sharks also occur along the Atlantic coast of South America from Venezuela to southern Argentina. In the eastern Atlantic, *A. vulpinus* ranges from the central coast of Norway south to, and including, the Mediterranean Sea and down the African coast to the Ivory Coast. They appear to be most abundant along the Iberian coastline, particularly during spring and fall. Specimens have also been recorded at Cape Province, South Africa (Goldman, 2009). In the Indian Ocean, *A. vulpinus* is found along the east coast of Somalia, and in waters adjacent to the Maldive Islands and Chagos archipelago. They are also present off Australia (Tasmania to central Western Australia), Sumatra, Pakistan, India, Sri Lanka, Oman, Kenya, the northwestern coast of Madagascar and South Africa. A few specimens have been taken from southwest of the Chagos archipelago, the Gulf of Aden, and northwest Red Sea. In the western Pacific Ocean, the range of *A. vulpinus* includes southern Japan, Korea, China, parts of Australia and New Zealand. However, Romanov (2015) raises serious questions regarding the occurrence of *A. vulpinus* in the equatorial and northern tropical Indian Ocean, suggesting the species demonstrates strong fidelity to subtropical and temperate coasts of South Africa and Australia. They are also reported from around several Pacific Islands, including New Caledonia, Society Islands, Fanning Islands, Hawaii and American Samoa. In the Northeast Pacific Ocean, the geographic range of common thresher sharks extends from Goose Bay, British Columbia, Canada to the Baja Peninsula, Mexico and out to about 200 miles from the coast (Goldman 2009). Additionally, they are found off Chile and records exist from Panama (Compagno, 1984, Ebert et al., 2014).

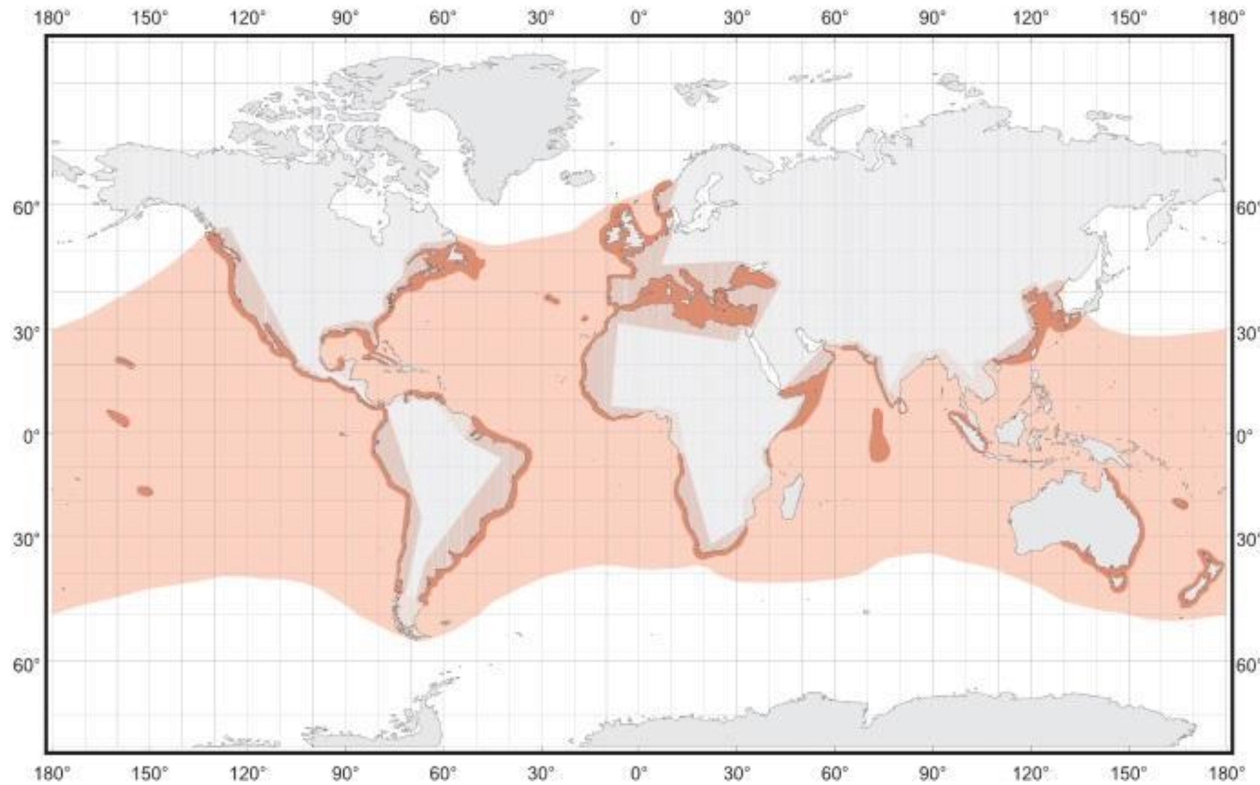

Figure 3. Geographic distribution of *A. vulpinus* (Source: Compagno 2001). Note that highest concentrations of common thresher shark occur in coastal temperate waters.

Common thresher sharks are both coastal ranging over continental and insular shelves, and epipelagic ranging far from land in temperate to tropical waters, though they are most abundant near land approximately 40-50 nautical miles (nmi) from shore (Strasburg, 1958, Bedford, 1992). In the northwestern Indian Ocean, *A. vulpinus* shows a high degree of spatial and depth segregation by sex (Compagno, 1984). Between January and May, pregnant females are found in the western Indian Ocean and males are concentrated around the Maldives. However, pregnant females have also been noted in August and November indicating that birth of young thresher sharks in this area occurs throughout the year (Gubanov (1978) cited in Goldman (2005)). Additionally, surveys of common thresher sharks from NOAA Southwest Fisheries Science Center (SWFSC) demonstrate habitat separation between juveniles and adults (PFMC, 2003, Smith et al., 2008b). Juveniles occupy relatively shallow water over the continental shelf (<200 m), while adults are found in deeper water (up to at least 366 m, with dive depths up to at least 640 m), but rarely range beyond 200 nmi (321.87 km) from the coast. Both adults and juveniles are associated with highly biologically productive waters, found in regions of upwelling or intense mixing (PFMC, 2003, Smith et al., 2008b). Off the Northeast Coast of North America, *A. vulpinus* is considered common both in offshore and cold inshore waters during the summer months (Gervelis and Natanson, 2013). Off the West Coast of North America, Cartamil et al. (2010) found that *A. vulpinus* utilizes deeper waters over the continental slope and offshore basins, likely due to prey distribution, predation risk, and physical habitat characteristics. Studies from North America and Australia show that common thresher sharks make daily vertical migrations, moving to deeper water during the day, with a maximum depth reported to 640 m in Australia (Last and Stevens, 2009, Stevens et al., 2009, Cartamil et al., 2010, Cartamil et al., 2011b). In the Marshall Islands, common thresher sharks showed a preference for an optimum swimming depth, water temperature, salinity and dissolved oxygen range of 160-240 m, 18-20˚C, 34.5-34.8 ppt and 1.0-1.5 ml/l, respectively, during daytime (Cao et al., 2011). These studies indicate that common thresher sharks may spend most of the day at deeper depths below the thermocline (>200 m) and most of the night in shallower waters between 0-200 m.

In California, common thresher sharks tagged by NMFS/SWFSC (Fisheries Resources Division, La Jolla, CA) with satellite pop-up tags in June 1999 off Laguna Beach and Santa Monica Bay traveled south to Baja California, Mexico by the following October and an additional 540 miles southwest of La Paz, Mexico by the following January. Conventional tagging data (N=110 tag returns) from NMFS/SWFSC also show that common thresher often migrate between the U.S. and Mexico on the West Coast. These data confirm active transboundary migration in this species between U.S. and Mexico but there is no evidence to support regular migration beyond the West Coast of North America. Other, more indirect evidence, including spatio-temporal patterns of catches, suggest a seasonal north-south migration between Oregon and Washington and San Diego, California/Baja California Mexico. Bedford (1992) proposed that large adult common thresher sharks pass through southern California waters in early spring of the year, and remain in offshore waters from one to two months during which time pupping occurs. Pups are then thought to move in to shallow coastal waters while the adults continue to follow warming water and perhaps schools of prey northward, arriving off Oregon and Washington by late summer. Subadult (>101 cm Fork Length (FL) and <167 cm FL) individuals appear to arrive in southern California waters during early summer; as summer progresses, they move up the coast as far north as San Francisco, with some moving as far north as the Columbia River area. In fall, these subadults are thought to move south again, arriving in the Channel Islands area. Little is known about the presumed southward migration of the large adults, which do not appear along the coast until the following spring (PFMC, 2003).

In the Atlantic, mark recapture data (number tagged = 203 and recaptures = 4) from the NMFS Cooperative Shark Tagging Program (CSTP) between 1963 and 2013 provide supporting evidence that common thresher sharks do not make transatlantic movements (Kohler et al. 1998, NMFS unpublished data). The range of movement for common threshers based on CSTP data was relatively small, with an observed maximum straight-line distance travelled of 86 nmi (159 km) in the Northwest Atlantic (Figure 4A, below) and 271 nmi (502 km) in the Northeast Atlantic (Figure 4B, below).

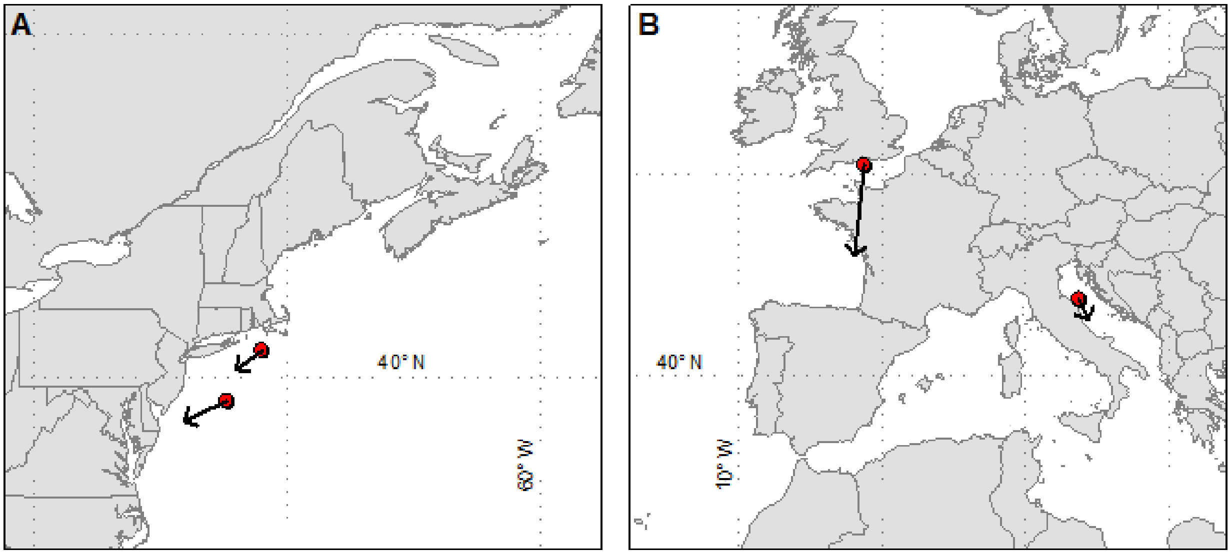

Figure 4 (A and B). Mark/recapture data for *A. vulpinus* from the NMFS Cooperative Shark Tagging Program between 1963 and 2013 in the Northwest Atlantic (A) and the Northeast Atlantic (B). Red circles denote the release site for a tagged shark and the arrowhead points at the recapture location for the same shark. Each grid square represents ten degrees latitude by ten degrees longitude.

Bigeye thresher

The bigeye thresher shark (*A. superciliosus*) is a large, highly migratory oceanic and coastal species of shark found throughout the world in tropical and temperate seas. In the western Atlantic (including the Gulf of Mexico), bigeye threshers can be found off the Atlantic coast of the United States (from New York to Florida), and in the Gulf of Mexico off Florida, Mississippi and Texas. They can also be found in Mexico (from Veracruz to Yucatan), Bahamas, Cuba, Venezuela, as well as central and southern Brazil. In the eastern Atlantic, bigeye threshers are found from Portugal to the Western Cape of South Africa, including the western and central Mediterranean Sea. In the Indian Ocean, bigeye threshers are found in South Africa (Eastern Cape and KwaZulu-Natal), Madagascar, Arabian Sea (Somalia), Gulf of Aden, Maldives, and Sri Lanka. In the Pacific Ocean, from west to east, bigeye threshers are known from southern Japan (including Okinawa), Taiwan (Province of China), Vietnam, between the Northern Mariana Islands and Wake Island, down to the northwestern coast of Australia and New Zealand, as well as American Samoa. Moving to the Central Pacific, bigeye threshers are known from the waters surrounding Wake, Marshall, Howland and Baker, Palmyra, Johnston, Hawaiian Islands, Line Islands, and between Marquesas and Galapagos Islands. Finally, in the Eastern Pacific, bigeye threshers occur from Canada to Mexico (Gulf of California) and west of Galapagos Islands (Ecuador). They are also possibly found off Peru and northern Chile (Compagno, 2001, Ebert et al., 2014). Historically, Gruber and Compagno (1981) described *A. superciliosus* as a widespread but rare species, with the potential of local abundance in certain areas.

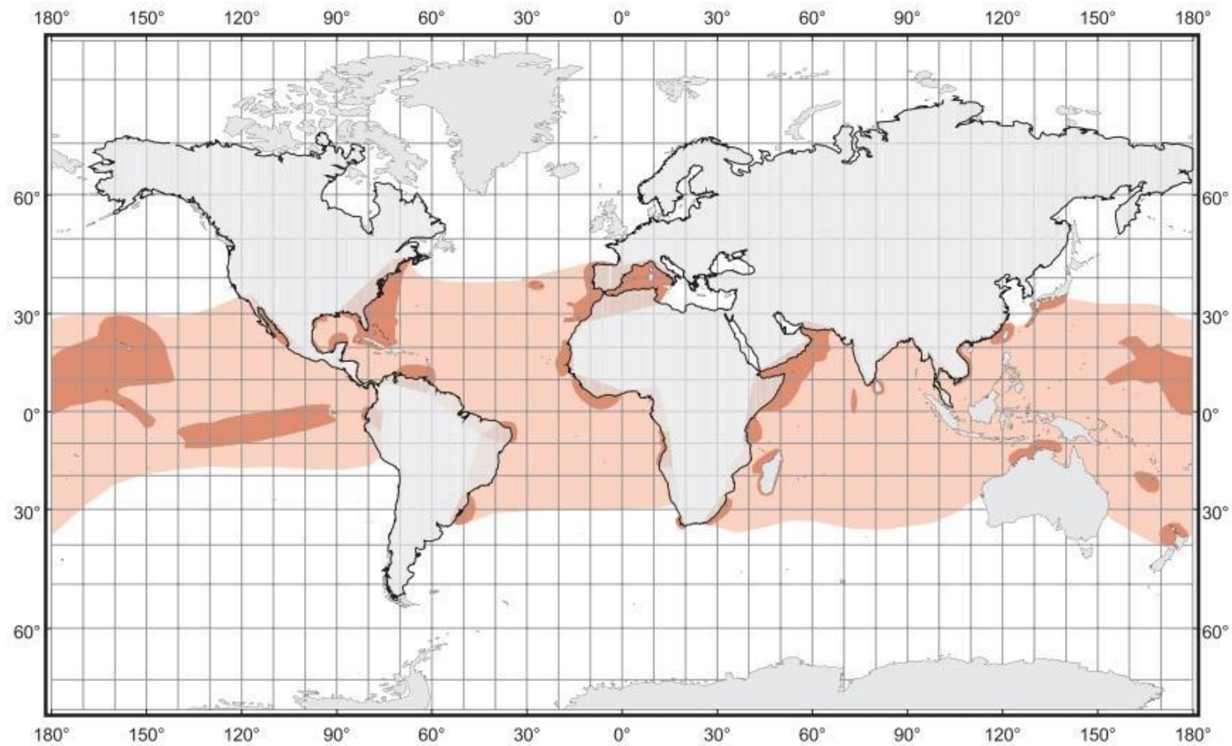

Figure 5. Geographic distribution of *A. superciliosus* (Source: Compagno 2001)

Bigeye thresher sharks are found in a diverse spectrum of locations, including in coastal waters over continental shelves, on the high seas in the epipelagic zone far from land, in deep waters near the bottom on continental slopes, and sometimes in shallow inshore waters. They are an epipelagic, neritic, and epibenthic shark, ranging from the surface and in the intertidal to at least 500 m deep, and have even been recorded as deep as 723 m (Nakano et al., 2003), but mostly occur in depths below 100 m (Compagno, 2001). Bigeye threshers are known to endure colder water and remain longer in deeper waters than many other pelagic sharks (Gruber and Compagno, 1981, Fernandez-Carvalho et al., 2015a). Like common threshers, bigeye thresher sharks are also known to make daily diel vertical migrations, spending most of their day below the thermocline, and most of the night in the mixed layer and upper thermocline (Nakano et al., 2003, Weng and Block, 2004, Kohin et al., 2006, Stevens et al., 2009, Musyl et al., 2011). In the Marshall Islands, Cao et al. (2011) identified a preferred optimum swimming depth of 240-360 m, water temperature of 10-16˚ C, salinity of 34.5-34.7 ppt and dissolved oxygen range of 3.0-4.0 ml/l for bigeye threshers. Nakano et al. (2003) recorded the deepest dive to date in the Eastern Tropical Pacific, extending the known depth distribution for bigeye thresher to 723 m. In another study in the Eastern Tropical Pacific, a tagged bigeye thresher displayed a broad vertical niche during daylight hours, which could bring them in contact with deep set (tuna) longline gear, and a shallow niche at night where they could overlap with shallow set (swordfish, mahi mahi) gear (Kohin et al., 2006). Long-range horizontal movements were found in two bigeye thresher sharks tagged with pop-up satellite archival tags (PATs) near Hawaii. Both sharks made long easterly directed movements towards Mexico, where one shark covered a distance of 1,532 nmi in 181 days and the other travelled 1,873 nmi over 240 days (Musyl et al., 2011).

In an analysis of shark catch records by Japanese tuna longline vessels from 1992–2006 in the Pacific, Matsunaga and Yokawa (2013) found that catch per unit effort (CPUE) for bigeye thresher was highest in the area of 10–15°N and 5–10°S, with juveniles <150 cm also distributed in this area (see Figure 6 below). Seasonal changes in the distribution of abundance are thought to represent seasonal migrations in latitude. An increase in the ratio of large individuals at high latitude was observed, indicating an increased thermal capacity allowing them to migrate farther north than smaller individuals. Males were captured more often than females, suggesting that there is potential latitudinal segregation by sex. Pregnant females were observed from 0°N - 36°N in the north Pacific. An area between 10–15°N and 150–180°W where neonates were observed overlaps with an area in which large numbers of juveniles were captured. Thus, this area may represent the parturition and nursery grounds for bigeye thresher in this region (Matsunaga and Yokawa, 2013). Overall, observations from this study suggest that bigeye thresher occupy the area between the equator and 35°N in the northern Pacific and extend to 38°N in the Kuroshio Extension, which flows northeastward off the south coast of Japan and 33°N in other areas. However, it should be noted that this is based on fishing effort of the Japanese fleet that was concentrated between 10°N and 20°N in winter and spring, and between 20°N and 35°N in summer and autumn (Matsunaga and Yokawa, 2013).

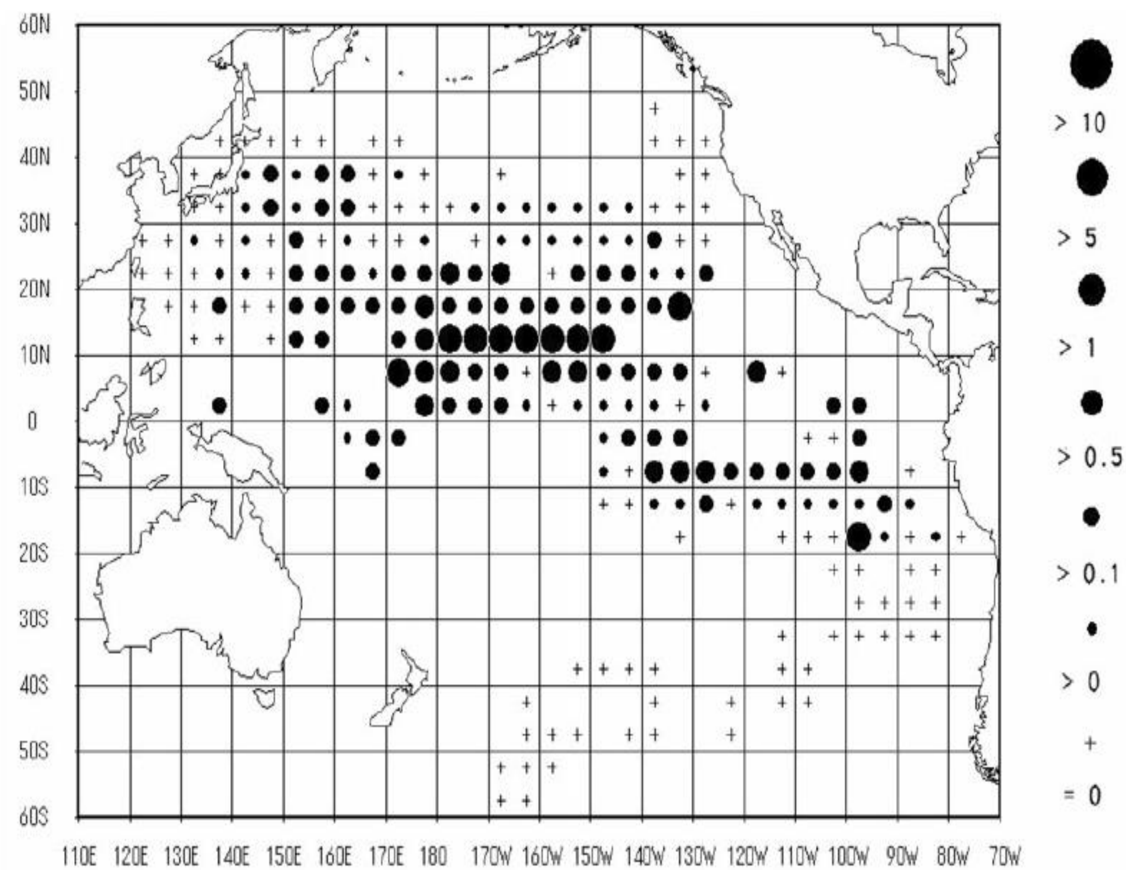

Figure 6. Total distribution of bigeye thresher CPUE (catch in number of sharks per 1000 hooks), 1992–2006 (Source: (Matsunaga & Yokawa 2013).

In the Atlantic, mark/recapture data (number tagged = 400 and recaptures = 12) from the NMFS CSTP between 1963 and 2013 showed that the range of movement in the bigeye thresher was much larger than the common thresher (Kohler 1998; Kohler and Turner 2001; NMFS unpublished data), with a maximum straight-line distance travelled of 2,067 nm (3,828 km, NMFS unpublished data). This transatlantic movement was from a shark tagged in 1984 by a NMFS shark biologist 565 nm (1046 km) southwest of the Cape Verde Islands off the west coast of Africa and recaptured in 1994 by a commercial longliner 19 nm (35 km) off the Venezuelan coast (see Figure 7 below; NMFS unpublished data), confirming that this species is highly migratory.

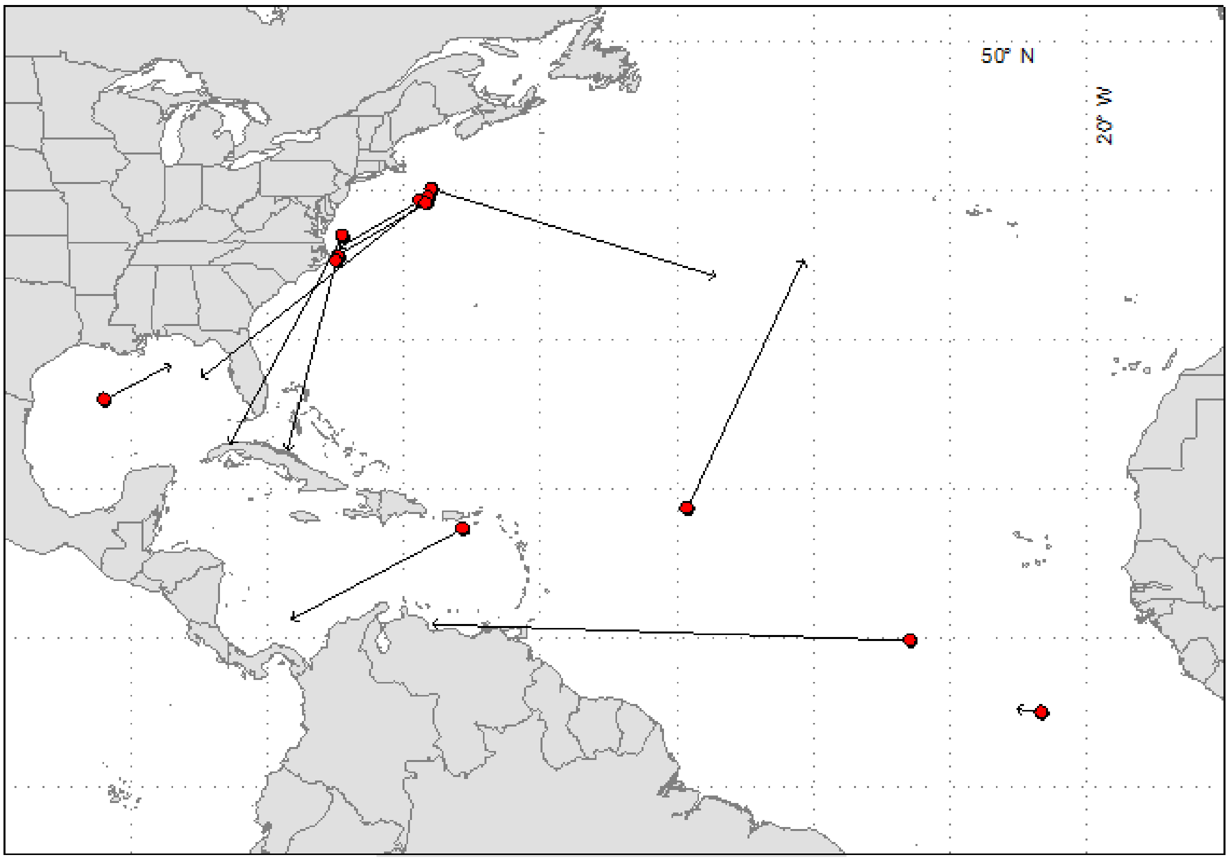

Figure 7. Mark/recapture data for *A. superciliosus* from the NMFS Cooperative Shark Tagging Program between 1963 and 2013 in the Atlantic. Red circles denote the release site for a tagged shark and the arrowhead points at the recapture location for the same shark. Each grid square represents ten degrees latitude by ten degrees longitude.

In a recent satellite archival tagging study of one bigeye thresher in the Gulf of Mexico, the shark moved 51 km and was found most frequently between 25.5-50 m depths and 20.05-22°C. The bigeye thresher dove up to 528 m with deeper dives occurring during the day (Carlson and Gulak, 2012).

In a comprehensive analysis of information collected by fishery observers between 1992 and 2013 and through scientific projects from several nations that undertake fishing activities in the Atlantic (Japan, Portugal, Spain, Taiwan, Uruguay and U.S.), Fernandez-Carvalho et al. (2015a) analyzed 5,590 bigeye thresher records as well as datasets including information on location, size, sex and, in some cases, maturity stage. This study provides important information on the distributional patterns of the bigeye thresher caught by pelagic longlines in the Atlantic Ocean (see Figure 8 below).

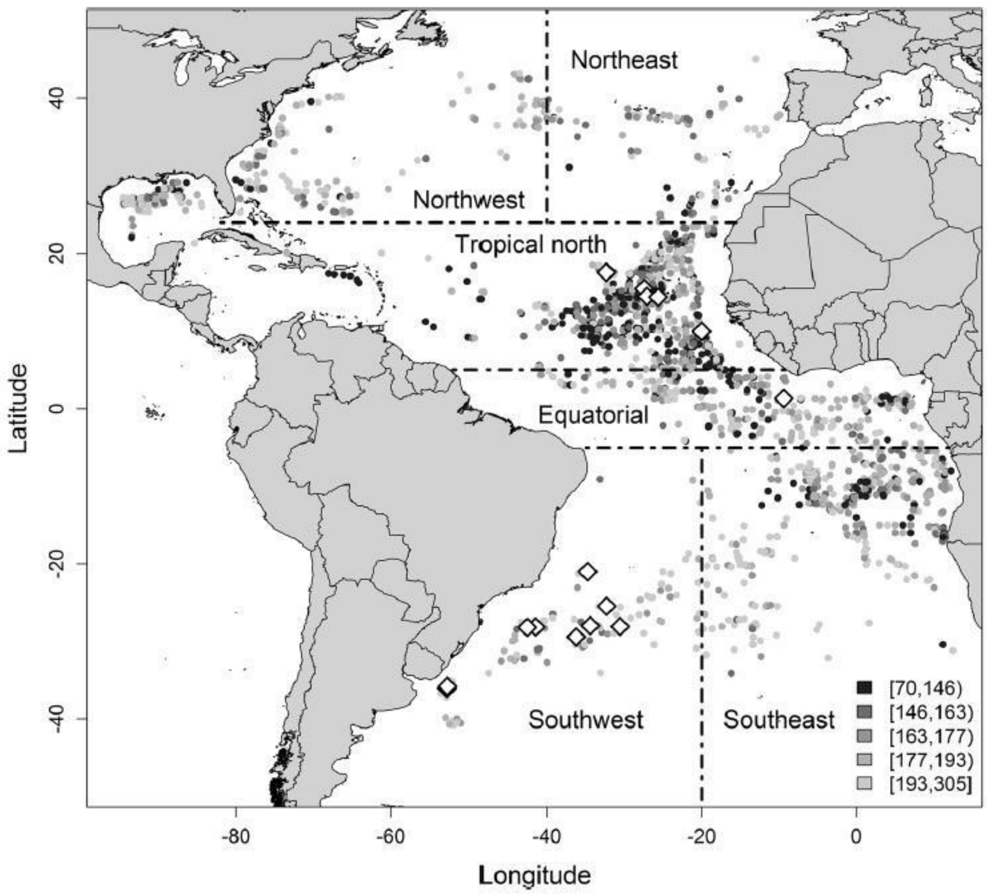

Figure 8. Location and sizes (fork length, FL in cm) of bigeye thresher (*A. superciliosus*) recorded in the six sampling regions of Fernandez-Carvalho et al. 2015a. The gray scale of the dots represents specimen sizes, with darker colors representing smaller specimens and lighter colors representing larger specimens. The categorization of size classes for the map was carried out using the 20th percentiles of the size data. The location of pregnant females recorded by the Spanish, Portuguese and Uruguayan fleets during this study is represented by diamond symbols.

This study found considerable variability in the spatial distribution of males and females among the Atlantic regions based on their sizes. For example, larger-sized specimens tended to be captured mainly in the higher latitudes, predominantly in the northwest and southwest Atlantic, while smaller specimens tended to be captured mainly in the tropical north and northeast areas. Of note is that a very low prevalence of smaller sized specimens (<150 cm FL) was recorded in all regions. These regional trends tended to be common for both males and females. In terms of seasonal distribution, sizes were much smaller and tended to be relatively similar throughout the year in the tropical north, while in the equatorial region there was a tendency for increasing sizes throughout the year. Of particular interest is the tropical region where mean sizes tended to be smaller than in the other Atlantic regions, and the proportion of juveniles (both males and females) higher throughout the entire year. In addition, the occurrence of pregnant females was recorded in this region (i.e., tropical northeast) and in the southwest (Fig. 7) with these two regions possibly serving as nursery areas for bigeye thresher. Of the total number of bigeye threshers recorded, 2,664 (47.7%) were females and the remaining 2,926 (52.3%) were males (Fernandez-Carvalho et al., 2015a).

2.3 Feeding and Diet

Common thresher

Based on a few studies, common thresher sharks feed at mid-trophic levels on a mix of small pelagic fish and cephalopods (Cortés 1999; Bowman et al. 2000; Estrada et al. 2003; MacNeil et al. 2005). Studies from the U.S. West Coast and southern coast of Australia showed common thresher sharks exhibit narrower dietary preferences in comparison to other local pelagic shark species (Preti et al., 2012, Rogers et al., 2012). Given their more specialized diet, they are more likely to exert top-down effects on their prey, although this remains to be demonstrated. Based on studies at NMFS' SWFSC, the top six prey species, in order, are northern anchovy, Pacific sardine, Pacific hake, Pacific mackerel, jack mackerel, and market squid (Preti et al., 2001, Preti et al., 2004, Preti et al., 2012). Similarly, Rogers et al. (2012) found that the top two important prey species for common threshers in southern Australia are Australian anchovy and sardine.

Bigeye thresher

Bigeye threshers have larger teeth than common threshers and feed on a wider variety of prey, including small to medium sized pelagic fishes (e.g., lancetfishes, herring, mackerel and small billfishes), bottom fishes (e.g., hake) and cephalopods (e.g., squids). Thus, the bigeye thresher appears to be an opportunistic feeder, foraging on diverse species covering a broad range of habitats, whereas niche separation is more apparent for common threshers (Preti et al., 2008). The arrangement of the eyes, with keyhole-shaped orbits extending onto the dorsal surface of the head, suggest that this species has a dorsal/vertical binocular field of vision (unlike other threshers) which may be related to fixating on prey and striking them with its tail from below (FAO, 2015). Based on a study at NMFS' SWFSC, the top five prey species, in order, are barracudinas, Pacific hake, Pacific saury, Pacific mackerel, and northern anchovy. At least eight cephalopod species were also observed, although most species were found in only a few stomachs (Preti et al., 2008).

As previously described, both common and bigeye thresher sharks make diel vertical migrations, and spend their days well below the thermocline. These patterns of vertical movements in sharks can reflect foraging, thermoregulation, predator avoidance, energetics and reproduction behaviors (Nakano et al., 2003, Shepard et al., 2006). Because thresher sharks are active at night and feed primarily on small schooling fish and cephalopods, their vertical migrations at night are presumed to be associated with their hunting strategy (Oliver et al., 2013). Thresher sharks are unique in that they use their exceptionally long tail in a whip-like fashion to incapacitate their prey prior to consumption (Aalbers et al., 2010, Oliver et al., 2013). This feeding strategy likely contributes to the effectiveness of alopiid sharks as predators of lower trophic level organisms (Aalbers et al., 2010).

2.4 Growth and Reproduction

Common thresher

Common threshers are the largest of the three *Alopias* spp. Historical records indicate *A. vulpinus* can reach maximum lengths of 690-760 cm Total Length (TL) (Bigelow and Schroeder, 1948, Hart, 1973). More recent studies report *A. vulpinus* reaching 573 cm TL and possibly up to 600 cm depending on sex and geographic location (Smith et al. 2008; Goldman 2009), and a maximum estimated size of 550 cm for common thresher sharks along the U.S. West Coast (Smith et al., 2008b, Gervelis and Natanson, 2013). Typically, the largest specimens, ranging from 487 cm to 573 cm TL, have been reported from the Northwest Atlantic and California (Leim and Scott 1966; Calliet and Bedford 1983; Bedford 1992), whereas smaller adult specimens tend to come from the Indian Ocean (325-425 cm TL) (Gubanov (1972) cited in Goldman (2009)) and Northeast Atlantic (325-472 cm TL) (Moreno et al., 1989). Maximum weight is 348 kg (Calliet and Bedford, 1983, FAO, 2008). However, these sharks can likely grow much larger than what's reported in published literature. In 2007, a common thresher shark was incidentally captured in a commercial trawl in Cornwall, UK, measuring an estimated 975 cm and weighing in at 567 kg (Cleland, 2007).

The life span of the common thresher shark is broadly estimated between 15 and 50 years (Gervelis and Natanson, 2013). Calliet and Bedford (1983) suggested that males and females from the eastern North Pacific population reach a maximum age of 50 years, with an age at first maturity between 3 and 8 years. However, this study admittedly lacked older, larger individuals. Later, Smith et al. (2008b) expanded upon Calliet and Bedford (1983) by incorporating data from 175 additional individuals. They estimated maximum age of 25 years and age at first maturity of approximately 5 years for both sexes. However, although the Smith et al. (Smith et al., 2008b) study improved upon previous age estimates and refined age at maturity for the common thresher shark, it also lacked data from larger size-classes (Gervelis and Natanson, 2013). More recently, Gervelis and Natanson (2013) estimated common threshers in the Northwest Atlantic reach 22 years of age for males and 24 years for females, with growth of both sexes being similar until approximately age 8 (185 cm FL), after which male growth slowed. Most recently, Natanson et al. (in press) updated their 2013 results, in which the primary finding was the increase in longevity for this species from a band pair count estimate of 24 years to a bomb radiocarbon validated estimate of 38 years, indicating this species lives much longer than previously thought.

Gervelis and Natanson (2013) also determined males matured at a median size of 188 cm FL and females matured at a median size of 216 cm FL, corresponding to ages 8 and 12 years, respectively. For males, von Bertalanffy growth parameters generated from the data were:

Asymptotic length [$L\infty$] = 225.4 cm FL; growth coefficient [k] = 0.17.

For females, the standard three-parameter von Bertalanffy growth model showed:

$L\infty$ = 274.5 cm FL; k = 0.09; and theoretical age at a length of zero [t_0] = −4.82.

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. Size at birth varies considerably, ranging between 114 cm and 160 cm TL with slight variation among geographical locations (Calliet and Bedford, 1983, FAO, 2008, Goldman, 2009). Common thresher sharks grow approximately 30 cm per year for the first 5 years of their lives (Smith et al., 2008b, Gervelis and Natanson, 2013). See Table 1 below for a summary of life history characteristics reported in published literature. A length-weight equation is given by Kohler, Casey and Turner (1996) (Figure 9) for fork length: W(kg) = 1.8821 x 10-4 FL(cm)$^{2.5188}$ (n = 88; both sexes) where: FL(cm) = 0.5474 x TL(cm) + 7.0262 (n = 13).

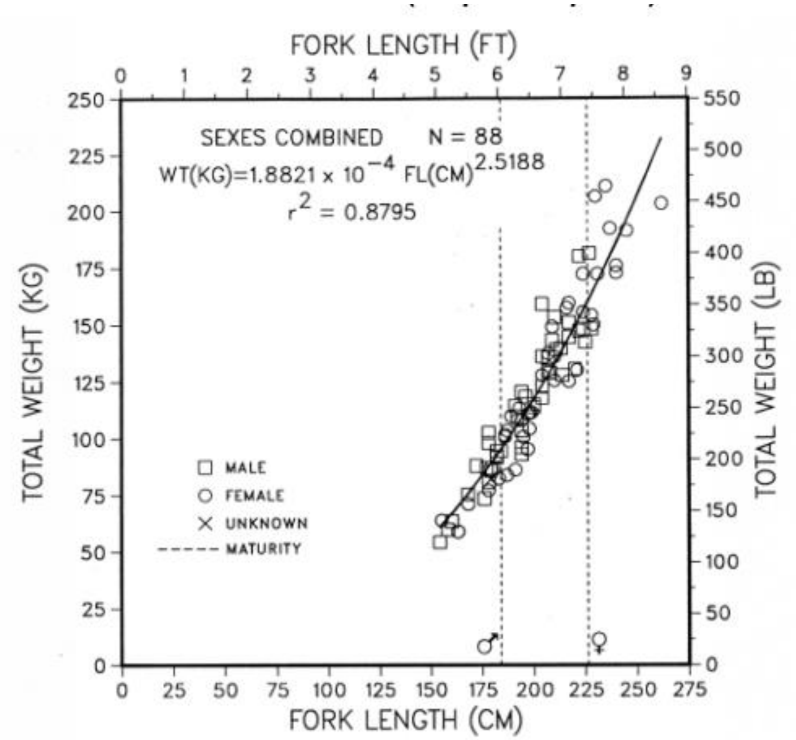

Figure 9. Relationship between fork length and total body weight (sexes combined) for the thresher shark (*A. vulpinus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female) (Source: Kohler et al. 1996).

The mode of reproduction used by common thresher sharks is aplacental ovoviviparity with oophagy (i.e., eggs are deposited into one of two uterine horns and developing embryos are nourished by feeding on other eggs), and gestation is thought to be around 9 months (PFMC, 2003, Smith et al., 2008b). Pupping is thought to occur in the springtime, with mating thought to occur in the summer in both the Northeast Atlantic and Eastern Pacific. In all locations, young thresher sharks generally remain close to shore for the first few years in nursery grounds within shallow continental shelf waters 90 m deep or less (PFMC, 2003, Smith et al., 2008b, Goldman, 2009). Evidence from Natanson and Gervelis (2013) suggest that common threshers do not reproduce every year; rather, they appear to mate every other year. However, pregnant females in the Western Indian Ocean have been observed in August and November, indicating that birth of young thresher sharks in this area may occur throughout the year (Gubanov (1978) cited in

Goldman (2009)). Litter sizes are typically small, and may vary depending on geographic location; they range from only 2 pups in the Indian Ocean to between 3-7 in the Northeast Atlantic, while 3-4 (predominantly 4) pups are common in the Eastern Pacific, (with occasional litters of up to 6 pups off California) (Holts, 1988, Moreno et al., 1989, Bedford, 1992, Goldman, 2009). A recent study estimated the average litter size in the Northwest Atlantic to be 3.7 pups (Gervelis and Natanson, 2013). Because thresher pups are already about 150 cm TL at birth, natural mortality is assumed to be quite low (Calliet and Bedford, 1983). Mean survivorship for common thresher was calculated to be 0.83 $year^{-1}$ (Cortés et al., 2012).

Table 1. Life history characteristics of *A. vulpinus* from published literature

	Maximum length	Age at maturity (years)	Size at maturity	Size at birth	von Bertanlanffy Growth Coefficient (K)		Average litter size (number of pups)	Longevity (years)	Reference
					Males	Females			
Northeast Atlantic	537 cm TL	3-8	Males: 314-420 cm TL Females: 315-400 cm TL	114-160 cm TL			3-7	45-50	Moreno et al. 1989
Northwest Atlantic	264 cm FL	Males: 8 Females: 12	Males: 188 cm FL Females: 216 cm FL	81 cm FL	k = 0.17	k = 0.09	3-7	Males: 15-25 Females: 28-46	Leim and Scott 1966; Smith et al. 2008; Gervelis & Natanson 2013;
Eastern Pacific	487-573 cm TL	Males: 5 Females: 5	Both sexes: 166 cm FL	139-142 cm TL	k = 0.19	k = 0.12	3-4	25-50+	Holts 1988; Calliet et al. 1983; Bedford 1992; PFMC 2003; Smith et al. 2008
Indian Ocean	325-425 cm TL	Unknown	260 cm TL	114 cm TL			2	Unknown	Gubanov 1972 (cited in Goldman 2009)

Bigeye thresher

Bigeye threshers have a maximum estimated age of about 20 years, and can grow to a maximum total length of 4.6 m (Liu et al., 1998). As reviewed in Liu et al. (1998), the maximum TL for female bigeye thresher sharks was 450 cm in Florida waters (Gilmore, 1983), 452 cm in Cuba (Guitart, 1975 cited in Gruber and Compagno, 1981), 458 cm in New Zealand (Grey, 1928), and 422 cm in northeastern Taiwan (Liu et al., 1998). Maximum TL for males was determined to be 410 cm in the Northeast Atlantic, and 357 cm in northeastern Taiwan (Moreno and Moron, 1992, Liu et al., 1998). Bigeye threshers may be smaller in northeastern Taiwan as a result of different environments, genes, gear selection, sampling bias, and fishing mortality (Liu et al., 1998). Likewise, the maximum size recorded in Indonesia (378.6 cm) is significantly smaller than maximum TL recorded in other areas (White, 2007). Size at maturity for bigeye threshers has been relatively consistent among areas, ranging between 290-341cm TL for females and 275-300 cm TL for males. These sizes correspond to ages of maturity ranging from 8-15 years and 7-13 years old, respectively (see Table 2 below for a summary of size differences among regions and other life history characteristics). Size at birth ranges from 64 to 106 cm (Gilmore, 1993). A length-weight equation is given by Kohler, Casey and Turner (1996) (Figure 10) for fork length: $W(kg) = 9.1069 \times 10^{-6} FL(cm)^{3.0802}$ (n = 55; both sexes).

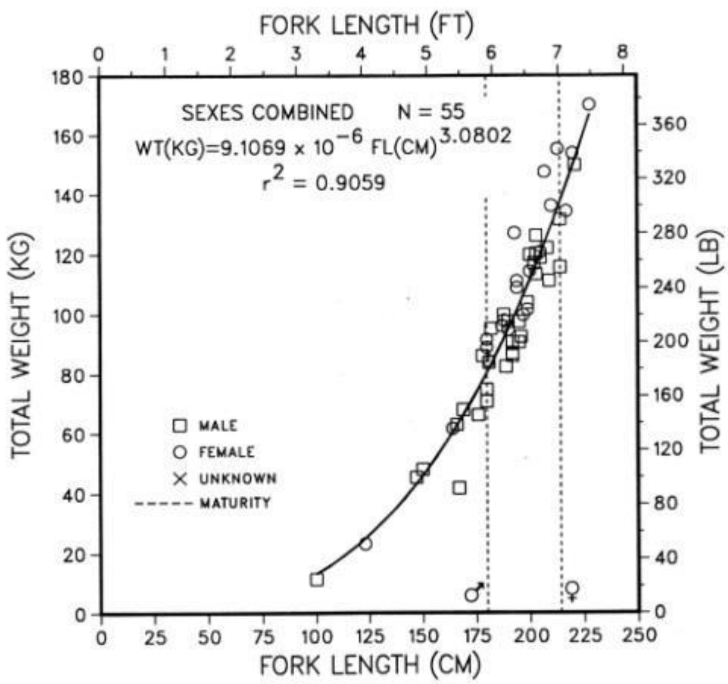

Figure 10. Relationship between fork length and total body weight (sexes combined) for the bigeye thresher (*A. superciliosus*) from the western North Atlantic. (Dotted lines indicate fork length at maturity by sex: ♂ = male, ♀ = female). (Source: Kohler et al. 1996).

Growth rate of the bigeye thresher has been estimated in a couple studies. Based on Liu et al. (1998), von Bertalanffy growth parameters (where L_∞ = the asymptotic length; k = growth coefficient; and t_0 = the theoretical age at zero length) from specimens in the Northwest Pacific are:

Females: $L_\infty = 230.5$ cm, $k = 0.092^{-1}$, $t_0 = -3.69$
Males: $L_\infty = 224.4$ cm, $k = 0.087^{-1}$, $t_0 = -4.61$

The von Bertalanffy growth parameters (where L_{inf} = asymptotic maximum fork length for the model of average fork length-at-age; k = growth coefficient; and L_0 = fork length at birth) calculated by Fernandez-Carvalho et al. (2011) from the Eastern Central Atlantic produced the following results:

Females: $L_{inf} = 293$ cm FL, $k = 0.06\ y^{-1}$ and $L_0 = 111$ cm FL for females
Males: $L_{inf} = 206$ cm FL, $k = 0.18\ y^{-1}$ and $L_0 = 93$ cm FL for males.

The estimated growth coefficients confirm that *A. superciliosus* is generally a slow-growing species. Overall, bigeye thresher sharks have the slowest population growth rate of all thresher sharks (see Demography section below). Like other thresher species, the reproductive mode of bigeye thresher is aplacental viviparity with oophagy; however, bigeye threshers usually bear only two pups per litter – one per uterus (although cases of up to four embryos may occur), resulting in an extremely low fecundity (Chen et al., 1997, Compagno, 2001, Moreno and Moron, 1992). Mean survivorship of bigeye thresher was estimated to be 0.88 $year^{-1}$(Cortés et al., 2012). Bigeye threshers also have a late age of maturity (12 years for females and 10 for males), and the gestation period in bigeye threshers may be 12 months long, but remains uncertain due to a lack of birthing seasonality data (Liu et al., 1998). However, there have been some observations and hypotheses regarding potential birthing seasons and nursery areas of bigeye thresher sharks from various parts of its range. For example, Gilmore (1993) suggested parturition periods for *A. superciliosus* occur in the summer, fall, and winter in the Florida Straits. Another nursery for this species may exist in nearshore Cuban waters, as many small juveniles and females with full-term litters have been observed there (Guitart, 1975 cited in Camhi et al. 2008). Moreno and Morón (1992) concluded that birth occurs over a protracted period from autumn to winter in the Strait of Gibraltar. More recently, Fernandez-Carvalho et al. (2015a) observed the presence of large embryos (closer to the size at birth) in October/November in the northeast Atlantic and in March in the Southwest Atlantic, which seem to suggest that birth may be taking place during late summer and autumn in both hemispheres. This corroborates what has been previously suggested for both regions, particularly by Moreno and Morón (1992) for the northeast, which suggested the existence of a nursery area for this species off the Southwestern Iberian Peninsula based on the records of several pregnant females. In fact, Fernandez-Carvalho et al. (2015a) hypothesize that such an area not only exists, but possibly extends further south, into the tropical northeast Atlantic and equatorial waters closer to the African continent. This may be validated by the fact that smaller and mainly juvenile specimens tended to be captured in the tropical northeast and equatorial waters, as well as pregnant females both in mid- and late-term stages. Another cluster of pregnant females was recorded in the southwest Atlantic, some close to the Rio Grande Rise and a few inside the Uruguayan Economic Exclusion Zone (EEZ), suggesting these areas may also be nurseries for this species in the south Atlantic. This was previously suggested in a study by Amorim et al. (1998), who also reported the presence of pregnant females in this area. In contrast, a different reproduction and birth seasonality may exist in the Pacific Ocean, where Matsunaga and Yokawa (2013) reported that neonates (<80 cm pre-caudal length) were caught mainly during winter and spring in an area between 10 and 15˚N.

Table 2. Life history characteristics of *A. superciliosus* from published literature

	Maximum length	Age at maturity	Size at maturity	Size at birth	von Bertanlanffy Growth Coefficient (K) Males	Females	Average litter size (# of pups)	Longevity	Reference
Atlantic (General)	Males: 504 cm TL Females: 496 cm TL		Males: 159.2 FL Females: 208.6 FL				2		Fernandez-Carvalho et al. 2015
Northeast Atlantic	Males: 410 cm TL Females: 408-484 cm TL		Males: 276 cm TL Females: 340 cm TL	100 cm TL			2		Moreno and Moron 1992; Thorpe 1997
Eastern Central Atlantic	Males: 210 cm FL Females: 242 cm FL				k =0.18	K = 0.06		Males: 17 Females: 22	Fernandez-Carvalho et al. 2011
Northwest Atlantic	452 cm TL (Cuba)		Males: 290-300 cm TL Females: 355 cm TL				2		Guitart 1975 and Stillwell and Casey 1976 (cited in Gruber and Compagno, 1981)
Northwest Pacific	Males: 357 cm TL Females:422 cm TL	Males: 9-10 Females: 12.3-13.4	Males: 270-288 cm TL Females: 332-341 cm TL	135 -140 cm TL	k = 0.088	k = 0.092	2	Males: 19 Females: 20	Liu et al. 1998; Chen et al. 1997

Indian Ocean	325-425 cm TL		Males: 279-283 Females: Unknown	74.2-158 cm TL			2	Unknown	White 2007; Benjamin 2015

2.5 Population Structure and Genetics

There have been relatively few studies on the population structure and genetics of thresher sharks. As previously mentioned, Eitner (1995) used allozymes to infer phylogenetic relationships in the genus *Alopias*, and suggested the existence of an unrecognized fourth thresher shark species. Results from a recent genetics study (Cardeñosa et al., 2014) suggest that this fourth thresher shark species may be a second species of pelagic thresher shark. Eitner (1997) later found evidence of significant genetic heterogeneity among *A. vulpinus* populations in the Eastern North Pacific, but subsequent genetic analyses of tissue biopsies collected off the U.S. West Coast (Oregon/Washington, CA) and Mexico (Baja California), showed no significant differences in haplotypic frequencies, indicating a single homogenous West Coast population (Eitner, 1999). More recently, Trejo (2005) conducted a global population genetic study using DNA sequences from the mitochondrial control region of 108 specimens of *A. vulpinus* from eight locations, and 64 specimens of *A. superciliosus* from nine locations. Results indicated significant structuring of *A. vulpinus* populations within the Pacific Ocean, and significant structure between Pacific and Northwest Atlantic populations. For bigeye thresher, results support shallow population structure between Indo-Pacific and Atlantic populations, but not among populations spanning the entire Indo-Pacific Ocean. However, due to the preliminary nature of these data, and low sample size throughout the study, these results cannot be relied upon to confirm one or more genetically distinct stocks of the common or bigeye thresher shark. In the absence of records of transatlantic migrations, a single Northeast Atlantic and Mediterranean stock of *A. vulpinus* is assumed (ICES, 2007) but not confirmed, which, in turn, assumes a single Western Atlantic stock.

2.6 Demography

Common thresher

Common thresher sharks exhibit life-history traits and population parameters that are intermediary among other shark species. Among the three *Alopias* species, the common thresher shark is considered the fastest-growing and earliest-maturing of the three species, and attains the largest size (Smith et al., 2008b). In a 1998 study, productivity values and rebound rates were derived for 26 shark species, in which *A. vulpinus* ranked among the highest, based strongly on age of sexual maturity and less so for maximum age (Smith et al., 1998). This study calculated the productivity (r_{2m}) of common thresher sharks with no fecundity increase and with a 25% fecundity increase to be 0.069 and 0.099, respectively, and a population doubling time of 7 years. Cortés (2002) also found that the common thresher ranked among the more productive species of sharks, with an annual population growth rate (λ) of 1.125 year^{-1} and a generation time of 8.9 years. Similar results were found in Smith et al. (2008a), in which the common thresher ranked the 3rd most productive species of out of 11 pelagic elasmobranchs evaluated, and a natural mortality rate of 0.179 year^{-1} was estimated, assuming a maximum age of 25 years (Cortés, 2008). A more recent study from 2012 found similar results, with an estimated annual population growth rate (λ) of 1.128 year^{-1} and intrinsic rate of population increase (*r*) of 0.121 (Cortés et al., 2012). This study also estimated the generation time for common threshers to be 11 years. Another recent study also found that *A. vulpinus* ranked among the highest in productivity when compared with other pelagic shark species (ranking 9 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, it should be noted that these studies relied on earlier estimated age at maturity for *A. vulpinus* females from the Eastern Pacific (i.e., 5-6 years; (Calliet and Bedford, 1983)) and did not take into account more recent age at maturity estimates calculated for *A. vulpinus* females in the Northwest Atlantic (i.e., 12 years (Gervelis and Natanson, 2013)), which may slightly decrease the species' overall productivity.

Bigeye thresher
Bigeye thresher sharks exhibit life-history traits and population parameters that are on the low end of productivity among other shark species, ranking as one of the least productive species of elasmobranch in several demographic studies. Cortés (2002) analyzed demographic factors for 38 species of sharks, and found that bigeye threshers are among the least productive species analyzed, with an annual population growth rate (λ) of 0.996 $year^{-1}$ and a lengthy generation time of 16.7 years. Similarly, Chen and Yuan (2006) analyzed demographic factors for 18 species of shark from the East China Sea, including *A. superciliosus*, and determined that bigeye threshers had one of the lowest intrinsic rates of population increase among elasmobranchs. Bigeye threshers were found to have a natural mortality rate of 0.147 $year^{-1}$ and a lengthy population doubling time of 15.4 years. The study also reported a low generational reproduction rate of 1.84, which indicates the number of offspring each female shark has over her lifetime. A low reproduction rate and a lengthy population doubling time indicate a lower resilience to fishing and a longer time for the species to recover from exploitation (Chen and Yuan, 2006). Similar results were found in the 2008 ICCAT Standing Committee on Research and Statistics (SCRS) Ecological Risk Assessment (ERA), as well as an expanded ERA from 2012: of all the species examined, Atlantic bigeye thresher sharks were once again identified as one of the least productive and most vulnerable shark species, with a significantly low population growth rate (λ) of 1.009 $year^{-1}$, low intrinsic rate of population increase of 0.009 $year^{-1}$, and a generation time of 17.2 years (Cortés, 2008, Cortés et al., 2012). These demographic factors arguably render the bigeye thresher particularly vulnerable to any level of exploitation.

3. DESCRIPTION OF FISHERIES AND RELATIVE ABUNDANCE TRENDS

Overall, global quantitative abundance trends for both common and bigeye thresher sharks are lacking. However, there are several studies on the abundance trends for a few regions and/or stocks of common and bigeye threshers, or thresher shark complex. There is also a recent stock assessment on the stock of common thresher shark along the West Coast of North America (Teo et al., 2015). Thus, the following section provides a description of relevant fisheries that catch these species, and describes the available catch data from various locations throughout the species' global range. It should be noted that catch records of sharks, especially non-target shark species, are often inaccurate and incomplete. Thresher shark catch is often only identified as unspecified shark catch or as a thresher shark complex (*Alopias* spp.). In addition, thresher sharks are predominantly bycatch and the reporting requirements for bycatch species have changed over time and differ by organization, and have therefore affected the reported thresher catch. In general, it is important to estimate total removals from a population in order to estimate the total fishing impact on a population. Reported catches of common and bigeye thresher sharks alone should therefore not be used to infer abundance trends of these species.

3.1 Global overview

Thresher sharks (*Alopias* spp.) are targeted and indirectly taken as bycatch in various fisheries around the world. Thresher sharks are widely caught or formerly caught in offshore pelagic longline and pelagic gill net fisheries including those of the former USSR, Japan, Taiwan, Spain, the United States, Brazil, Uruguay, Mexico, and other countries. Especially important areas for these fisheries are the Northwestern Indian Ocean, the Pacific Ocean, and the North Atlantic Ocean. Thresher sharks are also fished with anchored bottom and surface gill nets, and accidentally caught in other gear including bottom trawls and fish traps (Compagno, 2001). There is very little information on current global abundance of thresher sharks, with limited information in historical records outside the United States. Worldwide catches of Alopiids are reported in the Food and Agricultural Administration (FAO) of the United Nations (UN) Global Capture Production dataset, mainly at the genus level, but also specifically for common and bigeye threshers. According to the FAO, total catches of the thresher family (Alopiidae) increased drastically from 2004 to 2005, and peaked in 2011 at 18,464 mt (Figure 12). Worldwide landings for common thresher sharks for the last 10 years of available data (2003-2013) have ranged from 150 to 468 mt per year. Total catches of common threshers increased sharply in the late 1990s peaking at 654 mt in 2000, and then declined to 188 mt in 2013 (Figure 11). For bigeye threshers, reported worldwide landings for 2000-2009 have ranged from 49-301 mt per year, with landings fluctuating widely in recent years, from a low of 27 mt in 2010 to 440 mt per year in 2013.

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 the catch of these species through time. For example, the United States has reported at least several hundred tons annually of common thresher shark landings on the West Coast from 1981 through 1999 (PFMC 2003), but these data do not appear to be in the FAO dataset (cf. Figs. 11 & 12). Because FAO data are derived by reports from the fisheries agencies of individual countries, the data are affected by the same limitations in reporting capabilities, including issues related to species identification and a lack of species-specific reporting altogether. Further, some species may only be reported from 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). Although more countries and Regional Fishery Management Organizations (RFMOs) are working towards improving reporting of species-specific fish catches, catches of common and bigeye thresher sharks have gone and continue to go unrecorded in many countries. Further, many catch records that do include thresher sharks do not differentiate between the *Alopias* species or even shark species in general. As described previously, these numbers are also likely under-reported as many catch records reflect dressed weights instead of live weights and/or do not account for discards (e.g., fins are kept but the carcass is discarded). In fact, recent research suggests that annual global catch data compiled by the FAO are significantly underestimated (Clarke et al., 2006b). Thus, given these types of data, global population trends for common and bigeye thresher sharks are largely unavailable and highly uncertain.

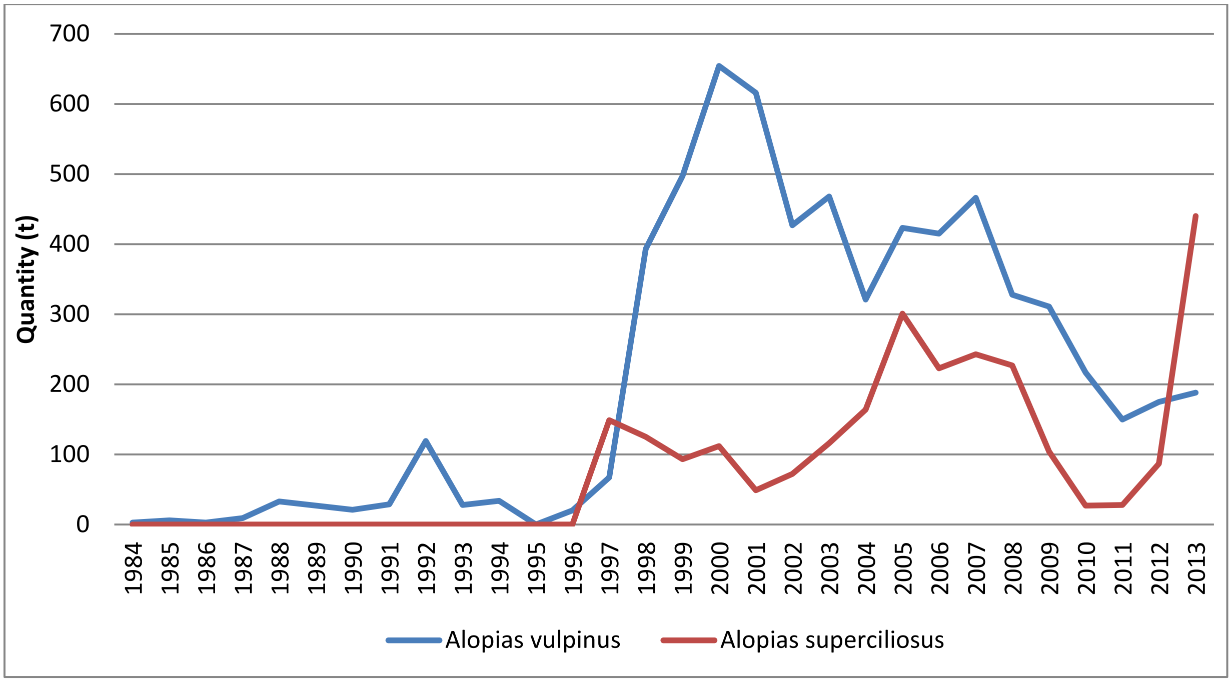

Figure 11. Global capture production for common and bigeye threshers from 1984-2013 (FAO species fact sheets, 2014). Global capture production is production weight of the retained individuals before processing and thus may differ from landings weights. (Source: FAO Global Capture Production; accessed March 11, 2015).

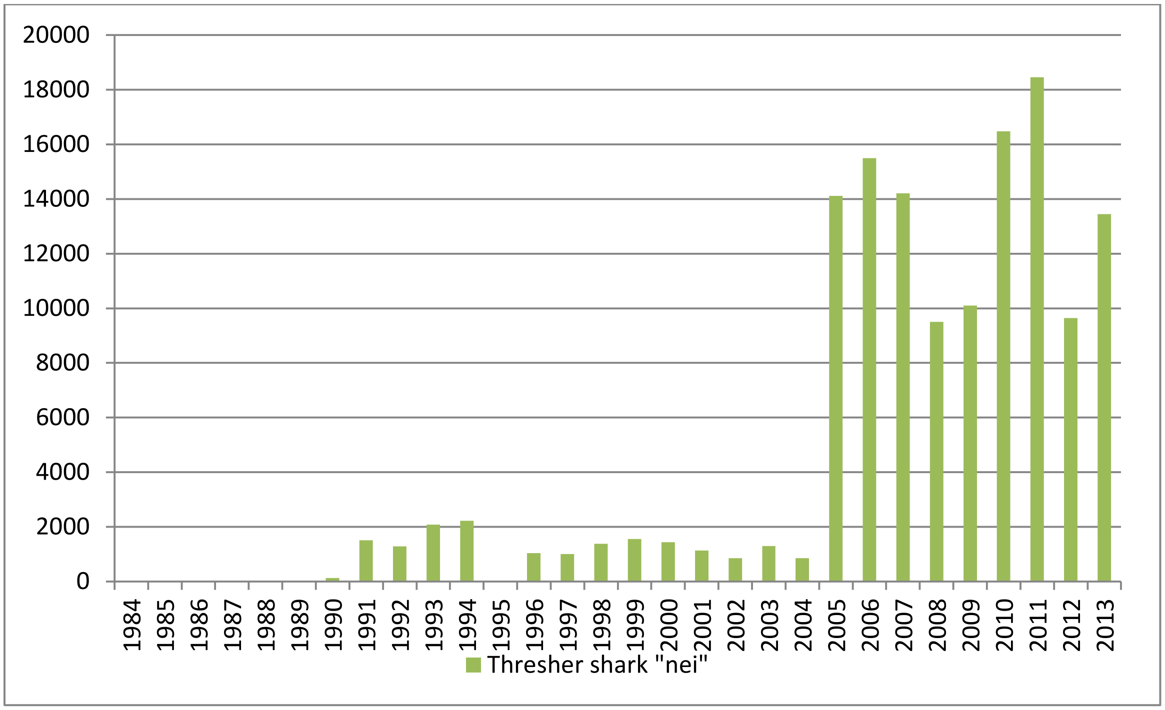

Figure 12. Global capture production for all unidentified thresher sharks (*Alopias* spp.) combined from 1984-2013. Global capture production is production weight of the retained individuals before processing and thus may differ from landings weights. (Source: FAO Global Capture Production; accessed March 11, 2015).

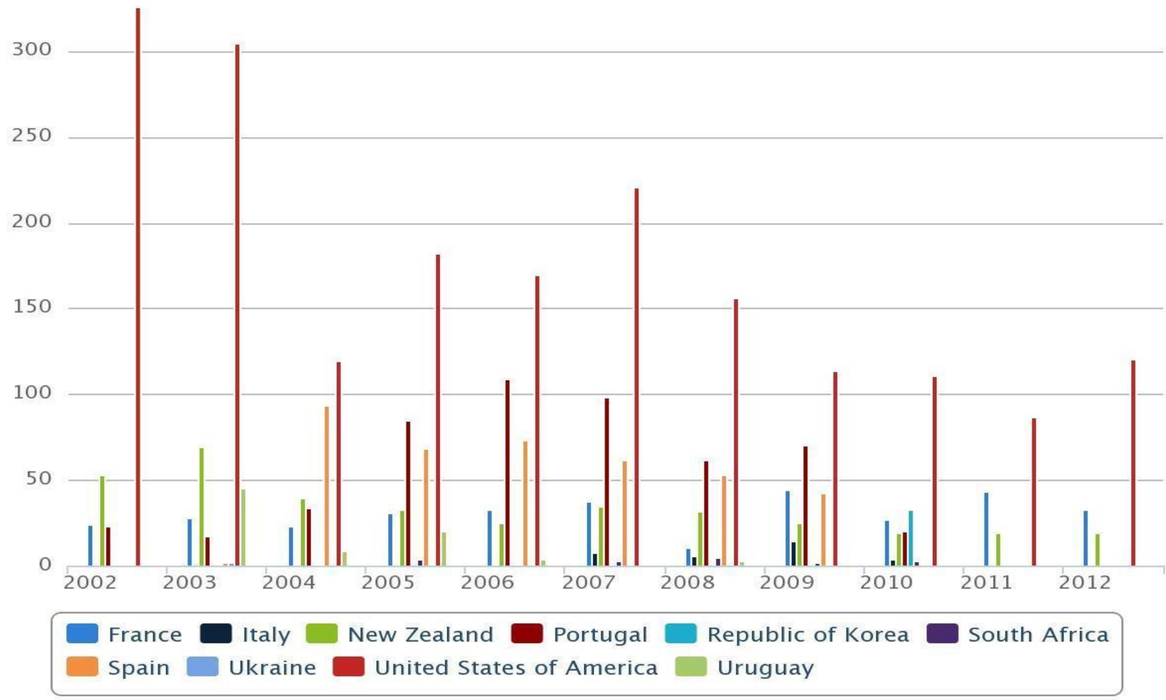

Figure 13. Global capture production of threshers (*Alopias* spp.) in all fishing areas. Source: FAO 2013 (FishStat Dataset; Accessed: March 3, 2015)

A recent FAO review of the status of highly migratory pelagic species states: "unless demonstrated otherwise, it is prudent to consider *Alopias* species as being fully exploited or overexploited globally" (Maguire et al. 2006). A number of studies have investigated the life history characteristics that make fish species vulnerable. Reynolds et al. (2005) reviewed evidence regarding the influence that life history traits had on fishing mortality, and found that 10 of the 15 studies they analyzed linked large size with vulnerability. Another study by Le Quesne and Jennings (2012) suggested that body size (maximum length) was the only life history trait needed to give a reliable measure of sensitivity to fishing mortality, for both commercially-targeted and non-targeted species. In a recent study, Oldfield et al. (2012) conducted a rapid assessment using life history variables to determine the intrinsic vulnerability of harvested shark species. Based on life history parameters, both common and bigeye thresher sharks received a “High” vulnerability score of 2.5 (“High” range = 3 to 2.50; “Medium” range = <2.50 – 2.00; “Low” range = <2.00) and a “High” size score (“High” size ranking = ≥350 cm) based on maximum size, ranking 5th and 7th among 60 species reviewed in the study, respectively (Oldfield et al. 2012). In another recent study, Dulvy et al. (2014) ranked the Alopiidae family as the 7th most threatened family of chondrichthyans based on their large body size and exposure to fisheries (see Figure 14 below).

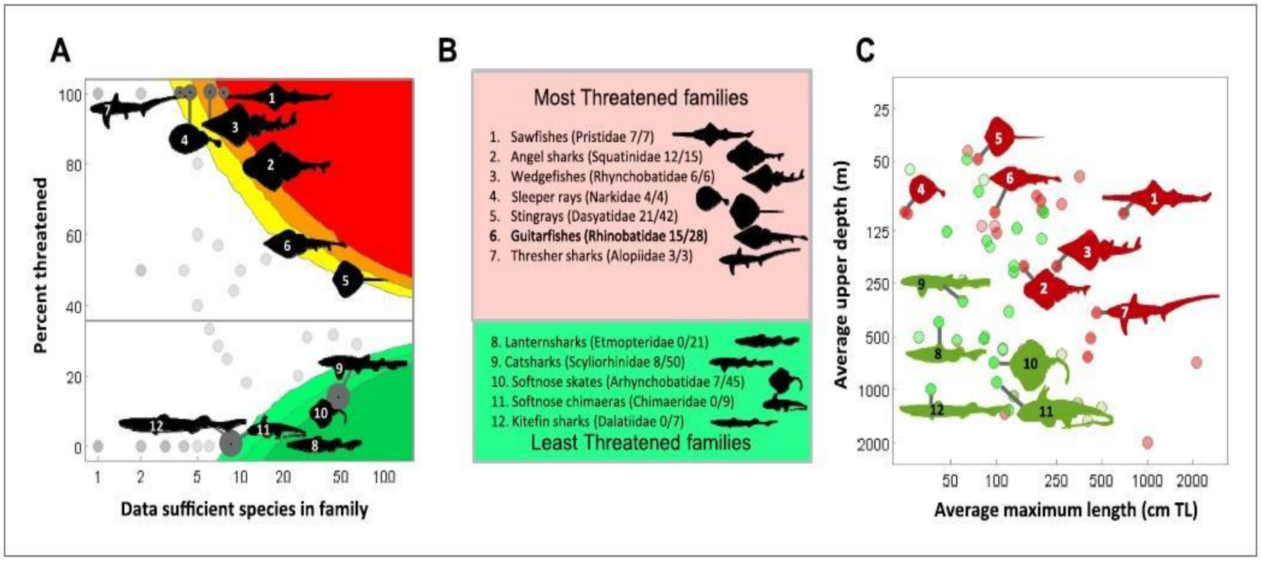

Figure 14. Evolutionary uniqueness and taxonomic conservation priorities. Threat among marine chondrichthyan families varies with life history sensitivity (maximum length) and exposure to fisheries (depth distribution). (A) Proportion of threatened data sufficient species and the richness of each taxonomic family. Colored bands indicate the significance levels of a one-tailed binomial test at p=0.05, 0.01, and 0.001. Those families with significantly greater (or lower) than expected threat levels at p<0.05 against a null expectation that extinction risk is equal across families (35.6%). (B) The most and least threatened taxonomic families. (C) Average life history sensitivity and accessibility to fisheries of 56 chondrichthyan families. Significantly greater (or lower) risk than expected is shown in red (green) (Source: Dulvy et al. 2014).

3.2 Regional Overview

The following section describes relevant fisheries and catch information for common and bigeye thresher sharks from the following regions: Atlantic and Mediterranean, Eastern Pacific, Western and Central Pacific, and Indian Ocean. Most 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 common and bigeye thresher 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 thresher sharks from vessels operating in these convention areas are provided below, and provide limited information regarding the species' distribution and population abundance within those management areas.

Eastern Pacific Ocean

Fisheries information and catch data for the Eastern Pacific are available from the Inter-American Tropical Tuna Commission (IATTC), with some species-specific shark catches that are publicly available. In the Eastern Pacific, both common and bigeye thresher sharks are caught on a variety of gear, including longline and purse-seine gear targeting tunas and swordfish. To date, IATTC has only conducted stock assessments on two species of sharks (blue and silky sharks). The IATTC, which is the RFMO responsible for the conservation and management of tuna and other marine resources in this region, requires the collection of data on principal 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. Collectively, thresher sharks (*Alopias* spp.) represented approximately 3% of the species observed during this project, with common threshers representing only 0.2% (n= 7), bigeye and pelagic threshers each representing only 1% (n = 29 and 28, respectively) and unidentified threshers representing only 0.7% (n= 19) (Roman-Verdesoto and Orozco-Zoller, 2005). Table 3 below shows more recent catches, in tons, of thresher sharks (*Alopias* spp.) by large purse-seine vessels with observers aboard in the Eastern Pacific Ocean from 2010-2014.

Table 3. Catches, in tons, of thresher sharks by large purse-seine vessels with observers aboard in the Eastern Pacific Ocean, 2013 (Source: IATTC Fishery Status Report 2013).

	Floating Object	Unassociated	Dolphin	Total
2010	1	2	6	9
2011	6	6	5	17
2012	2	4	5	11
2013	2	2	6	10
2014	2	5	4	11

More recently, some species-specific observer data has become available, upon which Murua et al. (2013a) based 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).

Table 4. Average yearly studied sharks species catch estimated during the study (tons/year) by purse seine fleet (Source: (Murua et al., 2013a).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
A. vul	1	2	4	2	3	2	9	2	2	2	2	1
A. sup	10	8	18	19	24	9	29	6	5	3	3	5
Alopias spp.	4	8	18	10	8	2	4	2	3	2	2	2

Although thresher sharks are not usually encountered in purse seine fisheries, they are sometimes a significant component of the bycatch in longline fisheries. However, information regarding catch rates of thresher sharks in longline fisheries of the Eastern Pacific are not readily available.

Western and Central Pacific Ocean

Fisheries information and catch data for the Western and Central Pacific Ocean are available from the Western and Central Pacific Fisheries Commission (WCPFC). The WCPFC is the RFMO that seeks the conservation and sustainable use of highly migratory fish stocks in the Western and Central Pacific Ocean. In the Pacific, there is a historical lack of shark reporting on logsheets for most fleets. In addition, if shark catch is reported, it is usually aggregated shark catch data. Furthermore, while Conservation Management Measure (CMM) 2009-04 (and CMM 2008-06 and CMM 2006-05 before it) call for CCMs to include key shark species in their annual reporting of catch and fishing effort statistics in accordance with agreed Commission reporting procedures, these provisions are non-binding (Clarke and Harley, 2010). For example, in the Taiwanese large-scale and small-scale tuna longline fisheries, bycatch data were not reported until 1981 due to the low economic value of the bycatch in relation to tunas (Liu et al., 2009). All shark data collected prior to 2003 were recorded in logbooks under the category "sharks." After 2003, species-specific information was recorded for the blue, mako, and silky sharks, but all other sharks remained lumped in the category "other sharks" (Liu et al., 2009). Due to these data gaps, the WCPFC recently revised its scientific data reporting requirements. Beginning in 2011, WCPFC vessels are required to report species-specific catch information for the following shark species: blue, silky, oceanic whitetip, mako, thresher, porbeagle, and hammerheads (WCPFC, 2011). Despite this requirement, recent catches of thresher sharks 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 (Miller et al., 2014). Table 5 below provides the available aggregated thresher shark catch information as reported by Australia, Japan, Korea, New Caledonia, New Zealand, and the United States.

Table 5. Annual catch estimates in (mt) or individuals of thresher shark species by longliners in the WCPFC Convention Area (compiled from Annual Reports to the Commission available at http://www.wcpfc.int/meetings/).

Country	2008	2009	2010	2011	2012	2013
Australia*	0.1	0.6	0.2	0.5	1.1	0.4
Japan**					338	456
Korea				1	33	98
New Caledonia					>1	0
New Zealand**		138	209	349	246	256
United States	38	29	16	18	13	5

*Denotes species level information for *A. vulpinus*. The rest are aggregated catch of all thresher sharks.
**Denotes individuals rather than mt.

Table 6. Annual longline discard estimates (in numbers) of common thresher sharks by the Australian fleet in the WCPFC Convention Area for 2008–2013.

2008	2009	2010	2011	2012	2013
140	137	52	132	165	118

In total**,** thresher sharks represent only 1.81% of commonly caught shark species in longline fisheries of the WCPFC convention area. The most frequently encountered thresher shark is the bigeye thresher, which shows a particular area of interaction with longline fisheries south of

Hawaii (see Figure A1 in Clarke et al. (2011a)). Overall, the common thresher is infrequently encountered, but is most often encountered by longline fisheries off Australia and New Zealand. Figure 15 below shows nominal catch rates of thresher sharks determined from observer data collected onboard longliners in the Western and Central Pacific Ocean.

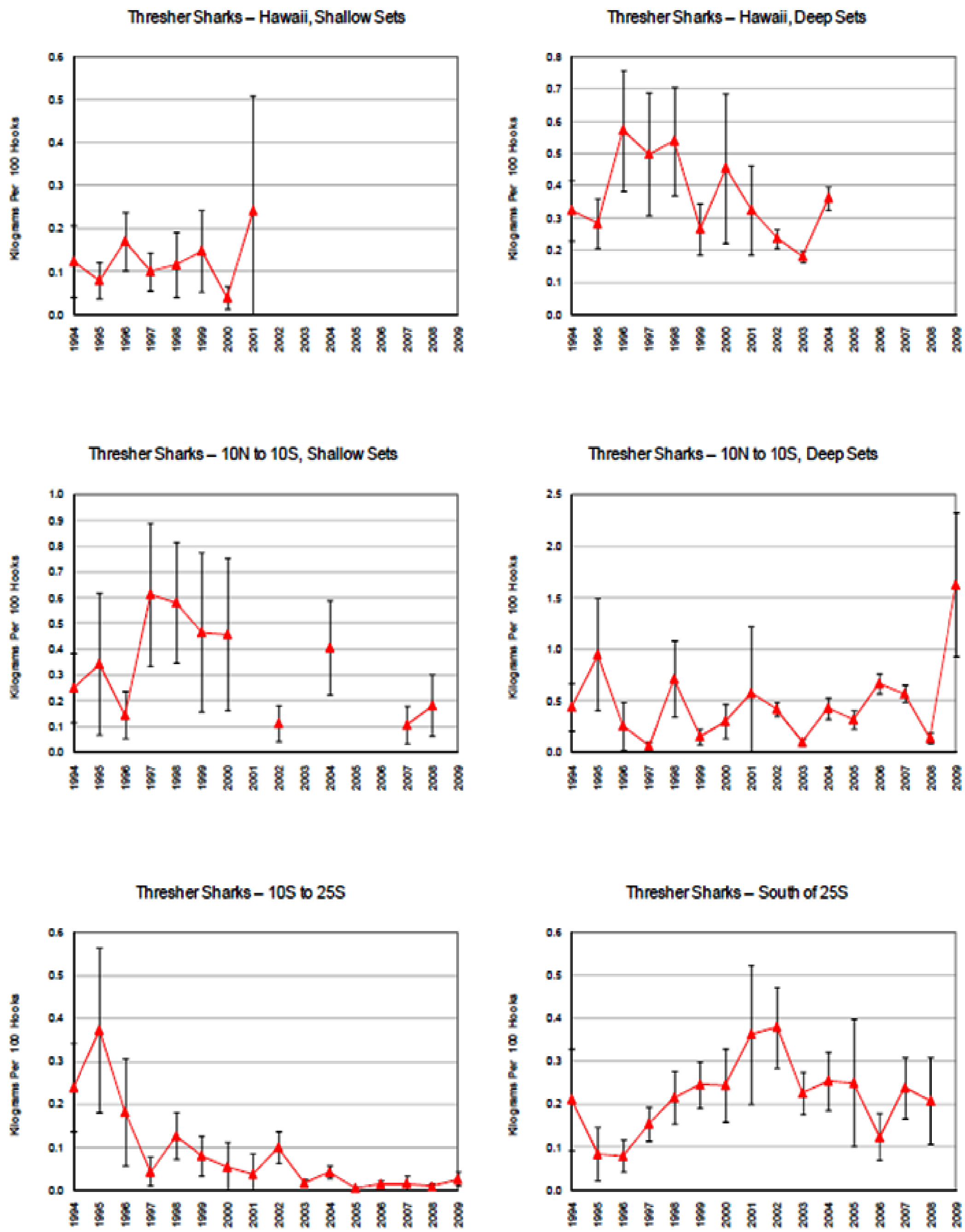

Figure 15. Nominal catch rates of thresher sharks determined from observer data collected onboard longliners in the Western and Central Pacific Ocean (Source: SPC 2010).

The data should be viewed with caution as longline observer coverage in the WCPFC convention area is very low. 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 is also lacking for the distant-water fleets of Japan, South Korea, and Chinese Taipei, which account for a large proportion of longline effort in the Western and Central Pacific Oceans (SPC, 2010). Since 2009, total observer coverage in the longline fishery remains below 2% (Clarke, 2013).

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. However, available data do not suggest thresher sharks are caught in large numbers by the purse seine fleets. For example, in 2010, the EU estimated that its purse seine bycatch of thresher sharks was only 0.11 mt in the WCPFC convention area (see EU's Annual Report to the Commission[3]). Since 2009, observer coverage in the purse seine fleet has increased to 100% and all thresher species interact only rarely with this fishery (Clarke, 2013). However, it should be noted that although the required observer coverage level is 100 percent, the actual achieved level of observer coverage is much less (Williams et al., 2015).

Atlantic Ocean and Mediterranean Sea

Fisheries information and catch data for the Atlantic and Mediterranean are available from the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the General Fisheries Commission for the Mediterranean (GFCM). 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 common and bigeye thresher sharks from ICCAT vessels in the Atlantic are shown below in Figures 16 and 17, respectively. Common thresher sharks are taken in the ICCAT convention area by longlines, purse seine nets, gillnets, trawls, and trammel nets; however, approximately 70% of the total catch (n= 802 mt) from 1987-2013 was caught by longline gear.

[3] http://www.wcpfc.int/node/3142

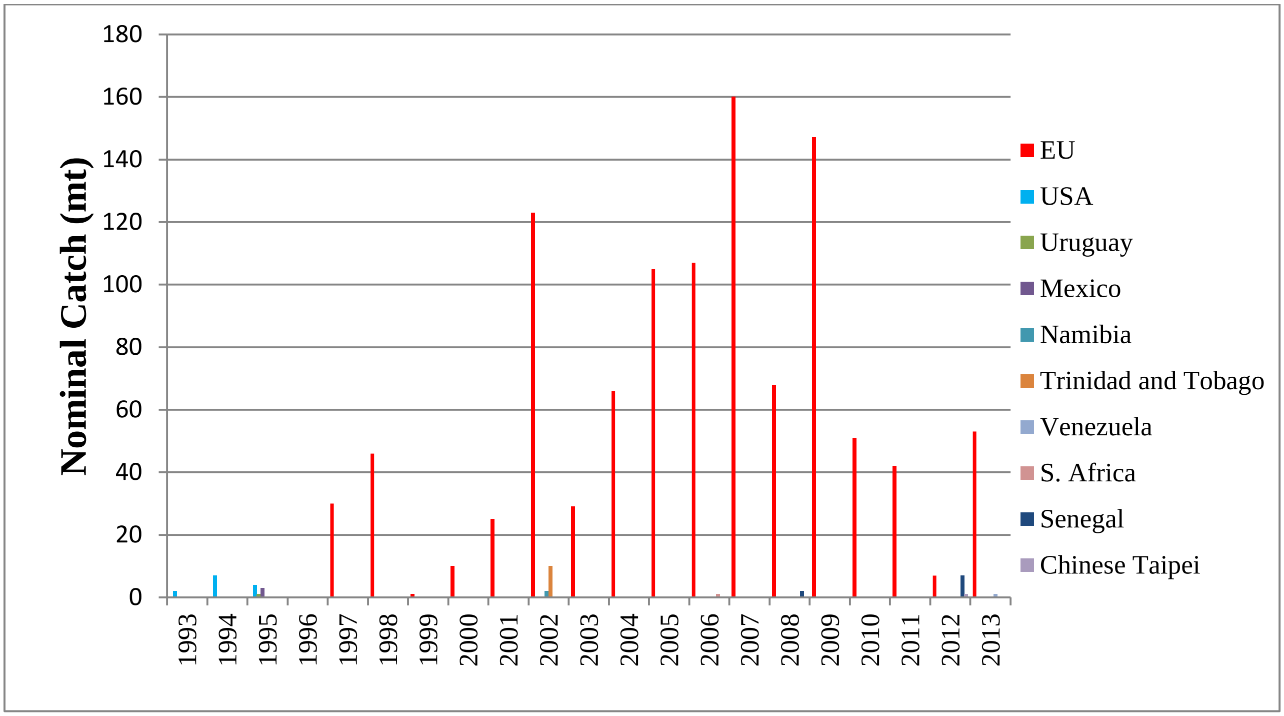

Figure 16. Nominal catches (mt) of *A. vulpinus* reported to ICCAT by CPC vessel flag from 1993-2013. (Source: ICCAT nominal catch information: Task I web-based application, accessed March 3, 2015).

In total, approximately 1,142 mt of common thresher catches were reported to ICCAT from 1993-2013. Around 96% of the total catch (n = 1,096 mt) was caught by fleets flying under the EU flag (e.g., Spain, Portugal, Malta, Italy, France). Catches of common thresher shark by EU vessels peaked in 2007 at 160 mt and declined by approximately 66.9% to 53 mt in 2013.

Bigeye threshers are also taken in the ICCAT convention area predominantly by longline fisheries (see Figure 17 below). From 1993-2013 approximately 1,608 mt were reported to ICCAT. Nearly half of the total catch (741 mt) was caught by Brazilian fleets. Reported catches of bigeye thresher by Brazilian fleets peaked in 2003 with 109 mt, and declined by approximately 92% to only 9 mt in 2013. In 2009, ICCAT developed recommendation 09-07, which specifically prohibits the retention, transshipping, landing, storing, selling, or offering for sale any part or whole carcass of bigeye thresher sharks, which may have contributed to the drastic decline in reported catches. While catches reported to ICCAT declined significantly after 2009, the species is still regularly caught as bycatch. For example, the U.S. reported in 2010 that the bigeye thresher shark represented the second largest amount of dead discards in the Atlantic commercial fleet, reporting a total of 46 t (NMFS, 2010).

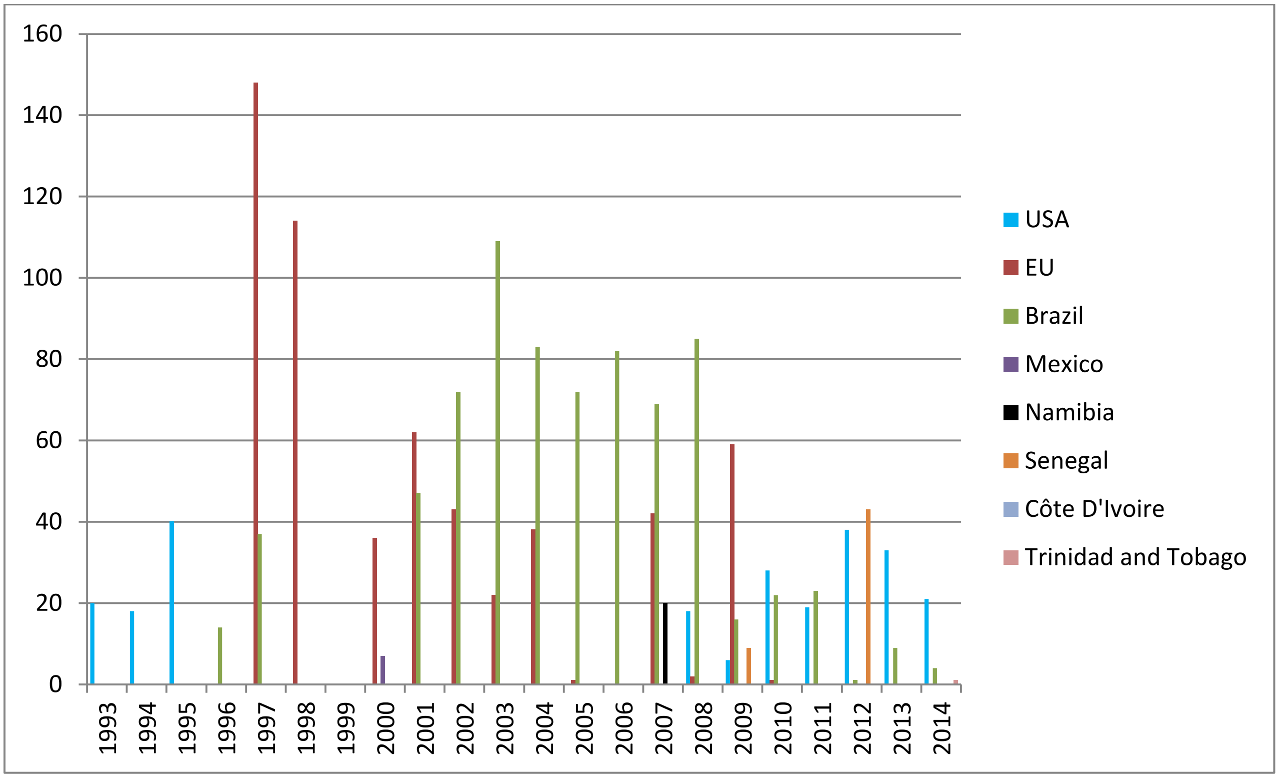

Figure 17. Nominal catches (mt) of *A. superciliosus* reported to ICCAT by CPC vessel flag from 1993-2013. (Source: ICCAT nominal catch information: Task I web-based application, accessed June 16, 2015).

In the Mediterranean, a quantitative assessment of historical shark populations has not yet been attempted, likely due to an ongoing paucity of abundance data. Historically, large sharks occurred throughout the Mediterranean Sea; in the early 20th century many coastal fisheries targeted sharks or landed them as bycatch. However, in recent decades, large sharks seem to be restricted to the eastern and southern Mediterranean coasts or to offshore pelagic waters, where they have been caught, albeit in very low numbers (Ferretti et al., 2008). The GFCM is the RFMO responsible for promoting the development, conservation, rational management and best utilization of living marine resources in the Mediterranean. Catches of thresher sharks in the Mediterranean have been reported to GFCM since 1997. Total catches of common thresher reported in the GFCM region are shown below in Figure 18.

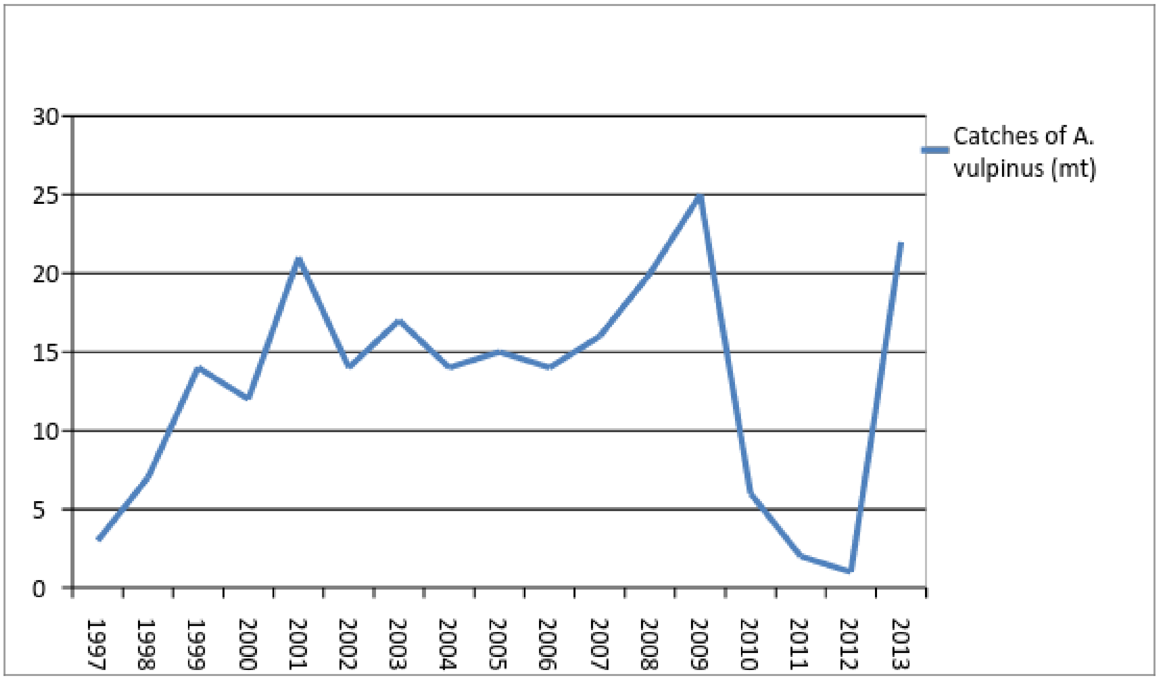

Figure 18. Capture production statistics for *A. vulpinus* in the GFCM region from 1997-2011. (Source: FAO Production Statistics (Fishery Statistical Collection), accessed March 10, 2015).

Catch trends of *A. vulpinus* in the Mediterranean peaked at 25 mt in 2009, and then declined precipitously by 76% to 6 mt in 2010. In 2010, Spain, a major contributor of thresher shark catch in the GFCM, prohibited the retention of all thresher species, which may have influenced the steep decline in catches of common threshers from 2009-2010 shown above in Figure 18. However, this steep decline was short lived, as catches of common threshers increased significantly from 2012 to 2013. According to Ferretti et al. (2008), during the past two centuries, common thresher sharks have declined between 96 and 99% in abundance and biomass in the Mediterranean Sea (See Figure 19 and Table 8 below). Data from this fishery suggest that both annual catches and mean weights of common thresher shark have fallen significantly as a result of fishing mortality.

Bigeye thresher has been poorly documented in the Mediterranean and is considered scarce or rare (Amorim et al., 2009). As a result, no data are available on catch trends for this species in the region, and in fact, catches of bigeye thresher are rarely reported to GFCM despite the fact that they are known as bycatch in several fisheries in this region. Since 1990, only 5 mt were reported in 1999 and 1 mt reported in 2009.

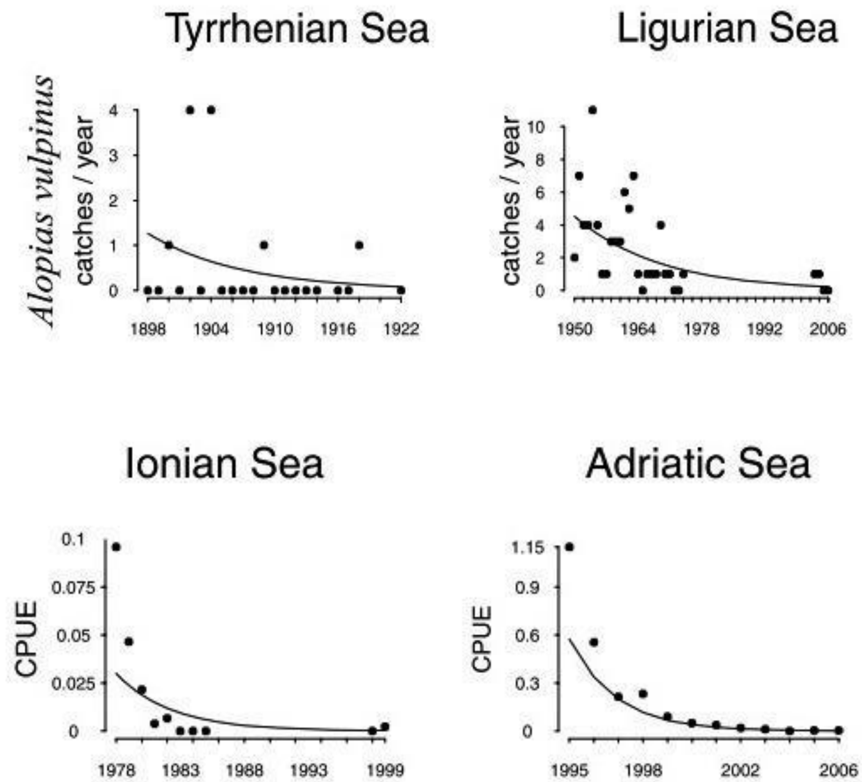

Figure 19. Trends in *A. vulpinus* population abundance in the Mediterranean Sea. Dots represent standardized annual catches or annual sightings. Catch per unit effort (CPUE) for *A. vulpinus* in the Adriatic Sea are landed sharks per yacht-club member per year, standardized by a constant number of tuna catches (mean value over time period). Trends (solid lines) were calculated with the year-effect estimate (Source: Ferretti et al. 2008).

Table 7. Summary of estimated local change in population abundance and biomass and associated confidence intervals for *A. vulpinus* over the considered time intervals. ∗Upper Wald Confidence Intervals (CI) and lower Wald CI are, respectively, the upper and lower Wald CI at 95% level of statistical significance. A negative sign indicates a reduction over the indicated time period (Source: Ferretti et al. 2008).

Abundance	**Area**	**Time range (year)**	**Abundance estimate (%)**	**Lower Wald CI**	**Upper Wald CI**	**Data Set**
	Ionian Sea	21	-99.19	-99.99	-33.88	4
	Ligurian Sea	55	-94.67	-99.18	-65.02	3
	Tyrrhenian Sea	24	-93.15	-99.91	408.96	2
	Adriatic Sea	11	-80.82	-90.86	-59.74	9
	Ligurian Sea	8	-7.76	-98.61	60.26	8
Biomass						
	Spanish waters	19	-98.20	-99.45	-94.03	6
	Ionian Sea	21	-96.96	-99.88	-24.69	4

	Ligurian Sea	55	-41.35	-91.11	284.78	3
	Tyrrhenian Sea	24	-18.84	-97.24	2287.00	2

Indian Ocean

Fisheries information and catch data for the Indian Ocean are available from the Indian Ocean Tuna Commission (IOTC). According to the IOTC, the RFMO that manages tuna and tuna-like species in the Indian Ocean and adjacent waters, catches of all thresher species (including common and bigeye thresher shark) are ranked as "High," meaning the accumulated catches from 1950–2010 make up 5% or more out of the total catches of sharks recorded (Herrera and Pierre 2011). The IOTC requires CPCs to annually report thresher shark catch data (See IOTC Resolutions 05/05, 10/12, 12/09). However, prior to the adoption by IOTC of resolution 05/05, there was no requirement for sharks to be recorded at the species level in logbooks. As a consequence, it is only since 2008 that some very patchy statistics started to become available on shark catch, mostly representing retained catch and not accounting for discards (Ardill et al., 2011). The data in the IOTC public domain database contains catches of both common and bigeye thresher sharks, as well as aggregated catches of unidentified *Alopias* spp. under the name "thresher shark nei" (nei = not elsewhere included), which are shown in Figure 20 below. This graph represents catches from all gears (including longlines and gillnets). For *A. vulpinus*, the trend in catch shows a significant increase in the late 1990s, which likely corresponds with the rise in the shark fin trade (Clarke et al., 2007), a peak at 956 mt in 1999, and then a sharp decrease by 94% to 56 mt in 2008. This sharp decline precedes the Resolution adopted by IOTC in 2010 that prohibits the retention of all thresher shark species (see IOTC Resolution 12/10), thus the reason for this decline is unclear. Reported catches of *A. superciliosus* have been historically very low, although a significant increase occurred recently in which reported catches increased from only 2 mt in 2011 to 208 mt in 2012, thus producing an average of 75 t from 2009-2013 (IOTC). The group "Thresher shark nei," shows an increasing trend for the entire time period, with total catches amounting to 63,473 t from 1986-2013. This could indicate that catches of thresher sharks continue despite Resolution 12/10.

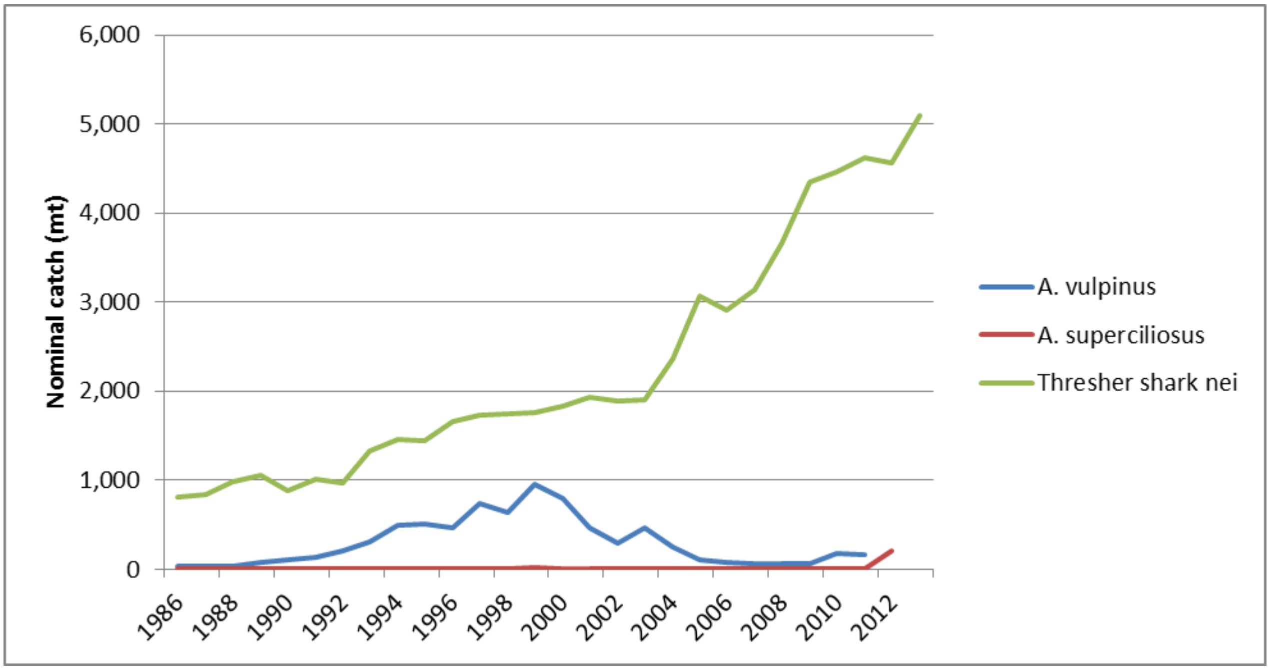

Figure 20. Total catches (mt) (all gears) of *A. vulpinus*, *A. superciliosus*, and thresher shark nei (not elsewhere included) as reported to the IOTC from 1986-2013. (Source: IOTC Nominal Catch Database, accessed March 4, 2015).

The drastic increase in catch of thresher sharks over the years may be attributed to an increase and improvement in reporting practices. For example, Resolution 08/04 “Concerning The Recording of Catch by Longline Fishing Vessels in the IOTC Area,” which builds upon Resolution 07/03, whereby CPCs would be subject to a data recording system and commit themselves to adopting a minimum standard for logbooks for all longline vessels over 24 meters (see IOTC Resolution 08/04). However, recording and reporting thresher shark catches to the IOTC were not required until 2013. Therefore, it is uncertain whether the sharp increase in catches is a result of improved reporting, although it has likely had some effect. Still, the IOTC acknowledges that catches of sharks are usually not reported. Additionally, 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, 2011). Therefore, the current reported catches are thought to be incomplete and largely underestimated. In fact, a recent project estimated possible thresher shark catches for fleets/countries based on the ratio of shark catch to target species, and highlighted a potentially significant underestimation of thresher shark in the IOTC database. Murua et al. (2013b) concluded that the estimated catch of thresher shark is approximately 70 times higher than declared/reported and contained in the IOTC database. The IOTC also acknowledges that it is difficult to differentiate between thresher shark species, thus the species-specific data for *A. vulpinus* and *A. superciliosus* are likely not accurate (Romanov, 2015). However, it is clear that the reported catches of thresher sharks in the Indian Ocean are likely grossly underestimated and that thresher sharks are caught in high numbers in this region.

In some Indian Ocean fisheries, catches of *A.vulpinus* appear to be relatively low. For example, in a study of observer data from Taiwanese longline fisheries operating in the Indian Ocean, *A. vulpinus* was recorded in the yellowfin and bigeye tuna fisheries, representing 0.2% and 0.1% of species caught from 2004-2008, respectively. In total, only 67 individuals were recorded during the study period, whereas 445 bigeye threshers were caught over the same time period (Huang and Liu, 2010). Most fishing effort in this study took place in tropical latitudes between 10˚N and 10˚S) and in the Southern Indian Ocean (south of 25˚S). Likewise, six observers collected bycatch information from Japanese longline vessels in the Indian Ocean from July 2010 – January 2011. A total of 174 thresher sharks were recorded (162 were bigeye (*A. superciliosus*) and an additional 12 were unidentified *Alopias* spp.) (Ardill et al., 2011).

In a recent study, Lack et al. (2014) developed an assessment framework for exposure and management risk (M-Risk), based on three elements: (1) stock status; (2) adaptive, species-specific management; and (3) generic management. The element of adaptive, species-specific management carries the most weight in calculation of M-Risk scores. Both common and bigeye thresher sharks received high M-Risk ratings for each management unit (i.e., GFCM, WCPFC, IOTC, IAATC, ICCAT, as well as Spain and the Convention of the Conservation of Southern Bluefin Tuna) (Lack et al., 2014).

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 common and bigeye thresher shark.

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

This section analyzes potential threats to common and bigeye thresher shark habitat, including impacts from fishing and climate change.

Habitat in United States

In the U.S. EEZ, the Magnuson-Stevens 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 habitat necessary for spawning, breeding, feeding, and growth to maturity and requires the identification of EFH in FMPs.

<u>Atlantic</u>

The NMFS has funded two cooperative survey programs intended to help delineate shark nursery habitats in the Atlantic and Gulf of Mexico. The Cooperative Atlantic States Shark Pupping and Nursery Survey and the Cooperative Gulf of Mexico States Shark Pupping and Nursery Survey are designed to assess the geographical and seasonal extent of shark nursery habitat, determine which shark species use these areas, and gauge the relative importance of these coastal habitats for use in EFH determinations.

Shown below are the designated EFH areas along the U.S. East Coast that support EFH for common thresher shark (Figure 21) and the bigeye thresher shark (Figure 22). Due to insufficient data to differentiate EFH by size classes in this region, EFH is the same for all life stages.

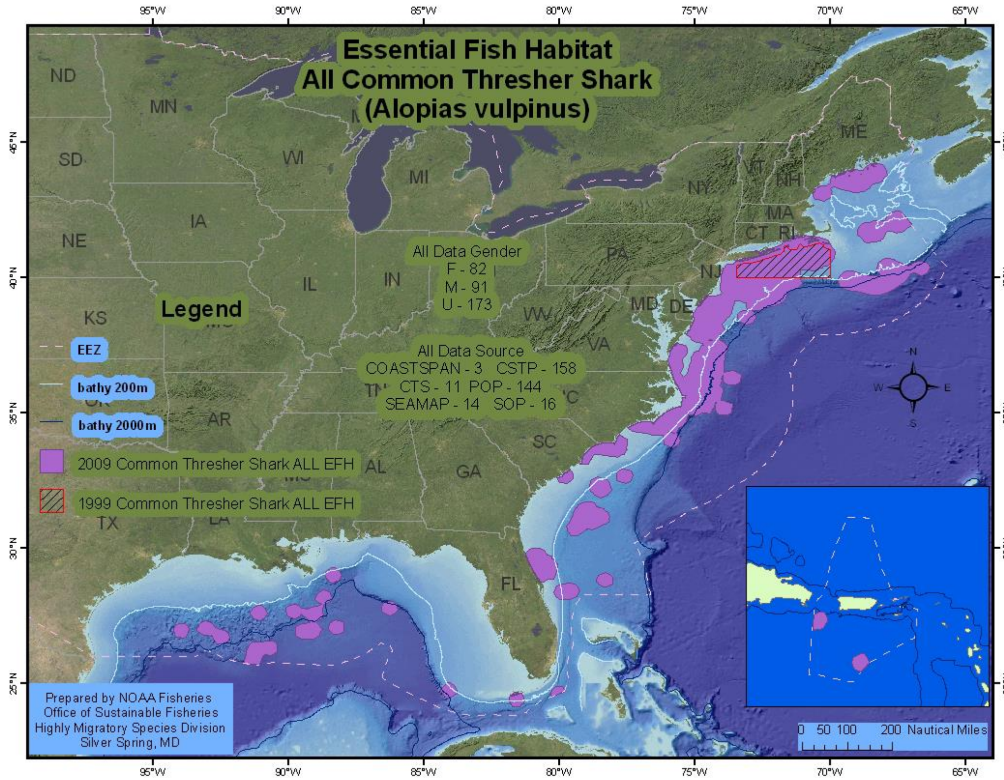

Figure 21. EFH for common thresher (identified by the light purple area): Atlantic east coast from the Florida Keys to Maine; scattered in the Gulf of Mexico from the southern coast of Florida to Texas; areas south and southwest of Puerto Rico. (Source: NMFS 2009).

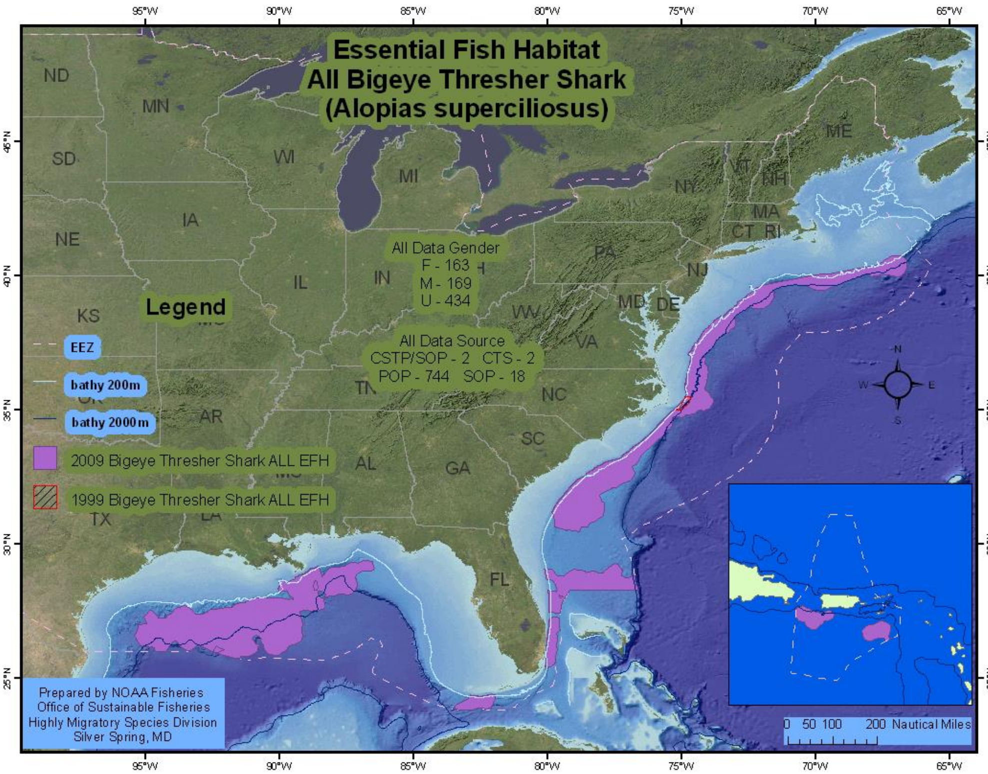

Figure 22. EFH for bigeye thresher (identified by light purple area): Central Gulf of Mexico and off Key West, Florida. Atlantic east coast from southern to the mid-Florida coast, and from Georgia to southern New England. Localized areas off of Puerto Rico and the U.S.Virgin Islands.

Pacific

On the U.S. West Coast, common thresher pups are found in near-shore waters of the Southern California Bight (SCB). These waters are considered EFH for thresher shark pups, but the extent of this habitat is poorly defined. In 2003, the SWFSC began a survey to develop a pup abundance index and determine the continuity of thresher pup distribution along the coast of the SCB. While it is still too early to develop a pre-recruit index from the survey results, a number of patterns are emerging. Depth-stratified sampling revealed that over half of the neonates were caught in shallow waters from 0 to 46 m and almost all individuals are caught shallower than 90 m. The distribution of thresher sharks is very patchy and areas of high abundance are not consistent across years. In all years, a large percentage of the catch has been neonates, which were found in all areas surveyed. Currently, the SWFSC Fisheries Resources Division is collaborating with experts from Scripps Institution of Oceanography and Mexico's Centro de Investigación Científica y de Educación Superior de Ensenada to examine the movements, EFH, and fisheries for thresher sharks off Baja California, Mexico. Based on tag recoveries and satellite tracks, it is clear that the thresher shark nursery spans the waters of both countries (NMFS, 2011b). Essential Fish Habitat is described for three age classes: neonate/early juveniles, late juveniles/subadults, and adults. For neonate/early juveniles (<102 cm FL) EFH includes epipelagic, neritic and oceanic waters off beaches, in shallow bays, in near surface waters from the U.S.-Mexico EEZ border north to off Santa Cruz (37° N) over bottom depths of

6 to 400 fathoms (fm; 11-732 m), particularly in water less than 100 fm (183 m) deep and to a lesser extent further offshore between 200-300 fm (366-549 m). For late juveniles/subadults (>101 cm FL and <167 cm FL), EFH is described as epipelagic, neritic and oceanic waters off beaches and open coast bays and offshore, in near-surface waters from the U.S. -Mexico EEZ border north to off Pigeon Point, California (37° 10' N) from the 6 to 1,400 fm (11-2,560 m) isobaths. For adults (>166 cm FL), EFH is described as epipelagic, neritic and oceanic waters off beaches and open coast bays, in near surface waters from the U.S.-Mexico EEZ border north seasonally to Cape Flattery, WA from the 40 fm (73 m) isobath westward to about 127° 30' W longitude north of the Mendocino Escarpment and from the 40 to 1,900 fm (73-3,474 m) isobaths south of the Mendocino Escarpment. In the U.S. Western Pacific, including Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands, EFH for common thresher 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).

The bigeye thresher population off California and Oregon appears to be predominantly adult males (71% of observed catches are mature males), which range north to Oregon, and immature females, which primarily occur south of Monterey Bay and in the Southern California Bight. Juveniles off the U.S. West Coast appear to be associated with a broader range of sea surface temperatures (15°-25°C) than adult males (15°-18.5°C), judging from observed temperatures at catch locations 1997-1999, although more data are needed to determine actual temperature preferences off the U.S. West Coast. Essential Fish Habitat is described for two age classes: late juveniles/subadults and adults. Neonates/early juveniles (~90 to 115 cm FL, 0 to 2 and 3 yr olds) are not known to occur in the U.S. West Coast EEZ, thus EFH is not defined for this size class. For late juveniles/subadults (>115 cm FL and <155 cm FL males and <189 cm females), EFH is described as coastal and oceanic waters in epi- and mesopelagic zones from the U.S.-Mexico border north to 37° N latitude off Davenport, California, South of 34° N latitude from the 100 fm (183 m) isobath to the 2,000 fm (3,568 m) isobaths and north of 34° N from the 800 fm (1,463 m) isobath out to the 2,200 fm (4,023 m) isobath. For adults (>154 cm FL males and >188 cm FL females) EFH is described as coastal and oceanic waters epi-and mesopelagic zones from the U.S.-Mexico border north to 45° N latitude off Cascade Head, Oregon. In southern California EFH is south of 34° N latitude from the 100 fm (183 m) isobath out to the 2,000 fm (3,568 m) isobath and North of 34° N latitude from the 800 fm (1,463 m) isobath out to the outer EEZ boundary. In the U.S. Western Pacific, including Hawaii, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands, EFH for bigeye thresher is described identically to common thresher (see description in previous paragraph above).

Based on an examination of published literature and anecdotal evidence, NMFS assessed the impact of fishing gears on HMS EFH and determined that there are few anticipated impacts from federally regulated and non-federally regulated gears to HMS EFH (which includes common and bigeye thresher shark EFH) (NMFS, 2006). Since EFH is defined for the common and bigeye thresher 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 thresher sharks within those habitats is needed in order to determine the effects of fishing activities on habitat suitability for *A. vulpinus* and *A. superciliosus*. 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 either the common or bigeye thresher shark. In addition, while some areas are thought to be important nursery areas, particularly for common thresher sharks (e.g., Southern California Bight), more information is needed to assess the potential threat of degradation within these areas.

Non-U.S. Habitat

Information on threats to common and bigeye thresher habitat areas outside of the U.S. is limited. However, some information indicates important nursery habitat areas for common thresher sharks may be located in Baja California waters off Mexico's Pacific coast (Cartamil et al. 2011a). Additionally, there are likely some important parturition and nursery areas in the Mediterranean region as aggregations of pregnant females have been observed in the Alboran Sea and around the Gibraltar Strait region (ICES, 2009). However, aside from impacts from overfishing, information on threats to these habitat areas is not available.

Climate Change

Studies on the impacts of climate change specific to thresher sharks have not been conducted. However, because both common and bigeye thresher 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 common and bigeye thresher sharks.

In a study to assess the vulnerability of sharks and rays on Australia's Great Barrier Reef (GBR) to climate change, Chin (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 UV 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 habitat and diversity shifts 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 23).

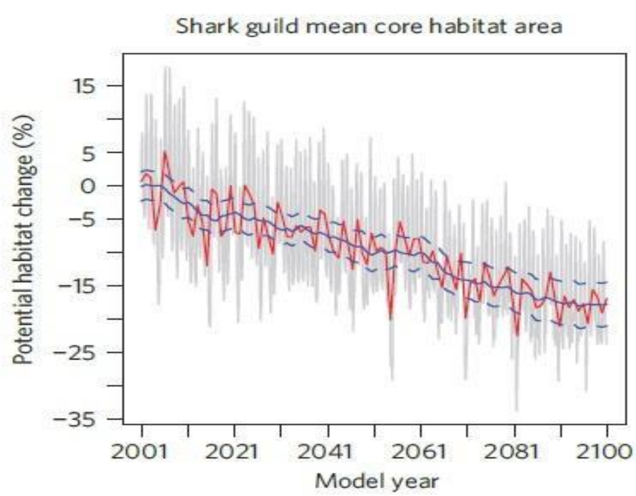

Figure 23. Core habitat area for sharks from the year 2000 to 2100 shown as monthly (grey), yearly (red) and 5-year filtered (blue) time series with 1 standard deviation marked by dashed lines (Source: Hazen et al. 2012).

Overall, the model predictions in Hazen et al. (2012) and the vulnerability assessment in Chin (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 thresher sharks. 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 common and bigeye thresher sharks and their 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 common and bigeye threshers and their habitat are currently unknown, but likely minimal.

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

Threats to thresher sharks related to overutilization (as it pertains to the ESA) stem from commercial and recreational fisheries, as well as impacts from the shark trade (utilizaiton of both fins and meat) and illegal, unregulated and unreported (IUU) fishing. Both thresher shark species in this review are preferred species for human consumption, with the common thresher meat being particularly favorable for eating. The meat is highly prized fresh (cooked) but is also eaten smoked and dried-salted. Additionally, the fins are valuable for shark-fin soup, the hide is usable for leather, and the liver oil can be processed for vitamins. Also, because common threshers fight strongly and occasionally jump clear out of the water when hooked, recreational fisheries seek these sharks as prized game fish with rod and reel (Compagno, 2001). Despite the amount of sharks that may be discarded or released alive in both commercial and recreational fisheries, post-release survivorship is difficult to evaluate because standard methods are not applicable to large oceanic fishes (Skomal, 2007). However, preliminary studies show that thresher sharks may experience high levels of at-vessel and post-capture mortality. For example, common threshers show high mortality after extended fight times in recreational fisheries (Heberer et al., 2010) and bigeye threshers exhibit high bycatch-related mortality rates in numerous fisheries throughout its range (Beerkircher et al., 2002, Bromhead et al., 2012, IOTC, 2014, Fernandez-Carvalho et al., 2015b). For the purposes of this status review, population dynamic characteristics, such as current population size, abundance trends by regions, and the effects of fisheries (commercial and recreational) and the shark fin trade on the species were considered when evaluating whether these two species are currently experiencing overutilization throughout their respective ranges. Much of the data come from localized study sites and over small periods of time and thus is difficult to extrapolate to the global populations. In addition, data are often aggregated for the entire thresher complex and species misidentifications in records are common. Relative information regarding overutilization of these species is broken down into the following categories: commercial fisheries, recreational fisheries, and the shark trade (though there may be some overlap in information). Additionally, this section includes information from the following geographic regions: Eastern Pacific, Western and Central Pacific, Northwest and Central Atlantic, Northeast Atlantic and Mediterranean, South Atlantic, and Indian Ocean.

Commercial Fisheries

PACIFIC

Eastern Pacific Ocean

Both common and bigeye thresher sharks are taken in fisheries throughout the Eastern Pacific Ocean. The following section discusses fisheries information from the U.S. Eastern Pacific and international waters. In the Eastern Pacific, particularly in U.S. waters, most information is relevant to common threshers, with little to no information available for bigeye threshers from this region.

United States

In the Eastern Pacific, common thresher sharks are one of the most commonly caught shark species in the U.S. West Coast-based HMS fisheries, predominantly in the California drift gillnet fishery. Annual commercial landings of common thresher sharks on the West Coast (Washington, Oregon, and California) compiled from PacFIN reports from 1981-2014 are shown below in Figure 24.

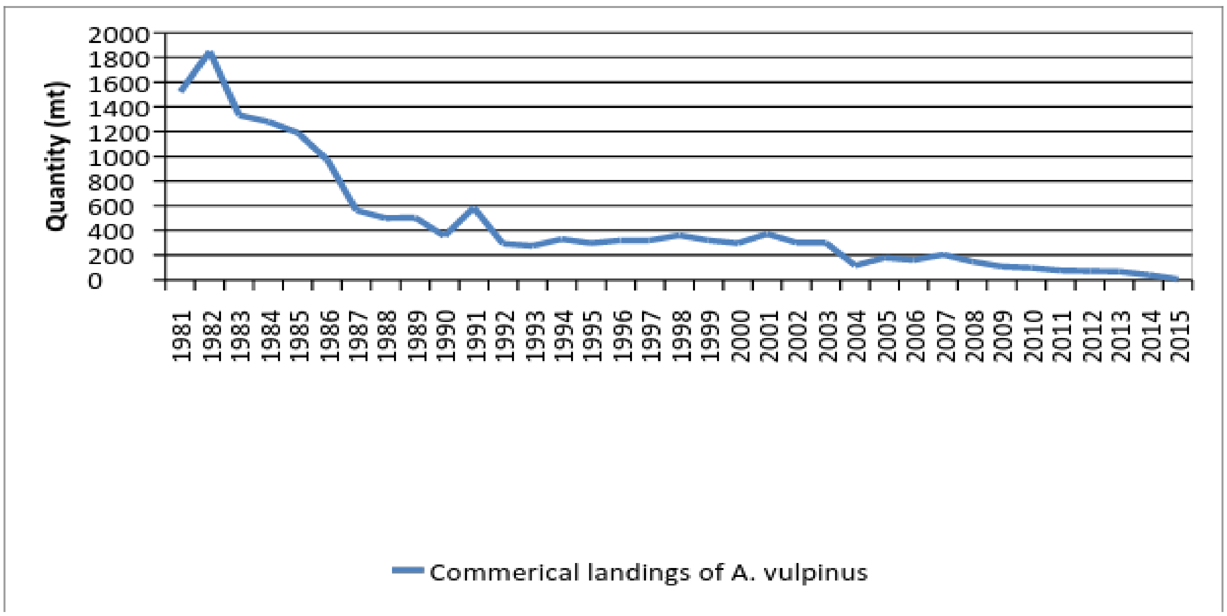

Figure 24. West Coast commercial landings for common thresher shark (round weight equivalent in metric tons) for California, Oregon, and Washington, 1981–2014 (Source: PacFIN W-O-C- All Species Reports[4]).

The drift gillnet fishery targets swordfish and pelagic sharks, like shortfin mako and common thresher sharks, and most drift gillnets are used off California; this gear is no longer legal in Washington or Oregon. Historically, common thresher sharks were targeted and caught in the drift gillnet fishery beginning in the late 1970s. Starting with 15 vessels in 1977, the fishery expanded to over 225 vessels in 1982 (Holts, 1988, Hanan et al., 1993). The California fishery for common threshers peaked in 1982 with estimated landings of approximately 1,800 mt, then sharply declined in 1986, when all subadults were virtually eliminated from the population due to overfishing (Camhi et al., 2009, Goldman, 2009). By 1990, the fishery shifted to a swordfish fishery primarily due to economic drivers but also to protect pupping female thresher sharks

[4] http://pacfin.psmfc.org/pacfin_pub/all_species_pub/woc_r307.php

(PFMC, 2003) with a series of regulations restricting the time-areas allowed for fishing, gear configurations, and bycatch limitations (Teo et al., 2015). Specifically, due to concerns regarding increased targeting of common threshers by recreational fishers, a precautionary annual harvest guideline was implemented in 2004 under the Pacific HMS FMP. Since then, common thresher sharks have only been targeted secondarily or caught incidentally in the drift gillnet fishery. Commercial landings from the U.S. West Coast swordfish/shark drift gillnet fishery are down from 1,800 mt in the early 1980s to approximately 10 mt by 18 vessels in 2014 (PFMC, 2015); http://www.pcouncil.org/wp-content/uploads/HMS-SAFE-Table-12.htm). Annual U.S. commercial landings from 2004-2014 have averaged around 115 mt (PFMC, 2015), which is well below the current established sustainable and precautionary harvest level of 340 mt and has allowed the population to further rebuild. The drift gillnet fishery is heavily regulated by the states of California and Oregon and by the federal government. Regulations on commercial fishing operations (e.g., time and area closures) to protect gravid females during the pupping season (March through August), combined with a switch in the primary target of the driftnet fishery from thresher sharks to swordfish, have contributed to the rebuilding of the common thresher shark in the Eastern Pacific Ocean over the past 25 years (PFMC, 2003). In fact, based on analyses of productivity, CPUE, and catch data, fishing mortality is estimated to be below the rate that would produce maximum sustainable yield; thus, the Pacific Fishery Management Council (PFMC) determined that overfishing of this population is not currently occurring (PFMC, 2010).

More recently, NMFS/SWFSC and Mexican scientists collaborated to conduct the first stock assessment of the common thresher shark stock along the West Coast of North America, incorporating data from the U.S. and Mexico for the period 1969-2014 (Teo et al. in prep). Teo et al. (in prep) considered common thresher sharks along the West Coast of North America to be a single, well-mixed stock based on evidence from fisheries, genetics, and tagging data. The Stock Synthesis modeling platform (version 3.24U) was used to conduct the analysis and estimate management quantities. Fisheries-dependent data like estimated removals, size compositions, indices of relative abundance, and conditional age-at-length from U.S. and Mexican fisheries were included in the assessment. The U.S. fisheries included the swordfish/shark drift gillnet, recreational, nearshore setnet and small-mesh drift gillnet, and miscellaneous fisheries. The Mexican fisheries included the swordfish/shark drift gillnet, pelagic longline, and artisanal (panga) fisheries. Removals from Canadian fisheries were thought to be negligible (McFarlane et al., 2010). In addition, fisheries-independent data like size compositions and an index of relative abundance for juvenile common thresher sharks were included from an annual juvenile thresher survey conducted by NMFS/SWFSC in the Southern California Bight. The base case model of the assessment assumed that the biology of this common thresher shark stock is consistent with the biological studies conducted in the eastern North Pacific (e.g., Smith 2008; Smith 2008). However, sensitivity model runs were conducted to examine the effect of alternative biological parameters and model assumptions.

As noted previously, removals of this common thresher shark stock peaked in the early 1980s (1980-1982) but a series of regulations on the U.S. and Mexican fisheries, especially the swordfish/shark drift gillnet fisheries, resulted in declining catches from that period (Figure 25).

Over the past few years, the estimated total removals for this common thresher stock has been at approximately the same level as in the early 1970s, which is before the development of the U.S. swordfish/shark drift gillnet fishery, and have been less than the U.S. harvest guidelines of 340 t (PFMC, 2003).

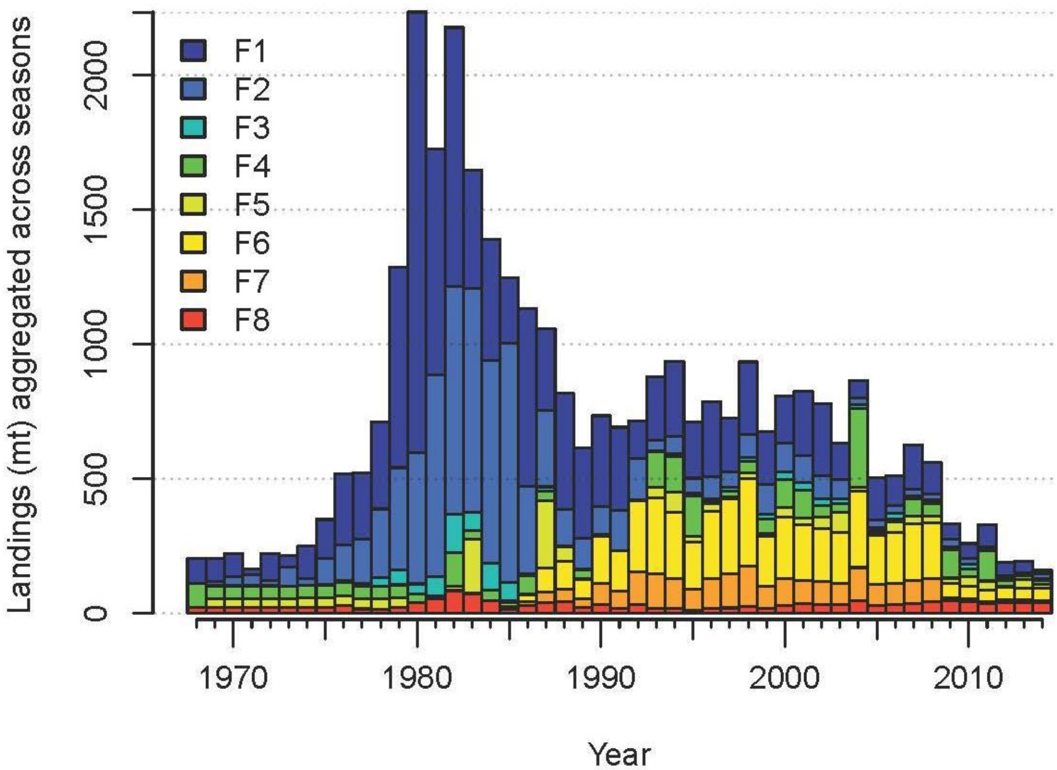

Figure 25. Total estimated removals in metric tons (mt) of common thresher shark along the west coast of North America. F1 - US swordfish/shark drift gillnet and miscellaneous fishery in seasons 1, 3, and 4; F2 - US swordfish/shark drift gillnet and miscellaneous fishery in seasons 1, 3, and 4; F2 – US swordfish/shark drift gillnet and miscellaneous fishery in season 2; F3 – US set net fishery; F4 – US recreational fishery in seasons 1, 3, and 4; F5 – US recreational fishery in season 2; F6 – Mexican drift gillnet and longline fisheries in seasons 1, 3, and 4; F6 – Mexican drift gillnet and longline fisheries in season 2; F8 – Mexican artisanal fishery. (Source: Teo et al. in prep).

The fishing impact on the female spawning stock (represented by 1-SPR, where SPR is the spawning potential ratio) therefore follows a similar trajectory, with estimated 1-SPR peaking at 0.773 in 1982-1984 (Figure 26 below), indicating that approximately 77% of the spawning potential relative to the unfished stock was removed by fishing during that period. The estimated 1-SPR has decreased since that period, with 1-SPR in 2011-2014 estimated at 0.080. The estimated 1-SPR at MSY for this stock is 0.39 and MSY is 806 t. The spawning output in 2014 was estimated to be at 94.4% of its unexploited level (see Figure 27).

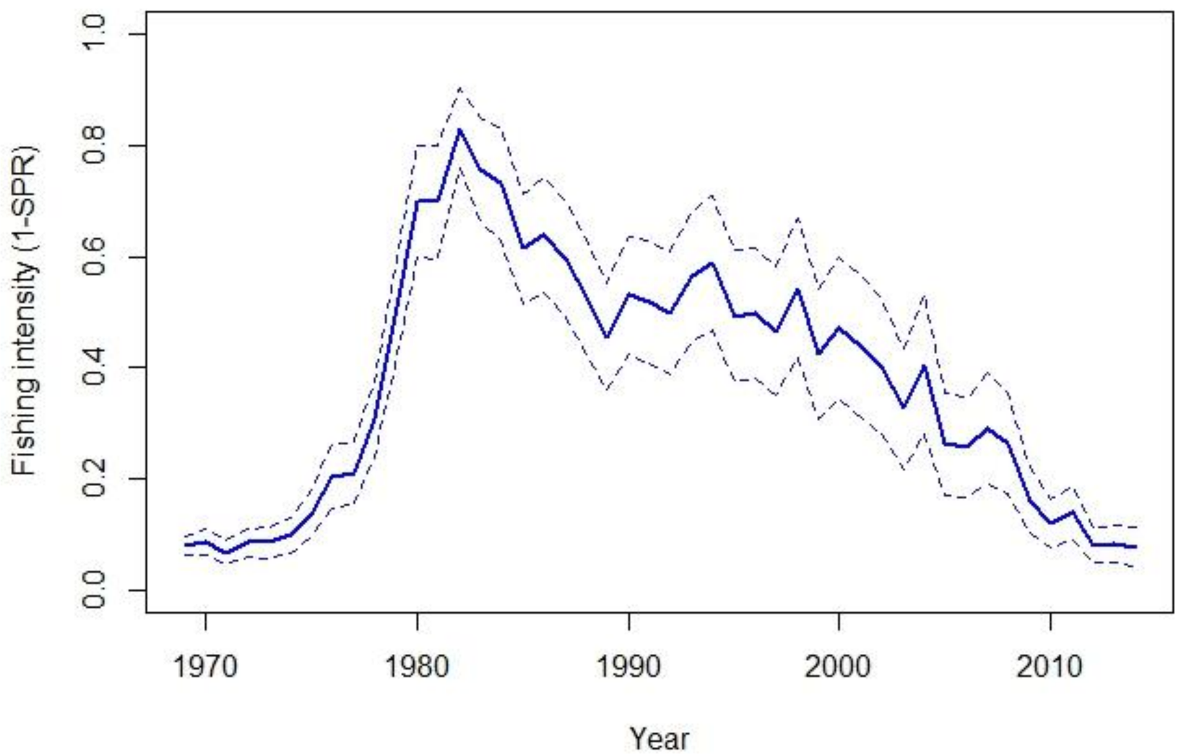
Fishing intensity (1-SPR)
0.0
0.2
0.4
0.6
0.8
1.0
1970
1980
1990
2000
2010
Year

Figure 26. Estimated fishing intensity (1-SPR, where SPR is the spawning potential ratio) on the common thresher shark stock along the west coast of North America (1969-2014). Dashed lines indicate 95% confidence intervals.

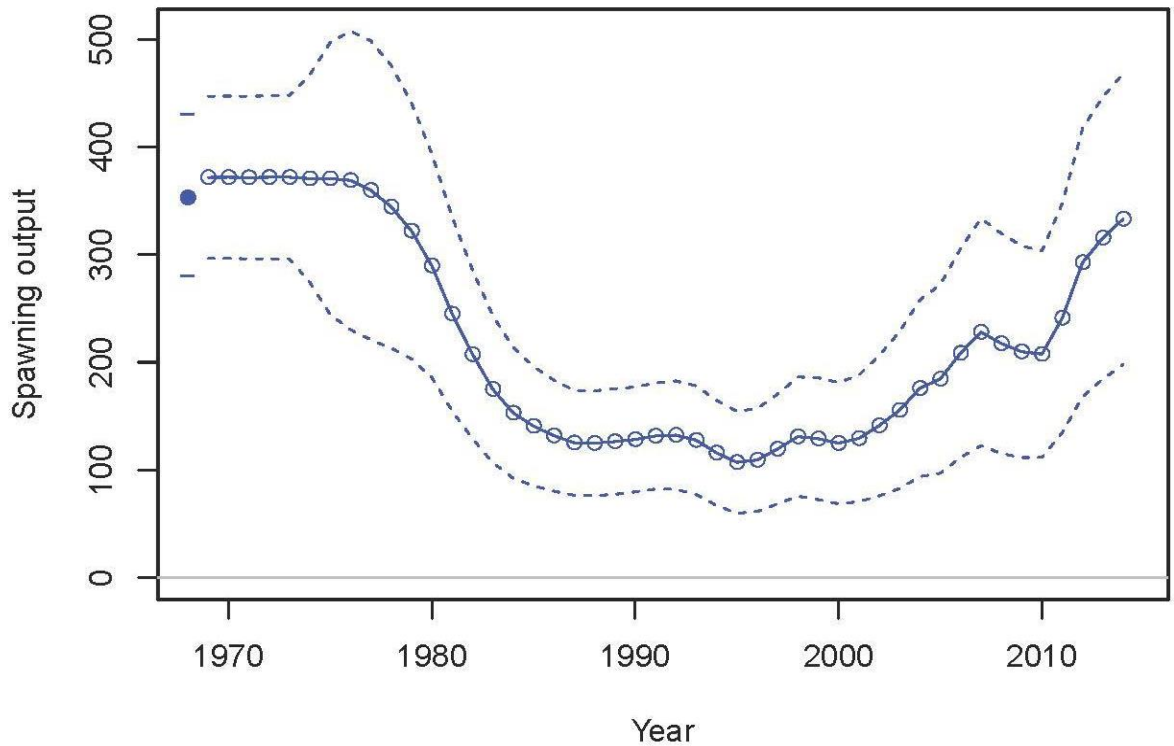

Figure 27. Estimated spawning output in 1000s of pups of common thresher shark stock along the west coast of North America (1969-2014). Dashed lines indicate 95% confidence intervals (Source: Teo et al. in prep).

Based on these recent stock assessment results, the common thresher shark stock along the West Coast of North America (including Mexico and Canada) experienced a large decline in spawning output with the advent of the drift gillnet fishery in the late 1970s, but the decline was arrested in the mid-1980s with a series of regulations restricting the fishery and the stock has recovered gradually over time. Currently, the stock is not likely in an overfished condition or experiencing overfishing (Teo et al. 2015). Overall, the California drift gill net fishery serves as a well-documented case of marked population depletion of a small, localized stock of common thresher shark over a short time period (less than a decade) followed by a gradual recovery after the implementation of regulatory measures. Based on the recent stock assessment results of Teo et al. (2015), the common thresher stock along the West Coast of North America is not considered to be in an overfished condition and overfishing is not occurring. Alternative states of nature and model assumptions also result in similar conclusions about the state of the stock (i.e., not in an overfished condition, and overfishing is not occurring). Given the evidence that this population has gradually rebuilt and current rates of fishing intensity appear sustainable, overutilization is not presently a threat in this portion of the common thresher's range.

Bigeye threshers sometimes co-occur with common thresher as incidental catch, but they are generally more prevalent offshore, especially north of Point Conception. The first reported catch within the U.S. West Coast EEZ occurred in 1963 when a bigeye was taken in a set gill net in southern California; it is now a regular incidental species in the drift net fishery (NMFS, 2009a) and is estimated that bigeye threshers comprise approximately 9% of the total thresher catch. Overall, bigeye thresher represents a minor component of West Coast fisheries. Individuals taken within the management area are thought to be on the edges of their habitat ranges, and they are presumably not overexploited, at least locally (PFMC, 2003). Annual commercial landings of bigeye thresher sharks on the West Coast (Washington, Oregon, and California), which were compiled from PacFIN reports from 1984-2009, are shown below in Figure 28. There are no records of bigeye thresher in the catch records from 2010-2015. The trajectory of bigeye thresher shark landings closely follows that of the common thresher shark.

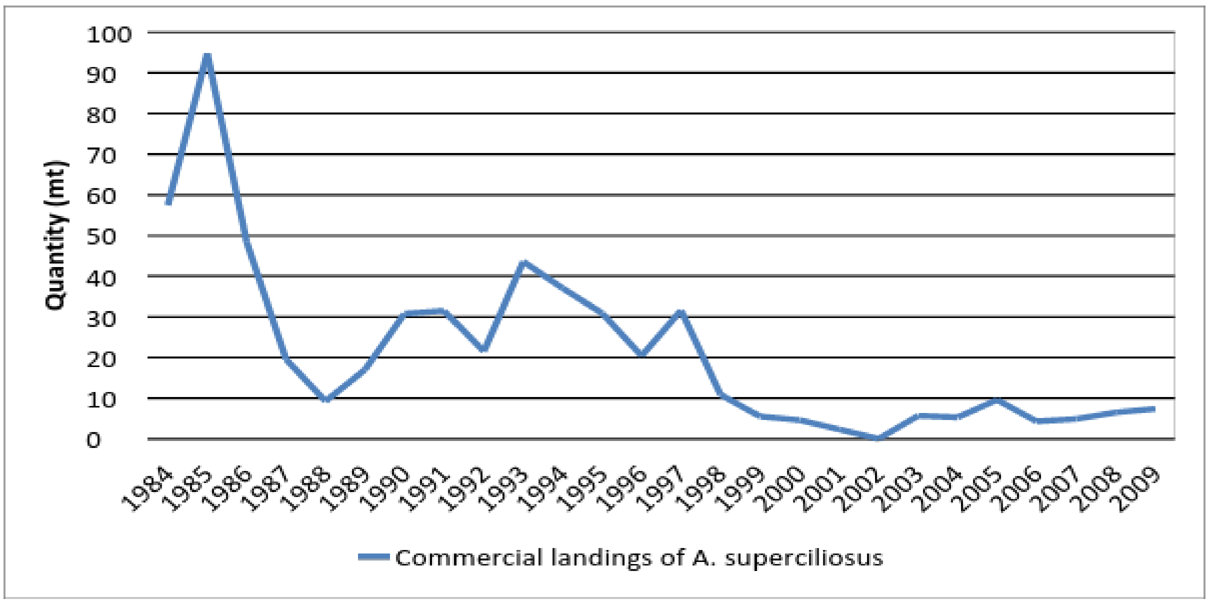

Figure 28. West Coast commercial landings for bigeye thresher shark (round weight equivalent in metric tons) for California, Oregon, and Washington, 1981–2014 (Source: PacFIN W-O-C- All Species Reports).

<u>International</u>

Common threshers are taken in the artisanal, pelagic longline and gillnet fisheries targeting pelagic sharks off Mexico's Pacific Coast (Sosa-Nishizaki et al., 2008). In Baja California waters, common thresher sharks may be specifically targeted by drift gillnet and artisanal shark fisheries (Cartamil et al., 2011a). Relatively little is known about the fisheries off Mexico since landings there are not routinely reported to species level (PFMC, 2003). However, the recent stock assessment of common thresher shark along the West Coast of North America estimated and included the removals by these Mexican fisheries (Cartamil et al., 2011a).

Artisanal fisheries are thought to account for up to 80% of elasmobranch fishing activity in Mexican waters but details associated with fishing effort and species composition are generally unavailable (Cartamil et al., 2011a). In a survey of artisanal fishing camps along the Pacific coast of Baja California, 44 camps were identified, with five camps directly targeting elasmobranch species, and an additional 25 camps targeting elasmobranchs as secondary species. Among these camps, Laguna Manuela was identified as one of the most important elasmobranch fishing camps, where Cartamil et al. (2011a) conducted a detailed study of elasmobranch species composition and fishery characteristics, including information regarding gillnet, longline, and trap fisheries. Figure 29 below shows the sex-specific size frequency distributions of *A. vulpinus* sampled from the gillnet fishery at Laguna Manuela.

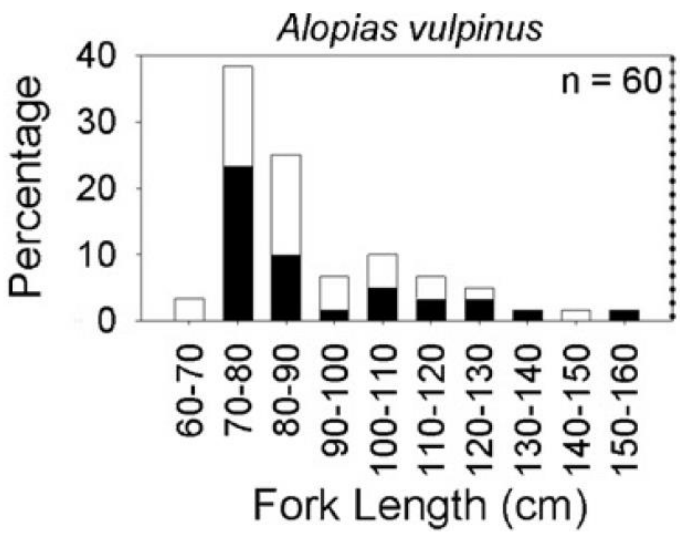

Figure 29. Sex-specific size frequency distributions of *A. vulpinus* sampled from the gillnet fishery at Laguna Manuela. n refers to the number of measured individuals upon which size histograms are based, and not necessarily the total number captured. Females are depicted in black, males in white (Source: Cartamil et al. 2011).

The observed size ranges for *A. vulpinus* suggests that the specimens were likely juveniles, which also suggests the surrounding areas may serve as important juvenile habitat. Thus, the capture of significant *A. vulpinus* juveniles in this area extends the known juvenile habitat southward from California waters. Compared to some other sharks (e.g., smooth hammerhead, tope shark, Pacific angelshark) common threshers are caught in relatively low numbers in the Laguna Manuela gillnet fishery; however, they represent the most commonly caught species among pelagic sharks (e.g., blue, mako, and white sharks). In contrast, catches of common threshers in the longline fishery are low. Catch per unit effort (catch per trip) between September 2006 and December 2008 was calculated as 0.28 and 0.04 for the gillnet and longline fisheries of Laguna Manuela, respectively. During the same study period, carcass discard sites were analyzed, in which a total of 137 *A. vulpinus* were identified, representing 0.43% of the total discards. Although base-line data comparable to Cartamil (2011a) does not exist in western Baja California, interviews with older fishermen suggest while the Laguna Manuela camp has existed for over 35 years and apparently sustained consistently high elasmobranch catch rate, both the abundance and average size of elasmobranchs have declined significantly in recent decades off the western coast of Baja California. The significant capture of sexually immature juveniles in the artisanal gillnet fishery at Laguna Manuela is cause for some concern, especially because these areas are thought to provide important nursery habitats for the Eastern Pacific population.

However, as previously noted, the recent stock assessment of common thresher shark on the West Coast of North America included the estimated removals by these Mexican artisanal fishery camps, and the common thresher shark stock is not likely in an overfished condition and overfishing is not thought to be occurring (Teo et al., 2015). Thus, removals from these fisheries are thought to be sustainable.

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) noted that from 1950-2010, Peru had the second highest number of chondrichthyan landings in the Eastern Pacific after Mexico, and the sixth highest accumulated landings in the entire Pacific. The common thresher shark is reportedly caught in longline and gillnet fisheries in Peru and has been reported as the sixth most important commercial shark species in Peruvian fisheries, representing 6% of total shark landings (Romero Camarena and Bustamante Ruiz, 2007, Gonzalez-Pestana et al., 2014). Though shark landings in Peru have experienced a constant annual decline of 3% from 2000-2010 despite an increase in fleet size, there has been no significant trend detected for common thresher shark landings for the same time period (Gonzalez-Pestana et al., 2014). However, it is highly likely that these records were misidentified pelagic thresher sharks. In a recent genetic study focused on the landings of the small-scale Peruvian shark fishery, Velez-Zuazo (2015) discovered a long-term misidentification between the common thresher shark and the pelagic thresher shark (*A. pelagicus*) at landing points. Although the common thresher is the only species listed in official landing reports, all samples in the study labeled as thresher shark corresponded to pelagic thresher shark (n = 12) indicating that landing reports may be pooled for all *Alopias* species, (Velez-Zuazo et al., 2015) with the majority possibly comprised of pelagic threshers.

Reports of common thresher shark landings are less common in Costa Rica and Ecuador. According to observer data recorded on Costa Rican longline vessels, a total of only 23 common thresher sharks were caught from 1999-2010 (Dapp et al., 2013) and bigeye threshers were not recorded at all. While both *A. pelagicus* and *A. superciliosus* are listed as a commonly caught species in Ecuadorian waters, *A. vulpinus* is not listed and pelagic threshers are the dominant thresher species in thresher shark landings (Jacquet et al., 2008, Reardon et al., 2009, Martinez-Ortiz et al., 2015). In Chile, species-specific data on official landings and exports of shark product are scarce. For example, *A. vulpinus* has been absent from fishery records since 1989; however, in a genetic study of shark fins from cooperative traders in north-central Chile, a sack of unidentified fins (n = 22) were determined to be *A. vulpinus.* Thus, despite an absence in fishery records, common thresher sharks appear to be utilized in the Chilean shark fin trade (Sebastian et al., 2008).

Currently, there is very little information regarding the status of bigeye thresher in the Eastern Pacific; however, they are known bycatch in purse-seine and longline fisheries operating in this region. In a 2005 experiment to compare catch rates of bycatch species in the Korean longline fishery operating in the Eastern Pacific (between 1°48’S ~7°00’S and 142°00’ ~149°13’W) using different hook types, bigeye thresher represented the most incidentally caught shark species. In this study, bigeye threshers comprised 12.8% of the total shark catch, with 35 individuals caught in only 29 days (Kim et al., 2006). Bigeye thresher is also the prevalent thresher shark bycatch in purse-seine fisheries operating in the Eastern Pacific. As previously described, thresher sharks (*Alopias* spp.) collectively represented approximately 3% of the species observed during the Shark Characteristics Sampling Program, with bigeye threshers comprising 1% of the catch, and unidentified threshers representing 0.7%. In total, 56 mt of threshers were caught as bycatch in the purse-seine fishery from 2010-2014 (Roman-Verdesoto and Orozco-Zoller, 2005). Bycatch in this fishery increased from 9 mt in 2010 to 17 mt in 2011, and has remained stable between 10-11 mt since. In the principal port in Manta, Ecuador, a total of 150,321 individual sharks were landed between 2003 and 2006, with *A. supercilious* comprising 3% of the total shark catch in Ecuador, and *A. pelagicus* comprising 36% (Amorim et al., 2009). Carr et al. (2013) reported that bigeye threshers and blue sharks comprised 87% of shark fins in a seizure of illegal fins from the Galapagos Marine Reserve; however, given that 64% of the thresher sharks from this catch had their heads removed, and genetic testing was not conducted to identify to species, there is some uncertainty as to whether all of the sharks were actually bigeye thresher. In fact, given that pelagic threshers are the dominant thresher species landed, with *A. pelagicus* comprising up to 92% of thresher shark landings in Ecuador's principal port of Manta (Reardon et al., 2009), it is possible that some of the thresher sharks illegally taken were misidentified pelagic threshers.

Overall, it appears the common thresher shark stock along the West Coast of North America has recovered from heavy exploitation in the late-1970s through mid-1980s, and is currently not experiencing overfishing and is not likely in an overfished condition (Teo et al., 2015). Thus, this particular stock of common thresher shark is not currently experiencing overutilization in this portion of its range. However, due to a lack of adequate catch records for common thresher sharks, and common misidentification between species, it is unclear whether common thresher sharks are currently overutilized in other areas of the Eastern Pacific. Additionally, while bigeye thresher sharks are prevalent in various fisheries as bycatch in the Eastern Pacific Ocean, they seemingly comprise a relatively small portion of the total shark catch in several areas. However, it is unknown whether the present level of fishing pressure on the species in this portion of its range is a threat negatively impacting the population and contributing to the species' extinction risk.

Western and Central Pacific Ocean

The Western and Central Pacific Ocean supports the world's largest industrial tuna fishery, and despite this fact, there have been few quantitative assessments of the impact of this level of fishing effort on shark populations (Bromhead et al., 2012). Shark catches in this region can be estimated from limited observer sampling and it is clear that the majority of pelagic sharks are captured by longlines (Lawson, 2011). The longline fishery in the Western and Central Pacific is comprised of vessels that specifically target sharks, vessels engaged in 'mixed targeting' (in which vessels use methods that aim to catch shark and tuna species simultaneously) and vessels which target tuna and other non-shark species and take sharks solely as bycatch. Even in the case when sharks are caught as bycatch, survival is often low due to the practice of finning or rough handling during gear retrieval. Total catches of sharks in the longline fisheries of the Western and Central Pacific was estimated to be 1 million sharks per year (Lawson, 2011).

United States

In the U.S. Pacific, the Hawaii-based pelagic longline (PLL) fishery began around 1917, and underwent considerable expansion in the late 1980s to become the largest fishery in the state (Boggs and Ito 1993). This fishery currently targets tunas and billfish 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 nearly 25 million lbs (11 million kg) resulting in revenue exceeding $62.7 million in 2007 (WPFMC, n,d.). An observer program for the Hawaii-based PLL was initiated in 1994, with 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 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. The fishery catches all three species of thresher, with the dominant species being the bigeye (*A. superciliosus*), which represented 4.1% of the total shark catch from 1995-2006. The majority of bigeye threshers are typically discarded, but some are kept for consumption or sale. Additionally, while the common thresher is reported from Hawaiian waters, its occurrence has been described as "enigmatic" (Walsh et al., 2009) Thus, catches of common and pelagic threshers have been combined, resulting in uncertain individual catches of pelagic and common threshers (Walsh et al., 2009). Based on catch data compiled from the Hawaii-based logbook annual summary reports, catches of thresher sharks have trended upward since 1991 (see Figures 30 and 31 below); however, actual landings of thresher sharks in Hawaii have decreased from 50 mt in 2001 to 16 mt in 2010, presumably due to the implementation of state and federal laws regarding shark finning (NMFS, 2011b).

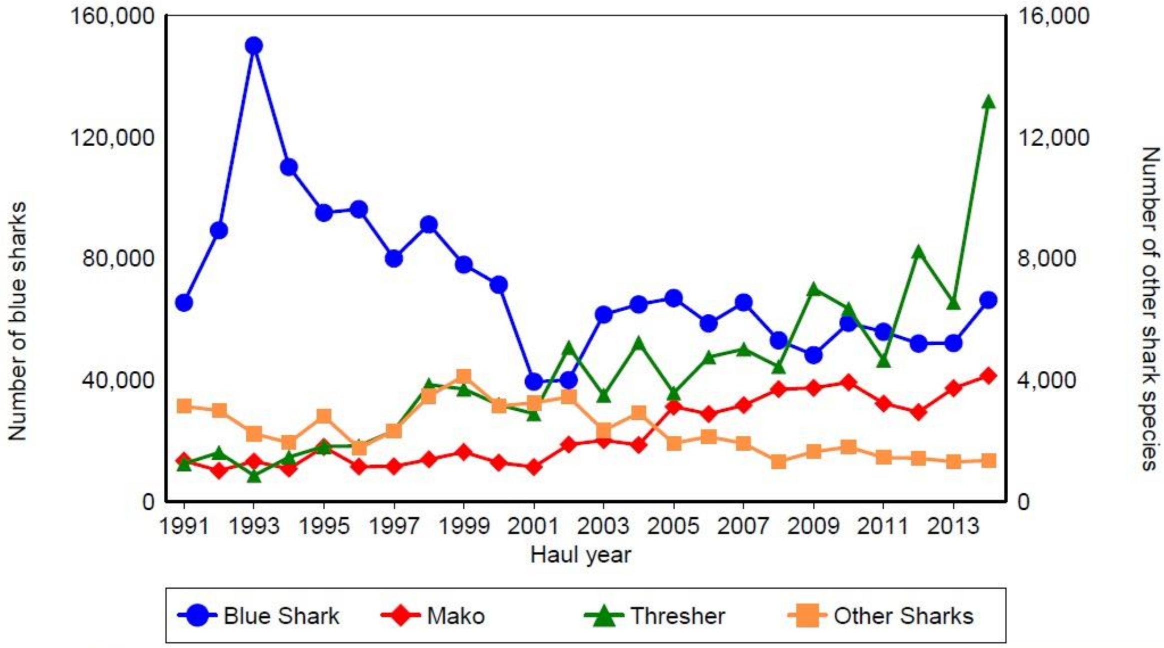

Figure 30. Annual catch of blue shark, mako shark, thresher shark, and other sharks by longline vessels based in Hawaii from 1991-2013 (Source: PIFSC Hawaii-based longline logbook summary report, 2014).

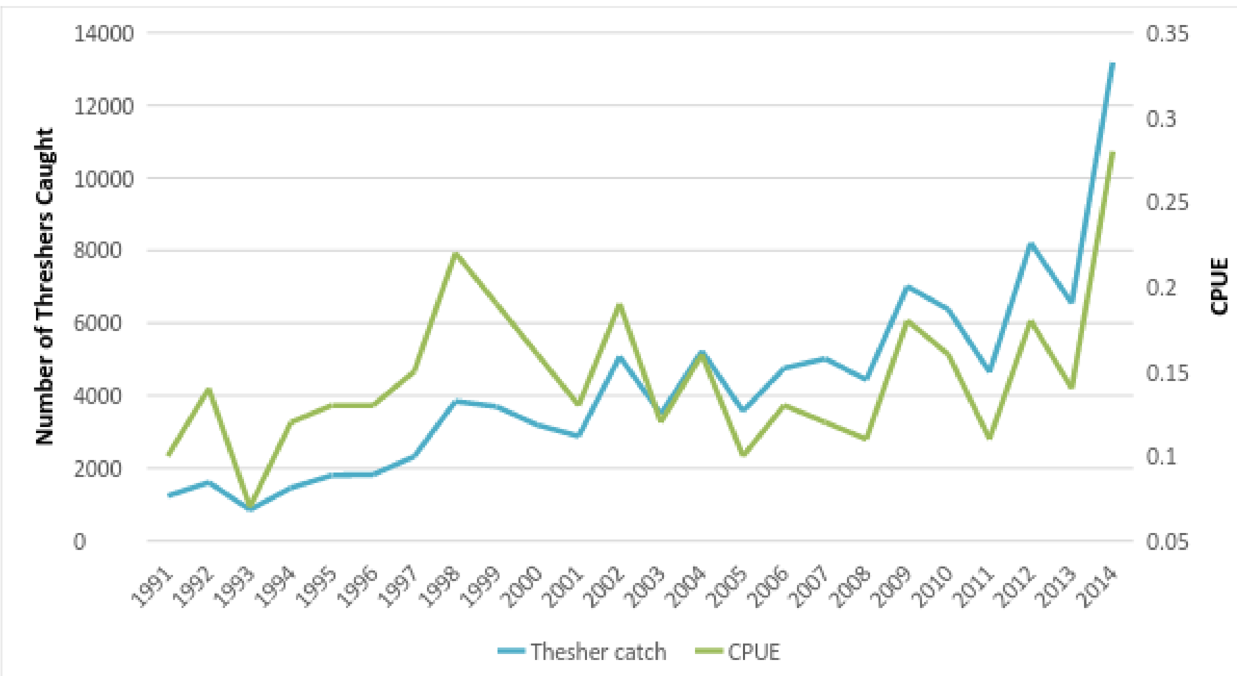

Figure 31. Summary report of fishing effort and catch statistics for U.S. longline vessels landing in Hawaii from 1991-2014, compiled from PIFSC Annual Summary Reports as derived from NMFS Western Pacific Daily Longline Fishing Log records (Source: PIFSC Hawaii Logbook Summary Reports).

Observer data from 1995-2006 indicated a low catch of common thresher sharks (7 individuals of *A.vulpinus* and 1,246 individuals for the combined category of *A. vulpinus*/*A. pelagicus* on 26,507 sets total, both fishery sectors combined). In terms of bycatch, annual bycatch of approximately 426,336 lbs (193,382 kg) and 6,538 lbs (2,965 kg) of bigeye thresher were estimated for the Hawaii-based deep-set and shallow-set longline fisheries, respectively, based on data from 2005 (NMFS, 2011c). Likewise, annual bycatch of approximately 57,203 lbs (25,946 kg) and 1,029 lbs (467 kg) of unidentified threshers were estimated for the Hawaii-based deep-set and shallow-set longline fisheries, respectively. More recently in 2014, the fleet caught 13,188 thresher sharks, which is nearly double the catch in 2013 (n = 6,550).

Landings in the Pacific Islands region were not reported by thresher shark species, but were reported for thresher sharks in general. Total landings for the year 2005 for the thresher shark family (Alopiidae) were 63,314 pounds (28,718 kg). Annual bycatch estimates included 432,874 lbs of bigeye thresher and 58,232 lbs of unidentified threshers. In the updated report (NMFS, 2013b), annual bycatch estimates included 778,192 lbs (352,982 kg) of bigeye thresher, 478 lbs (217 kg) of common thresher, and 33,127 lbs (15,026 kg) of unidentified threshers based on data from 2010. Total landings for the year 2010 for Alopiidae were 39,865 lbs (18,082 kg). Thus, it appears that while overall landings have decreased for thresher sharks in general, bycatch of bigeye thresher has increased in 2010 compared to 2005. These numbers could not be used to develop a bycatch ratio for thresher shark species, as the exact composition of the landings reported for Alopiidae is unknown (NMFS, 2011c). However, based on analyses of observer data in this region, bigeye thresher are dominant in the catches and commonly interact with longline fisheries south of the Hawaiian Islands, whereas common threshers are considered relatively uncommon in this area (see below).

The federally-mandated observer program accurately distinguishes the three encountered species of thresher sharks. Common thresher sharks are rarely encountered although there are indications that fishing effort might be undergoing spatial shifts and increasing the encounter rate with this temperate species. Bigeye thresher sharks are the most commonly encountered thresher species in the observer data and were examined in further detail by the ERA team. A standardized CPUE annual index was estimated using a generalized linear model (GLM) using a delta lognormal modeling approach in the statistical programming language R. This 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 high frequency of zero catches (~80% overall). Using a binomial distribution for the non-zero catch component and a Gaussian distribution for the positive catch component, the final GLM annual CPUE index is shown in Figure 32 below. Two standardized indices are presented for comparison: a run that excludes 2014 data and a run that includes 2014 data in the model developments. These additional steps were deemed necessary since the most recent year of data involved a near doubling of catch and CPUE. There is ongoing work to better understand the 2014 high catch and high CPUE but for the moment it is shown that the influence of the 2014 data on the overall trajectories of the standardized indices appears to be negligible.

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 an exercise to glean relative abundance and trend information from a historically reliable data stream. Based on this preliminary analysis, it would appear that bigeye thresher shark abundance is relatively stable in this region of the Central Pacific Ocean.

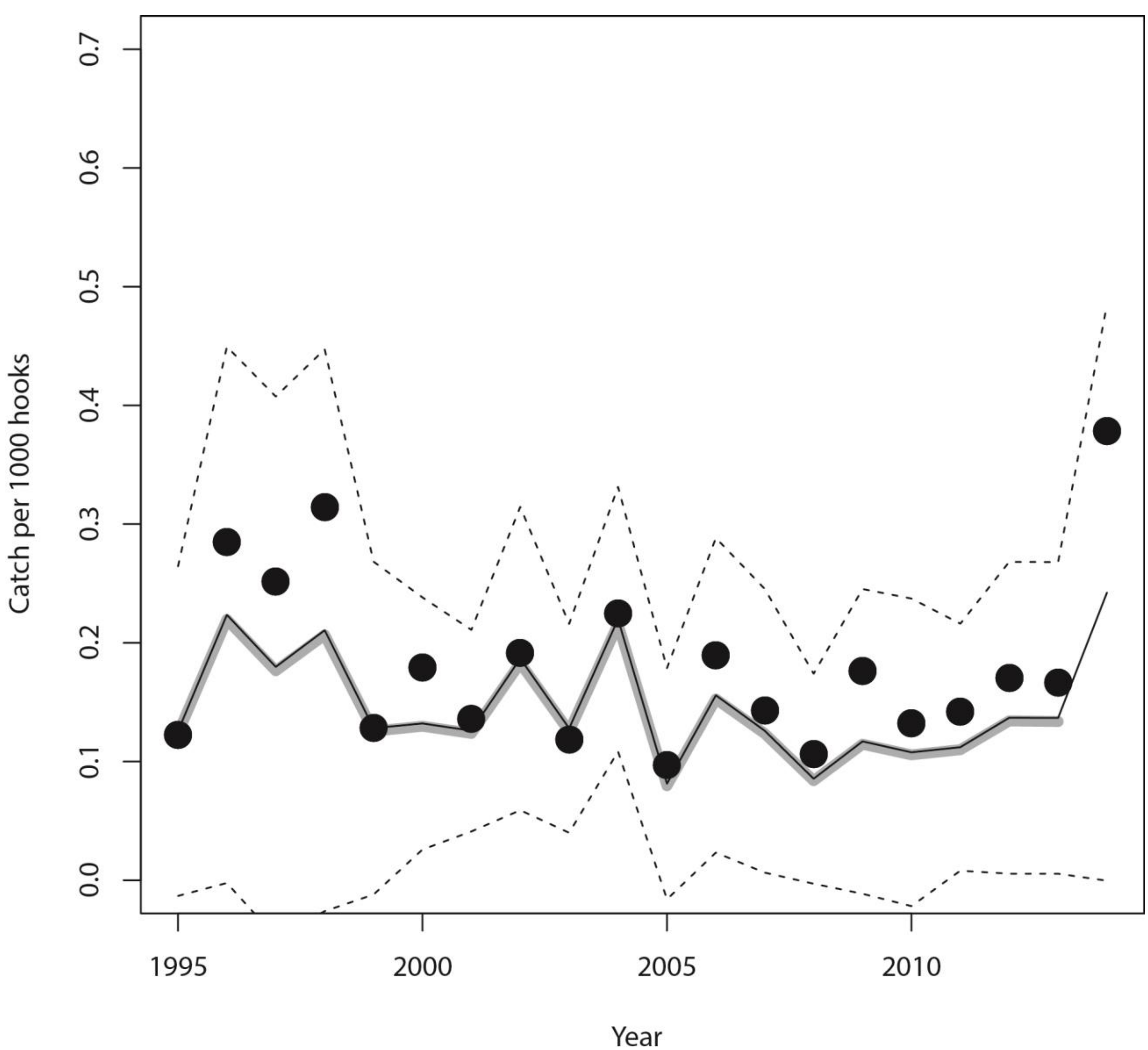

Figure 32. Delta lognormal generalized linear model (GLM) annual index (solid line, dashed lines are +/- 1 standard deviation) from bigeye thresher shark standardized CPUE for the Hawaii-based longline observer data from 1995-2014. Both the GLM standardized CPUE and the nominal CPUE (circles) are shown. The GLM standardized CPUE time series is intended to represent annual estimates of relative abundance conditioned upon the variability introduced into the nominal pattern due

to inputs from other variables included in the analysis. Two standardized indices are presented. The thick gray line is the standardized index generated excluding data from 2014 in the model development. The thin black line is the standardized index generated using all data, including 2014, in the model development.

In American Samoa, thresher sharks are also caught primarily as bycatch in longline fisheries, although in much fewer numbers than the Hawaii-based longline fishery. The American Samoa longline fishery targets albacore tuna and is managed under the Pacific Pelagic FEP. The American Samoa longline 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, catches of thresher sharks have trended downward (Figure 33 below).

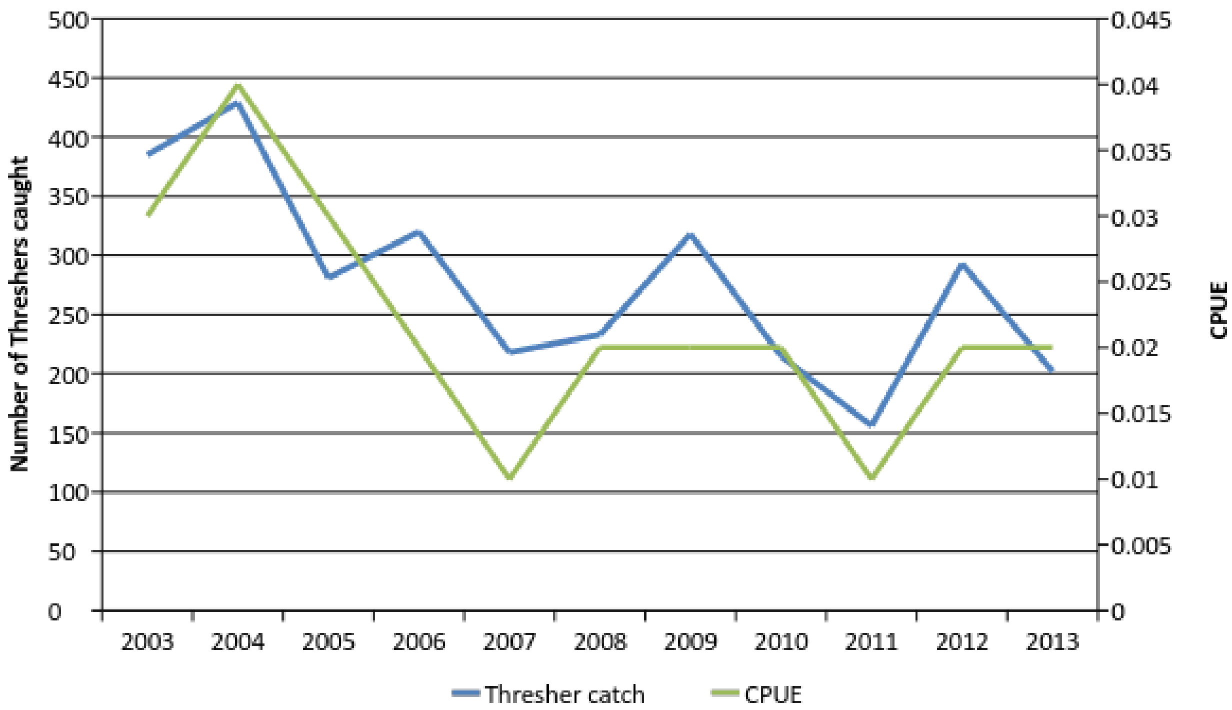

Figure 33. Summary report of unstandardized fishing effort and catch statistics for U.S. longline vessels landing in American Samoa from 2003-2013, compiled from PIFSC Annual Summary Reports as derived from NMFS Western Pacific Daily Longline Fishing Log records (Source: PIFSC American Samoa Longline Fishery Logbook Summary Reports).

Landings of sharks in American Samoa have also declined since 1999, and this trend, like Hawaii landings, is attributed to regulations pertaining to shark finning (e.g., the Shark Finning Prohibition Act) (NMFS, 2011b). Catches of thresher shark species in American Samoa are aggregated and not reported by species, thus species-specific catch statistics for *A. vulpinus* and *A. superciliosus* are not available from these regions.

<u>International</u>

All three *Alopias* species interact with longline fisheries throughout the Western and Central Pacific Ocean (Clarke et al., 2011a). While records of bigeye and pelagic threshers are recorded in the catches of fisheries operating in this region, albeit very under-reported, very little information is available on catches of common thresher shark. Recent catch estimates of longline fisheries from 1992-2009 indicate that *Alopias* spp. comprise approximately 3% of the total shark catch in the Western and Central Pacific Ocean (Clarke, 2014). Historical observations made by Strasburg (Strasburg, 1958) characterized thresher sharks as “uncommon” in this region (relative to the more dominant blue and silky sharks) with only 127 specimens taken in longline catches from surveys conducted from 1952-1955. In 2005, Ward and Meyers (2005) compared estimates of body mass and indices of abundance and biomass derived from data collected in recent years by observers on commercial longliners in the tropical Pacific with those from a scientific survey conducted in the same region in the early 1950s. They discovered a major shift in size composition, indices of species abundance, and the pelagic fish community biomass, coincided with the start of fishing in the region. The largest and most abundant predators, including sharks, suffered the greatest declines in abundance (21% on average). This analysis was not species-specific but estimated a decline in combined thresher abundance of 83%, with a decline in biomass to approximately 5% of virgin levels. The authors also showed significant reductions in mean body mass. For thresher sharks specifically, mean body mass (kg) declined by nearly 30% (from 17 kg to 12 kg). Although differences in sampling and changes in oceanographic conditions may have played a role in the shift between the two time periods, the changes in body mass are typical of a demographic change known as "fishing down of an accumulated biomass." Additionally, increases in the biomass indices of several small species and the appearance of extra species are consistent with release from predation (Ward and Myers, 2005). Data specific to thresher sharks in this analysis were sparse, and thus the conclusions are not highly reliable. Given the relative rarity of common threshers in this region, it is likely that these reported declines are representative of bigeye and pelagic threshers.

Lawson (2011) conducted statistical analyses to estimate catches of key shark species in the Western Central Pacific Ocean. Thresher shark catches in the Western Central Pacific Ocean were estimated based on data holdings of the Secretariat of the Pacific Community (SPC) for longline fleets collected by observers onboard fishing vessels (Figure 34 below).

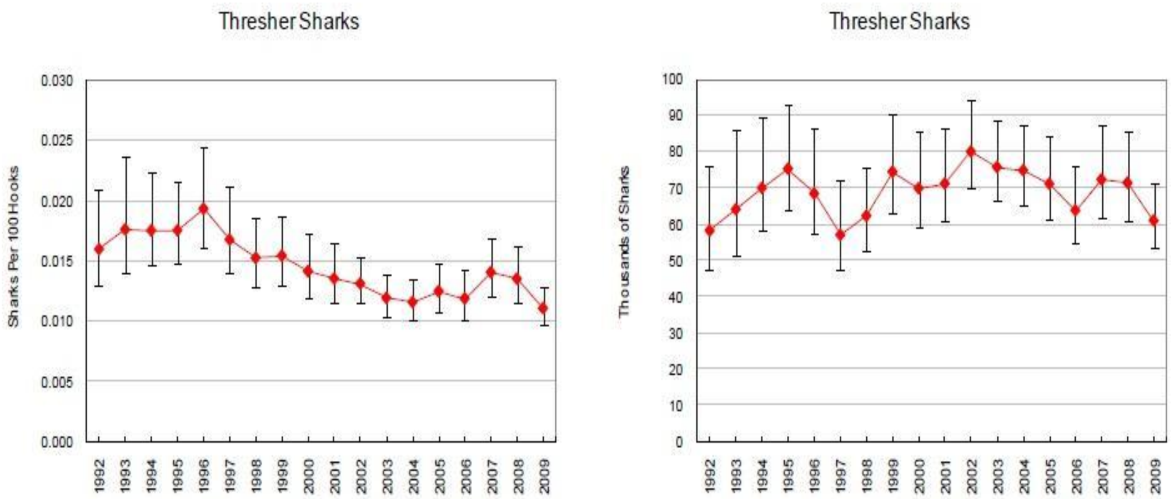

Figure 34. Estimates of longline catch rates (left) and catches (right) of thresher sharks in the WCPFC Statistical Area east of 130°E (Source: Lawson 2011).

Thresher sharks comprised 3.44% of the total shark catch. The observer data were dominated by bigeye threshers, followed by common threshers, while pelagic threshers were less common. The accuracy of the estimates of catch rates shown in Figure 34 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. Since peaking in 2004, longline effort in the region has declined (Lawson, 2011). Further, the following operation changes in longline fishing are known to have 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, observer coverage in the Western and Central Pacific has been highly variable, ranging from negligible to moderate. Large areas in the WCPFC Statistical Area - to the west of 130°E, the northwest and the southeast - have not been covered by observer data, which complicates the estimation of catch rates and catches of sharks and other non-target species (Lawson, 2011). However, catch estimates of thresher sharks in the WCPFC Statistical Area east of 130°E indicate removals have been stable in the past decade, with estimates fluctuating from ~58,000 to 80,000 individuals, and an overall average of 69,000 individuals from 1992-2009 (Lawson, 2011).

Clarke (2011b) conducted a separate analysis of North Pacific shark data 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). While thresher sharks were analyzed as a group, the results of this study mainly reflect the status of bigeye thresher. In total, 258,824 sharks were recorded in the RTV dataset of which 195,097 (75%) were blue sharks. Thresher sharks, primarily bigeye threshers (89% of the total thresher catch) accounted for 15% of the total shark catch (38,016). In the LLL dataset, nearly 9.8 million sharks were recorded, of which 94% were blue sharks. The number of threshers recorded comprised less than 1% of the total, and common threshers specifically were characterized as “rarely encountered” (Clarke et al., 2011b). Catch rates of thresher sharks are shown in Figure 35. See Clarke et al. (2011b) for the region map.

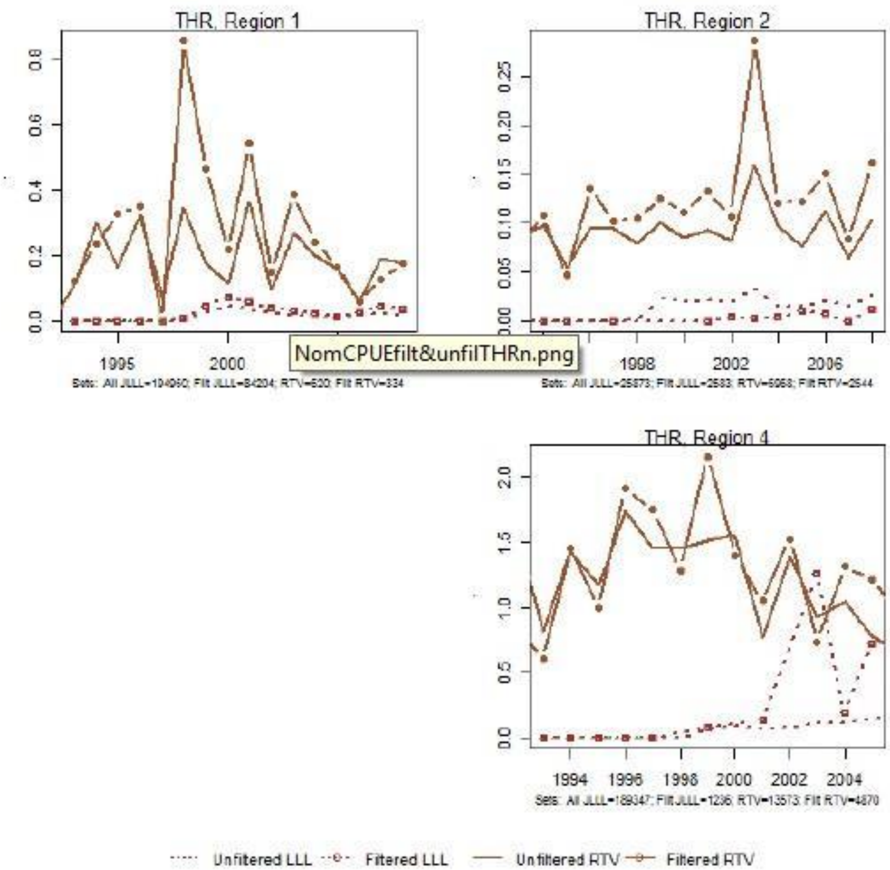

Figure 35. Nominal catch rates for filtered and unfiltered RTV and LLL datasets for thresher sharks in Regions 1, 2 and 4 (1993-2008) (Source: Clarke et al. 2011(a)).

Thresher shark data in this analysis was concentrated in Region 4 (Central Pacific south of Hawaii) and to a lesser extent Region 2 (Central Pacific north of Hawaii) (see Figures 36 and 37 below); however, catch rates in both regions showed no clear trend of increase or decrease for either the RTV or LLL data set. Based on RTV data, catch rates for threshers are approximately 10 times higher in Region 4 (1 thresher per 1000 hooks) than in Region 2 (0.1 thresher per 1000 hooks). Further, standardized catch rate trends for threshers showed a slight increasing trend in the RTV data and an inconclusive pattern in the LLL data. The lack of significant trends in both the nominal and standardized catch rates may be a result, in part, from analyzing the three thresher species jointly (Clarke et al., 2011b).

Clarke et al. (2011a) also conducted an indicator-based analysis to determine the stock status of key shark species in the Western and Central Pacific Ocean by examining data holdings from the Secretariat of the Pacific Community–Oceanic Fisheries Programme (SPC-OFP) for sharks taken in longline and purse seine fisheries. However, it should be noted that several caveats related to the datasets used in this indicator-based analysis were identified as follows:

- Operational-level longline logsheet data have an overall coverage of only ≤35% and have major gaps in coverage for certain areas, particularly the northwest Pacific.
- Aggregated longline logsheet data provide better coverage but lack the spatial resolution essential for some analyses.
- Both operational-level and aggregated longline logsheet data are substantially handicapped by non-reporting, under-reporting and/or lack of species-specific reporting of shark catches.
- Longline observer data coverage is low (typically <1%) and not representative of the WCPO longline fishery as a whole.

Due to the major limitations of logsheet data, the indicator analyses relied primarily on observer data. However, the results should be interpreted with caution due to the caveats associated with observer data outlined above. Additionally, since thresher sharks are rarely encountered in the purse seine fisheries in this region, only results from longline data are discussed. Despite the shortcomings of the available 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), described below.

The common thresher is most often encountered in longline fisheries off Australia and New Zealand, but is infrequently encountered overall. Based on fishery interaction maps and nominal longline catch rates series for thresher sharks (see Figures 36, 37 and 38 below), a decline was detected in Regions 2, and in the latter half of the time series in Regions 5 and 6, driven by data from deep sets. Threshers in Region 2 are likely to be bigeye or pelagic threshers whereas those in Regions 5 and 6 are likely to be common or pelagic threshers (assuming species ID is accurate). Overall, catch rate trends for threshers are ambiguous due to poor performance of the standardization model for longline data and varying patterns in the nominal longline analyses possibly reflecting variation in the status and distribution of the three thresher species among areas (Clarke et al., 2011a).

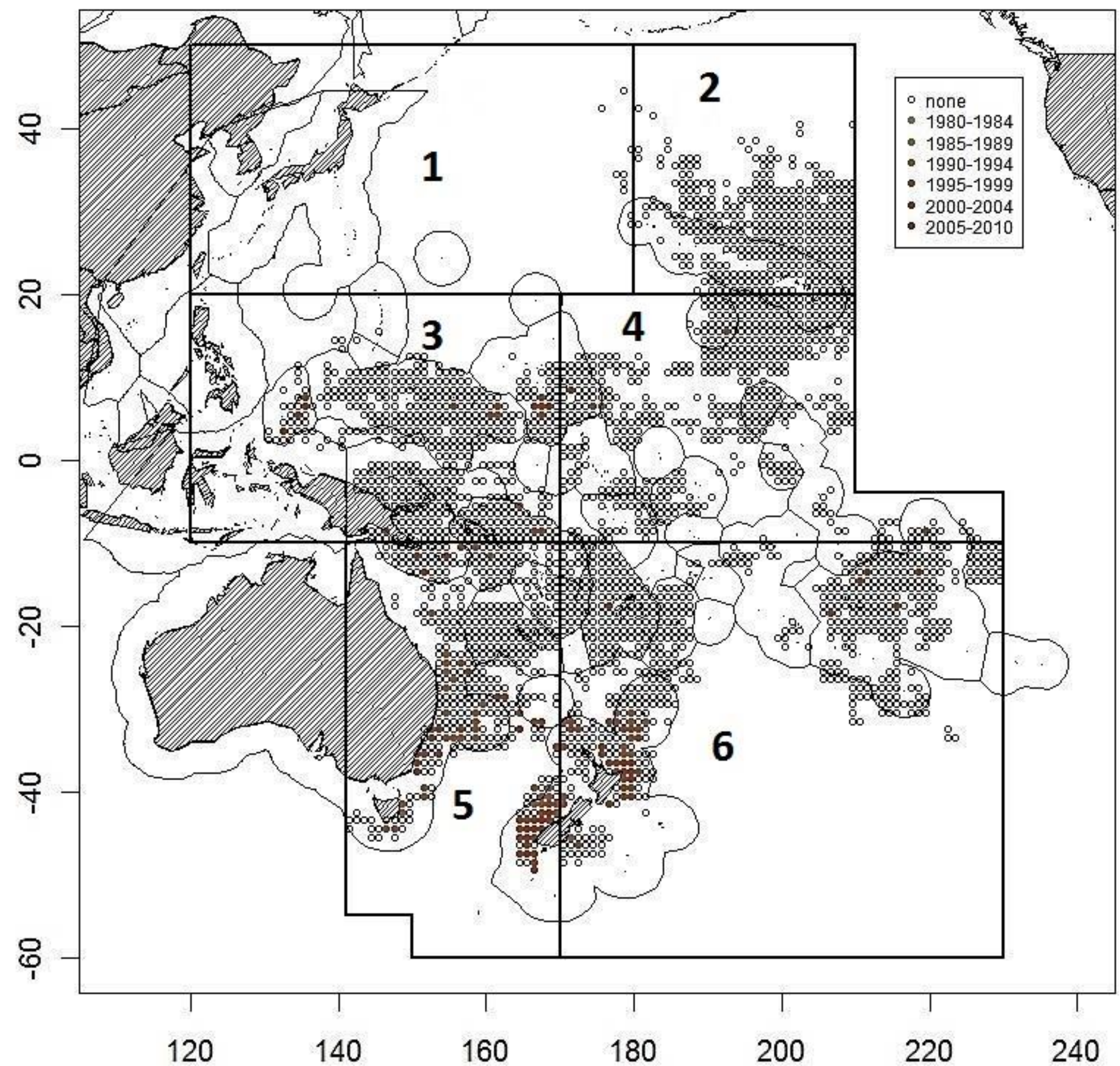

Figure 36. Longline catches of *A. vulpinus* (Source: Annex 1 of Clarke et al. 2011)

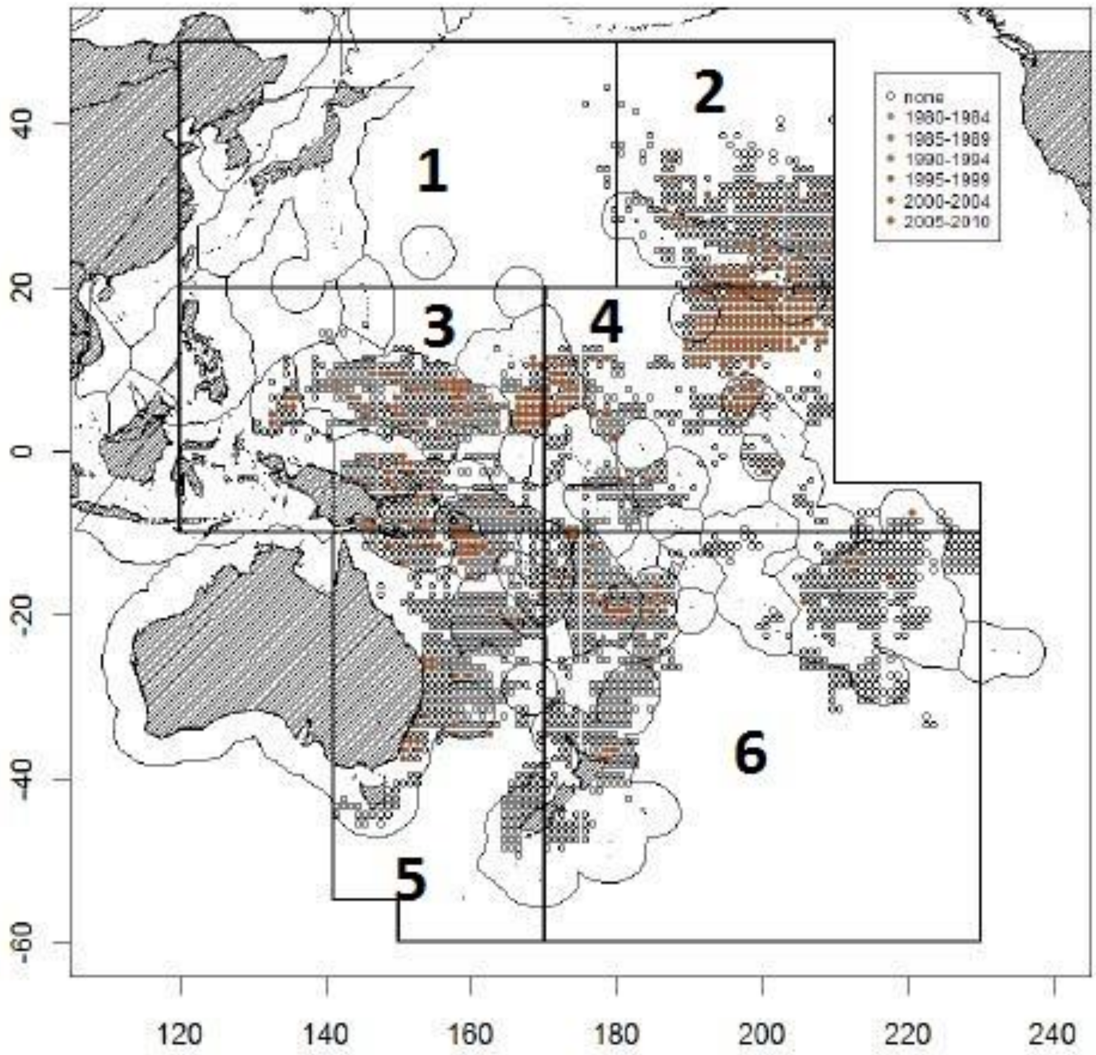

Figure 37. Longline catches of *A. superciliosus* (Source: Annex 1 of Clarke et al. 2011).

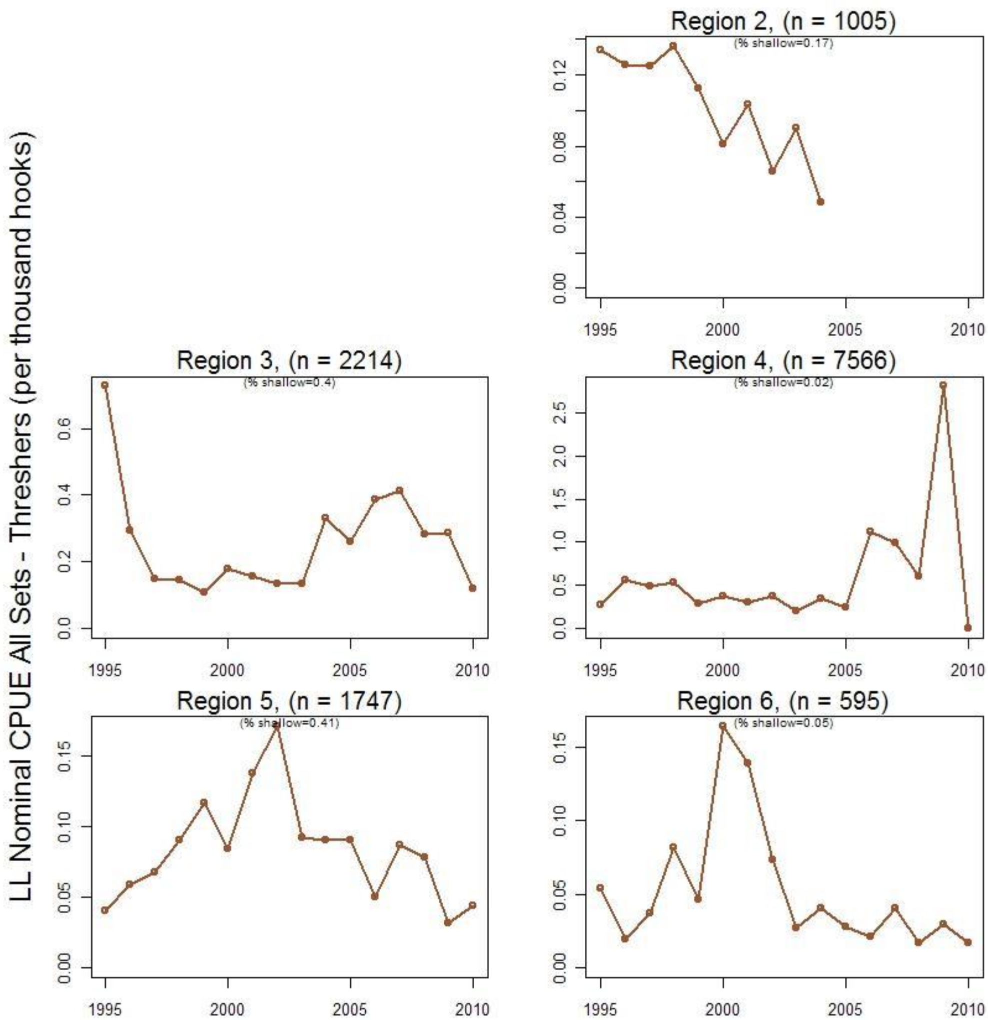

Figure 38. Nominal longline catch rates by region and year for thresher sharks (Source: Clarke et al. 2011)

Though thresher size samples were limited, median lengths show significant decreases over time in standardized longline data for both Regions 3 (females only (but males' p-value is marginally significant at 0.052)) and 4 (both sexes). Differences in length at maturity between the three species may be responsible for the large number of samples that appear to be immature. For example, the size samples were based on length at maturity for bigeye thresher (332-355 cm TL), which is 166-189 cm larger than the estimated size of maturity for common threshers based on Eastern Pacific estimates. However, as previously noted, common threshers seem to be rarely encountered in this region, thus these immature specimens are more likely bigeye or pelagic threshers.

Results of the indicator analysis for thresher sharks from Clarke et al. (2011a) are summarized as follows: The three species in the thresher family have divergent, but not necessarily distinct, distributions and interact with longline fisheries throughout the WCPO. Threshers comprise a notable portion of the longline catch only in Region 4, and mainly in deep sets. While catch rate analysis produced no clear trends for the group as a whole, decreasing size trends were identified in tropical regions, which most likely reflect trends in bigeye thresher. However, Lee et al. (2015) notes that standardized CPUE data is a more reliable indicator of species status than average size; however, it should be noted that this study was for mako sharks and not specific to thresher sharks. The indicators assessed in this study can be used to provide initial signals of the status of key shark species in the Pacific to the extent possible given available data.

Finally, a "status snapshot" was developed for thresher sharks to depict their current status in the Western and Central Pacific Ocean (See Figure 39 below). This status snapshot encapsulates the findings previously described above from several papers based on SPC data holdings (Clarke et al., 2011a, Lawson, 2011), Japan (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).

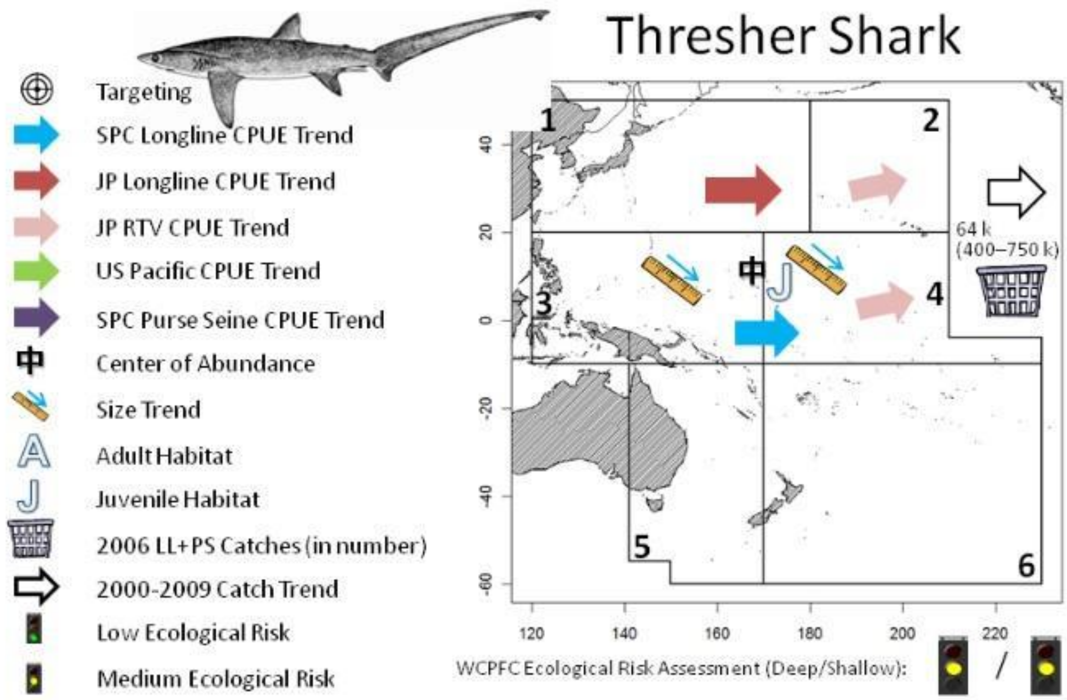

Figure 39. Status snapshot of thresher sharks (*Alopias* spp.) in the WCPFC Statistical Area (Source: Clarke 2011(b)).

Rice et al. (2015) also developed standardized CPUE series for bycatch in Pacific longline fisheries using generalized linear models using longline catch and effort data (i.e., an update to results from Clarke (2011)). Standardized CPUE values for thresher sharks were similar to the nominal CPUE except for additional variability in the nominals. They both rise for the first six years of the series (1995-2001) but diverge thereafter (See Figure 40 below).

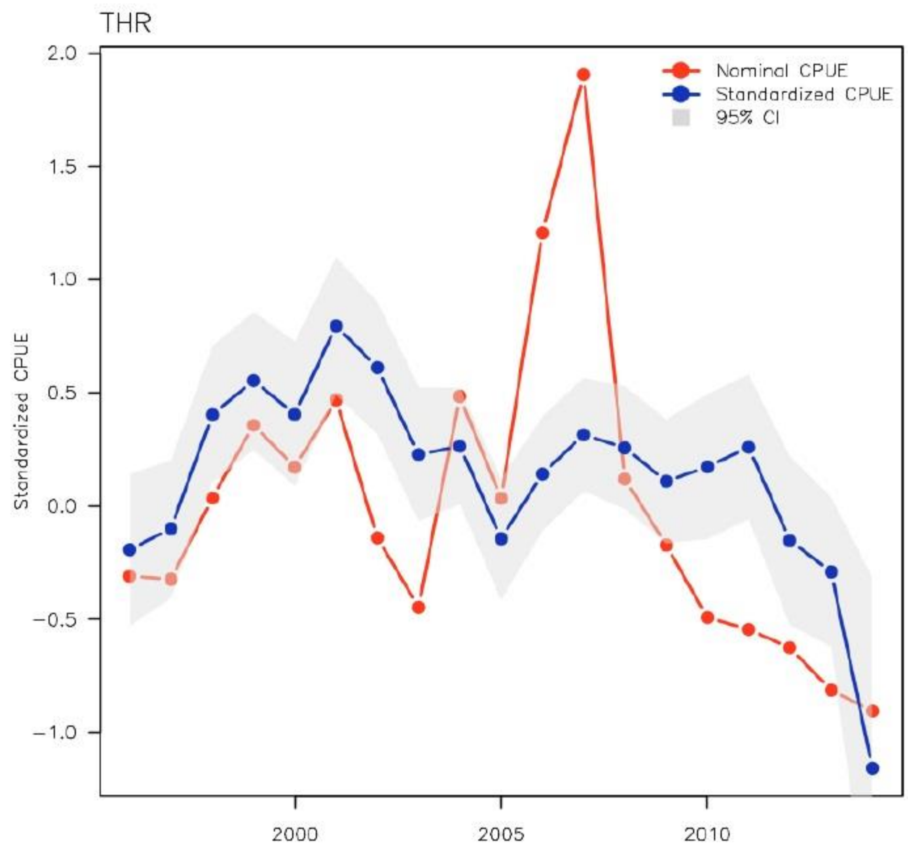

Figure 40. Nominal and standardized CPUE for thresher shark. Grey shaded area indicates the limits of the 5% and 95% confidence intervals (Source: Rice et al. 2015).

For 2002-2014, the standardized CPUE is less variable, decreasing slightly from 2003-2011. The last three years of both the standardized and nominal CPUEs show a steep decline. However, the CPUE from the thresher complex is difficult to interpret as the second most commonly reported thresher species is the general “thresher shark" category (after bigeye thresher). Overall, the thresher shark complex appears to be declining though the last data point; however, this is based on relatively few data, which may exaggerate the trend in the last year (Rice et al., 2015). In fact, while the last year (2013) is the lowest catch rate in the series, the overall trend is only declining since 2011. In terms of biological indicators, the majority of observed thresher sharks occurred in region 4 (see Figure 37 above) where the lengths of both male and female sharks were relatively stable throughout the time period. Observed female thresher sharks were predominantly immature while male thresher sharks did not show any clear maturity trends.

Overall, as previously mentioned, the three *Alopias* species have divergent, but not necessarily distinct distributions, that, in combination with low sample sizes, produced no clear catch trends for the group (Compagno et al., 2005, Clarke, 2011, Rice et al., 2015). Thus, though the relative vulnerability of thresher sharks to longline fisheries in this region is evident, the degree to which the population has actually been impacted is still unclear. Clarke (2011) detected declines in median sizes in tropical areas of the Western and Central Pacific, which may be reflective of bigeye thresher, but strong catch rate trends were not found in any data set (Clarke, 2011). Most recently, studies of longline CPUE in the area show a decline for the thresher shark complex in recent years (Rice et al., 2015); when combined with decreasing size trends, this likely indicates some level of population decline in this area. Common thresher sharks were characterized as “rare” or “not frequently encountered” in all analyses; in contrast, the bigeye thresher is likely the dominant thresher species encountered in fisheries in this region. Therefore, it is likely that these trends largely reflect those of bigeye thresher. Thresher sharks as a genus were given a “medium ecological risk” rating for the Western and Central Pacific as a whole. With high pelagic fishing effort in this region, and reported increases in recent years, it is likely that this level of fishing pressure is negatively impacting the population of bigeye thresher shark in some areas. However, further information needs to be collected on records and catches of both common and bigeye thresher sharks specifically to determine the status of these species in the Western and Central Pacific Ocean, and whether overutilization is a threat negatively impacting these thresher shark populations to the point that it contributes significantly to the extinction risk of these species.

Australia

Several studies have been conducted to assess the ecological risk of species in various fisheries throughout Australia. While both common and bigeye threshers are known from Australian waters, common threshers are more commonly encountered in Australian fisheries. Therefore, the following information pertains mostly to common threshers. In a fishery-independent study of the Gillnet Hook and Trap Fishery from 2007-2008, post-capture mortality of common thresher sharks was high, with >66% immediate mortality (n = 9) (Braccini et al. 2012). These results are similar to the post-capture mortality results discussed for the Western Australia Tuna and Billfish Fishery in the Indian Ocean section.

Eastern Tuna and Billfish Fishery (ETBF)

The ETBF operates from the eastern part of the Australian Fishing Zone (AFZ) from the tip of Cape York (142º31’49”E) to the South Australian/Victorian border (141ºE). It includes 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 principal fishing methods (longlining, poling and minor line), of which the predominant method is pelagic longlining. In 2007, two different risk assessments were conducted for *A. vulpinus* in the ETBF: an ERA and a rapid quantitative risk assessment. In the ERA, average logbook catch of *A. vulpinus* was 2,496 kg (2.75 mt) from 2001-2004. The ERA used typical productivity and sensitivity attributes to derive a vulnerability score and an overall risk category to overfishing. In this study, *A. vulpinus* received a vulnerability score of 3.06 (low-high range for all scores = 1.41 to 4.24) and an overall medium risk ranking to overfishing (Webb et al., 2007). In the rapid quantitative risk assessment, *A. vulpinus* received a “precautionary” medium risk ranking to overfishing in the ETBF fishery. The precautionary ranking is used when there is increasing uncertainty as to the category to which a species truly belongs. For reference, a medium risk ranking means that overfishing is occurring but the population can be sustainable.

Southern and Eastern Scale Fish and Shark Fishery (SESSF)

In addition to conducting a rapid quantitative risk assessment on the ETBF fishery, the same study conducted quantitative risk assessments on the various sub-fisheries of the Southern and SESSF, which is one of the most important Commonwealth-managed fisheries. The SESSF fishery extends from waters off southern Queensland, south and west to Cape Leeuwin in Western Australia, and is a complex multi-sector, multi-gear and multi-species fishery targeting scalefish and shark stocks of various size, distribution and composition. Almost half the waters of the Australian Fishing Zone off southern mainland Australia and Tasmania are in the fishery management area (Zhou et al., 2012). Impacts to *A. vulpinus* were noted in three of the five sub-fisheries: South East trawl, Great Australian Bight trawl, and shark gillnet. Specific results for common threshers were only discussed for the shark gillnet sub-fishery and the cumulative impacts of all sub-fisheries within the SESSF. In the SESSF shark gillnet sub-fishery, *A. vulpinus* received a risk rating of "eh" (precautionary high and precautionary extremely high). However, after the completion of the quantitative assessment for this fishery, the authors solicited expert opinion from biologists who have first-hand knowledge about the fishery and species on the risk list. *Alopias vulpinus* was among a few species in the shark gillnet sub-fishery whose results were "overridden" by experts. Comments for *A. vulpinus* included that it was mainly pelagic and encounterability with gillnet is low because the nets tend to be high in the water column. Thus, as previously mentioned, the precautionary label is to address higher levels of uncertainty regarding the category to which a species truly belongs.

Finally, Zhou et al. (2007) looked at the potential risk of overfishing as a result of cumulative impacts from five sub-fisheries in the SESSF. Common threshers received a rating of ehM (precautionary extremely high; precautionary high; and medium risk to overfishing). In effect, this means that overfishing of *A. vulpinus* is occurring due to the cumulative impacts of the SESSF sub-fisheries, and there is a chance the impacts could be more severe (e.g., high = may drive population to very low levels in longer term; extremely high = population is unsustainable in long term – possibility of extinction). However, due to the simplicity of the methods used, and because input parameters for estimating fishing mortality rates and sustainability reference points typically involve large uncertainty, it should be noted that results for many species in this study are also highly uncertain (Zhou et al., 2007). Bigeye threshers were not included in any of these assessments as their distribution does not necessarily overlap with these fisheries.

New Zealand

Large pelagic species are the focus of important commercial fisheries in New Zealand, including a surface longline fishery. Both common and bigeye thresher sharks are reported as bycatch in New Zealand's surface longline fishery. For example, according to observer data from 2006-2009, an estimated 1,304 thresher sharks were bycaught in the New Zealand longline fishery. While many pelagic species in New Zealand are subject to a quota management system, thresher sharks are not managed directly; however, bycatch numbers are considered stable at this time (New Zealand Fisheries, 2015).

Pacific Island Countries and Territories (PICT)

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 PICT reveal that the 12 highest risk shark species, including bigeye thresher, comprise less than 15% of the observed shark catch. Thresher sharks have been observed in longline and purse seine fisheries within PICT waters, with bigeye thresher comprising 3% of the total shark catch (Lack and Meere, 2009). Bigeye threshers consistently rank in the top ten shark species identified by observers in PICT longline fisheries, including the Cook Islands, Micronesia, Fiji, Kiribati, Marshall Islands, New Caledonia, Palau, Solomon Islands, Tonga, and Vanuatu. Throughout the PICTs, bigeye threshers experience various finning and discard rates, ranging from 56% and 83% in the tropical shallow and deep longline fisheries, respectively, to only 34% in the tropical albacore fishery. For example, in the Republic of the Marshall Islands (RMI), recent average annual catches of sharks are estimated to be between 1,583 and 2,274 mt. Bigeye thresher 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 bigeye thresher of 0.5181 in RMI longline fisheries. In these fisheries, bigeye thresher exhibits a low survival rate of only 50%, meaning half of all bigeye threshers caught were judged to be dead or unlikely to survive after release (n = 1,636). Additionally, 98.9% of bigeye threshers caught in these fisheries were finned and discarded.

<u>Taiwan</u>

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). Historically, annual landings of bigeye threshers in Taiwan were estimated to be approximately 220 mt from 1989-1994, comprising 13% of the total shark catch (Liu et al., 1998). Between 1996 and 2006, annual Taiwanese shark landings (coastal, offshore, and pelagic combined) averaged between 39,000 and 55,000 mt. Bigeye thresher is still considered one of the dominant species caught in these fisheries and now comprises an average of 5% of the total shark catch, which translates to a substantial increase in catches in recent years. 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*, *Carcharhinus falciformis*, *Isurus oxyrinchus*, and *Prionace glauca*) indicating that these species might be heavily consumed in Taiwan. While both pelagic and bigeye threshers were identified in the 548 shark meat samples (representing 23% and 0.07%, respectively) (Liu et al., 2013) common thresher sharks were not identified in this study, and pelagic threshers dominated the records.

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

Based on historical observations and best available current information, it appears that common thresher sharks are relatively rare in the tropical Western and Central Pacific Ocean, and are more commonly distributed in temperate waters. This is evidenced by the lack of catch and genetic records in areas of high fishing effort, which is seemingly concentrated in more tropical waters. Additionally, most of the data from WCPFC sources is based on the offshore fisheries and common thresher may be more inshore. However, it is also important to note that most of the data from WCPFC sources is based on the offshore fisheries and common thresher may be more inshore due to its tendency to remain close to shore. In contrast, bigeye threshers are relatively common and appear to be the dominant thresher shark species in this region. Because there is a paucity of species-specific CPUE trends, potential misidentification between species, and available catch records are typically aggregated at the genus level for all thresher species, it is unclear whether overutilization is occurring in the Western and Central Pacific Ocean. However, species-specific observer data from Hawaii pelagic longline fisheries indicate that abundance of bigeye thresher is stable (and possibly increasing) in the region, while standardized species-aggregated thresher shark longline CPUE data from the rest of the Western and Central Pacific shows a slight decline. These results indicate that there may be population declines of bigeye thresher in some areas of this region, but trends are highly variable.

ATLANTIC OCEAN

Northwest and Western Central Atlantic

For the purposes of this status review, the Northwest and Western Central Atlantic refers to those waters north of 24˚N and west of 40˚W, including the U.S. eastern seaboard from Maine to Florida and the Gulf of Mexico. This section also includes information from Cuba. Both common and bigeye thresher sharks are caught as bycatch in Northwest and Western Central Atlantic pelagic longline fisheries. 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 primary fishing line, or mainline, of the PLL gear can vary from 5 to 40 miles in length, with approximately 20 to 30 hooks per mile. The U.S. PLL fishery has historically been comprised of five relatively distinct segments with different 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. There are many PLL gear and area restrictions and the fishery is strictly monitored.

Landings and dead discards of sharks by U.S. PLL fishers in the Atlantic are monitored every year and reported to ICCAT. Total catches of thresher sharks peaked at about 5,200-5,600 fish in 1984, 1999, and 2007, and showed a high peak in 2006, as a result of an unusually high estimate of recreationally caught thresher sharks. A maximum of about 1,500 fish were estimated to have been landed by the commercial fishery in 1997, and the maximum estimate of dead discards from the PLL fishery was about 700 fish in 1989, and never exceeded about 630 fish thereafter (NMFS, 2009b). From 1992-2000, elasmobranchs represented 15% of the total catch in numbers by the PLL fishery, with *A. vulpinus* included in an “Other” sharks category (with 9 other shark species) that comprised 4.2% of the shark bycatch (Beerkircher et al., 2002). Observer data recorded 148 common thresher sharks caught on U.S. PLL gear between 1992 and 2005, representing 19% of the identified thresher catch, whereas 627 bigeye threshers were recorded, representing 81% of the identified thresher catch. This does not include the 1,067 thresher sharks that were not identified to species level (Baum and Blanchard 2010). The following table (Table 8) shows Atlantic domestic commercial landings of thresher species which were compiled from the most recent stock assessment documents and updates provided by the NMFS Southeast Fisheries Science Center (SEFSC).

Table 8. Commercial landings of Atlantic pelagic sharks (lbs, dressed weight) and fins (mt) from 2003-2013 (Source: NMFS (2012) and (2014)).

Pelagic Sharks	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
A. sup.*	0	719	267	68	0	0	0	28	135	276	0
A. vul.	46,502	44,915	41,230	27,740	46,391	47,528	33,333	61,290	47,462	63,965	48,768
Thresher fins						-	-	-	-	-	1,638
Unclassified fins						-	-	-	-	-	22,712

*Retention of bigeye threshers was prohibited as of 2000.

Commercial landings of common thresher sharks in the U.S. Atlantic have been variable, but averaged approximately 46,284 lb (20,994 kg; 20 mt) per year from 2008-2013. Although bigeye thresher sharks have been prohibited in U.S. Atlantic commercial fisheries since 2000, they are still caught as bycatch in U.S. longline fisheries and occasionally landed. Since 2000, a total of approximately 1,493 lb (677 kg) dressed weight of bigeye thresher were landed in the Atlantic (NMFS, 2012, NMFS, 2014). While this is equates to a small number of sharks landed (based on average weight) the bigeye thresher is one of the most commonly discarded species in U.S. Atlantic commercial fisheries. For example, in 2010, the United States reported that bigeye thresher represented the second largest amount of dead discards in the Atlantic commercial fleet, reporting a total of 46 t (NMFS, 2010). In 2011, this number dropped to 27 t of bigeye thresher dead discards (NMFS, 2011a). This indicates that indirect fishing pressure continues in the face of species-specific regulations to protect bigeye threshers.

According to an ERA 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, common thresher sharks were one of the least vulnerable species. The ERA was presented in two documents: One document (SCRS/2008/138) contained a level-3 quantitative ERA, with susceptibility to pelagic longline fishing data from a range of different fleets; the other (SCRS/2008/140) used a multidimensional measure of risk that added the estimated position of the inflection point of the population growth curve (a proxy for the level of depletion at which MSY occurs) and IUCN Red List status to productivity and susceptibility (mostly from U.S. observer data). The two ERAs provide similar overall estimates of risk of over-exploitation for the species considered; however, the common thresher shark had somewhat contradictory levels of risk between the two assessments. The multidimensional ERA indicated higher levels of risk, while the two-dimensional ERA indicated lower levels of risk. Since the same biological productivity values were used in the two ERAs, differences in risk levels for *A. vulpinus* were the result of differences in susceptibility values. A more recent ERA conducted by the SCRS categorized the relative risk of overexploitation of the eleven major species of pelagic sharks, including common and bigeye thresher sharks (Cortés 2010; Cortes 2012). The study derived an overall vulnerability ranking for each of the 11 species, which was 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" (Cortés et al., 2010, Cortés et al., 2012). This assessment again found that common thresher sharks are relatively productive species that show very low susceptibility to the combined pelagic longline fisheries in the Atlantic Ocean (Cortés et al., 2010, Cortés et al., 2012). In contrast to the common thresher, the bigeye thresher shark has been ranked as one of the most vulnerable shark species to fisheries in numerous ERAs throughout its range. According to the same previously described ERA conducted by the ICCAT SCRS in 2008, Atlantic bigeye thresher sharks were identified as one of the least productive and most vulnerable shark species of the species examined by SCRS. In addition, a more recent ERA found that the bigeye thresher's combination of low productivity and high susceptibility to pelagic longline gear places the species at a high risk of overexploitation (Cortés et al., 2010, Cortés et al., 2012). The bigeye thresher's vulnerability to Atlantic fisheries is further confirmed by Gallagher et al. (2014) who found bigeye thresher emerged as one of the most vulnerable to longline bycatch mortality, as a result of the species' combined low fecundity and productivity, moderate age of maturity ranking, and low mean survival rate when caught (only 48%).

Several studies have been conducted in this region to determine trends in abundance of various shark species, including common and bigeye thresher sharks. These analyses encompass the confirmed range of threshers in the region (i.e., from the equator to about 50°N). In the Northwest Atlantic longline fisheries, thresher sharks (both common and bigeye threshers) are typically recorded at the genus level by observers as well as in logbooks, of which the bigeye thresher shark is more common. In 2003, Baum et al. (2003) analyzed logbook data for the U.S. pelagic longline fleets targeting swordfish and tunas in the Northwest Atlantic, and reported an 80% decline in relative abundance for thresher sharks (common and bigeye threshers combined) from 1986 to 2000. However, these results were challenged (see discussions in Burgess et al. (2005a) and Burgess et al. (2005b)) on the basis of whether correct inferences were made regarding the magnitude of shark population declines in the Atlantic. In a more recent re-analysis of the same logbook dataset using a similar methodology, Cortés et al. (2007) reported a 63% decline from 1986-2005, and a 50% decline from 1992-2005. In contrast, the analysis of the observer dataset from the same fishery resulted in an opposite trend to that of the logbook analysis, with a 28% increase in abundance from the same period of 1992-2005 (Cortés et al., 2010). In 2010, Baum and Blanchard also analyzed observer data from 1992-2005 and reported no change in the population trend over the time period (Baum and Blanchard, 2010), concluding that individual year estimates for thresher sharks suggest that the population potentially stabilized. It should be noted that while the sample size in the latter observer analysis was very small (n = 14-84) compared to that in the logbook analysis (n = 112-1292) (Kyne et al., 2012), observer data is generally regarded as more reliable than logbook data for non-target shark species (Walsh et al., 2002). Using a similar approach as Cortés et al. (2007), the Extinction Risk Analysis team analyzed the most recent observer data (1992-2013) and found no obvious change in the population trend over time for either common or bigeye thresher shark indicating that the populations in the Northwest Atlantic Ocean have stabilized (Figure 41).

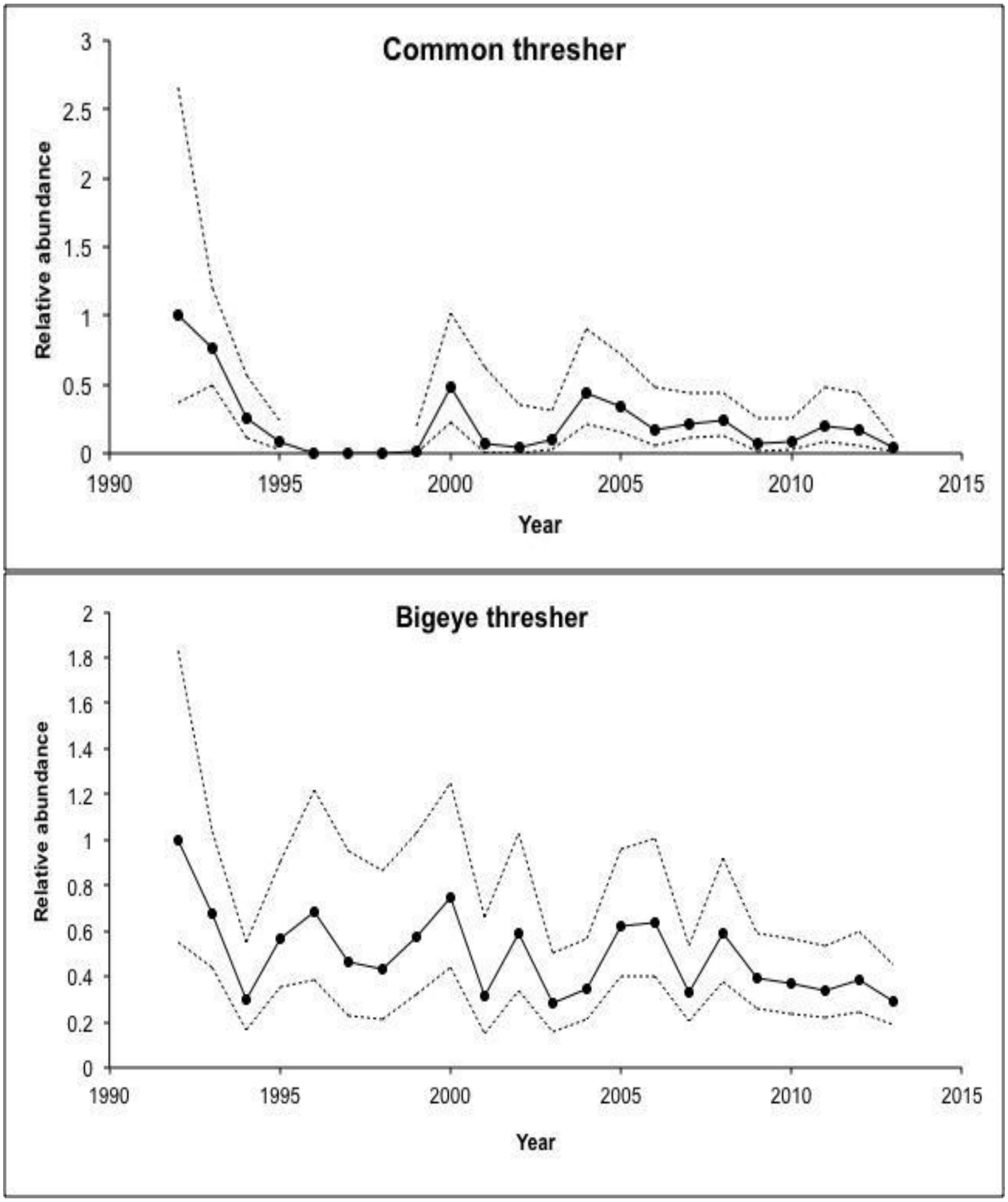

Figure 41. Estimated change in relative abundance (standardized catch per 1000 hooks) between 1992 and 2013 based on the observer data for thresher sharks. Relative abundance is expressed as the year's estimated mean index divided by the maximum estimated yearly mean index in each time series. Dotted lines represent upper and lower 95% confidence limits.

However, it should also be noted that fishing pressure on thresher sharks began over two decades prior to the start of this time series; thus, the estimated historical declines are not from virgin biomass and the stabilization of common and bigeye thresher populations are therefore at a diminished abundance.

In the southeastern U.S., both common and bigeye threshers are caught as bycatch in the U.S. PLL fishery, though bigeye threshers are more common in this region. In a study of observer data from the U.S. PLL fishery operating in the Southeast, Beerkircher et al. (2002) showed that the nominal CPUE of bigeye threshers during the period of the study (1992-2000) was variable without a trend. Beerkircher et al. (2002) also reported an apparent decline in the average nominal CPUE for bigeye thresher during the 1992-2000 study period relative to the average nominal CPUE from a previous study on shark bycatch for pelagic longliners operating off Florida during 1981-1983 (Berkeley and Campos, 1988). However, Beerkircher et al. (2002) noted that "Berkeley and Campos (1988) observed trips only in the Florida Straits (about lat. 25°N to 28°N), and there were at least some sets made in the Bahamian EEZ. The majority of the 111 sets made in the 1988 study were from a single vessel. Such significant spatial and vessel differences reduce direct comparability with the present data set, which is drawn from a much larger area and sampling effort from 65 different vessels." Berkeley and Campos (1988) found that annual reported shark landings over the study period (from 1981-1983) was only 3.3% of the actual catch. Catch of bigeye thresher in this fishery was relatively low, comprising 1.6% of the total shark catch, with an average annual CPUE of 0.06. Additionally, approximately 73% of bigeye threshers caught were female, and 80% were determined to be sexually immature. Berkeley and Campos (1988) concluded that as a result of the large portion of specimens caught under the size of maturity, suggest that the development of a fishery, directed or otherwise, should proceed with caution. In an analysis of longline observer data from 1992-2000, bigeye thresher had one of the highest dead discard rates, with a 53.7% mortality rate upon gear retrieval (Beerkircher et al., 2002). In total, from 1992-2002, 479 bigeye threshers were caught as bycatch, and approximately 40% were discarded dead. In contrast, common threshers exhibited a lower mortality rate, with 97 individuals caught and approximately 28% discarded dead (Beerkircher et al., 2004).

Historically, bigeye threshers were an important component of the pelagic fishery operating off the northwestern coast of Cuba. Longlines are set year round in the Cuban fishery and 11 shark species are caught in commercially exploitable numbers, including bigeye thresher, which was the third most abundant species and amounted to some 20% by weight of the total 1973 shark catch. Between 1971 and 1975, the Cubans doubled their catch of bigeye thresher, yielding a total commercial catch of 3,400 kg (Guitart, 1975 cited in Gruber and Compagno (1981)). In general, shark catches increased until 1981 and have been variable since. Since 1985, a substantial decline was observed in some species (e.g., silky and oceanic whitetip) (Claro et al., 2001) but information specific to bigeye thresher could not be found.

The U.S. National Bycatch Report (NMFS, 2011c) estimated that annual thresher shark bycatch from 2005 to 2006 was 162 individuals in the US Southeast Region, based on data from the U.S. GOM Reef Fish Handline (Vertical Line) fishery. A recent update to this report (NMFS, 2013b) estimated thresher annual bycatch was 44 individuals from 2006 through 2010, including thresher sharks reported from the US South Atlantic Snapper-Grouper Handline (Vertical Line)

Fishery, as well as the fishery reporting thresher shark catches in the original report. Estimated annual thresher shark bycatch using the only fishery included in both bycatch reports, the U.S. GOM Reef Fish Handline (Vertical Line) fisheries, shows a decrease in annual bycatch from the 2005-2006 annual estimate of 162 individuals to the 2006-2010 annual estimate of 30 individuals. This perceived reduction in bycatch may be attributed to the establishment of an individual fishing quota (IFQ) system for the US GOM commercial red snapper fishery and its implementation before the start of the 2007 fishing season. The primary targets of the U.S. GOM Reef Fish Handline (Vertical Line) fishery are red snapper, vermillion snapper, and red grouper. The ITQ system was established to reduce overcapacity in the U.S. GOM commercial fishery for red snapper and to eliminate, to the extent possible, the problems associated with derby fishing, in order to assist in achieving optimum yield. The establishment of the ITQ system may have led to a reduction in the number of participants in the U.S. GOM Reef Fish Handline fishery, as they may have left the fishery or increased targeting of other species to account for any reduction in available quota. The ITQ system also opened the fishery to year round fishing instead of seasonal restrictions, which may have reduced the amount of fishing effort in areas at times when thresher shark interactions were possible. This potential reduction in effort would likely lead to a reduction in thresher shark interactions with handline gear.

Northwest and Central Atlantic Summary

Overall, abundance trend estimates derived from standardized catch rate indices of the U.S. PLL fishery suggest that both common and bigeye threshers have likely undergone historical declines in abundance in the Northwest Atlantic. Logbook data indicates that thresher shark populations (common and bigeye threshers combined) declined sharply from 1986-2000 by approximately 63-80%; however, the claim of such a drastic decline was criticized for a lack of understanding of logbook data (Burgess et al. 2005a, 2005b) and a contrasting trend in observer data was found, indicating the population had increased by 28% since 1992. In addition, a recent species-specific analysis by the Extinction Risk Analysis team using standardized abundance indices derived from observer data shows that common and bigeye thresher shark populations in this region have likely stabilized since 1990.

Northeast Atlantic and Mediterranean

For purposes of this status review, the Northeast Atlantic and Mediterranean refers to those waters north of 24˚N and east of 40˚W, as described in Fernandez-Carvalho et al. (2015a). While there are no target fisheries for thresher sharks in the Northeast Atlantic, they are taken as bycatch in longline and driftnet fisheries (e.g., Buencuerpo et al. (1998), Mejuto et al. (2002), Tudela et al. (2005)). Both common and bigeye thresher species are caught mainly in longline fisheries for tunas and swordfish, although they may also be taken in driftnet and gillnet fisheries (ICES, 2005, ICES, 2007). Fisheries data for thresher shark landings in the Northeast region are scarce and unreliable because they are reported irregularly and variably, and it is likely that the two thresher species (*A. vulpinus* and *A. superciliosus*) are mixed in the records (ICES, 2014). As highly valuable species, it is very likely that this bycatch is retained (ICES, 2005). Limited information is available on thresher shark catch in this region and there are large discrepancies between national landings data presented to ICES and those reported to ICCAT. The main landing nations are Portugal, Spain and France, although the large quantities reported by

Portugal to ICCAT in 2006 and 2007 (i.e., 95 and 82 t) have been deemed suspicious (ICES, 2014). The ICES (2006) reports estimated landings of thresher shark between 13-107 t from 1996 to 2005 in the ICES area; however, these data are still considered incomplete. Prior to 2000, estimated landings fluctuated between 17 t in 1996 and 13 t in 1999. From 2000-2001, they exceeded 100 t, after which they dropped to 4 t in 2002. More recently, a 2013 ICES report estimated 34 t of thresher sharks landed, with 33 t originating from France. Poisson and Seret (2009) assessed the status of five pelagic shark species (including common and bigeye threshers) caught by French domestic fisheries by collating information from national commercial landings statistics, logbook data, and biological information from commercial and scientific samples. According to national statistics presented in Poisson and Seret (2009), thresher shark catches fluctuated between 10 and 20 t per year during the 1990s before abnormally high peaks of more than 100 t in 2000 and 2001 in the Atlantic Ocean. These values have been removed temporarily from the data set for further verification by ICES. In the Mediterranean Sea, catches decreased slightly since 1996; however, considering the trends for both areas, catch statistics for these species seem highly uncertain (see Figure 42 below).

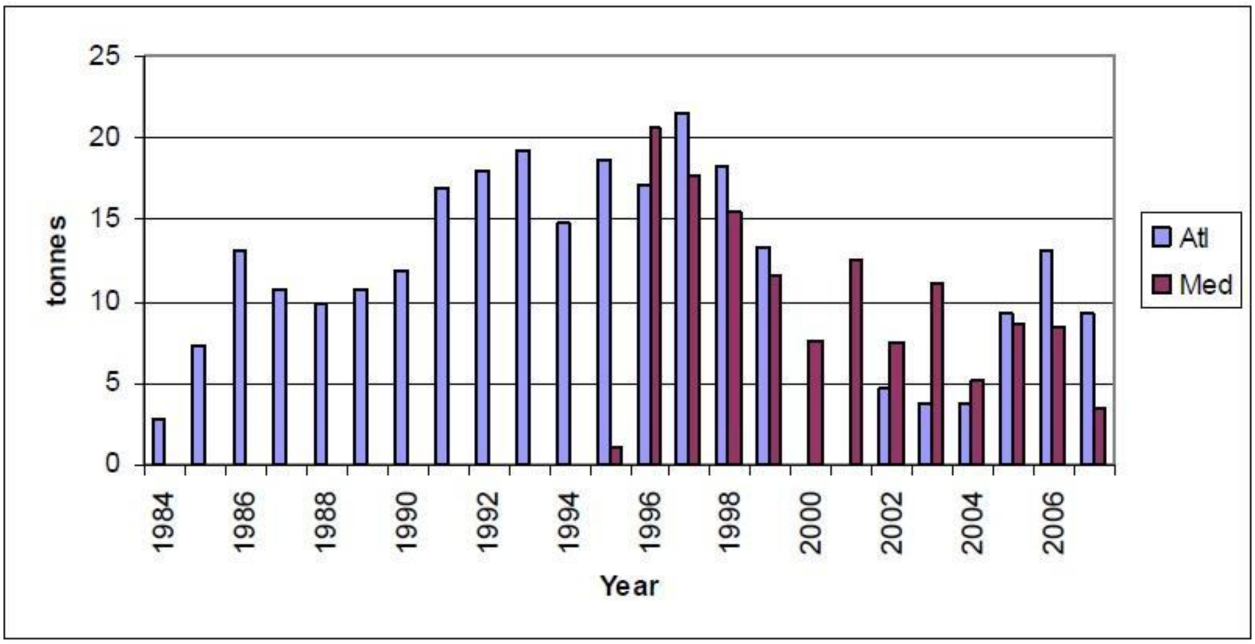

Figure 42. Thresher sharks (*Alopias* spp.) catch (t) per year in Atlantic Ocean (1984-2007) and Mediterranean Sea (1995-2007). Due to unusually high peaks of more than 100 tons in 2000 and 2001, these values have been temporarily removed from the data for further verification (Source: Poisson and Seret 2009).

In the French domestic fisheries, *A. vulpinus* and *A. superciliosus* have been caught mainly by pelagic trawls (48%) and longline gears (25%) and to a lesser extent by nets (8%) from 1999-2007 (see Figure 43 below).

Name	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
Net	5,431	102,850	108,870	264	493	329	816	1,038	525
	40.8%	95.7%	96.7%	5.7%	12.7%	8.8%	8.8%	7.7%	5.3%
Longline	1,342	2,464	1,173	858	1,234	1,623	2,209	2,019	1,555
	10.1%	2.3%	1.0%	18.4%	31.9%	43.5%	23.8%	15.0%	15.7%
Trawl (pelagic)	4,249	1,375	2,412	2,710	1,716	858	5,287	8,910	3,830
	31.9%	1.3%	2.1%	58.0%	44.4%	23.0%	57.1%	66.4%	38.7%
Trawl (demersal)	2,291	757	78	701	423	923	893	1,402	3,973
	17.2%	0.7%	0.1%	15.0%	10.9%	24.7%	9.6%	10.4%	40.1%
Unclassified	11	51	10	136			60	56	15
	0.0%	0.0%	0.0%	1.3%			0.0%	0.0%	0.1%
Total	**13,324**	**107,497**	**112,543**	**4,670**	**3,865**	**3,734**	**9,265**	**13,424**	**9,897**

Figure 43. Thresher sharks (*Alopias* spp.) catch (kg and in percentage) by generic gear in Northeast Atlantic Ocean, 1999–2007 (Source: Poisson and Seret 2009).

In Portugal, Correia and Smith (2001) conducted an analysis of elasmobranch landings for the Portuguese commercial fishery from 1986 to 2001. During this time period, *A. vulpinus* was one of the 14 most heavily landed elasmobranch species (>250 t) reported in the Portuguese commercial fishery, with a total of 359 t (wet weight landed). In total, annual elasmobranch landings have been decreasing in Portugal since 1990. While average yearly price per kg of *A. vulpinus* increased by 14% over the time period, discernable trends in annual landings could not be detected, thus the status of *A. vulpinus* could not be determined (Correia and Smith, 2001). While bigeye thresher has been recorded in Portuguese waters, landings of bigeye thresher are unconfirmed.

A quantitative assessment of historical shark populations has not yet been attempted in the Mediterranean likely due to an ongoing paucity of abundance data. Historically, large sharks occurred throughout the Mediterranean Sea; in the early 20th century many coastal fisheries targeted sharks or landed them as bycatch. It is thought that these species potentially found refuge from intense historical coastal exploitation in offshore pelagic waters. However, in recent decades, large sharks seem to be restricted to the eastern and southern Mediterranean coasts or to offshore pelagic waters, where they have been caught, albeit in very low numbers. Pelagic fishing expanded in the Mediterranean Sea in the 1970s, after which it is thought many shark populations, including common threshers, collapsed (Ferretti et al., 2008). According to Ferretti et al. (2008), during the past two centuries, common thresher sharks have declined between 96 and 99% in abundance and biomass in the Mediterranean Sea (Refer back to Figure 19 and Table 7 in Section 3.2). Data from this fishery suggest that both annual catches and mean weights of common thresher shark have fallen as a result of fishing mortality.

Adults and juveniles of common thresher shark have been reported as bycatch in all fishing gears used in the Mediterranean basin, including longline, purse seine, trawl, driftnet, trammel net, gillnet, fish traps, and mid-water fisheries. Common threshers are also caught in recreational fisheries (Bradai et al., 2012). Kabasakal (2007) reported *A. vulpinus* as one of the most common incidentally caught sharks in the swordfish fishery in Turkish waters. In Tunisian waters, Hattour and Nakamura (2004) noted a significant population reduction of adult *A. vulpinus*, with small-scale fisheries now targeting neonates. Recent investigations show common thresher sharks are being increasingly targeted in the Alboran Sea by the illegal large-scale swordfish driftnet fleet based primarily in Morocco. This is despite a total ban on driftnet fishing on large pelagic species by the EU fleet in the Mediterranean that was entered into force in January 2002. The Moroccan driftnet fishery quickly developed in Northern Morocco in the early 1990s, and by 1995, had a fleet that likely exceeded 200 vessels and often used nets in excess of 2.5 km. Tudela et al. (2005) monitored 369 fishing operations made by the driftnet fleet between December 2002 and September 2003 and estimated a total of 4,791 common threshers caught over the 8-month sampling period. When extrapolated to 12-months, incidental catches of common thresher sharks are estimated at about 7000-8000 individuals in the Alboran Sea alone (see Table 9 below).

Table 9. Estimates (in number of individuals) of total catch of cetaceans and pelagic sharks by driftnetters from Al Hoceima and Nador based on the ratio method and different measures of catch per unit effort (CPUE) (Adapted from: Tudela et al. 2005).

	Estimates of the 8-month sampling period				Extrapolation to 12-month sampling period			
	CPUE 1		CPUE 2		CPUE 1		CPUE 2	
	Total catch	95% CI	Total catch	95% CI	Total catch	95% CI	Total catch	95% CI
A. vulpinus	4791.20	535.81	*4466.65*	*161.99*	7186.82	803.71	*6699.98*	*243.00*

CPUE 1: daily catch per boat (N/fishing operation); CPUE 2: daily catch per km net set per boat (N/km net set). Estimation of bycatch of *A. vulpinus* using CPUE 2 (in italics) is not fully adequate since GLM analyses show a significant effect of net in the catch of both species.

Of concern is the fact that the Alboran Sea has been identified as a potential nursery area for common threshers, as aggregations of gravid females have been observed in this area (Moreno and Moron, 1992, Tudela et al., 2005). The intensive fishing pressure and potential targeting of common thresher sharks by the swordfish driftnet fleet in the Alboran Sea has the potential to significantly impact the population of common threshers in the area, as well as affect recruitment into the local population. In fact, Megalofonu (2005) reported low catch rates for common thresher sharks in the Mediterranean (ranging from 0.001 to 0.05 individuals/1000 hooks), most of which were of immature size. Based on Eastern Pacific age of maturity estimates (315 cm TL for females; 333 cm TL for males) Megalofonu (2005) estimated that 40% of female common thresher sharks caught were immature and 50% of males caught were immature (see Figure 44 below).

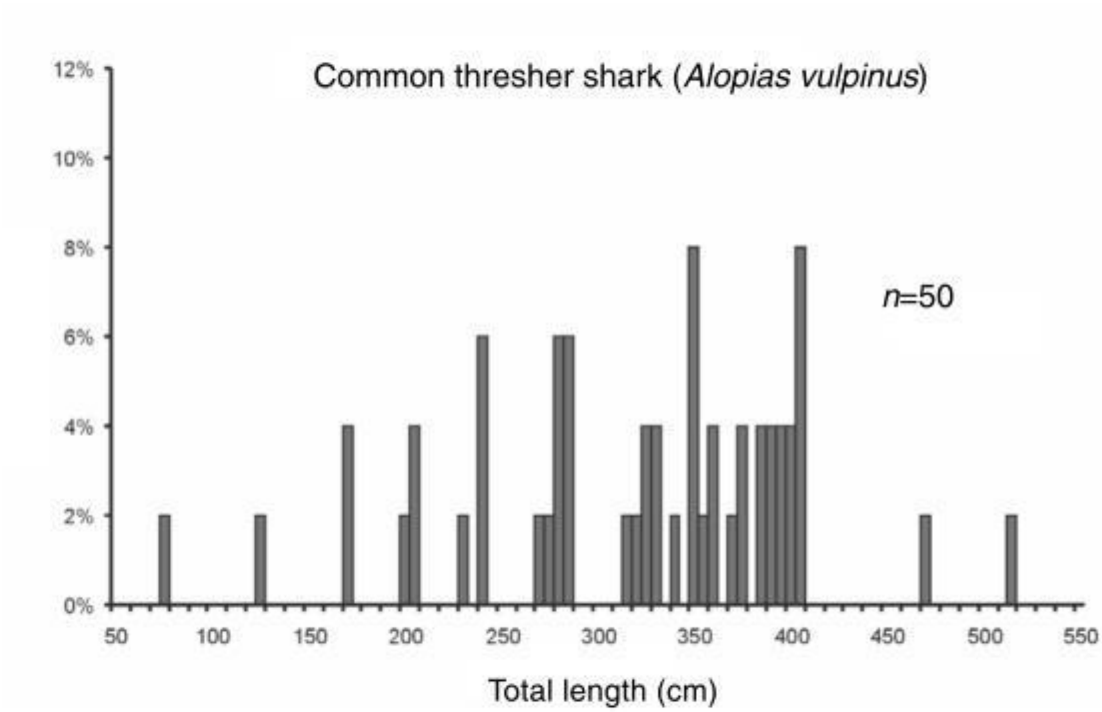

Figure 44. Length-frequency distribution (in percentage by 5-cm size classes) for *A. vulpinus* sampled in the Mediterranean Sea during 1998–2000 (Source: Megalofonu et al. 2005). Size of maturity in the Northeast Atlantic has been reported as 315-420 cm TL.

It should be noted that while age of first maturity has not been calculated for common thresher sharks in the Mediterranean Sea, there is some uncertainty regarding whether females mature at a smaller size than males in the same region. Thus, the study concluded that fishing pressure was very intense on juvenile and subadult groups. The previously described low catch rates of *A. vulpinus* in the Mediterranean reported by Megalofonu et al. (2005) are almost identical to results reported by Buencuerpo et al. (1998) for the Gibraltar Strait region, in which common thresher sharks represented the lowest proportion of species landed in all five areas examined. Recently, Fortuna et al. (2010) documented large numbers of *A. vulpinus* as bycatch in the pair trawl fishery in the Adriatic Sea of Italy (annual estimate n = 245 fish). Likewise, Storai et al. (2011) recently documented that *A. vulpinus* were the most common shark bycatch (n = 11 fish; 26% of elasmobranch bycatch; 1990-2009) in the traditional tuna trap (tonnare) fishery off of Sardinia. This indicates that common thresher sharks continue to experience high levels of fishing pressure throughout the Mediterranean Region. As previously noted, during the past two centuries, common thresher sharks have declined between an estimated 96 and 99% in abundance and biomass in the Mediterranean Sea (Ferretti et al. 2008). Data from this fishery suggest that both annual catches and mean weights of common thresher shark have fallen significantly as a result of fishing mortality.

The bigeye thresher has been poorly documented in the Mediterranean and is considered scarce or rare (Amorim et al., 2009). The bigeye thresher is often referred to as “False Thresher” in this region as a result of a perceived low local value (Cavanagh and Gibson, 2007). Available data on catch trends for this species are lacking in the region; however, in recent years, an increasing number of new records from the eastern Mediterranean (sometimes multiple captures) demonstrate that this species is widely distributed to the east of Malta, occurring in the waters off Israel (Levantine basin), in the Aegean Sea off Turkey and southern Greece, and off southern Crete (I. Fergusson pers. obs., Golani 1996, Clò et al. 2005, Clò et al. 2008 cited in Cavanagh and Gibson 2007). Evidence from offshore pelagic fisheries in southern Sicily and Malta indicate that *A. superciliosus* is caught in unknown numbers each year, but routinely discarded at sea (Cavanagh and Gibson, 2007). The bigeye thresher is also thought to have some important parturition and nursery areas in this region, with a nursery area suspected in the waters off the southwestern Iberian Peninsula (Moreno and Moron, 1992, ICES, 2009) .

Northeast Atlantic and Mediterranean Summary

Overall, given that pelagic fishing pressure is high and ongoing throughout the Mediterranean Sea, targeting of *A. vulpinus* has increased, and catches of *A. vulpinus* have potentially declined precipitously, as described above, the common thresher shark has likely suffered significant declines in abundance in this region. However, these extreme declines should be regarded with caution, as these results rely on only one study of abundance trends in a data-poor region. In the absence of records of trans-Atlantic migrations, a single northeast Atlantic and Mediterranean stock of *A. vulpinus* is assumed (ICES, 2007). Due to the lack of information regarding bigeye thresher catch trends, it is difficult to determine the status of bigeye thresher in the Mediterranean, and whether the species' scarce abundance in this region is a result of population declines due to fishing pressure or its natural rarity, or both.

South Atlantic

For purposes of this status review, the South Atlantic includes those waters south of 5˚S, but also includes the tropical and equatorial waters of the Atlantic (from 24˚N to 5˚S) as described in Fernandez-Carvalho et al. (2015a) (Figure 8). There is little information on the catch rates or trends of thresher sharks in the South Atlantic Ocean. Some countries still fail to collect shark data while others collect it but fail to report (Frédou et al., 2015). Both common and bigeye thresher sharks occur in the South Atlantic and are taken as bycatch in various fisheries, including Cuban, Brazilian, Uruguayan, Taiwanese, Japanese, Venezuelan, and Portuguese longline fisheries. However, catches of common thresher sharks are typically rare in the South Atlantic, whereas catches of bigeye thresher are relatively common. Thus, the following descriptions of fisheries operations in the South Atlantic predominantly focus on bigeye threshers.

Both common and bigeye thresher sharks are caught as bycatch in the Venezuelan pelagic longline fishery in low numbers. Based on observer data from 1994-2000, common and bigeye thresher represented 1.6 and 2.2% of the total shark catch, respectively. The average size of bigeye threshers caught was 150.7 cm FL and the average size of common threshers was 143.7 cm FL (Arocha et al., 2002).

In Brazil, *A. vulpinus* has been reported in catches of Santos longliners, albeit only occasionally. In contrast, almost 100% of thresher catch in Brazil is represented by *A. superciliosus*, which was also one of the most commonly caught shark species in the Santos longline fishery from 1974-1997 (Amorim, 1998). Here, the meat of bigeye thresher has low value and fins have regular price, so they were generally rejected in the early 1970s. However, in the last three decades, their commercialization improved and fishermen now unload all shark species (Amorim *et al*., 1998). In general, this fleet does not practice shark finning because of the existing market for the meat. Annual catches of bigeye thresher in the Santos longline fishery gradually increased from 1971 to 1989, with catches ranging from 1 t (1971 and 1972) to 119 t (1989) (Arfelli and Amorim 1994 cited in Amorim 1998). After 1989, catches decreased gradually to 10 t in 1996. In 2008, Mourato et al., (2008) estimated standardized CPUE of bigeye thresher shark from the data of the Santos and Guaruja tuna longline fishery that operated in the southwest Atlantic from 1971 to 2006. Bigeye thresher CPUE showed a slight decline from 1978 to 2006 (see Figure 45 below), which corroborates results in Mancini (2005) that also showed a generally declining CPUE trend from the early 1980s to 2001.

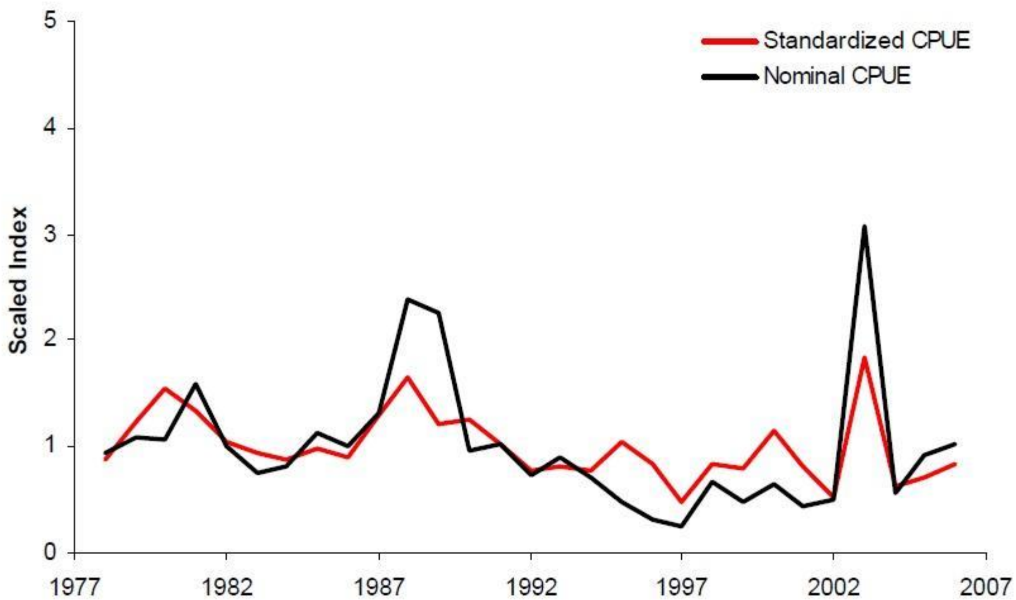

Figure 45. Standardized catch rate of bigeye thresher shark caught by São Paulo, Brazil longliners in southwest Atlantic in the period between 1978 and 2006.

Since 1991, the medium weight of individuals has also declined, likely due to a change in fishing gear that selects smaller, immature females, which could be adversely affecting the breeding biomass (Mancini, 2005). More recently, Fredou et al. (2015) analyzed catch and effort data of 14,860 longline sets from the Brazilian chartered tuna longline fleet, between 2004 and 2010. As of 2004, thresher sharks (both common and bigeye threshers) were still the 3rd most important elasmobranch group in the Brazilian longline fisheries, with very low overall CPUE scattered across the South Atlantic, and in 2006, thresher sharks disappeared from the catches all together. However, a shift in the distribution of fishing effort also occurred in 2006, moving from the equatorial Atlantic between 7˚N and 5˚S to around 20˚S in the Atlantic. Thus, the disappearance of thresher sharks, and bigeye threshers in particular, from Brazilian longline catch can likely be attributed to the shift of fishing effort into more temperate waters, where bigeye threshers are less prevalent.

Observer data from the Uruguay longline fleet was analyzed from 2001-2005 in Berrondo et al. (2007), in which a total of 439 thresher sharks (295 *A. superciliosus*, 88 *A. vulpinus* and 56 non-identified species) were recorded. The average size of captured *A. vulpinus* was 332 cm TL (n = 49, range: 226-400 cm), which corresponds to approximately 50% of specimens as mature. The average size of *A. superciliosus* was 303 cm TL (n = 211, range 176-458 cm), which is slightly smaller than the average size of 318 cm TL (n = 29, range: 165-370) observed by Garcia & Mejuto (2002) for the South Atlantic, and approximately 50% of individuals captured between 310-320 cm TL are just reaching maturity length (Berrondo, 2007). Figure 46 and 47 below show the five fishing zones in which the observer data were collected, and the level of CPUE for *A. vulpinus* and *A. superciliosus*, respectively, in each zone.

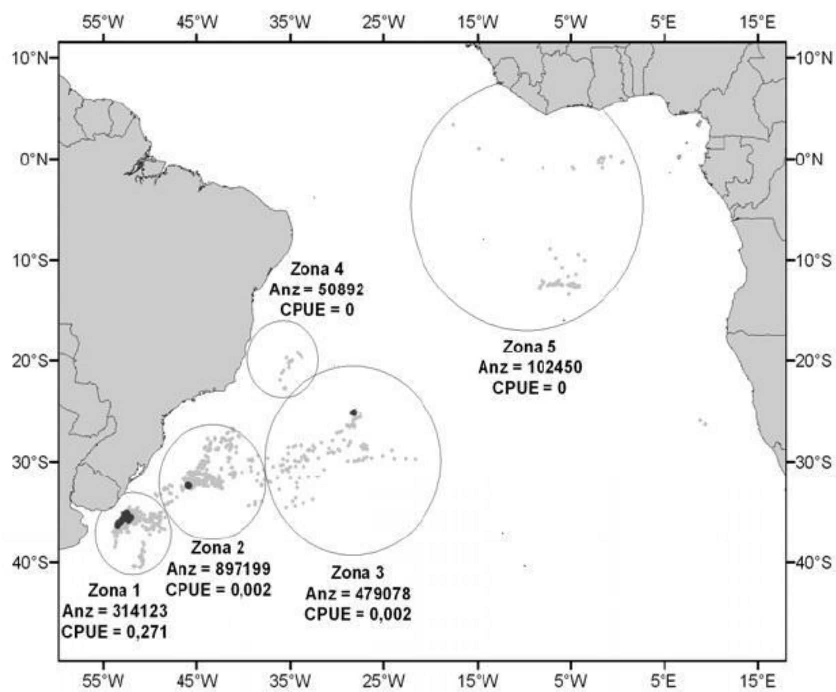

Figure 46. Spatial distribution of *A. vulpinus* and CPUE per zone for the study period (Source: Berrondo et al. 2007).

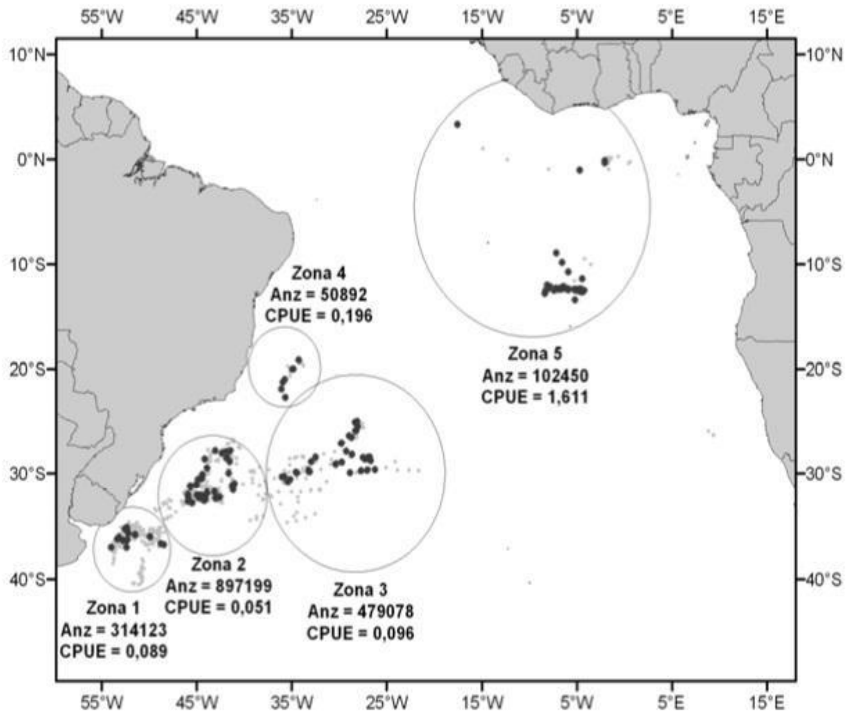

Figure 47. Spatial distribution of *A. superciliosus* and CPUE per zone for the study period (Source: Berrondo et al. 2007).

Alopias superciliosus was found throughout the entire area where the fleet operated. For this species, an increase in CPUE was observed in zone 5 where a unique boat operated between May and August 2003, which captured 165 *A. superciliosus* with an effort of 106,040 hooks. Matsushita & Matsunaga (2002) also found catches of thresher sharks in this area were all *A. superciliosus,* with CPUE values higher than those found for other areas analyzed in the South Atlantic. For common threshers, most CPUE was observed in Zone 1, which relates to more coastal habits of this species (Berrondo, 2007). In Zones 2 and 3, only two and one individuals were recorded, respectively, despite the fishing effort monitored in these areas. Figures 48 and 49 below show the CPUE trend and effort (number of hooks) for *A. vulpinus* and *A. superciliosus* in all zones.

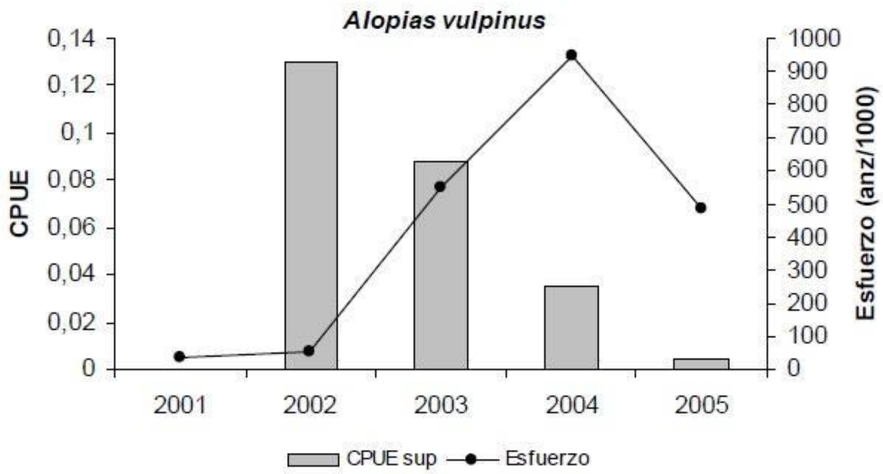

Figure 48. Values of effort (number of hooks observed in thousands) and CPUE for *A.vulpinus* for the entire study period (Source: Berrondo et al. 2007).

For *A. vulpinus*, CPUE values ranged from 0.13 in 2002 to 0.004 in 2005. These values are directly related to the spatial distribution of effort into areas where the occurrence of *A. vulpinus* is lower.

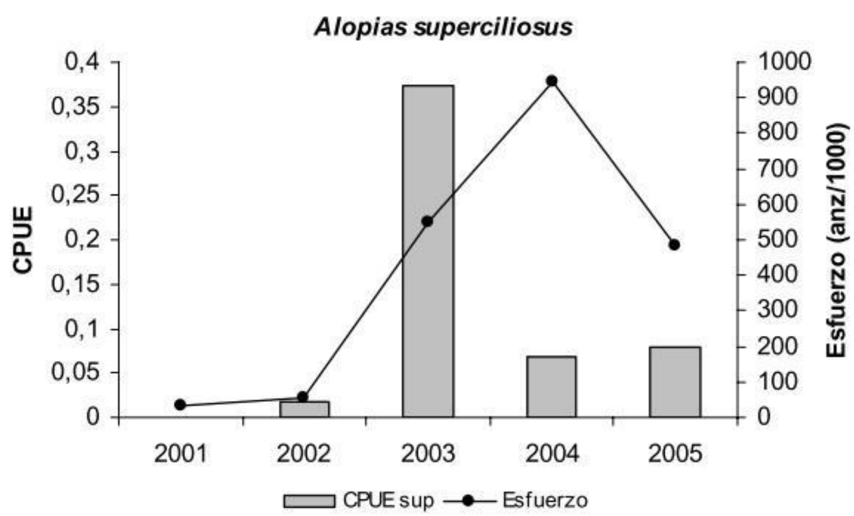

Figure 49. Values of effort (number of hooks observed in thousands) and CPUE for *A.superciliosus* for the entire study period (Source: Berrondo et al. 2007).

Berrondo et al. (2007) concluded that the species' low abundance combined with their occurrence in areas subject to high fishing intensity and life history traits, warrants special attention and urgent assessment of their conservation status. The authors noted that *A. vulpinus* was of particular concern for having the lowest CPUE values and a reportedly very restricted distribution in the area; however, no real trend was discernible in this dataset for either species.

Bigeye threshers are also commonly taken in Taiwanese longline fisheries operating in the South Atlantic. According to Taiwanese observer data, from 1999-2003 bigeye thresher was the second highest caught species from 5°N-15°S, comprising 3.6% in number and 4.9% in weight of total shark catches. However, *A. superciliosus* was not found from 15°S-40°S, which are more southern and temperate waters (Joung et al., 2005). Species-specific CPUE was calculated for bigeye threshers as 0.039 (n/1,000hooks) for the entire South Atlantic, which was lower than any of the CPUE recorded by Berrondo et al. (2007) for the Uruguayan fleet, but trends over time are not currently available from this fishery.

In a recent study of observer data from the Portuguese longline fishery targeting swordfish in the Atlantic Ocean, fishing mortality was analyzed in elasmobranchs captured (including areas of the temperate NE, tropical NE, equatorial, and southern Atlantic Ocean), where bigeye thresher comprises 3% of the total elasmobranch catch. For the most captured species, including bigeye threshers, logistic generalized linear models were carried out to compare the mortality rates between sexes, specimen sizes and the regions of operation of the fleet. For the bigeye thresher, none of the variables considered were significant, meaning that there were no differences in mortality rates depending on specimen size, region or specimen sex. Between August 2008 and December 2011, a total of 1,061 *A. superciliosus* were caught, with a 50.6% mortality rate (Coelho et al., 2012). Similarly, over the same time period, Fernandez-Carvalho (2015b) compared mortality rates between hook and bait type from 202 experimental pelagic longline sets in the eastern tropical Atlantic Ocean to determine potential bycatch mitigation methods. In this study, bigeye threshers were the most discarded species of elasmobranch, with mortality rates ranging from 49 to 59%. Additionally, bigeye thresher catch rates did not differ between hook type (i.e., circle hooks vs. J-style hooks), but mortality increased with the use of mackerel as bait (Fernandez-Carvalho et al., 2015b).

South Atlantic Summary

Overall, while common thresher sharks are relatively rare in the South Atlantic, bigeye threshers are common bycatch in numerous fisheries throughout the region. In the Brazilian longline fishery, slight declines in CPUE were observed up to 2006, at which point the species disappeared from the catch records. However, the disappearance of threshers from Brazilian catches was likely a result of a change in the distribution of fishing effort to more temperate latitudes rather than population declines. Low CPUE rates were also observed in Uruguayan longline fisheries despite high fishing pressure; however, temporal trends were not discernable. Further, bigeye threshers exhibit high bycatch-related mortality in the Southwest Atlantic, similar to other portions of the species' range, of 49-59%. Thus, given the high fishing pressure in this portion of the range, with evidence of high bycatch-related mortality and slight declines in CPUE, overutilization is potentially negatively affecting the species in this part of its range. However, due to the shift of the Brazilian longline fleet to more temperate latitudes, fishing pressure on bigeye thresher may be on a decline in this part of its range in recent years.

Indian Ocean

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. All three thresher species occur in the Indian Ocean, where they are taken in target, bycatch and recreational fisheries, especially in the Eastern Indian Ocean. Few studies have been conducted on the abundance of common and bigeye threshers in the Indian Ocean, making it difficult to determine the level of exploitation of these species within the ocean basin. However, thresher sharks make up an estimated 16% of the total shark catch in the Indian Ocean (Murua et al., 2013b) and they display high hooking mortality (IOTC, 2014). In order to assess the relative vulnerability of shark species caught in various tuna and tuna-like species in the Indian Ocean, Murua et al. (2012) conducted a preliminary ERA using similar methods to those of Cortés et al. (2010) (described earlier). Results of this study ranked common thresher as one of the least vulnerable species, ranking 15 out of 16 species assessed. However, this assessment, like others, used age of sexual maturity estimates based on *A. vulpinus* females from the Eastern Pacific (i.e., 6 years), and did not take into account more recent age of maturity estimates by Gervelis and Natanson (2013) for *A. vulpinus* females in the Northwest Atlantic (i.e., 12 years), which may slightly decrease the species' overall level of productivity. Also, age of maturity estimates have not been calculated for the Indian Ocean, so it is difficult to say with certainty what the relative vulnerability of the common thresher is to fisheries in this region; however, the best available information at this time suggests that common threshers generally have low vulnerability. In contrast, the bigeye thresher was ranked the 2nd most vulnerable species among the 17 species assessed, due to its low productivity and high susceptibility.

In an analysis of long-term trends from research and fisheries data collected in the Indian Ocean from 1961-2009, both *A. vulpinus* and *A. superciliosus* were recorded in catches from each time series (e.g., 1961-1970; 1971-1980; 1981-1989; 2002-2009) (Romanov et al., 2010). Data from Romanov et al. (2010) suggests decreased species richness in recent decades, noting that probable misidentifications for some taxa could introduce biases in the observed patterns. This historical research data shows overall decline both in CPUE and mean weight of thresher sharks in the Indian Ocean (Romanov pers. comm. cited in IOTC (2013)). Additionally, the fisheries in this region typically take bigeye thresher sharks between 140–210 cm FL or 40 to 120 kg (Romanov pers. comm. cited in IOTC (2013)), which is below the average age of maturity for the species.

Both common and bigeye thresher sharks have been reported as bycatch in Indian Ocean longline and gillnet fisheries, with gillnet fisheries reporting the highest nominal catches of sharks in 2014, and making up nearly 40% of catches (Ardill et al., 2011, IOTC, 2015). The three principal longline fleets fishing in the Indian Ocean include Japan, Korea, and Taiwan (Prov. of China). Longline fishing in the Indian Ocean was initiated by the Japanese fleet in 1952 and rapidly spread throughout the entire Indian Ocean. Korean, Taiwanese and Chinese freezer fleets followed, and were joined later by over 1,000 small Indonesian fresh fish longliners which fish with fewer hooks but otherwise in a similar manner to the deep-freezer longliners. Recently, a progressive shift in distribution of fleets away from the East African coast (which was previously one of the most heavily exploited areas) has occurred due to piracy. Figure 50 below shows how much of the effort was redistributed to the Eastern Indian Ocean, and notably, to temperate waters (Ardill et al. 2011) where common threshers may be more common and, as mentioned previously, are taken in target, bycatch and recreational fisheries in this area.

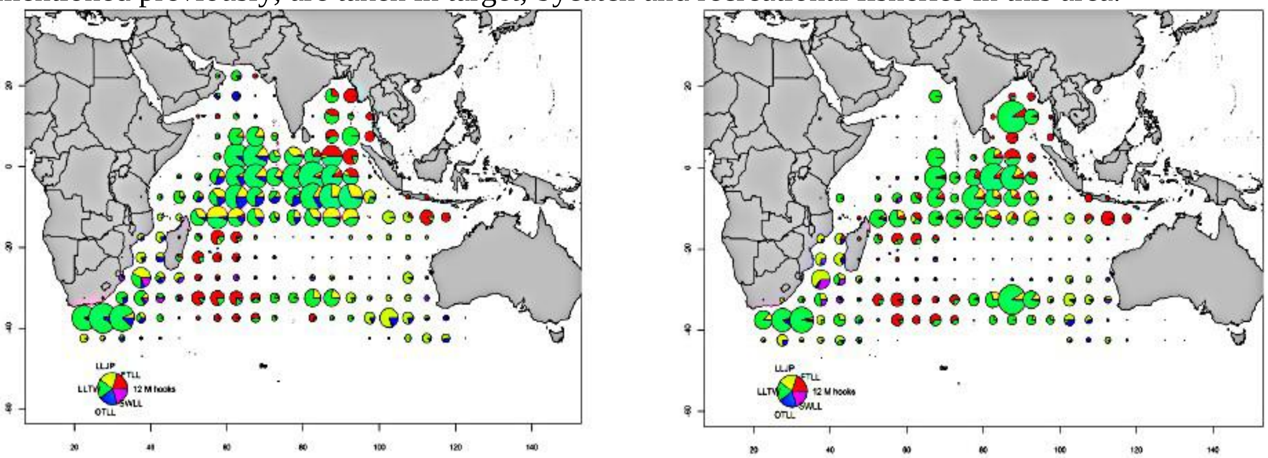

Figure 50. Number of hooks set (millions) from longline vessels by five degree square grid and main fleets, for the years 2009 (left) and 2010 (right) (Data as of August 2011) (Source: Ardill et al. 2011).

Thresher sharks reportedly have high hooking mortality and discard rates in the Indian Ocean (IOTC, 2014). For example, in a review of bycatch and discard issues in the Indian Ocean, Ardill et al. (2011) noted that all thresher sharks (including both *A. vulpinus* and *A. superciliosus*) are discarded. Observer data from Taiwanese longline fleets (with coverage ranging from only 2.2% in 2004 to 20.8% in 2007) recorded a total of 445 bigeye threshers caught as bycatch from 2004-2008, with approximately 61% discarded (Huang and Liu, 2010). In the Portuguese longline fleet operating in the Indian Ocean, bigeye threshers experienced a high rate of at-vessel mortality of 68.4% (n = 19) from May to September 2011 (Ardill et al., 2011). Bigeye threshers are also incidentally caught in Japanese longline fisheries, and according to observer data, 162 bigeye threshers were caught as bycatch in 6 months (from July 2010 to January 2011). These data do not include live-released bigeye thresher sharks (Ardill et al., 2011). More detailed information and data from other shark catching countries in the Indian Ocean are described below.

Indonesia

Indonesia is the largest shark-catching country in the world. The total elasmobranch catch in Indonesia was estimated at more than 110,000 t in 2007 (Camhi et al., 2009), representing the largest recorded harvest in the world (Tull, 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). According to fish landing site surveys in eastern

Indonesia, conducted between April 2001 and March 2006, the Alopiidae family was the most abundant family in the landings, with pelagic and bigeye threshers contributing 13% and 2.2%, respectively, to the total biomass of all sharks recorded. Common threshers were not recorded in these surveys. For *A. superciliosus*, landings consisted of significantly more females than males and the maximum size of *A. superciliosus* recorded in Indonesia of 378.6 cm TL is considerably less than the known maximum size of this species of 484 cm TL (White, 2007), which may be indicative of intense fishing pressure.

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 thresher sharks. Overall, thresher sharks comprised nearly 15% of tested fins, with bigeye thresher representing 7.6%. According to Sembiring et al. (2015), the high frequency of these species, including bigeye threshers, across Indonesia strongly suggests that they are not the result of bycatch or small-scale artisanal fisheries, but rather, the result of large-scale targeted fisheries. However, it should be noted that while species composition of thresher sharks in this study included bigeye and pelagic threshers, common thresher sharks were not recorded.

Additionally, an analysis of Indonesian longline scientific observer data in the Indian Ocean from 2005-2013 showed a total of 3,421 individual sharks comprised of 19 species, including thresher sharks, were caught. While bigeye and pelagic threshers were recorded at the species level (representing 0.90% and 1.37% of the total catch, respectively) common threshers were not recorded to the species level. However, part of the total thresher catch was aggregated in the group “thresher sharks nei,” representing 1.23% of the total catch (Novianto et al. 2014), thus it is unknown whether any common threshers were actually caught. In another study, data were collected and analyzed from numerous fish markets and landing sites throughout Indonesia from 2001-2005, including Central Java, Bali, Jakarta, West Java, and Lombok. This study revealed that *Alopias* spp. (bigeye and pelagic threshers) are among the most commonly taken shark species as bycatch. Bigeye threshers specifically comprised nearly 4% of bycatch taken in the tuna longline fishery (Blaber et al., 2009).

Overall, based on the genetic results of shark fins from numerous fish markets throughout Indonesia and the observed species-specific composition of Indonesian longline fisheries bycatch and landings, it is evident that bigeye threshers are commonly caught as bycatch and are potentially targeted for fins in this portion of its range. It also appears that effort of Indonesian fishers are likely not concentrated in areas where common threshers are prevalent, or that common threshers are naturally rare in this region, as they are more commonly distributed in more temperate waters. This is evidenced by the fact that common threshers were not recorded in any of the species-specific analyses described above.

India

India is the second largest shark producing nation in the world. Although all three *Alopias* species are known from Indian waters, the common thresher is reportedly the most commonly occurring species of thresher sharks from the Southeast coast, whereas bigeye thresher was recorded only in the Arabian coast, and has been designated as a rare (Gowthaman et al., 2014). 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 & 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 alarming scenario on the east and west coasts, where the average hooking rate recorded during the last five years was less than 0.1%. Common thresher sharks represented 0.5, 2.4, and 11.8% of the catch from the west coast, east coast, and Andaman and Nicobar waters, respectively. Bigeye threshers represented 4.2 and 0.6% of the catch from the east coast and Andaman and Nicobar waters, respectively. In the Andaman and Nicobar region, where catch of *A. vulpinus* is most prevalent, total shark CPUE declined sharply (approximately 81%) from peak CPUE in years 1992-1993 to years 1996-1997. On the East Coast, where catch of *A. superciliosus* is most prevalent, total shark CPUE also declined significantly by approximately 89% from 1984-2005. Despite the significant decline in CPUE in the Andaman and Nicobar waters, CPUE has remained relatively stable since the initial decline in 1996, although this time series ends in 2005. On the East and West Coasts of India, shark CPUE remained significantly low through 2005. However, the lack of species-specific CPUE information for common and bigeye thresher sharks, or even genus-level information for thresher sharks, make it difficult to evaluate the potential changes in abundance for these two species in this region based on John and Varghese (2009) alone. In addition, given that common thresher shark are more commonly found in temperate waters, and the prevalence of pelagic threshers in the catch of Indonesian fisheries fishing in nearby waters, the reported *A. vulpinus* catch may be misidentified pelagic thresher sharks.

Mozambique

Longline fisheries in Mozambique have likely significantly impacted elasmobranchs in the region. At the inception of tuna longline fisheries in southern Africa from 1964-1967, catch rates were 26 sharks per 1000 hooks, but reported catches for the same area have declined to 2.1 sharks per 1000 hooks. Thresher sharks, including *A. vulpinus* and *A. superciliosus*, are reportedly caught in offshore Mozambique waters by Taiwanese vessels (Pierce et al., 2008) but no other information could be found.

Western Australia

In Western Australia, a study was conducted in 2004 to monitor longline fishing in the Western Tuna and Billfish Fishery in which observers monitored 13 longline trips from April 2003 – June 2004. Ward and Curran (2004) found thresher sharks were among the top 20 species most frequently caught, and approximately 40% of these thresher sharks were dead when the long lines were retrieved, with an additional 10% described as “just alive” (i.e., barely). However, in a subsequent sustainability assessment of this same fishery, the likelihood of risk to the sustainability of non-target species (including *A. vulpinus*) was deemed to be very low. Similarly, while common thresher sharks are also caught in the Western Deep-Water Trawl Fishery, instant mortality rate of *A. vulpinus* is low, due to low effort and catch volume in this fishery (Zhou et al., 2009). Bigeye thresher was not included in this sustainability assessment, presumably because they are seldom caught in these fisheries.

<u>Sri Lanka</u>
Although, sharks were dominant in the historical large pelagic fish landings in Sri Lanka, their production is presently at a low level and catches are mostly a result of bycatch. From 1950 to 1974, sharks accounted for more than 45% of the total large pelagic fish production. However, at present, the contribution of sharks to the total large pelagic fish production is less than 4% (Hasarangi et al., 2012). 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 the level sustainable level of was likely surpassed as far back as 1974. In this study, O’meara et al. (2011) highlighted the lack of proper accounting for total fisheries catches. Without a realistic estimate of what is being extracted, pelagic fisheries are likely mismanaged and possibly overexploited in Sri Lanka (O'Meara et al., 2011). Both common and bigeye thresher sharks are of commercial importance in Sri Lanka. Catches of threshers have been recorded in commercial fishery landings from drift gillnet and bottom longline fisheries, though in relatively small numbers compared to other shark species caught in the region (e.g., silky and blue sharks). Landings of threshers have been variable, peaking in 1999 and 2003 at approximately 2,000 mt and show a slight decline in 2004, with no data available since (Hasarangi et al., 2012). Thresher shark landings have declined in recent years when compared to the catches reported in previous years. The decline in thresher landings is reportedly a result of regulations that Sri Lanka gazetted in July 2012 to ban all thresher sharks in accordance with IOTC resolutions (Hasarangi et al., 2012).

<u>Indian Ocean Summary</u>
Overall, it appears that thresher sharks are heavily utilized in the Indian Ocean basin as a result of both direct and indirect fishing pressure, given they comprise an estimated 16% of the total shark catch. Hooking mortality is apparently high for thresher sharks in this region, and thus the population is likely significantly affected by bycatch-related mortality. In addition, thresher sharks may be targeted for their fins in this region, as they comprised 15% of fins in Indonesian fish markets, with bigeye and common thresher sharks representing 7.6% and 0% of the fins, respectively. Historical research data shows overall decline both in CPUE and mean weight of thresher sharks in the Indian Ocean (Romanov pers. comm. cited in IOTC 2013). Additionally, the fisheries in this region typically take bigeye thresher sharks between 140–210 cm FL or 40 to 120 kg (Romanov pers. comm. cited in IOTC 2013), which is below the average age of maturity for the species.

Recreational Fisheries
Historically, species-specific landings data from recreational fisheries is lacking for sharks. However, while recreational fisheries for pelagic sharks are not documented in most countries, some information exists in records from fishing clubs, cooperative tagging programs, and the

International Game Fish Association (IGFA). Countries with the most significant pelagic shark recreational fisheries include the U.S., Australia, New Zealand, and the U.K. Thresher sharks are among the most common pelagic shark species caught (Babcock, 2008). As of 2008, the 44 thresher shark records were widely distributed, including several in Italy, South Africa, the U.K., and the U.S. Pacific, as well as Australia, New Zealand, and the U.S. Atlantic. Thresher sharks, particularly common threshers, are prized game fish because of their fighting ability, and are targeted in several recreational fisheries throughout their ranges, including in the U.S. and Australia, and the Mediterranean (primarily off the Italian coast). They are also occasionally caught in South Africa and New Zealand. Common thresher sharks caught are generally landed as their meat is considered desirable for human consumption (Compagno, 2001), although catch and release angling practices are increasingly used. In contrast, bigeye thresher meat has a mushy texture; therefore, their meat is not necessarily favored for consumption.

PACIFIC

United States

Recreational landings of sharks are an important component of HMS fisheries. Recreational shark fishing with rod and reel is a popular sport at every social and economic level. Depending upon the species, sharks can be caught virtually anywhere in salt water. Recreational shark fisheries often occur in nearshore waters accessible to private vessels and charter/headboats; however, shore-based and offshore fishing also occur. The following sections describe recreational fisheries occurring on the Pacific and Atlantic coasts of the United States.

On the West Coast of the U.S., recreational fisheries are economically, socially, and culturally important. For example, roughly 1.6 million anglers took part in an estimated 7.4 million fishing trips on the West Coast in 2012 alone. These anglers made over $1.8 billion in fishing trip and equipment expenditures, which supported over 18,800 jobs and approximately $2.5 billion in sales. In California, recreational anglers take the entire suite of management unit species (MUS) included within the HMS FMP using rod-and-reel gear, almost exclusively. In Oregon and Washington, anglers only occasionally take HMS species other than albacore, such as blue sharks (PFMC, 2015). Thresher sharks have long been a desired species for recreational fishers, and considered a prized fighting fish. Generally, common threshers appear to be more important in recreational fisheries than bigeye threshers; thus, the following description is mainly focused on recreational fisheries for common threshers. Table 10 below provides a summary of recreational landings of common thresher sharks on the West Coast (California, Oregon, and Washington).

Table 10. Catches of *A. vulpinus* (in numbers of fish) for the West Coast recreational private sport fishing fleet, 2002-2013 (Source: PFMC 2015).

2002	**2003**	**04**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
1,600	2,000	4,500	300	500	700	800	1,100	700	1,000	400	2,000

In particular, the common thresher shark is the focus of a popular southern California recreational fishery that targets individuals using multiple fishing gears and techniques. Recreational thresher shark catches are highest from May through August for both kept and released fish, which overlaps with the springtime pupping season. Most recreationally-caught thresher sharks are taken by private/rental boats and many recreational fishers release their catch. Catch estimates for common thresher sharks in the California recreational fishery are shown below in Figure 51.

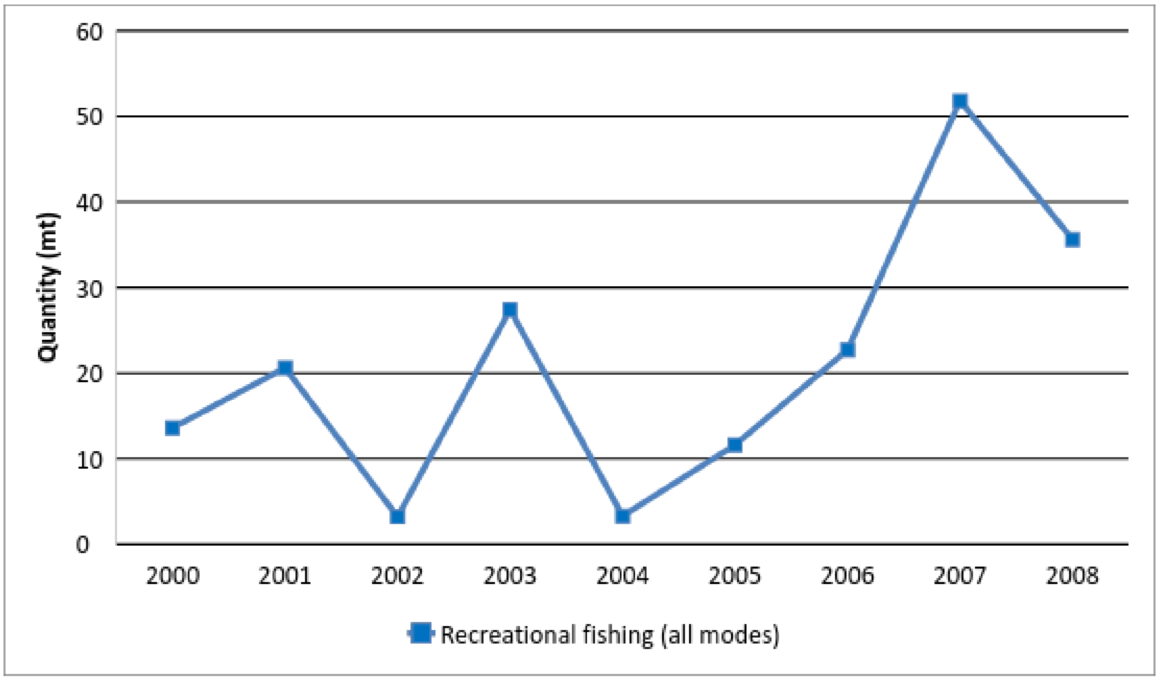

Figure 51. Catch Estimates (metric tons) for common thresher shark (*A. vulpinus*) harvested by California recreational fisheries for the period 2000–2008 (Source: California Department of Fish and Game 2009).

According to the California Department of Fish and Game (CDFG) recreational catch varies widely from year to year, but has averaged roughly 20 mt annually in recent years (CDFG, 2008). The estimated level of catch in this fishery may be imprecise because the fishery is patchy and sporadic. From 2004 to 2007, recreational catches of common thresher shark increased substantially due to the sport fishing public becoming more educated on how to target them, and increasing use of internet websites to disseminate information on fishing areas and thresher shark occurrence. This prompted some concerns regarding whether the annual harvest guideline of 340 t for both commercial and recreational fisheries might be exceeded, and that the majority of this catch was occurring during the spring thresher shark pupping season. Further, it appeared that many of the fish caught were pregnant females. However, upon closer examination of California Recreational Fishery Survey (CRFS) data, estimates of recreational thresher catch were not causing cumulative landings to exceed the harvest guideline (see Figure 52 below) (CDFG, 2009). It should be noted that data collected by the CRFS are scarce for sharks, and may not adequately represent shark catch and effort.

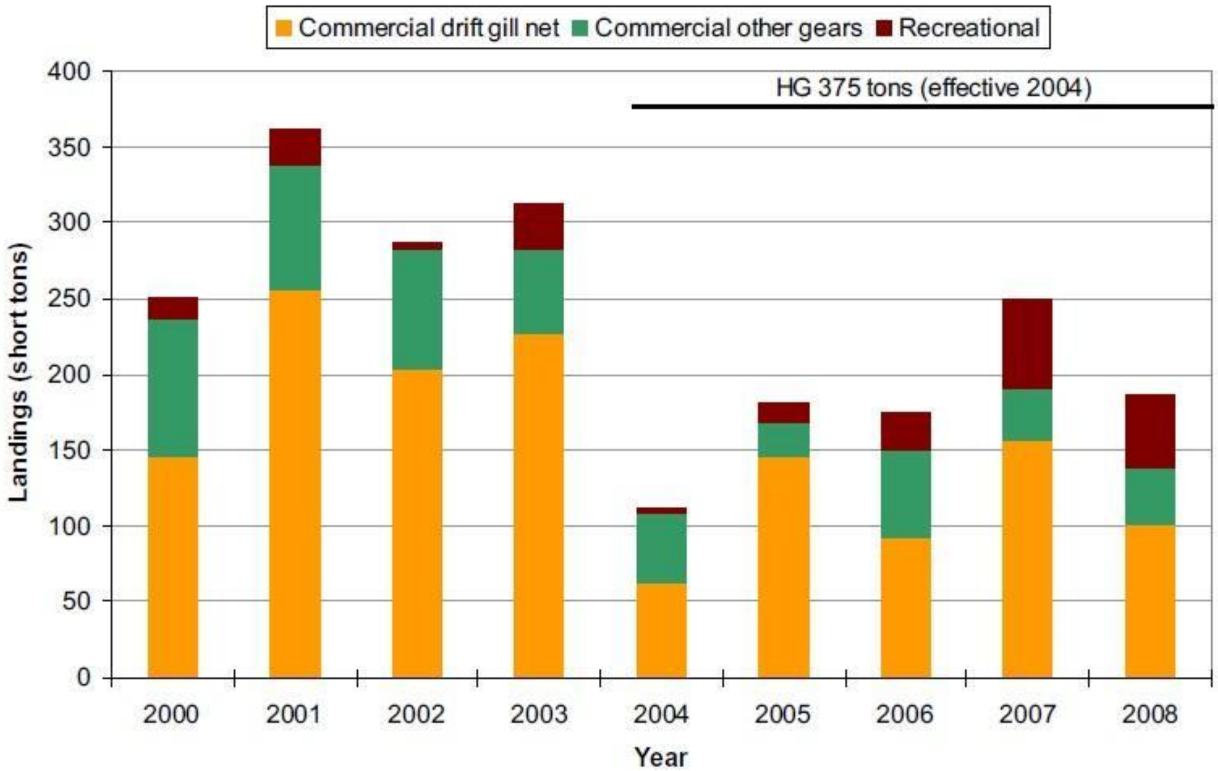

Figure 52. California landings of common thresher shark (*A. vulpinus*) by commercial gear type and by the recreational fishery compared to the harvest guideline adopted in 2004. Notes: Commercial landings are from CFIS converted from pounds to round weight in metric tons, recreational landings are reported in Marine Recreational Fisheries Statistics Survey (all modes) from 2000 to 2003, and California Recreational Fishery Survey (all modes), 2004-08 (Source: CDGF 2009).

Heberer (2010) identified the potential negative impact of recreational fishing on the survival of the common thresher shark by assessing post-release survivorship of sharks captured using the caudal-fin-based techniques used by most recreational fishers in southern California. Since common thresher sharks use their elongate upper caudal lobe to immobilize prey before it is consumed, the majority of thresher sharks captured in the recreational fishery is hooked in the caudal fin and hauled-in backwards (Heberer et al., 2010). The common thresher is an obligate ram ventilator, which means it requires forward motion to ventilate the gills (Heberer et al., 2010), thus, the reduced ability to extract oxygen from the water during capture as well as the stress induced from these capture methods may influence recovery following release. The findings of Heberer (2010) demonstrate that common threshers experience a heightened stress response when hooked, which may contribute to an increased mortality rate. In fact, results from Heberer (2010) revealed that large tail-hooked common thresher sharks with prolonged fight times (≥85 min) experienced 100% mortality. This work suggests, especially for larger thresher sharks, that recreational catch-and-release may not be an effective conservation-based strategy for the species. A recent paper by Sepulveda (2015) found similar evidence for high post-release mortality of recreationally caught common thresher sharks in the California recreational shark fishery. Their results demonstrated that caudal-fin-based angling techniques, which often result in trailing gear left embedded in the shark, can negatively affect post-release survivorship. For example, out of nine common thresher sharks released with trailing gear left embedded, six sharks died within 5 days after release, one died after 81 days, and two sharks survived the deployment period for an overall survivorship rate of 22%. In contrast, all seven mouth-hooked common thresher sharks survived the acute (~10 days) effects of capture for an overall survivorship rate of 100%. This work suggests that mouth-based angling techniques can, when performed properly, result in a higher survivorship of released sharks. However, these techniques are not a common practice in California (Sepulveda et al., 2015).

Although common threshers comprise an important aspect of the recreational fishery in southern California, it is not known whether bigeye threshers enter the California recreational fishery on any regular basis, but presumably only few are taken. Further, there are no records of bigeye threshers from the recreational fishery off Oregon or Washington (NMFS, 2007), and in fact, a strict prohibition on recreational fishing of all thresher species was implemented in Washington State in 2013. Farther west in Hawaii, there were no catch records of bigeye thresher in the Hawaii recreational survey from 2003-2014 (Pers. comm. with NMFS Fisheries Statistics Division, October 14, 2015).

ATLANTIC

United States

The recreational landings database for Atlantic HMS consists of information obtained through surveys including the Marine Recreational Information Program (MRIP), Large Pelagics Survey (LPS), Southeast Headboat Survey (HBS), Texas Headboat Survey, Recreational Billfish Survey (RBS) tournament data, and the HMS Recreational Reporting Program (non-tournament swordfish, billfish, and bluefin tuna). Table 11 below provides a summary of recreational landings of common thresher sharks in the Atlantic and Gulf of Mexico.

Table 11. Estimated recreational harvest of *A. vulpinus* in the Northwest Atlantic and Gulf of Mexico, in number of fish, from 2002-2013. (Source: NMFS (2012); NMFS (2014)).

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1,467	0	0	1,504	12,171	4,822	798	3,422	214	0	0	0

In the U.S. Northwest Atlantic, a survey was conducted to determine target HMS species of charter and headboat fishing trips. Regionally, bluefin tuna (73%) were the primary target species followed by pelagic sharks (42%) (i.e., shortfin mako, blue sharks, thresher sharks) (NMFS, 2014). While bigeye threshers are prohibited species and rarely caught (see below for more details), common thresher sharks appear to be increasing in importance at shark tournaments, particularly in the northeastern United States. For example, in June 2015, the first annual Thresher Shark Tournament[5] was held in New York City, with entry of up to 50 boats and cash prizes for heaviest qualifying thresher shark exceeding $5,000. Additionally, common

[5] http://www.thefisherman.com/index.cfm?fuseaction=page.eventdetail&EventID=780

thresher shark numbers increased steadily at one major tournament, such that the percent of total catch increased from 0.1% to 4.8% from 1965 to 1995 and jumped to 27.8% of the total catch in 2004 (Gervelis and Natanson, 2013). In another study, standardized indices of abundance were derived for common thresher sharks using data from recreational shark tournaments in the state of Massachusetts for the years 1991 through 2006. In total, Massachusetts tournaments between 1991 and 2002 recorded a total of 182 common thresher sharks. Overall, common thresher shark CPUEs were low and variable, but appeared to increase in recent years (Babcock and Skomal 2008). Estimated recreational landings of common thresher sharks in the rod and reel fishery from Maine to Virginia are shown in Figure 53 below.

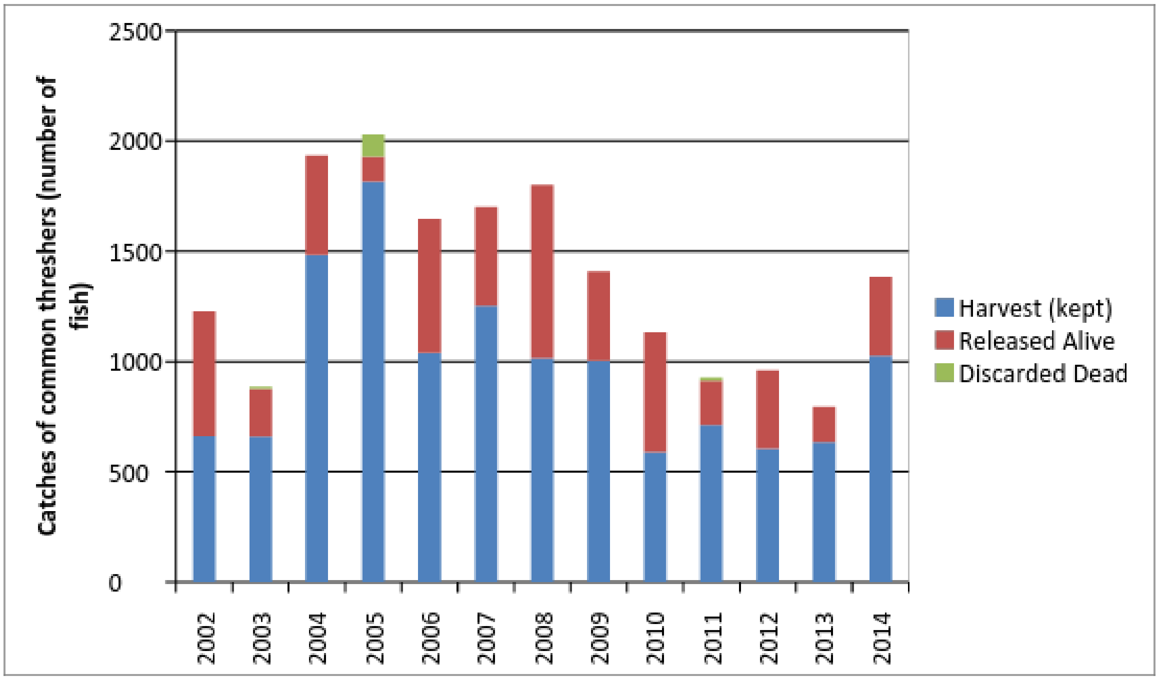

Figure 53. Estimated number of common thresher sharks kept, released, and discarded in the rod and reel fishery (ME-VA, 2004-2013) (Source: NMFS MRIP Data Query; Accessed May 01, 2015).

In total, an estimated 17,834 common thresher sharks were caught in the rod and reef fishery in the Northwest Atlantic from 2002-2014, with approximately 70% retained, and the remaining sharks released alive or discarded dead. Despite an increase in popularity of common thresher sharks in the recreational fishery, recreational catches have decreased by approximately 29% since 2004. Although these data only cover Maine through Virginia, recreational landings of common thresher sharks are extremely rare south of Virginia (Ron Salz, pers. comm., 2015). With most species retained, high post-release mortality rates seen in the southern California recreational fisheries are irrelevant in the Northwest Atlantic. Further, fishing techniques between southern California and the Northwest Atlantic are typically different, resulting in mostly mouth-hooked and higher survivorship of thresher sharks in the Atlantic, compared to mostly tail-hooked thresher sharks and lower survivorship in California (Pers. comm. Ron Salz, 2015).

To provide information on the relative abundance of common thresher sharks in the Northwest Atlantic using recreational fisheries data, the Extinction Risk Analysis team analyzed data collected by the NMFS NEFSC at five recreational fishing tournaments from 1978 through 2014. The tournaments were based out of New York (Bayshore Mako Tournament, Montauk Marine Basin Shark Tag Tournament, and Freeport Hudson Anglers, Inc. Shark Tournament) and New Jersey (Jersey Coast Shark Anglers Invitational Shark Tournament and South Jersey Shark Tournament). A generalized linear model with a Poisson distribution was used to model the tournament count data. Parameters considered as potential covariates affecting the common thresher catch per tournament were year, tournament, number of boats, number of days fished, and area (NY, NJ). Stepwise forward model selection was used to determine which variables to retain in final models based on the Akaike information criterion (AIC) and given a likelihood ratio test between the chosen model and the null model (intercept only) produced a test statistic value close to zero (≤0.01). All models retained "year" in order to develop annual indices of abundance. Residual plots were used to determine the adequacy of model fits. The best fit model for the NEFSC tournament data indicated that common thresher catches were primarily influenced by tournament location and number of days fished, with higher catches in tournaments based out of New York and tournaments that ran for multiple days. The final generalized linear model (common thresher shark catch ~ areas + days fished + tournament) was run using a quassipoisson distribution to account for overdispersion (overdispersion parameter = 2.07). The results show a fairly stable trend in relative abundance through the 1990s. This is followed by an increasing trend through the end of the time series, often with high inter-annual variability that the model could not account for with the available parameters (see Figure 54 below).

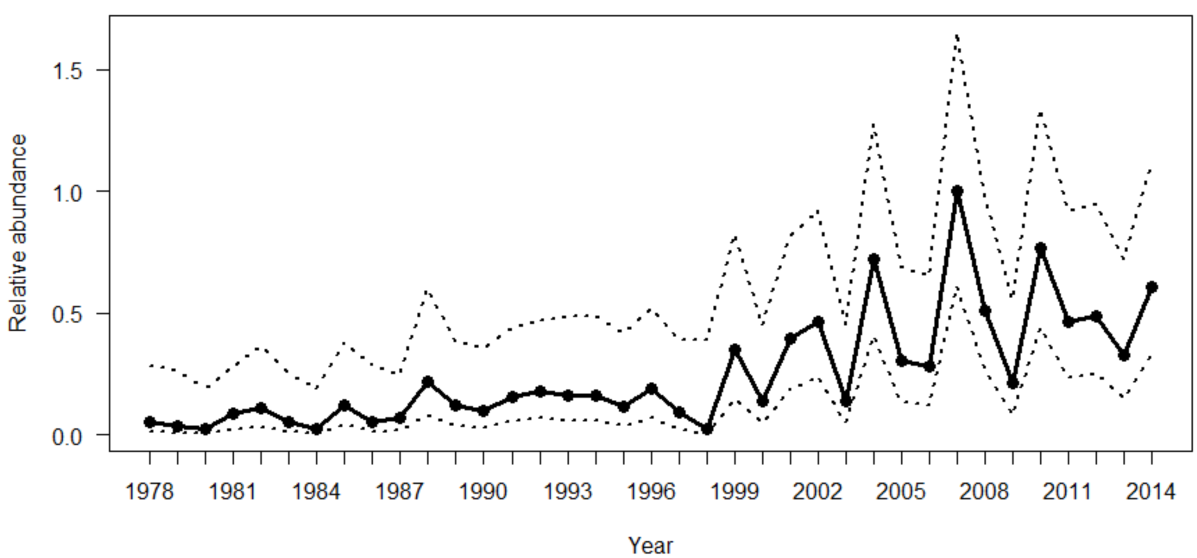

Figure 54. Relative abundance estimates divided by the maximum value for all years combined and 95% confidence interval for common thresher sharks caught during recreational tournaments in the western North Atlantic (Source: NMFS, unpublished data).

Bigeye threshers have been prohibited in Atlantic recreational fisheries by Federal regulations since 1999. Further, U.S. states from Maine to Florida have adopted the Interstate Fisheries Management Plan (FMP) for Atlantic Coastal Sharks adopted by the Atlantic States Marine Fisheries Commission (ASMFC), which prohibits recreational fishing of bigeye threshers. In general, data are extremely sparse for this species in U.S. recreational fisheries. Since prohibition of this species was implemented in 1999, there has been no observed recreational harvest of this species, with the exception of years 2002 and 2006, in which expanded survey estimates (which are highly unreliable due to large associated variances) estimated that 65 and 42 bigeye thresher sharks were caught and harvested, respectively (NMFS, 2012, NMFS, 2014). In fact, in most years of recreational data, dating back to 1981 and combining information from the LPS and general MRIP survey, bigeye threshers are typically not observed, with only five years showing bigeye threshers either landed or released alive throughout the Northwest Atlantic and Gulf of Mexico (Pers. comm. from the National Marine Fisheries Service, Fisheries Statistics Division October 14, 2015).

International

Recreational fishing is extremely popular in Australia. Historically, there has been a paucity of recreational fishing surveys in Australia, thus there is little documentation of recreational fishing effort and catch prior to the 1970s. In Victoria, there is a small but highly prized recreational fishery for thresher sharks. Thresher sharks are one of the premier game fish species in the State, providing considerable socioeconomic benefits to regional locations from Portland to Mallacoota. Although the world record[6] for recreational catch of common thresher is from New Zealand, thresher sharks are recognized as “bycatch gamefish” (i.e., they are not necessarily a targeted gamefish in New Zealand, but are rather caught secondarily in pursuit of other gamefish such as tuna and marlin, and other shark species such as makos and hammerheads) (New Zealand Fisheries, 2015). Recently, sport fishing has increased markedly in the Mediterranean region, mainly off the Italian coast, but also off Spain and France (Bianchi et al. 1997 cited in Goldman (2005)). Threshers are considered a target species, along with blue sharks, with catches primarily composed of young individuals, and sometimes even newborn specimens (Goldman, 2005).

Although recreational catch rate data are largely unavailable or highly unreliable, evidence for high post-release mortality of tail-hooked threshers suggests that increases in recreational fishing may pose a threat to the common thresher shark. However, given that this fishing technique is more prevalent on the U.S. West Coast (i.e., California), where recreational removals are sustainable, impacts of recreational catches on the global population abundance of common thresher shark remains unclear. There is also no information regarding the impact of recreational fishing on the global population of bigeye thresher.

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

[6] http://wrec.igfa.org/WRecordsList.aspx?lc=AllTackle&cn=Shark,%20thresher

due to the increasing demand for shark fin soup (Biery and Pauly, 2012); however, more recently, it appears that there has been a major surge in the meat trade in the last decade (Dent and Clarke 2015). 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). Shark fins fetch a high price of up to 1,000€ ($1,068) per fin or 80€ ($85) per bowl of shark fin soup; conversely, shark meat sells for considerably less, approximately 10 €/kilo ($10.68) for meat compared to 500 €/kilo ($534) for fins (Miller et al. 2014). Because of this stark difference in price, the practice of "finning," the act of removing fins at sea and discarding the remainder of the shark carcass, has been practiced historically both legally and illegally worldwide in order to feed the demand for valuable fins. Additionally, finning enables vessels to store fins more efficiently than if they were to retain entire carcasses, which allows for profit maximization (Biery and Pauly 2012).

Shark finning makes catch monitoring difficult because shark bodies are not present 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) (Clarke et al., 2006b). 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 (Jacquet et al., 2008). 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).

In order to determine the species composition of the shark fin trade, Clarke et al. (2006a) also 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 thresher sharks (all three *Alopias* spp.), represent approximately 2.3% of the Hong Kong shark fin market. The actual proportion in trade is also likely to be slightly higher given the discovery of thresher fins, albeit at low frequency, in other market categories than the one category (*wu gu*) used for threshers. This level of thresher shark fins in the trade translates to an annual estimate of up to 4 million individuals killed and traded per year (95% probability interval (PI): 2-4 million) (Clarke et al., 2006b). While the relative proportion of each thresher shark species comprising the shark fin trade is not available in this genus-level assessment, genetic testing conducted in various fish markets provides some insight into the species-specific prevalence of threshers in the shark fin trade. As previously described, genetic sampling was conducted on shark fins collected from several fish markets throughout Indonesia and revealed that five species represented more than 50% of the total fins sampled (n= 582). Within the top five species, the pelagic thresher and bigeye thresher collectively represented nearly 15% of the total fins sampled, with bigeye comprising 7.6% of the fins tested; however, the common thresher was not detected in these samples (Sembiring et al., 2015). In a genetic barcoding study of shark fins from markets in Taiwan, bigeye threshers were 1 of 20 species identified and comprised 0.07% of collected fin samples. In another genetic barcoding study of fins from United Arab Emirates, the fourth largest exporter in the world of raw dried shark fins to Hong Kong, the authors found that the Alopiidae family represented 5.9% of the trade from Dubai, with bigeye thresher comprising 2.31% (Jabado et al., 2015). Again, common threshers were not detected in the fin samples. Although it is uncertain whether these studies are representative of the entire market within each respective country, results of these genetic tests provide limited information that suggests the common thresher may not be as utilized in the fin trade as its congeners, *A. pelagicus* and *A. superciliosus*.

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. In this period, China, Hong Kong SAR recorded average annual shark fin imports of 10,490 t, worth $302 million, representing about 80% of the global total in value terms (62% of total volume). In 2012, 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 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. Overall, the trade in shark fins through China, Hong Kong 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. A number of factors 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.

Various indicators suggest that the shark fin trade through China, Hong Kong SAR and China will continue to contract. The shark fin trade as a whole has declined since 2003 (see Figure 55 below), and is contrary to expectations that there would have been an increase in demand with the continued expansion of the Chinese economy. The pattern of trade decline closely matches the pattern in chondrichthyan capture production and thus suggests a strong link between the quantity harvested and the quantity traded. However, a government-led backlash against conspicuous consumption in China, combined with global conservation momentum, appears to have had some impact on traded volumes (Eriksson and Clarke, 2015).

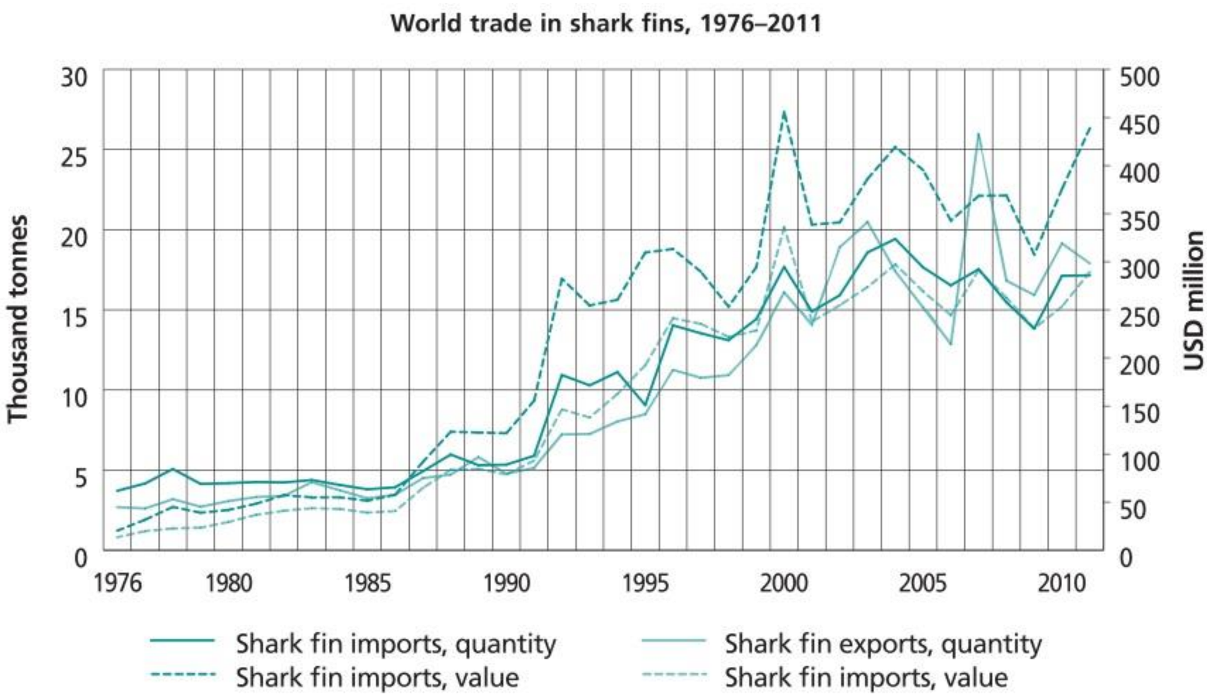

Figure 55. The trend in the global trade in shark fins from 1976to 2011 (Source: Dent and Clarke 2015).

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 56 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).

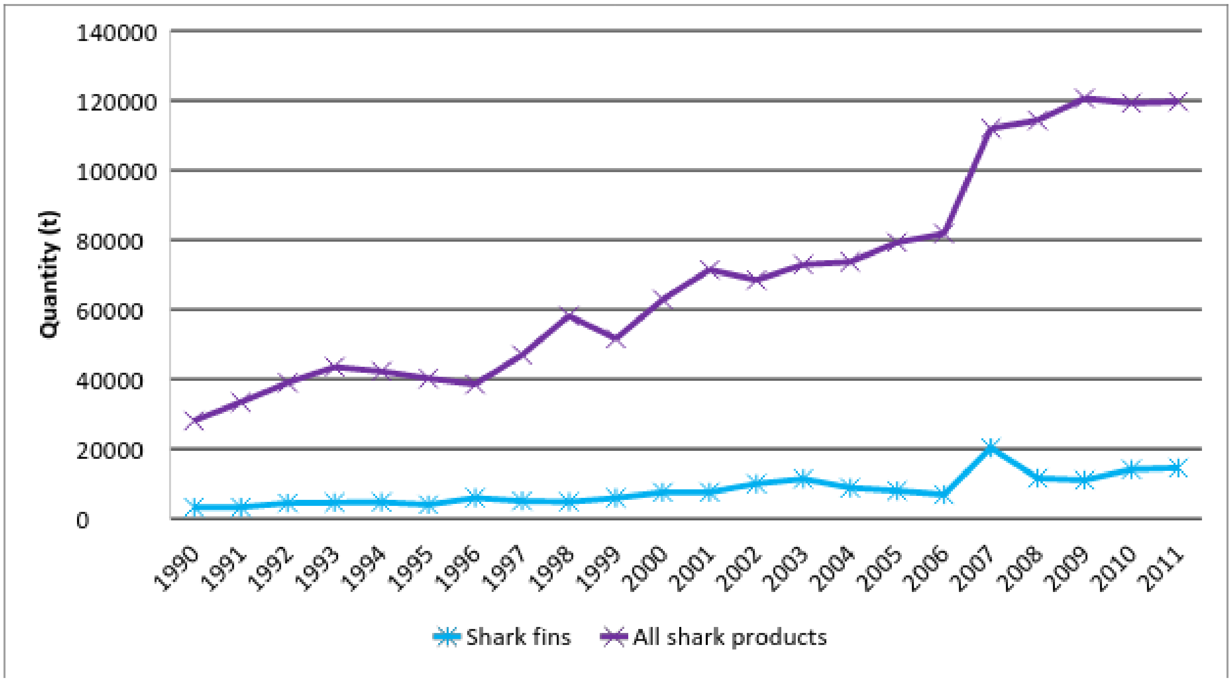

Figure 56. Global exports of shark products from 1990-2011, as reported in the FAO Fishery Commodities and Trade Database. Shark fins include: shark fins dried, salted; shark fins dried, unsalted; shark fins in brine but not dried or smoked; shark fins frozen; and shark fins prepared or preserved. Shark 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).

Additionally, in a recent report from WildAid, Whitcraft et al. (2014) reported the following regarding the declining demand for shark fins:

- 82% decline in sales reported by shark fin vendors in Guangzhou, China and a decrease in prices (47% retail and 57% wholesale) over the past two years;
- 85% of Chinese consumers surveyed online said they gave up shark fin soup within the past three years, and two-thirds of these respondents cited awareness campaigns as a reason for ending their shark fin consumption. The second and third most popular reasons given were that they "want to protect sharks" and that it is "cruel the way they kill sharks" – key messages of WildAid's public awareness campaign. The government banquet ban was cited as a reason by 28.2% of survey respondents;
- 43% of consumers responded that much of the shark fin in the market is fake;
- 24 airlines, 3 shipping lines, and 5 hotel groups have banned shark fin from their operations;
- There has been an 80% decline in prices paid to fishermen from 2007 levels in Tanjung Luar and Lombok in Indonesia and a decline of 19% since 2002-2003 in Central Maluku, Southeastern Maluku and East Nusa Tenggara; and
- Of 20 Beijing restaurant representatives interviewed, 19 reported a significant decline in shark fin consumption.

Overall, it is clear that the shark fin trade is asserting pressure on thresher sharks; however, the magnitude of impact specifically on the global population abundance of common thresher sharks is unclear, while the magnitude of impact to the global abundance of the bigeye thresher may be more significant, but also uncertain. The global trade in shark fins appears to have decreased slightly since the early 2000s; however, as a caveat to this decline, global trade data show the trade in shark meat expanding steadily over the last decade or so. In fact, the latest official FAO figure of chondrichthyan meat imported in 2011 (121,641 t worth $379.8 million) represents 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 sufficiently high such that, even if demand for shark fins declines, existing fishing pressure will not (Dent and Clarke, 2015). However, thresher sharks are not identified as "preferred" or "first choice" species for fins, with some traders considering thresher fins to be of low quality (FAO, 2002, Rose, 1996). Further, since thresher sharks have always been fully utilized for both their meat and fins, it is unlikely that new or increasing demand would develop for these species. This is particularly true for the bigeye thresher, given its meat is considered to be of lower quality (Vannuccini, 1999).

Summary

Commercial Fisheries

Based on best available scientific and commercial information, it appears that both common and bigeye thresher sharks have experienced declines throughout a large portion of their ranges due to pressures from commercial fisheries (e.g., Eastern Pacific, Northwest and Southwest Atlantic, Northeast Atlantic and Mediterranean). However, some populations appear to have stabilized or are slowly re-building (or have likely rebuilt), while others are likely declining or their status is unknown. All stocks of common and bigeye thresher sharks 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 (common thresher shark along the west coast of North America) due to the general lack of stock assessments on thresher sharks.

In the Eastern Pacific, the stock of common thresher shark along the west coast of North America (including Canada, Mexico, and the U.S.) serves as a well-documented case of marked population decline of a small, local population over a short time period (approximately a decade), after the development of the California swordfish/shark drift gillnet fishery. However, recent stock assessment results indicate this population has gradually rebuilt over several decades as a result of various management measures, and is not currently overutilized. Additionally, the common thresher is reportedly the 6^{th} most important commercial species in Peru but genetic analysis of fins indicate that these were not common thresher sharks. However, there is likely another stock of common thresher shark in Chilean coastal waters that are exploited by fisheries there but information on the catches is scarce. Overall, the magnitude of impact of commercial fisheries on common thresher sharks in the Eastern Pacific, other than the stock in North American waters, is uncertain. Limited information is available for bigeye threshers in the

Eastern Pacific Ocean; however, they co-occur in the California-based gillnet fishery for common threshers, and represent approximately 9% of the thresher catch.

In the Northwest Atlantic, several studies indicate large declines in combined common and bigeye thresher shark abundance (e.g., between 63-80% from 1996-2005); but, recent analyses by the Extinction Risk Analysis team indicate these populations have likely stabilized in recent years. However, fishing pressure on thresher sharks began over two decades prior to the start of this time series; thus the estimated declines are not from virgin biomass. There is still disagreement in the literature regarding the current status of thresher sharks in the U.S. Atlantic, and a stock assessment has not been conducted. However, the best available scientific information indicates that while population declines have occurred in this region in the past, populations of common and bigeye thresher sharks have likely stabilized in recent years.

In the Mediterranean, one study showed large declines (potentially up to 99%) of common thresher sharks. Common thresher sharks are reportedly taken in large quantities in various fisheries and have declined in both abundance and biomass. These data suggest that both annual catches and mean weights of common thresher shark have fallen as a result of fishing mortality. Illegal fishing operations are also thought to be targeting common threshers in this region, and fishing pressure is reportedly high on neonates and juveniles. Thus, due to the high level of continued fishing pressure and reported declines throughout the Mediterranean, it is likely that common thresher sharks are experiencing overutilization in this region. However, occurrence of bigeye thresher in this region is considered scarce or rare, and it is unknown at this time whether this is due to population declines as a result of fishing mortality, or because this species is naturally rare in this region. Nevertheless, fishing pressure continues to be high and is likely affecting the Northeast Atlantic populations of common and bigeye thresher sharks.

In the South Atlantic, encounters with common thresher sharks are relatively rare; for example, they exhibited the lowest CPUE rates among thresher species from Uruguayan fisheries. Thus, due to their natural rarity in this region, it is unclear if pressures from these commercial fisheries are impacting the status of these common thresher sharks. In contrast, bigeye threshers are commonly taken as bycatch in the South Atlantic in various longline fisheries, and represent almost 100% of thresher shark catch in Brazilian longline fisheries. Bigeye threshers have shown a gradual decline in CPUE in the Brazilian longline fishery, likely a result of fishing mortality as they exhibit high discard mortality rates in this region, ranging from 49-59%. Bigeye threshers disappeared from catch records in 2006, although this was likely a result of a shift in fishing effort to more temperate latitudes where bigeye threshers are less common.

In the Western and Central Pacific, some species-specific catch and abundance data are available for thresher sharks. Historical observations characterized common threshers in this region as "uncommon" and despite high fishing effort on large pelagic species in this region, with reported increases in recent years, common thresher sharks are rarely encountered in this region as a whole, with the exception of more temperate waters off Australia and New Zealand. Some ecological risk studies conducted in Australia indicate that common thresher sharks may be at a risk of overutilization as a result of pressures from various commercial fisheries. That said, the majority of information from catch data from the Western and Central Pacific region suggests common threshers are relatively rare in tropical fisheries of this region, likely due to their distribution in more temperate waters. However, there is a paucity of species-specific catch information, prevalence of misidentification between species, and available catch records are typically aggregated at the genus level for all thresher species. It is therefore unclear whether overutilization of common thresher shark is occurring in the Western and Central Pacific Ocean. In contrast, the bigeye thresher is the dominant thresher species encountered in fisheries in this region and studies of longline CPUE in the area suggest a decline in recent years as well as decreasing size trends, which likely indicate some level of population decline in this area. In contrast, standardized CPUE data from Hawaii show stable and increasing trends for bigeye thresher sharks. Thresher sharks as a genus were given a “medium ecological risk” rating for the Western and Central Pacific as a whole, but overall, more information is necessary to determine the status of common and bigeye thresher sharks in this region and whether overutilization is a threat contributing significantly to the extinction risk of the species.

In the Indian Ocean, common and bigeye thresher sharks have been recorded in fisheries data for over 60 years; however, due to a lack of catch and abundance information, the status of thresher sharks in the Indian Ocean is unknown. While decreases in nominal CPUE and mean weight of individuals have been demonstrated for major pelagic shark taxa, species-specific information for *A. vulpinus* and *A. superciliosus* is largely unavailable. One study from the Indian Ocean detected declines in shark CPUE that may be indicative of trends for common and bigeye threshers; however, this study was not species-specific. Overall, catch rates of thresher sharks are notably high in this region with no indication of fishing pressure ceasing in the foreseeable future; thus, given the prevalence of thresher sharks as bycatch in fisheries in this region, representing approximately 16% of the total shark catch, and their high mortality rate as a result, it is likely that the impact to thresher sharks is significant in the Indian Ocean.

Recreational Fisheries
Thresher sharks are prized gamefish in recreational fisheries due to their large size and fighting ability. As obligate ram-ventilators, common threshers in southern California recreational fisheries have exhibited a heightened stress response when tail-hooked, and increased mortality rates if fight times last ≥85 minutes. As a result, while some fishers may practice catch-and-release methods, these methods may not be an effective conservation-based strategy for the species unless fishing strategies change. However, while recreational catches of common thresher have increased in recent years in California, survey data indicate that the level of recreational catch is not causing cumulative catches (i.e., recreational + commercial) to exceed the annual harvest guideline. Additionally, a recent stock assessment for Eastern North Pacific threshers, including removals via recreational fisheries, shows that overfishing is not occurring and current fishing pressure is sustainable. In the Northwest Atlantic, recreational catches of common thresher appear to have declined by approximately 29% in the U.S. Northeast rod and reel fishery since 2004. However, relative abundance of common threshers appears to be increasing based on recreational tournament data. Due to differences in fishing techniques, it is unlikely that thresher sharks exhibit the same high mortality rates on the U.S. East Coast as seen on the U.S. West Coast where threshers are predominantly hooked and reeled in backwards by

their tail. Finally, while common threshers are also popular in recreational fisheries outside the U.S., like Australia and New Zealand, information on international recreational catches of common thresher sharks is unavailable. Thus, it is unclear whether the level of recreational catches of common thresher sharks is contributing to overutilization of the species in this portion of its range. Bigeye thresher sharks have been prohibited in Atlantic recreational fisheries since 1999. Bigeye thresher occurrence in the southern California recreational fishery is thought to be only occasional, with no records of bigeye thresher catches from Washington State or Oregon. Likewise, records of bigeye thresher in U.S. Atlantic recreational fisheries are exceedingly sparse, with few records since 1981 from the LPS and MRIP survey data. Finally, there is virtually no information regarding recreational fishery data for bigeye thresher outside of the United States.

Shark trade

Studies found that thresher sharks (all three *Alopias* spp.), represent approximately 2.3% of the Hong Kong shark-fin market, which has been used as in indicator of the global trade. This level of thresher shark fins in the trade translates to an annual estimate of up to 4 million individuals killed and traded per year. However, the relative proportion of each thresher shark species comprising the shark fin trade is not available in this genus-level assessment, thus the actual percentage of each thresher shark species utilized in the shark fin trade is unknown. While genetic studies of fins from markets in Indonesia, Taiwan, Peru, and United Arab Emirates recorded bigeye and pelagic threshers at the species level, none of these studies recorded common threshers. Thus, while it is clear that the shark fin trade is asserting pressure on thresher sharks in general, and bigeye threshers appear more prevalent in the trade than common threshers, the magnitude of impact on the global population abundance of common and bigeye thresher sharks is uncertain. However, demand for shark fins is seemingly on a decline in recent years, and although demand for shark meat has increased in recent years, it unlikely that this shift in the market will have any significant impact on thresher sharks.

4.3 (C) Disease or Predation

Disease

Disease is not thought to be a factor influencing the status of common and bigeye thresher sharks. Both thresher shark species harbor some parasites, though records are sparse throughout their range. A comprehensive host-parasite list compiled from the U.S. West Coast (California, Oregon, and Washington) indicated that *A. vulpinus* hosts 13 parasitic copepods and 10 parasitic cestodes (Love and Moser, 1983) in the region. Records from Chile documented *Crossobothrium angustum*, a cestode (a class of parasitic flatworm) in *A. vulpinus* (Carvajal, 1974). Additionally, nine species of copepods, genus *Nemesis*, parasitize thresher sharks. These parasites attach themselves to gill filaments, and can cause tissue damage. This damage to the gill filaments can impair respiration in the segments of the gills (Benz and Adamson, 1999). The known parasite fauna of the bigeye thresher and associated references are reviewed in Gruber and Compagno (1981) as follows: The bigeye thresher has been documented with gut cestodes and external copepods. Tapeworms of the order *Litoborthridea* were found in massive infections of the spiral valve of two bigeye threshers collected in southern California (Dailey, 1969). Kurochkin and

Slankis (1973) further described *L. daileyi* and *Renyxa amplifica* from the spiral valve of bigeye threshers also from the Pacific Ocean. Finally, Heinz and Dailey (1974) reported two cestodes from the stomach of the bigeye thresher: *Sphyriocephalus viridis* and *S. pelorosoma*. The only other parasites reported from the bigeye thresher were two species of copepods: *Pagina tunica* and *Bariaka alopiae. Pagina tunica* was removed from the body surface while *B. alopiae* was taken from the gills (Cressey, 1964, Cressey, 1966). The type-specimen of *B. alopiae* was collected from bigeye threshers captured off Madagascar and South America at stations separated by almost 20,000 km. Because of this great distance, Cressey speculated that *B. alopiae* has a specific affinity for the bigeye thresher. If the common and bigeye threshers are similar to other shark species, they likely harbor a diverse assemblage of macroparasites including cestodes, nematodes, leeches, copepods, and amphipods; however, the magnitude of impact these parasites may have on the health of these thresher shark species is unknown.

Predation

Predation is also not thought to be a factor influencing the status of common or bigeye thresher sharks. The most significant predator on thresher sharks is likely humans; however, a study from New Zealand documented predation of *A. vulpinus* by killer whales (Visser, 2005). In a 12-year period that documented 108 encounters with New Zealand killer whales, only 3 individuals of *A. vulpinus* were taken; thus, predation on *A. vulpinus* by killer whales is likely opportunistic and not a contributing factor to abundance levels of common threshers. It is likely that juvenile common thresher sharks experience predation by adult sharks; as a result, juveniles spend approximately the first three years of life in nursery areas until they attain a large enough size to avoid predation. The rate of juvenile predation and the subsequent impact to the status of common thresher sharks is unknown; however, because thresher sharks are born alive, and are already about 150 cm TL at birth, predation upon juvenile threshers is likely to be minimal (Calliet and Bedford, 1983). There is also currently no information on the predation of bigeye thresher sharks; however, they may be preyed upon by makos, white sharks, and killer whales.

4.4 (D) Inadequacy of Existing Regulatory Mechanisms

Existing regulatory mechanisms for thresher sharks include federal, state, and international regulations. Below is a description and evaluation of current domestic and international management measures that may affect common and bigeye thresher sharks. Though there are numerous regulatory mechanisms that may impact the status of sharks in general, as well as common and bigeye threshers specifically, given the lack of data reporting on thresher catches, as well as the lack of information on implementation of and compliance with management measures in most countries, it is difficult to measure the adequacy of current regulatory mechanisms as they relate to the global population of common and bigeye thresher sharks. Both thresher shark species in this review (*A. vulpinus* and *A. superciliosus*) are highly migratory species found worldwide and thus require protections in every ocean basin through international cooperation. Below is an analysis of existing international regulatory mechanisms.

United States

There are a number of management authorities governing U.S. Fisheries, including the Magnuson-Stevens Act, 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 Magnuson-Stevens Act 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 Magnuson-Stevens Act 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 ASMFC, which regulates fisheries in state waters from Maine to Florida, implemented a Coastal Shark FMP that mostly mirrors the federal regulations for sharks (Tables 12 and 13 below). 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 (Eastern and Western & Central)

Commercial fisheries

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). The PFMC's area of jurisdiction is the EEZ off the coasts of California, Oregon, and Washington. Prior to the development of a West Coast-based FMP for HMS, the fisheries were managed by the States of Washington, Oregon and California, although some federal laws also applied. In late October 2002, the PFMC adopted its FMP for U.S. West Coast Highly Migratory Species (HMS) Fisheries (FMP). This FMP’s management area also covers adjacent high seas waters for fishing activity under the jurisdiction of the HMS FMP. The final rule implementing the HMS FMP was published in the Federal Register on April 7, 2004 (69 FR 18443). Since its implementation, this FMP has been amended twice, once in 2007, and again 2011.

The California swordfish/shark drift gillnet fishery secondarily targets common thresher sharks and is an authorized fishery under the Federal List of Fisheries. Authorized commercial gear types include: harpoon, surface hook and line, drift gillnet (14 inch stretched mesh or greater), purse seine, and pelagic longline. This FMP manages several sharks as part of the management unit including both common and bigeye thresher sharks. Because common threshers are considered vulnerable to overexploitation due to their low fecundity, long gestation periods, and relatively high age at maturation, the FMP proposed precautionary annual harvest guidelines for common thresher sharks to prevent localized depletion, which could take decades to correct given the biological characteristics of the species (NMFS, 2004). A harvest guideline is a numerical harvest level that is a general objective that, if reached, will initiate a review of the species according to provisions in the HMS FMP and in consideration of PFMC recommendations. An annual precautionary harvest guideline of 340 mt was established by the HMS FMP final rule in 2004. This FMP allows incidental commercial landings of HMS, within limits, for non-HMS gear such as bottom longline, trawl, pot gear, small mesh drift gillnet, set/trammel gillnets, and others. Small mesh gillnetters and set net gillnetters would not be permitted to land swordfish (as currently required under California law), but would be permitted to land other HMS, with the restriction of 10 fish per landing of each non-swordfish highly migratory species. For the bottom longline (set line) fishery, landings would be restricted to 3 HMS sharks in total or 20% of total landings by weight of HMS sharks, whichever is greater by weight. For trawl, pot gear, and other non-HMS gear, a maximum of 1% of total weight per landing for all HMS shark species combined would be allowed (i.e., blue shark; shortfin mako shark; and bigeye, pelagic, and common thresher sharks) or two HMS sharks, whichever is greater. This discourages targeting of HMS with non-HMS gears by limiting the allowed landings and reduces wastage of HMS by still allowing traditional levels of incidental catch by those gears. Specific measures have been implemented for the California drift gillnet fishery to protect common thresher sharks. The drift gillnet fishery is managed by a limited entry permit system, with mandatory gear standards and seasonal area closures used to address various conservation concerns. The permit is linked to an individual fisherman, not a vessel, and is only transferable under very restrictive conditions; thus the value of the vessel does not become artificially inflated. To keep a permit active, current permittees are required to purchase a permit from one consecutive year to the next; however, they are not required to make landings using drift gillnet gear. In addition, a general resident or non-resident commercial fishing license and a current vessel registration are required to catch and land fish caught in drift gillnet gear. A logbook is also required. The HMS FMP requires a federal permit with a drift gillnet gear endorsement for all U.S. vessels that fish for HMS within the West Coast EEZ and for U.S. vessels that pursue HMS on the high seas (seaward of the EEZ) and land their catch in California, Oregon, or Washington.

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, both common and bigeye thresher sharks are designated as Pelagic MUS and, thus, are 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, thresher 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.

Recreational Fisheries

On the West Coast, recreational fisheries primarily occur in non-federal waters (0-3 nmi off the coast) and are managed by the states of Washington, Oregon, and California. Inter-state coordination is facilitated through the Pacific States Marine Fisheries Commission. Thresher sharks may be retained recreationally, except for in Washington State, where any fishing for *Alopias* spp. is prohibited. California recreational regulations impose a two fish bag limit on thresher sharks. This is cumulative for multi-day trips and most anglers seldom fill bag limits. Boat limits are in effect for multiple anglers per boat; with no more than the bag limit for each of the number of licensed anglers per boat. Again, these limits are seldom filled. If filleted at sea, a one inch patch of skin must be left on the fillets. Authorized fishing gear includes rod and reel, spear, and hook and line (CDFG, 2008). The following table (Table 13) shows relevant regulatory mechanisms from U.S. states and territories in the Pacific.

Table 12. Current and relevant shark regulations by U.S. state and territory in the Pacific (Source: Adapted from Miller et al. 2014; NMFS (2011a); NMFS (2013a); HMSMT Report 2008).

U.S. State	Shark Regulations
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. Recreational bag limits for common thresher sharks is 2 per day. California Legislature prohibited commercial drift gillnet fishing within 75 miles of the mainland from May 1through August 14 and continued a previously enacted prohibition from February 1 through April 30 to conserve pregnant and pupping thresher sharks throughout the region.
Washington	Washington's shark fin law prohibits the sale, trade or distribution of detached shark fins or derivative products in the state. The law does not restrict possession of detached shark fins. Includes exemptions for education and research. Drift gillnet fishing gear is prohibited and landings of thresher sharks are restricted under Washington Administrative Code (WAC) 220-44-050. Recreational fishing regulations strictly prohibit fishing for, retaining, or possessing thresher sharks (*Alopias* spp). This restriction is codified in WAC 220-56-235.
Oregon	An individual may not possess, sell or offer for sale, trade or distribute a shark fin within the state. The law includes a variety of exemptions including for fins from spiny dogfish. Recreational regulations allow for 25 offshore pelagic species in aggregate. May be taken by angling, hand, bow and arrow, spear, gaff hook, snag hook and herring jigs. No seasonal closures; waters open all year.
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	No drift gillnets. Gillnets must be moved every 6 hours. 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.

Analysis of U.S. Pacific Regulatory Mechanisms

Commercial fisheries

Many U.S. regulations have been implemented that help protect thresher sharks caught in Pacific U.S. fisheries, particularly common threshers. In the eastern Pacific, NMFS has implemented a number of management measures that help protect common thresher sharks. As previously described, the main fishery in the U.S. Pacific for common thresher shark is the California drift gillnet fishery, with an annual precautionary harvest guideline of 340 mt. Both participation and fishing effort (measured by the number of sets) have declined over the years. Industry representatives attribute the decline in vessel participation and annual effort to regulations implemented to protect marine mammals, endangered sea turtles, and seabirds. For example, in 2001, NMFS implemented two Pacific sea turtle conservation areas on the West Coast with seasonal drift gillnet restrictions to protect endangered leatherback and loggerhead turtles. The larger of the two closures spans the EEZ north of Point Conception, California (34°27' N. latitude) to mid-Oregon (45° N. latitude) and west to 129° W. longitude. Drift gillnet fishing is prohibited annually within this conservation area from August 15 to November 15 to protect leatherback sea turtles. In 2007, a smaller closure was implemented to protect Pacific loggerhead turtles from drift gillnet gear during a forecasted or concurrent El Niño event (72 FR 31756). Since the leatherback closure was enacted the number of active participants in the drift gillnet fishery declined by nearly half, from 78 vessels in 2000 to 40 in 2004, and has remained under 50 vessels since then. Although implemented for sea turtle protection, these closures act to help protect common thresher sharks from fishing pressures related to gillnet fishing (PFMC, 2015). Additionally, a recent stock assessment shows that this stock had gradually rebuilt, and is not currently experiencing overfishing and is likely not in an overfished condition. Therefore, it appears that regulatory mechanisms implemented in the U.S. eastern North Pacific are adequate to control for overutilization of *A. vulpinus.*

Recreational fisheries
On the West coast of the U.S., regulations to manage recreational fisheries of common thresher shark appears to be adequate at this time. In 2008, concerns over the increased recreational catch of thresher sharks prompted new recommendations by the PFMC's HMS Management Team to limit the recreational take of common thresher sharks, particularly because much of this catch was occurring during the spring thresher shark pupping season, and many of the fish caught appeared to be pregnant females. Additionally, although many thresher shark anglers advocate catch and release fishing methods, results from a preliminary study at the time indicated that thresher sharks caught by tail hooking had poor survival rates when released. Further, when added to commercial landings, recreational catches were thought to be approaching the annual harvest guideline of 340 mt (CDFG, 2009). However, upon a thorough review of recent CRFS data, estimates of recreational thresher shark catches were not causing cumulative landings to exceed the precautionary harvest guideline (refer back to Figure 52). Further, an analysis of bag limits showed that few anglers caught limits and a change in the bag limit would likely have little effect on recreational catch. Thus, for the 2009-2010 management cycle, the PFMC decided not to make changes to thresher shark recreational fishing regulations (CDFG, 2009). Finally, and as previously described, a recent stock assessment (Teo et al. 2015) confirmed that removal levels of common thresher as a result of recreational fisheries are presently sustainable and not contributing to the overutilization of the species. Overall, it appears that management of U.S. recreational fisheries for the U.S. West Coast population of thresher shark is precautionary, and

ensures that cumulative catches (recreational + commercial) do not exceed the harvest guideline (i.e., 340 mt) nor the maximum sustainable yield (MSY) (i.e., 806 mt) for the species.

Atlantic Ocean (Northwest Atlantic Gulf of Mexico)

Commercial Fisheries

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. Both common and bigeye thresher sharks are managed under this FMP.

In the Atlantic, both common and bigeye thresher sharks are managed under the pelagic species complex of the Atlantic HMS FMP. The first HMS FMP of 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 U.S. FMP for Atlantic Tunas, Swordfish, and Sharks[7] 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 designation of bigeye thresher sharks as a prohibited species was a precautionary measure to ensure that directed fisheries and/or markets did not develop.

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[8] (71 FR 58058, NMFS 2006). Since 2006, this FMP has been amended eight times, with one

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

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

more amendment currently under development. 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 (including common thresher 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 include: pelagic or bottom longline, gillnet, rod and reel, handline, or bandit gear. There are no restrictions on the types of hooks that may be used to catch common thresher sharks, and there is no commercial minimum size limit. 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. The common thresher shark quota is combined between the Gulf of Mexico and the Atlantic regions. Atlantic sharks and shark fins from federally permitted vessels may be sold only to federally permitted dealers; however, all sharks must have their fins naturally attached through offloading. The head may be removed and the shark may be gutted and bled, but the shark cannot be filleted or cut into pieces while onboard the vessel. Logbook reporting is required for selected fishers with a federal commercial shark permit. In addition, fishers may be selected to carry an observer onboard, and some fishers are subject to vessel monitoring systems depending on the gear used and where they fish. Since 2006, 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.

The HMS Management Division also recently published an amendment to the Consolidated 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 big-eye, 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 thresher sharks while in the Northwest Atlantic Ocean, Gulf of Mexico, and Caribbean Sea.

The following table (Table 14) describes relevant regulatory mechanisms in U.S. states and territories in the Atlantic.

Table 13. Current and relevant shark regulations by U.S. state and territory in the Atlantic (Source: Adapted from Miller et al. 2014; NMFS (2011a); NMFS (2013a); HMSMT Report 2008).

U.S. State	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 (including common thresher sharks) 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 & 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. Bigeye threshers are prohibited in recreational fisheries under the ASMFC. 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 Jersey during the seasonal closure. However, recreational fishers may still catch and transport common thresher sharks 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. Maryland requires reporting of all recreationally landed common thresher (and other) sharks through state administered HMS catch card program.
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 common thresher (and other) 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 & 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.
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.

Recreational fisheries
In the Atlantic, an HMS permit (either Angling or Charter/Headboat) is required for recreational fishing for sharks in federal waters. Common thresher sharks may be retained recreationally using authorized fishing gear, including rod and reel and handline. There are no restrictions on the types of hooks that may be used to catch Atlantic sharks on these gear types. Common thresher sharks that are kept must have a minimum size of 54 inches (4.5 feet; 137 cm) fork length. Sharks that are under the minimum size must be released. One common thresher shark may be kept per vessel per trip. There are no reporting requirements unless contacted by the Large Pelagic Survey or Marine Recreational Information Program. Sharks must be landed with their head, fins, and tail naturally attached. Bigeye thresher sharks have been prohibited in recreational fisheries since 2000.

<u>Analysis of U.S. Atlantic Regulatory Mechanisms</u>

Commercial fisheries
Although not strictly prohibited in commercial fisheries like the bigeye thresher, regulations to control for overutilization of common threshers in the U.S. Atlantic, including quotas and trip limits, are seemingly adequate, as evidenced by stable CPUE trends for the species since the 1990s, which corresponds with the implementation of management measures for pelagic sharks under the U.S. HMS FMP. Since 2008, commercial landings of the pelagic group (other than blue and porbeagle) have not exceeded the 488 mt quota (NMFS, 2014). While the minimum size limit for common thresher sharks (137 cm FL) is smaller than any of the estimated sexual maturity sizes throughout its range (e.g., in the Northwest Atlantic in particular, estimated size of maturity for females is 216 cm FL) the population has seemingly stabilized under existing regulatory mechanisms in this region.

Although bigeye thresher has been a prohibited species in U.S. Atlantic commercial fisheries since 2000, they are still incidentally taken as bycatch on pelagic longlines and in gillnets on the East Coast. For example, since the prohibition on bigeye threshers came into effect in 2000, approximately 1,493 lbs, dressed weight (677 kg) of bigeye thresher were landed in the Atlantic (NMFS, 2012; 2014) despite its prohibited status, although this equates to few sharks based on average weight. Further, the United States reported that bigeye thresher represents one of the largest amounts of dead discards in the Atlantic commercial fleet, reporting a total of 46 t in 2009 and 27 t in 2010 (NOAA, 2010 and 2011 Reports to ICCAT). In 2013, NMFS reported a total of 63 bigeye threshers caught as bycatch, with more than half released alive (NMFS, 2014). However, these numbers of dead discards are also down significantly from earlier reports of hundreds of dead discarded thresher sharks in the late 1980s and early 1990s, which was prior to management regulations. In fact, recent standardized CPUE data for bigeye thresher suggest the population has stabilized since the 1990s, which corresponds to the advent of pelagic shark species management as well as species-specific management measures for bigeye thresher. Thus, while the retention ban for bigeye thresher does not address incidental catch of the species or its associated high bycatch-related mortality rates, U.S. regulatory mechanisms for Atlantic bigeye threshers do not appear to be inadequate to control for overutilization of the species in this portion of its range.

Recreational fisheries

On the East Coast of the U.S., there are some management measures in place to regulate recreational catches of common thresher sharks, including bag and size limits. As described previously, an estimated 17,834 common thresher sharks were caught in the rod and reef fishery in the U.S. Northwest Atlantic from 2004-2013, with approximately 70% retained. Despite the increases in popularity and targeting of common thresher sharks in recreational fisheries in the Northeast U.S., standardized tournament data that accounts for increasing effort shows increasing relative abundance of common thresher sharks in recent years (refer back to Figure 54 in Section 4.2). Size limits for common thresher sharks imposed by the various states under the ASMFC may not be helpful for reducing recreational fishing pressure because the size limit (137 cm FL) is significantly lower than the reported size of maturity in the Northwest Atlantic, and thus, allows for sexually immature juveniles to be caught and landed. However, recent abundance indices indicate that the population is stable. Additionally, although common threshers have exhibited high mortality rates in the southern California recreational fishery as a result of fishing techniques that result in sharks being foul-hooked in the tail and hauled in backwards (Heberer et al. 2010; Sepulveda et al. 2015), fishing techniques on the East Coast are likely different, resulting in mostly mouth-hooked sharks. Thus, given that the population of common thresher appears stable, with relative abundance in recreational fisheries increasing, it appears that existing regulatory mechanisms are adequately controlling for overutilization of the species in recreational fisheries.

Prohibitive regulations pertaining to recreational harvest of bigeye threshers in the U.S. Atlantic are seemingly adequate to prevent overutilization as a result of recreational fisheries. As previously described, since recreational harvest of bigeye threshers was prohibited in 1999, there has been no observed recreational harvest of this species, with the exception of years 2002 and 2006, in which expanded survey estimates (which are highly unreliable due to large associated variances) estimated that 65 and 42 bigeye thresher sharks were caught and harvested, respectively (NMFS, 2012, NMFS, 2014). In fact, in most years of recreational data, dating back to 1981 and combining information from the LPS and general MRIP survey, bigeye threshers are typically not observed, with only five years showing bigeye threshers either landed or released alive throughout the Northwest Atlantic and Gulf of Mexico.

U.S. Finning Laws and Regulations

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; or possessing, transferring, or landing shark fins unless they are naturally attached to the corresponding carcass.

Analysis of U.S. Finning Laws and Regulations

After the passage of the Shark Finning Prohibition Act (which was enacted December 2000 and implemented by final rule on February 11, 2002; 67 FR 6194), U.S. exports of dried shark fins significantly dropped (Figure 57), which was expected. In 2011, with the passage of the U.S. Shark Conservation Act, exports of dried shark fins dropped again, by 58%, to 15 mt, the second lowest export amount since 2001 (Figure 57). 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. In 2012, the value of fins also decreased suggesting that the worldwide demand for fins may be on a decline. For example, as a result of 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.

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, subsequently decreasing 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 in 2001 (54% decrease, from 374 to 171 t) as Hawaii could therefore no longer be used as a fin trading center for the international fisheries operating and finning in the Central Pacific (Figure 58) (Clarke et al., 2007). As described previously, landings of thresher sharks declined since 2000 in both American Samoa and Hawaii, presumably due to the implementation of shark finning regulations. Thus, these regulations are likely conferring a conservation benefit for thresher sharks.

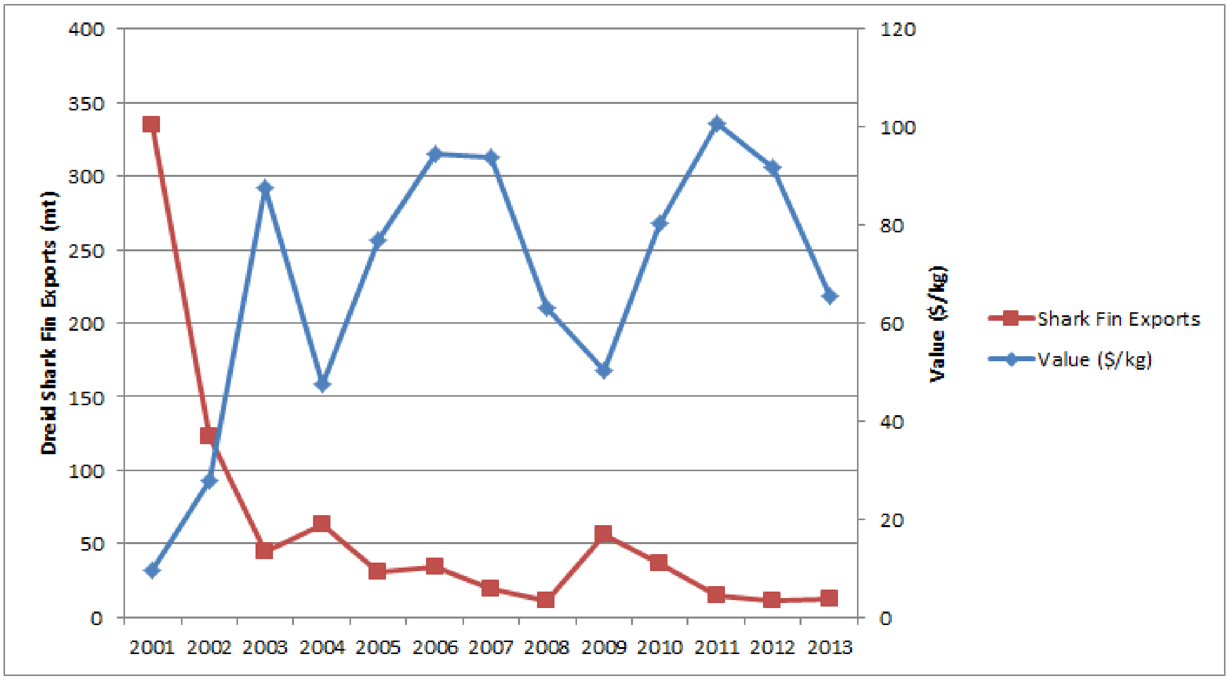

Figure 57. Amount and value of U.S. shark fin exports from 2001 to 2012 (Source: Adapted from Miller et al. 2014 and NMFS (2012); NMFS (2013a)).

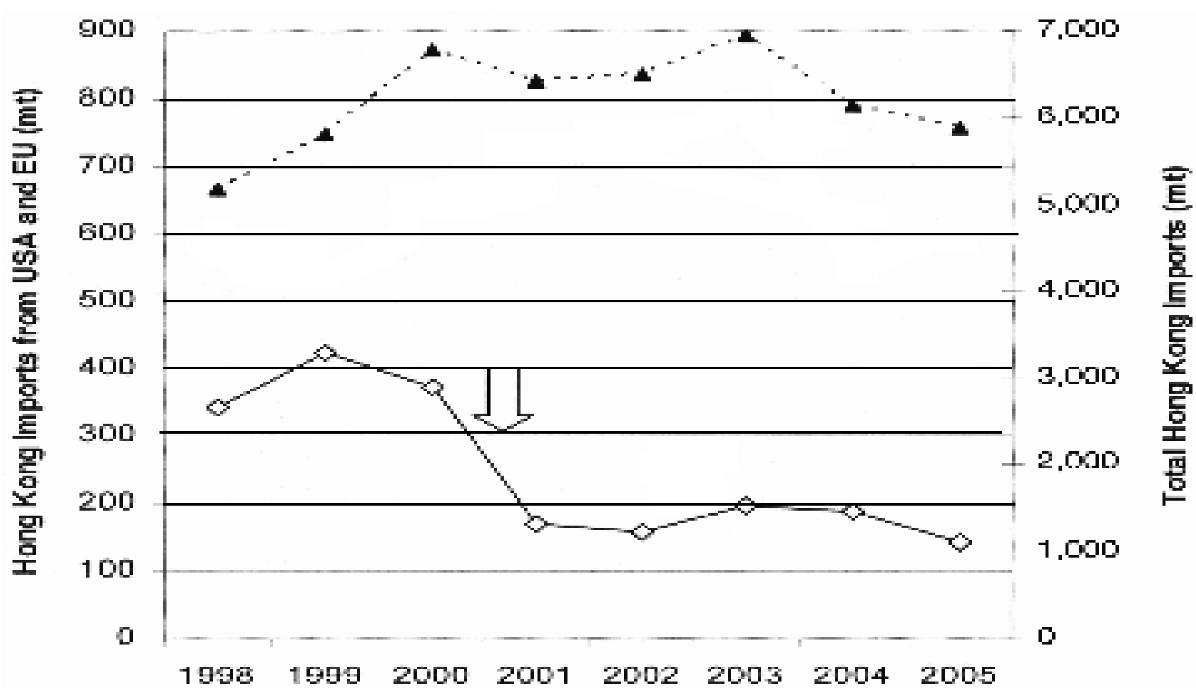

Figure 58. Annual imports of shark fin to Hong Kong from the U.S. (◊) and total Hong Kong imports (▲). The clear arrow indicates the implementation of finning regulations in the state of Hawaii (Source: Adapted from Clarke et al. 2007).

International Regulatory Mechanisms

Conventions and Agreements

Convention on the Conservation of Migratory Species of Wild Animals

The Convention on the Conservation of Migratory Species (CMS) is an environmental treaty under the auspices of the United Nations Environment Programme (UNEP). The CMS is the only global convention specializing in the conservation of migratory species, their habitats and migration routes. The CMS is comprised of two appendices: migratory species threatened with extinction are listed on Appendix I of the Convention, whereas migratory species that need or would significantly benefit from international co-operation are listed in Appendix II of the Convention. The Convention actively promotes concerted action by the Range States of species listed on its Appendices. The Range States of Appendix II species are encouraged to conclude global or regional Agreements for their conservation and management. In August 2014 at the Conference of the Parties (COP11) in Quito, Ecuador, the European Union and its 28 Member States submitted a proposal for the inclusion of all species of thresher sharks on CMS Appendix II. The proposal was accepted, and all members of the genus *Alopias* are now listed under Appendix II of the Convention. However, it should be noted that Australia took a reservation to the listing of the thresher species, among others, because Australia claims their national regulations are adequate for their management.

United Nations Convention on the Law of the Sea

The United Nations Convention on the Law of the Sea (UNCLOS) is an international treaty which was adopted and signed in 1982 in Montego Bay, Jamaica. The Law of the Sea Convention defines the rights and responsibilities of nations with respect to their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources. The importance of collaborative management for highly migratory species is addressed in Article 64, which states: The coastal State and other States whose nationals fish in the region for the highly migratory species listed in Annex I shall cooperate directly or through appropriate international organizations with a view to ensuring conservation and promoting the objective of optimum utilization of such species throughout the region, both within and beyond the exclusive economic zone. All thresher sharks (Family Alopiidae) are listed on Annex I, Highly Migratory Species, of UNCLOS.

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 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.

Helsinki Convention (Convention on the Protection of the Marine Environment of the Baltic Sea Area)

The primary aim of the Helsinki Convention is to protect the marine environment of the Baltic

Sea from pollution through intergovernmental cooperation. The Helsinki Commission or HELCOM is the governing body of the Convention. This organization has developed a Red List of Threatened Species or Declining Fish (HELCOM 2007), including several species of sharks as priority species. *Alopias vulpinus* is listed as a high priority; however, no specific measures are established for any listed species.

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 provided that the weight of the fins does not exceed 5% of the total weight of shark carcasses landed or found onboard. In addition to regulations specific to shark finning, numerous RFMOs and countries have implemented various regulations regarding shark fishing in general. A number of countries have enacted complete shark fishing bans, 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. See Appendices 1 and 2 for a description of the existing regulatory mechanisms in place for shark fishing and finning, respectively, throughout the ranges of *A. vulpinus* and *A. superciliosus*.

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

Countries with national or local legislation prohibiting the landing of all thresher sharks:

- Sri Lanka
- Spain
- South Africa
- Philippines (Batangas City, Ordinance Resolution 9, series 2008)

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

The IPOA-SHARKS was developed in 1998 with the objective of ensuring the conservation and management of sharks and their long-term sustainable use. As a result, 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, the FAO reported that only one third of the FAO membership (i.e., 68 of its members) had responded to its implementation questionnaire. Of those members, about 50% (i.e., around 34) had conducted an assessment as to whether an NPOA was needed, and of those 34, 90% had developed and implemented an NPOA (Lack and Sant, 2009). In 2009 and 2011, significant progress in the implementation of the IPOA-Sharks was observed, indicating that the international attention given to the sustainable use, conservation and management of sharks positively affected the motivation of governments to take action (Fischer et al., 2012). The most recent comprehensive review of implementation 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[9]. The development of NPOAs provides some indication of the level of commitment of a catching country to manage its shark fisheries, and 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[10] have completed a draft NPOA that is awaiting adoption by parliament and two[11] have initiated drafting of their NPOA). However, three (12% of the top shark fishing countries, areas and territories) have not yet addressed an NPOA-Sharks (Fischer et al., 2012). See Appendix 4 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 hindered by a number of problems and issues. As a result 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 in 2005, which focused on the challenges encountered by FAO Members with regard to the conservation and management of sharks. 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;

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

[10] Brazil, Peru and Thailand

[11] India and Sri Lanka

- 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 are linked 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, a lack of data pertaining to shark biological characteristics and fisheries was 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. Also, many of the top shark-fishing countries, areas and territories also experience difficulties in 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.

Regional Analysis

Atlantic (Northwest, Northeast, and Mediterranean)

In Atlantic waters, the main international regulatory body is ICCAT. Since the Convention was implemented in 1969, ICCAT has mostly focused on managing highly migratory species, except bycatch species like sharks, sea turtles, and birds. Despite its implementation in 1969, it was not until 2004 that the Commission conducted its first population assessment on pelagic sharks (Levesque, 2007). As previously mentioned, ICCAT afforded bigeye thresher sharks protection from fishing by ICCAT vessels by adopting Recommendation 09-07 in 2009, which prohibits the retention of bigeye threshers caught in association with ICCAT-managed fisheries. However, the retention ban implemented by ICCAT does not address the threat of bycatch-related mortality, especially since bigeye threshers in particular have high rates of hooking and at-vessel mortality upon capture and haul-back. Further, these protections do not apply to common threshers, although they may reap some benefits from ICCAT Recommendation 09-07 as it also states that CPCs should strongly endeavor to ensure that vessels flying their flag do not undertake a directed fishery for species of thresher sharks of the genus *Alopias*, although this is not a requirement.

In a review of the efficacy of ICCAT management of sharks, Levesque (2007) stated that while ICCAT has been successful at managing some highly migratory species, it is evident that ICCAT has been less successful at managing sharks. Levesque (2007) described several weaknesses of the Convention, including the inability to harmonize national reporting, inadequate implementation and coordination of efforts at the national level, and inadequate compliance and enforcement. More importantly, Levesque (2007) noted that ICCAT lacks performance metrics for measuring the effectiveness of the Convention and asserts, based on the first and only stock assessment conducted on pelagic sharks (blue and shortfin mako), that ICCAT has failed in properly addressing shark management issues effectively. In addition, there remains a paucity of direct management and enforcement by ICCAT regarding sharks taken in international waters (Mandelman et al., 2008). To date, ICCAT has not made public any data or review of the efficacy of its management measures.

In the Atlantic, thresher shark catches have been reported by ICCAT vessels since 1987. 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 2009, the EU proposed a prohibition on retention of all thresher sharks (*Alopias* spp.) but consensus could not be reached. Instead ICCAT adopted Recommendation 09-07 prohibiting onboard retention, transshipping, landing, storing, selling, or offering for sale any part or whole carcass of bigeye thresher sharks (*A. superciliosus*) in any fishery with exception of a Mexican small-scale coastal fishery with a catch of less than 110 fish. It also includes a requirement to submit catch and effort data for all thresher shark species. In 2010, despite a second proposal by the EU to prohibit retention of common thresher sharks, the proposal was not adopted due to questions about the scientific basis for the proposal.

According to ICCAT data as shown previously in Figure 16, approximately 96% of the total catch for common thresher sharks was caught by EU vessels, with Spain representing the majority of the EU's total catch. In 2009, the EU accounted for up to 17% of the global shark catch, and is the largest exporter of shark products to markets in mainland China and Hong Kong. The European Parliament recently passed a proposal prohibiting the removal of shark fins by all vessels in EU waters and by all EU-registered vessels operating anywhere in the world. Previously, the EU prohibited shark finning but allowed fins and bodies to be landed in different ports, resulting in enforcement difficulties. The EU also allowed justified exceptions and special permits for finning, essentially diminishing the effectiveness of the finning ban. Therefore, in an effort to close the loopholes in the original shark fin regulations and discourage the wasteful practice of finning, the European Parliament passed the proposal requiring fins be attached to landed sharks, and officially adopted this strict finning ban in July 2013. Further, in 2009 Spain enacted Orden ARM/2689/2009, which includes specific measures that prohibit Spanish fishing vessels from catching, transshipping, landing and marketing of sharks of the Family Alopiidae (all three *Alopias* spp.) in all fisheries, including territorial waters and in other countries with which there is a fisheries agreement between the European Union, and those to which can be accessed by private agreement or contract lease of fishing vessels. This regulation went into effect in 2010. Thus, given that Spain accounts for approximately 7.3% of the global shark catch (Lack and Sant 2011) and was the largest exporter of fins in 2008, this prohibition has likely decreased total fishing mortality on the Atlantic population of thresher sharks. In fact, total EU catches of common threshers dropped precipitously by approximately 65% from 2009 to 2010, and have continued to decline since.

In the Northeast Atlantic, ICES (2007) noted that due to the high amount of fishing effort in the region, the management of *A. vulpinus* is of concern due to the lack of precautionary management measures in place. In the Mediterranean Sea, despite several laws and regulatory mechanisms within the region, (e.g., EU Ban on driftnet fishing in EU waters, ICCAT ban on driftnets for large pelagics in the Mediterranean (Rec. 2003-04), and GFCM ban on use of driftnets in the Mediterranean) recent investigations show common thresher sharks are being increasingly targeted in the Alboran Sea by an illegal large-scale swordfish driftnet fleet based primarily in Morocco. As previously described, Tudela et al. (2005) monitored 369 fishing operations made by the driftnet fleet between December 2002 and September 2003 and estimated a total of 4,791 common threshers caught over the 8-month sampling period. When extrapolated to 12-months, catches of common thresher sharks are estimated at about 7000–8000 individuals in the Alboran Sea alone. This suggests that regulatory mechanisms are not adequate in this region to control for overutilization as a result of intensive fishing pressure.

Pacific (Western and Central)

In the Western and Central Pacific, the WCPFC is the main regulatory body for the management of sharks. Unlike ICCAT and IOTC, the WCPFC has no regulatory measures specific for the conservation of thresher sharks; however, they are considered “key shark species” and have been nominated for the purposes of an assessment. When key shark species are designated for assessment, they are included in the WCPFC’s Shark Research Plan (Clarke and Harley, 2010). In December 2010, the WCPFC adopted a Conservation and Management Measure (CMM) for sharks in general (CMM 2010-07), which requires Commission Members, Cooperating non-Members, and participating Territories (CCMs) to include key shark species (including thresher sharks) in their annual report of catch and fishing effort statistics and retained and discarded catches, including available historical data. In February 2011, the WCPFC revised its requirement of scientific data to include annual catch estimates and operational level catch and effort data for thresher sharks from longline, troll, purse seine and pole and line (in weight) fisheries. The WCPFC also 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, in a review of the existing WCPFC shark CMMs, Clarke (2013) found variable implementation rates of the CMM requirements by the WCPFC members (CCMs) 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, which increases the difficulty in verifying compliance and creates difficulties for data monitoring and review. Clarke (2013) identifies three main objectives of the shark CMMs: 1) to 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. In evaluating the success of the first two objectives, Clarke (2013) relied on available WCPFC observer data but noted that the data are very limited. For example, coverage of the longline fishery, which is responsible for the majority of shark bycatch, has been decreased (to likely <5%) due to the requirement for 100% coverage in the purse seine fishery. Based on the available data, Clarke (2013) concluded that finning rates in both purse seine and longline fisheries do not appear to be decreasing. In longline fisheries, finning rates are greater than 30%. In terms of thresher sharks, the observer data show that when incidentally caught, common threshers are finned 35% of the time, and bigeye threshers are finned at a higher rate of 48% (SPC, 2010). Clarke (2013) concludes that even with reductions in finning rates, the percentage of sharks released alive will not likely translate into substantial increases in survival due to the fact that most sharks, including common and bigeye thresher sharks, have been found to suffer high mortality rates when caught in purse seine nets and on longline gear. Thus, the expected benefit from implementation of these CMM measures appears to be negligible (Clarke 2013). For common threshers in particular, these regulations may not be effective in stopping finning, as a recent study found that common thresher sharks have an average wet-fin-to-round-mass ratio of only 2.06% (±0.05; n = 10) (Biery and Pauly, 2012). This ratio suggests that fishing vessels operating in the WCPFC convention areas would be able to land more common thresher shark fins than bodies and still pass inspection. A similar ratio for bigeye thresher is not available, and given the larger size attained by common threshers, it would be inappropriate to use the available common thresher ratio as a proxy. Finally, finning bans and ratios do not address incidental catch of thresher sharks and the subsequent high rates of mortality that result. In a recent study of longline fisheries (Rice et al. 2015), the percentage of key shark species that were finned reduced from 2010-2013, and the last year of the study saw an increase in finning and a decrease in the number of sharks retained. The decrease in finning from 2010-2013 corresponded with an increase in retention, which would be the expectation if fishers were beginning to retain the carcass to adhere to 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). The fate of thresher sharks in longline gear is shown in Figure 59 below, which shows a declining trend in the number of threshers finned since 2007.

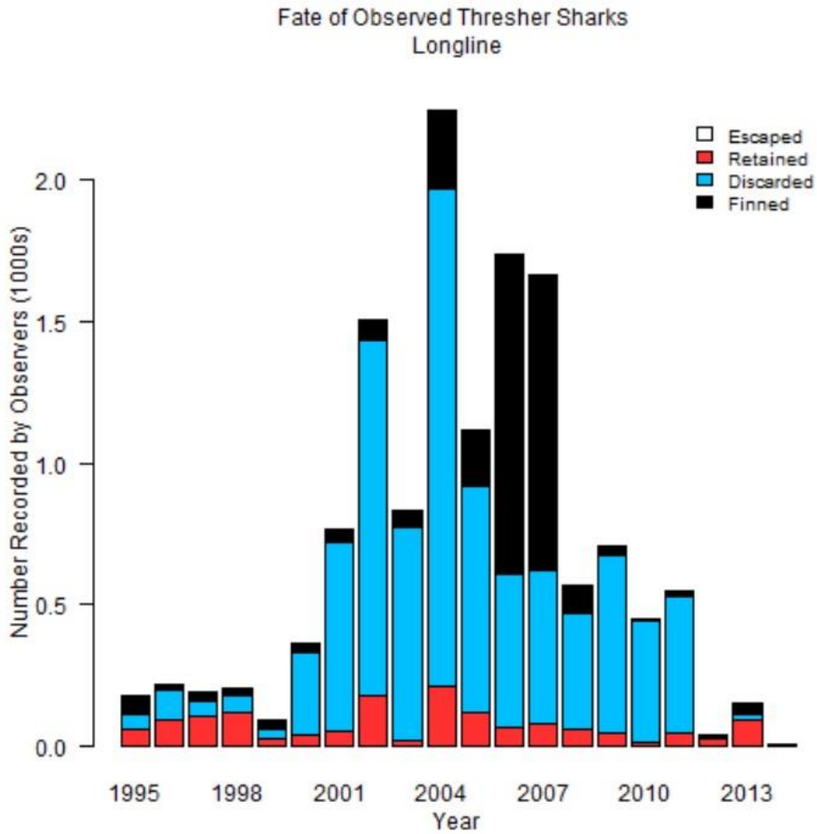

Figure 59. Fate of observed thresher sharks caught by longline in the WCPO (Source: Rice et al. 2015).

Overall, it remains unclear whether such controls on shark finning are effective in reducing mortality of thresher sharks. Most recently, the WCPFC also adopted measure (effective July 2015) that requires each national fleet to either ban wire leaders or ban shark lines, which may significantly reduce shark bycatch in the first place.

In Australia's states and territories, various shark regulations have been implemented that likely help protect thresher sharks when inside Australia's EEZ. In addition to various finning regulations, other regulations have been implemented in important fisheries. For example, in the Western and Eastern Tuna and Billfish Fisheries, a maximum quota was set specifically for common thresher sharks (maximum catch of 20) within the pelagic quota (maximum of 100) outside the EEZ, per vessel per trip. Australia has also prohibited the use of wire leaders (traces) on longline fishing gear in its Eastern Tuna and Billfish Fishery (ETBF) since 2002 as a shark bycatch mitigation method. This gear restriction has reduced the incidental mortality of sharks in general by about 50% (Fischer et al., 2012). As of 2007, common threshers received a medium risk ranking to overfishing in an ERA for the ETBF. As noted earlier, a medium risk ranking means overfishing may be occurring but the population may still be sustainable. Although this type of management measure has an impact on all shark species and is likely to be more effective and easier to enforce than single-species based approaches, more information is necessary to determine whether these gear restrictions are adequately reducing the risk of overfishing specifically to common thresher sharks in the ETBF fishery. A management plan was implemented for the Southern and Eastern Scale Fish and Shark Fishery (SESSF) in 2003; however, in a 2010 sustainability assessment of the fishery, common threshers received precautionary high and extremely high risk ratings as a result of cumulative impacts from five sub-fisheries within the SESSF. Therefore, it is questionable whether regulatory mechanisms are adequately controlling for risk of overutilization in this fishery. Additionally, as previously described, Australia's main environmental law for protecting threatened and endangered species is the Environment Protection and Biodiversity Conservation (EPBC) Act. This Act is usually automatically updated following any CMS and CITES listings; however, although Australia did not object to the listing of *A. vulpinus* or *A. superciliosus* under Appendix II of CMS in 2014, Australia did not subsequently list these species under the EPBC Act to provide further protection. However, without any catch and effort data from these fisheries, it is difficult to evaluate whether overutilization is occurring, and subsequently, whether regulations are inadequate to control for said overutilization to the point that it contributes significantly to the species' global risk of extinction.

Indian Ocean

In Indian Ocean waters, the main regulatory body is the IOTC, which has management measures in place specifically for thresher sharks that prohibit the landing of all *Alopias* species. In 2010, the IOTC passed recommendation 10-05 prohibiting the retention, transshipment, landing, storing, or offering for sale any part of carcass of thresher sharks of the family Alopiidae. The IOTC also requires CPCs to annually report shark catch data and provide statistics by species for a select number of sharks, including thresher 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, it is unclear how effective these measures have been. 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. Currently, only 12 of the 35 CPCs have developed NPOAs for sharks (IOTC, 2014). Additionally, due to the high hooking mortality of thresher sharks in this region, the IOTC's main regulation to protect thresher sharks (regulation 10/12 that prohibits the onboard retention of any part of any thresher species and promotes live release of thresher sharks) may be ineffective for the conservation of the species (IOTC, 2014). Of particular concern is the indirect fishing pressure of bigeye threshers due to their high hooking mortality rates at capture, as well as their vulnerability to longline fisheries and low reproductive capabilities.

Like the WCPFC, the IOTC also prohibits fins onboard that weigh more than 5% of the weight of sharks to curb the practice of shark finning. Again, these regulations do not prohibit the fishing of sharks and the IOTC Scientific Committee identified a number of issues associated with reliance on the 5% fins:body weight ratio requirement (which apply to other RFMOs as well), including:

- The ratio has no clear scientific basis as a conservation measure for sharks;
- It appears to be aimed at slowing down the rate of fishing to deter fishing on sharks by not allowing fins only to be landed and requiring vessels to return to port more often to unload fins and body parts;
- It precludes the collection of data on species-level interactions with fishing fleets which is crucial for accurate stock assessments for sharks;
- 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;
- The best way to ensure that sharks are fully utilized is to require that the trunks be landed with fins attached and this would also facilitate the collection of data for stock assessments; and
- The fins:body weight ratio measure should be replaced with a requirement that shark fins be landed attached to the body, either naturally or by other means so that they are able to be matched to a carcass (Lack and Sant, 2009).

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 in capacity to provide differential protection to those shark species most at risk from overfishing (Lack and Sant, 2009).

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). The current Indonesian regulations that pertain to sharks are limited to those needed to conform to international agreements (such as trade controls for certain species listed by CITES (e.g., whale shark) or prescribed by RFMOs) (Fischer et al., 2012). Ultimately, their 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. However, 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 outright 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.

South Atlantic

Countries fishing in the South Atlantic also adhere to management measures implemented by ICCAT, of which the most consequential is the retention prohibition of bigeye thresher sharks. However, current regulations that mandate the release of bigeye thresher sharks back to the sea might not be as effective for their protection as for other species, since the majority of the specimens are captured and discarded dead in this region (Fernandez-Carvalho et al., 2015b). In Brazil, which is one of the top 26 shark-catching countries in the world, sharks must be landed with corresponding fins and a 5% fin-carcass weight ratio is implemented. 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, implementation and enforcement of these regulations have been noted as difficult and likely poor. 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 thresher shark species. Thus, regulatory mechanisms in Brazil may not be effective to reduce the threat of bycatch-related mortality on bigeye thresher sharks. However, significant declines in landings reported to ICCAT since the prohibition on retention of bigeye threshers may give some indication that regulatory mechanisms are at least somewhat effective in reducing overall fishing pressure on the species in this area.

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 (OSPECA) was formed to address this situation by assisting with the development and coordination of fishery management measures in Central America. The OSPECA 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 pretty minimal. Fishing occurs year-round, including during shark breeding season, and, as such, both pregnant and juvenile shark species may be fished (Diop and Dossa, 2011). In fact, shark fins from fetuses 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 thresher sharks are in this region's fisheries. In fact, the only member state of the SRFC in which thresher sharks have been reported is Senegal, which reported the common thresher as "very rare" (Diop & Dossa 2011).

Illegal, unregulated and unreported (IUU) Fishing

In order to justify risks of detection and prosecution involved with IUU fishing, efforts focus on high value products (e.g., shark fins) to maximize returns to IUU fishing effort. Thus, the lucrative market for shark products, particularly shark fins, has historically increased targeting sharks around the world, posing a significant threat to vulnerable shark species. However, as previously discussed, given the recent downturn in fin prices (Eriksson and Clarke 2015), the threat of IUU fishing for the sole purpose of shark fins may not be as significant into the future. Nonetheless, it is 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 at least by adopting an NPOA IUU or similar plan (23%). Only 5 of the top 26 shark-fishing countries, areas and territories have not adopted an NPOA-Sharks, signed the PSMA or implemented an NPOA IUU. However, whether signing a PSMA or having an NPOA-IUU correlates with less IUU fishing activity is unclear. For example, in quite a few countries, the effective implementation of MCS schemes is problematic, often because of a lack of personnel and financial resources. Despite the number of regulatory mechanisms in place that may help conserve sharks, a number of instances of IUU fishing have been reported over the past decade. Most of the RFMOs maintain lists of vessels they believe to be involved in IUU fishing; however, given the unreported nature of IUU fishing, it is highly likely that many more vessels are undertaking IUU fishing for sharks without being identified or apprehended (HSI n.d.). In a review of IUU fishing, while members of the Alopiidae family were identified as species taken in IUU fisheries, they were not identified as having a particularly high threat of IUU fishing (Lack and Sant, 2008). For a detailed discussion of IUU fishing occurring globally, please see Miller et al. (2014).

Marine Protected Areas (MPAs)

Marine protected areas are a popular tool to enhance fisheries management. Effectiveness of protected areas depends not only on implementation and enforcement of regulations, but also on 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). While a number of countries, territories and areas have banned shark fishing in their EEZs, effectively creating shark MPAs or sanctuaries, a variety of limitations exist regarding the size, location, compliance and enforcement of these protected areas. For example, much of the range and habitat of common and bigeye thresher 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 these thresher sharks are highly migratory species, they only benefit from protected areas when they are actually inside the protected area's boundaries. As mentioned previously, effectiveness of these protected areas also relies on the level of implementation and enforcement of regulations therein. For example, in the Philippines, illegal fishing for thresher sharks has been detected in protected areas; in June 2014, 10 thresher sharks were illegally taken (Lack and Sant, 2008, Alkuino, 2014). In another example, an illegal shark fishing vessel seized within the borders of the Galapagos Marine Reserve had a total of 379 sharks from seven shark species found onboard, with a total of 303 threshers illegally taken (Carr et al., 2013). Thus, while MPAs may provide some benefit to sharks in various locations around the world, it is unclear whether and to what degree they confer conservation benefits to common and bigeye thresher sharks, specifically.

Summary

A wide variety of existing laws and regulations have been implemented throughout the range of *A. vulpinus* and *A. superciliosus* that may positively affect the conservation status of these species. For example, many RFMOs are making strides towards implementing regulations to protect thresher sharks, improve data reporting, and expand research. However, issues of underreporting, misreporting between species, and non-compliance remain problematic. Of note is the fact that species-specific retention bans do not address incidental catch and subsequent mortality. In particular, bigeye threshers have exhibited high at-vessel mortality rates upon capture throughout its global range. In addition, although various shark fishing and finning regulations and bans have been increasing in recent years globally, levels of compliance and enforcement are highly variable, evidenced by numerous incidents of IUU fishing throughout the world's oceans due to the high demand for lucrative shark products, particularly fins. Also, the efficacy of certain finning controls (e.g., the 5% fin:body ratio rule) is still under debate, particularly since an average wet-fin-to-round-mass ratio of only 2.06% was calculated for *A. vulpinus* (though no such ratio has been calculated for *A. superciliosus*). However, there has been a recent major downturn in the shark fin market and more information is necessary to determine the magnitude of impact the shark trade is having specifically on common and bigeye threshers. Moreover, as previously noted, finning controls, like retention bans, do not address incidental catch and subsequent mortality. 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 thresher species. National species-specific bans for thresher sharks have also been increasing, with bans recently enacted in Spain, Sri Lanka, and the Philippines. Although these national retention bans suffer from similar issues as the retention bans implemented by RFMOs, the implementation of national legislation to protect sharks in some major shark catching countries is encouraging. Additionally, management of common and bigeye thresher sharks is seemingly adequate in the U.S., with the West Coast stock of common thresher in recovery and the East Coast thresher population potentially stable. 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 thresher sharks occur can limit the effectiveness of well-intended statutes and legislation. However, whether existing regulatory mechanisms are inadequate such that they contribute to the species' risk of extinction throughout their global range is highly uncertain.

4.5 (E) Other natural or manmade factors

Climate Change

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. The following text describes the potential effects of climate change on important forage fish in the thresher shark diet.

According to a preliminary assessment by scientists advising West Coast fishery managers, the population of Pacific sardines, a crucial forage fish for marine life along the U.S. West Coast, including common thresher sharks, has dwindled to the point that it can no longer sustain a commercial fishery (Shively, 2015). In April 2015, the PFMC urged NMFS to close the Pacific sardine fishing season as quickly as possible, citing concerns about a declining biomass and the potential for the remainder of this year's quota to be caught rapidly[12]. A 2012 study stated that biomass of Pacific sardine, the second most important prey item to common thresher sharks (Preti et al., 2012), has experienced a precipitous decline as a result of a cold oceanographic regime combined with high exploitation (Zwolinski and Demer, 2012). However, the study also noted that other forage fish important in the common thresher diet, such as Pacific mackerel and Pacific anchovy, are actually thriving. In 2013, NMFS conducted a risk assessment due to climate change for coastal pelagic fish species in the California Current marine ecosystem to the year 2100. Using projections of changes in oceanographic climate, the study conducted a risk assessment of several marine forage species (of which 5 are top prey species of common thresher sharks), based on expected changes in the mean variability of sea surface temperature and chlorophyll concentrations, as well as species-specific sensitivity to these changes (Samhouri et al., 2013) (see Figure 60 below).

[12] http://www.pcouncil.org/2015/04/36528/council-urges-nmfs-to-close-this-years-sardine-fishery/

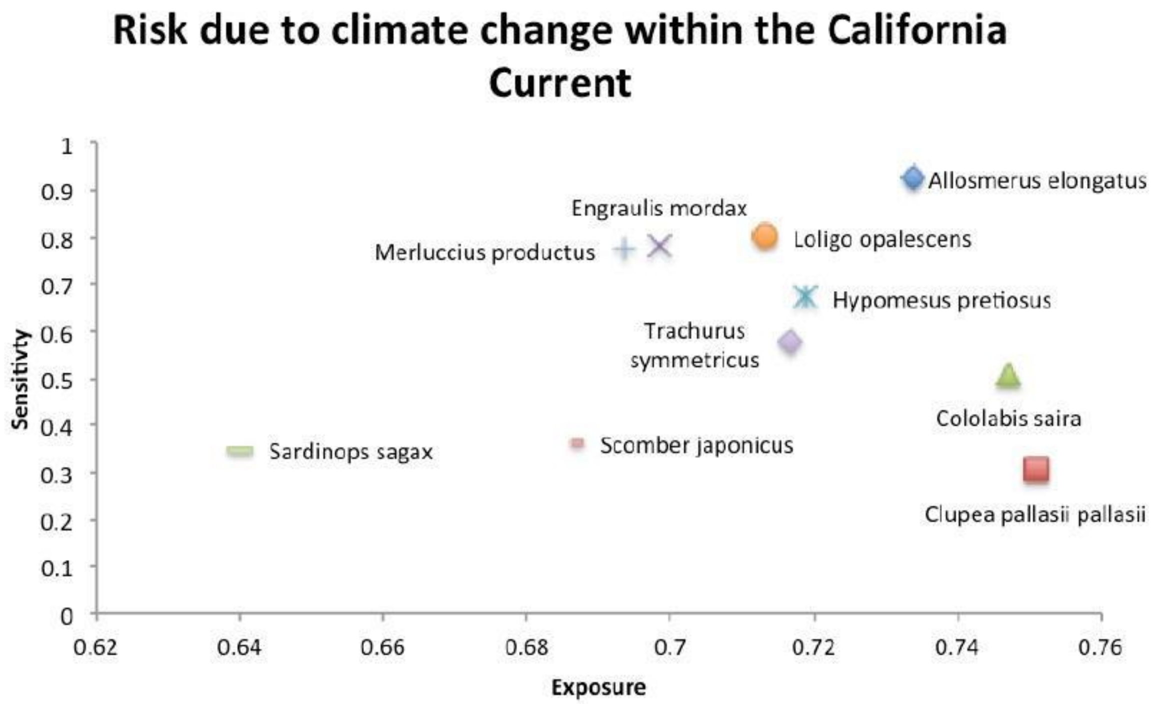

Figure 60. Preliminary risk scores of climate change effects on prey species within the California current based on exposure and sensitivity (Source: Samhouri et al. 2013).

Among the prey items important to *A. vulpinus* and *A. superciliosus, Sardinops sagax* (Pacific sardine) ranked the lowest in terms of risk to climate change, whereas *Trachurus symmertricus* (Jack mackerel) ranked the highest, followed by northern anchovy, Pacific Hake, and Pacific mackerel. A major caveat of this study is the coarse spatial scale of the global climate model that precludes adequate representation of coastal upwelling processes. Additionally, specific life history characteristics and ocean condition are not captured and precise predictions of complex interactions beyond warming, such as changes in stratification, upwelling, and intensity of the California Current are not possible. Thus, the results of this study represent only a first step in prioritizing species for management purposes (Samhouri et al., 2013). In another study from Tasmania, Australia, Johnson et al. (2011) found that warming off of the coast of Tasmania has created a cascade effect leading to a state where jack mackerel, a common thresher shark staple, have declined in population to the point where failure of the nation's mackerel fisheries—once a rare occurrence—has become status quo. However, because changes in prey species availability as a result of oceanographic shifts from climate change are likely to vary both spatially and temporally, these changes would not likely affect the status of thresher sharks in all locations at all times throughout their global range. However, the long-term effects of climate change on pelagic forage fish are still uncertain, and thus the future impacts to thresher sharks are also uncertain.

Pollution

Habitat pollution has resulted in various concentrations of pollutants in the bodies of common thresher sharks. For example, Suk et al. (2009) demonstrated that the level of mercury measured in the muscle of individual thresher sharks was quite low (mean 0.13 ± 0.15 ppm), with no traces of mercury detected in the liver. Mercury concentration increased with shark size to a maximum of 0.7 ppm for a 241 cm fork length (~425 lb) individual, still far lower than for other sharks examined in the study, including the shortfin mako and the sevengill shark (Suk, 2009). However, a recent study evaluated trophic pathways and size-based bioaccumulation rates of total mercury among recreationally caught common thresher sharks from offshore southern New England waters of the northwest Atlantic Ocean. Mercury concentrations were highest in mako (2.65 ± 1.16 ppm) and thresher sharks (0.87 ± 0.71 ppm), and significantly lower in teleosts. The relationship between body size and mercury concentration was positive and linear for tunas, and positive and exponential for sharks and dolphinfish, with the majority of fishes (including common threshers) exhibiting concentrations greater than the U.S. EPA recommended limit (Teffer et al., 2014). High concentrations of organic contaminants and mercury were also observed in common thresher embryos, prior to any external exposure, which provides clear evidence of maternal offloading in this species (Lyons et al., 2013). Although data are unavailable to assess the impact of these mercury levels on the health of the common thresher shark, lower mercury levels exhibited by common thresher sharks relative to other pelagic sharks likely relate to its tendency to feed on small schooling fish and cephalopods, at lower trophic levels than the prey consumed by other sharks studied. Other pollutants such as high levels of ecosystem contaminants (PCBs, organo-chlorines and heavy metals) that bio-accumulate and are bio-magnified at high trophic levels are associated with infertility in sharks (Stevens et al., 2005), but their specific impacts on thresher sharks are unknown.

In a recent study, plastic ingestion was documented in bigeye threshers, indicating that plastic pollutants may pose a potential threat to thresher sharks (Benjamin et al., 2014). This study noted that ingestion of plastic debris by turtles, seabirds, marine mammals, and occasionally fish has been well documented, but the impacts of the ingested plastic have not been widely analyzed. Further, the amount and type of plastic ingested by higher trophic level marine organisms such as sharks has not been investigated as vigorously. Carson (2013) suggests that fishes of a variety of sizes attack drifting plastic with high frequency, as evidenced by apparent bite marks commonly left behind. This study examined 5518 plastic items from random plots on Kamilo Point, Hawaii Island, and found 15.8% to have obvious signs of attack. When extrapolated to the entire amount of debris removed from the 15 km area, over 1.3 tons of plastic are attacked each year in this area alone. More research is needed to document the specific fishes and rates of plastic ingestion, as well as the overall impact of smaller plastic debris on the marine environment overall, in order to make any conclusions regarding sharks and other higher trophic level marine organisms (Carson, 2013, Benjamin et al., 2014). Entanglement in plastic debris, including derelict fishing gear (i.e., ghost fishing), has also been reported in sharks (Cliff et al., 2002, Sazima et al., 2002); however, the impact of shark mortality as a result of entanglement is unknown.

ASSESSMENT OF EXTINCTION RISK FOR THE COMMON THRESHER SHARK (*ALOPIAS VULPINUS*) AND THE BIGEYE THRESHER SHARK (*ALOPIAS SUPERCILIOSUS*)

Photo credits: Common thresher shark (Walter Heim; SWFSC); Bigeye thresher shark (Jason Arnold)

Conducted by the Extinction Risk Analysis (ERA) Team in September 2015

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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 the Status Review document, conduct a DPS analysis, and evaluate the overall risk of extinction facing common and bigeye thresher sharks.

DISTINCT POPULATION SEGMENT ANALYSIS

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.

Discreteness

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.

Significance

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.

Distinct Population Segment Analysis – ERA Team Results

NMFS determined at the 90-day finding stage that the petition to list the common thresher shark as six DPSs (Eastern Central Pacific, Indo-West Pacific, Northwest and Western Central Atlantic, Southwest Atlantic, Mediterranean, and Northeast Atlantic) did not present substantial scientific or commercial information to support the identification of these particular DPSs. As such, we (the ERA team) conducted the extinction risk analysis on the global common thresher shark population.

In terms of the bigeye thresher, the petition to list this species requested NMFS to list it throughout its range, or alternatively, as DPSs should NMFS find they exist. As part of the ERA team duties, we were asked to examine the best available data to determine whether DPSs may exist for this species. The petition, itself, did not provide any information regarding potential DPSs of bigeye thresher shark, aside from requesting that NMFS consider using the regions/populations as outlined and delimited in the petition (i.e., Northwest and Western Central Atlantic, Southwest Atlantic, Mediterranean Sea and Eastern Atlantic, Indo-West Pacific, and Eastern Central Pacific). The petition did not otherwise provide support to identify any DPSs of bigeye thresher shark. As previously noted, to meet the definition of a DPS, a population must be both discrete from other populations of the species and significant to the species as a whole (61 FR 4722; February 7, 1996). The petition did not provide biological evidence to support the existence of any "subpopulations" nor did the petition propose any boundaries for DPSs. Additionally, the petition did not describe in any detail the ways in which different management relating to international governmental boundaries may delineate the species into boundaries aligning with the suggested regions/populations. Specific gaps in management or intergovernmental boundaries were not described as they relate to any of suggested regions/populations. In our review of the best available data, we were also unable to find information to define any DPSs as discrete on biological grounds. We found only two preliminary studies to suggest population structure of the bigeye thresher shark. Trejo (2005) examined mitochondrial control region DNA, which demonstrated significant population structure between most pairwise comparisons, but the sample sizes were extremely low, and thus the results could not be interpreted with confidence. The data results support shallow population structure between Indo-Pacific and Atlantic populations, but not among populations spanning the entire Indo-Pacific Ocean (Trejo, 2005). In a genetic analysis by Naylor et al. (2012), little difference was seen among nine specimens spanning much of the global distribution of the species. Based on the preliminary nature of these data, and low sample size throughout the studies, these results cannot be relied upon to divide the bigeye thresher shark into any DPSs. Thus, we concluded that the best available information does not indicate that any population segment of the bigeye thresher shark would qualify as a DPS under the DPS policy. As such, we conducted the extinction risk analysis on the global bigeye thresher shark population.

EXTINCTION RISK ANALYSIS

The ability to measure or document risk factors to a species is often limited, and information is often not quantitative or lacking altogether. Therefore, in assessing extinction risk of a 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 common and bigeye thresher sharks after conducting demographic risk analyses. Likewise, the ERA team performed a threats assessment for both 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 each species are provided separately 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 each species. Longevity for the common thresher is broadly estimated to be around 50 years, although the most recent estimate of longevity is approximately 38 years. Longevity of the bigeye thresher is estimated to be about 25 years. Generation time, which is defined as the time it takes, on average, for a sexually mature female common thresher shark to be replaced by offspring with the same spawning capacity, is estimated to be around 11 years. Generation time for bigeye thresher is estimated to be approximately 17.8 years. As late-maturing species, with relatively slow growth rates and low to moderate productivity, it would likely take more than a generation time for any conservative management action to be realized and reflected in population abundance indices. This is supported by the fact that we have a well-documented example of how these species respond to intense fishing pressure, and the time required for the initial implementation of regulatory measures to be reflected in population abundance indices. For the North Eastern Pacific stock of common thresher, the time period from being in a overfished state (i.e., lowest point was approximately 30% of virgin reproductive output in 1995) to almost fully recovered after the implementation of management measures in 1985 was approximately 20-30 years (which comports with 3 generation times of the species). Given that the bigeye thresher has lower productivity than the common thresher, we assumed that the time required to observe changes in abundance indices would be longer, and would also similarly comport with 3 generation times (i.e., 50 years). We then discussed whether we could confidently predict the impact of threats on the species out to 50 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 common thresher and 50 years for the bigeye thresher.

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 each 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 1. Template for the risk matrix 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).

Demographics Risk Analysis Worksheet

RISK CATEGORY _ _ SCORE (0-3)

Abundance

Comments:

Growth rate/productivity

Comments:

Spatial structure and connectivity

Comments:

Diversity

Comments:

Threats Assessment

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.

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 perceived magnitude of impact each threat has on the extinction risk of the species. Below are the specific definitions of the threat effect levels:

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 both the common and bigeye thresher shark.

Table 2. 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			
	Recreational fisheries			
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 is at a low risk of extinction if it exhibits a trajectory indicating that it is not currently experiencing a moderate risk of extinction now, nor is it likely to have a high risk of extinction in the foreseeable future (see descriptions of "Moderate Risk" and "High Risk" below). More specifically, a species may be at low risk of extinction due to projected threats and its likely response to those threats (i.e., stable or increasing trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience).
>
> 2 = Moderate risk: A species is at moderate risk of extinction if it exhibits a trajectory indicating that it is more likely than not to be at a high risk of extinction (see description of "High Risk" below) in the foreseeable future. More specifically, a species may be at moderate risk of extinction due to projected threats and its likely response to those threats (i.e., declining trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience).
>
> 3 = High risk: A species is at high risk of extinction when it is at or near a level of abundance, spatial structure and connectivity, and/or diversity and resilience that place its persistence in question. Demographic risk may be strongly influenced by stochastic or depensatory processes. Similarly, a species 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 such imminent demographic risks.

To allow individuals to express uncertainty in determining the overall level of extinction risk facing both species, 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 each of the species, and the supporting data on which it was based, and was given the opportunity to revise scores if desired after the discussion. The scores were then tallied (mode, median, range), discussed, and summarized for the species.

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

Table 3. Template for the overall level of extinction risk analysis used in ERA team deliberations.

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

ERA Team's Extinction Risk Results and Conclusion for the Common Thresher 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 common thresher shark. The other factors, including growth rate/productivity, spatial structure/connectivity, and diversity, were not identified as demographic risks to the species. Below is a brief discussion of the rationale for our ERA team's conclusions regarding the demographic risk assessment for the common thresher shark.

<u>Abundance</u>
Currently, there is a lack of reliable global population and size estimates, with some evidence to suggest that this species may be naturally rare in fisheries throughout the tropical Western and Central Pacific and Indian Oceans due to its more coastal and temperate distribution. This is evidenced by the species' rarity in fisheries data as well as genetic studies of shark fins throughout these regions. If this is the case, the common thresher's predominantly coastal and temperate distribution may buffer the species from exposure to high levels of industrial high-seas fishing pressure in a large portion of its range.

When identified to species level, common thresher sharks do not appear to be a significant part of the direct or incidental shark catch throughout most of their range (e.g., Western and Central Pacific Ocean, Indian Ocean, South Atlantic). Similar to catches, species-specific population assessments and trends in abundance for common thresher sharks are lacking, with the exception of the North East Pacific and Western Atlantic populations. To use a thresher complex or other thresher species as a proxy for common thresher abundance could be erroneous because of the differences in the species' distributions, life history, as well as the proportions they make up in commercial catches. In most areas showing overall declines in Alopiids, the declines are not attributed to common threshers, with the exception of the Mediterranean. Additionally, common threshers identified in catches in tropical areas are likely misidentified pelagic threshers.

Presently, there is no evidence to suggest depensatory processes are at work. In areas where common thresher shark data are available, some trends show large historical abundance declines (e.g., Eastern Pacific, Northwest Atlantic, and Mediterranean). However, the available indicators of massive abundance declines appear to be regional and have either stabilized or reversed in recent years, with the exception of the Mediterranean. For example, while it is clear that the common thresher shark experienced a significant historical decline in U.S. West Coast fisheries, a recent stock assessment of the common thresher shark in the Eastern Pacific (including U.S. West Coast, Canadian, and Mexican fisheries) shows that the population has likely rebuilt to more than 90% of virgin, pre-fished levels. Similarly, while it is likely that the common thresher population in the Northwest Atlantic suffered a significant historical decline of 63-80%, we conducted an analysis of the most recent observer data from the U.S. Northwest Atlantic Pelagic Longline Fishery from 1992-2013, and determined that the population of common thresher shark in this area has likely stabilized. In the Mediterranean, only one study estimated a historical decline of up to 99% (Ferretti et al. 2008). Assuming this level of decline is accurate (though there are many limitations to this study), the ERA team agreed that while this level of decline is concerning, the Mediterranean represents a small portion of the common thresher shark's global range and likely does not affect the global population, particularly given the lack of evidence for trans-Atlantic migrations from the Mediterranean to other portions of the species' range. As previously noted, it is likely that the common thresher shark has experienced abundance declines due to fishing mortality; however, the best available abundance data included in this Status Review document suggest the population is either stable, recovered, or shows no clear trend for most areas.

Growth rate/productivity

Common thresher sharks exhibit life-history traits and population parameters that are on the higher end of the spectrum among other shark species. Relative to other thresher species, the common thresher shark is the most fecund and productive, with an intrinsic rate of population increase (*r*) of 0.121. The common thresher 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 (although new maturity ages have since been calculated, which may slightly decrease the species' overall productivity). Although the common thresher has a relatively high productivity rate relative to other elasmobranchs, it is still considered to be low for a fish species ($r < 0.14$) meaning the shark may be slow to recover from heavy exploitation. Overall, these demographic parameters place common thresher sharks towards the moderate to faster growing sharks along the "fast-slow" continuum of population parameters calculated for 38 species of sharks by Cortés (2002; Appendix 2). This species generally has a moderate potential to recover from exploitation. In addition, based on several ERAs, common threshers have been found to be less susceptible to pelagic longline fisheries in the Atlantic and Indian Oceans when compared to other shark species. However, based on the best available information, such as the fact that most species of elasmobranchs take many years to mature and have relatively low fecundity compared to teleosts (bony fishes), these life history characteristics could pose a risk to this species in combination with threats that reduce its abundance, such as overutilization.

Spatial structure/connectivity

The common thresher is a relatively widespread species, with multiple stocks in the Pacific, Indian, and Atlantic oceans. The population exchange between these stocks is unknown but probably low, so loss of a single stock would not constitute a risk to the entire species. Habitat characteristics that are important to this species are unknown, as are nursery areas. There is currently no evidence of female philopatry, 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 pose significant risks to this species.

Diversity

The ERA team concluded that the current level of information regarding the common thresher's diversity is either unavailable or unknown, such that the contribution of this factor to the extinction risk of the species cannot be determined at this time. Currently, there is no evidence to suggest the species is at risk due to a substantial change or loss of variation in genetic characteristics or gene flow among populations.

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 common thresher shark.

Habitat Destruction, Modification, or Curtailment

We did not identify habitat destruction, modification, or curtailment as a threat that contributes significantly to the species' risk of extinction, now or in the foreseeable future. We noted that there is very little information regarding habitat use of common thresher sharks, and little is known about their exact pupping and nursery areas. As such, it is extremely difficult to assess the threat of habitat loss. Additionally, common threshers are likely more confined by temperature and prey distributions than a particular habitat type. Given that they are highly migratory, it is very unlikely that the loss or degradation of any particular habitat type would have a substantial effect on the common thresher population. Thus, given the best available information, we concluded that the impact of habitat destruction, modification, or curtailment on the species' extinction risk is low.

Overutilization

The ERA team assessed three different factors that may contribute to the overutilization of the common thresher shark: bycatch in commercial fisheries (including at-vessel and post-release mortality rates), the international trade in shark products, and recreational fisheries. Because common thresher sharks are considered desirable for human consumption and are highly prized game fish, they are valuable target species, which increases their susceptibility to being overfished. This was evident in the California drift gillnet fishery in which the common thresher shark was an important secondary target to swordfish in the 1970s and 1980s. While the species experienced a significant historical decline as a result of overfishing in this fishery, a recent stock assessment (see discussion of Teo et al. (2015) in this Status Review document) shows that the population has slowly rebuilt as a result of management measures, and is not considered overfished at this time. In fact, common threshers in the Eastern Pacific are estimated to have recovered to approximately 94% of pre-fished levels, with average annual landings decreasing to approximately 115 mt in recent years, which is well below the maximum sustainable yield for the stock of 806 mt.

Aside from the North Eastern Pacific stock of common thresher, there is currently very little species-specific fisheries information on the catch or abundance of the common thresher shark, as most catch data are reported for the thresher complex and there are often misidentifications between thresher species. In the Northwest Atlantic, fisheries data show a historical decline of 63-80% in the thresher population (i.e., common and bigeye threshers combined) from 1986-2000, likely due to historical exploitation of the species. However, these data are largely based on fisheries logbooks and are not species-specific, with the bigeye thresher representing the majority of the catch. Additionally, as previously noted, recent 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, indicate that the population has likely stabilized since 1990 (see Figure 41 in this Status Review document). Reported landings for common thresher in the Northwest Atlantic have also remained stable in recent years, averaging approximately 21 mt. This indicates that current levels of catch and bycatch and associated mortality may be sustainable in this portion of the species' range. There is still uncertainty and the problem could get worse if longline fishing effort were to increase; however, the stabilization of thresher shark populations in the 1990s coincided with the first Federal Fishery Management Plan for Sharks in the Northwest Atlantic Ocean and Gulf of Mexico, which includes regulations on trip limits and quotas. Therefore, under current management measures, the ERA team concluded that overutilization is not a threat that contributes significantly to the species' extinction risk, now or in the foreseeable future.

Very little data is available from the Western and Central Pacific Ocean and Indian Ocean, with studies that either analyze the thresher complex (of which bigeye and pelagic threshers usually predominate the composition) or show no clear trend. The ERA team agreed that the rarity of common thresher sharks in catch data and genetic tests of shark fins in the tropical Pacific and Indian Oceans is likely a function of the species' more coastal and temperate distribution in areas where high seas longline fishing operations may not be as concentrated. In fact, a recent working paper from the IOTC suggests that common threshers may not even occur in the equatorial and northern tropical Indian Ocean, and previous observations of this species are likely misidentifications (Romanov, 2015). Thus, we concluded that the common thresher's distribution likely buffers it from significant impacts as a result of fishing mortality in this part of its range, where fishing pressure and inadequate regulatory measures may be more problematic. We noted that this threat may also be tempered by the species' relatively low vulnerability to high seas fisheries due to its more coastal distribution and wide range.

While the thresher complex has been reported as comprising a small portion of the shark fin trade (~ 2.3%), the proportion of common thresher in the fin trade is unknown. However, based on genetic analyses of fins in markets of major shark fin exporting countries throughout the range of the species, including Taiwan, Indonesia, and UAE, common thresher fins are rarely identified as present. Common threshers were identified to species in only one genetic study of fins from Chile, but in very small numbers. Although it is uncertain whether these studies are representative of the entire market in the respective countries, the ERA team concluded that the common thresher shark may not be as prevalent in the shark fin trade compared to other thresher species. Further, some evidence suggests that thresher fins are actually some of the least valued fins in the trade. Thus, based on the best available information, the shark fin trade is not likely a threat contributing to the overutilization of the species to the point where the species is facing an increased risk of extinction.

In addition to being valuable in commercial fisheries, common thresher sharks are highly prized game fish in recreational fisheries due to their large size and fighting abilities. Information regarding recreational fisheries data for common threshers are severely lacking outside of the U.S., where common threshers are popular in both East and West Coast recreational fisheries. Of concern are the high post-release mortality rates reported for common threshers after being foul-hooked in the tail and hauled in backwards. However, the recent stock assessment for Eastern North Pacific common threshers shows that the amount of recreational fishing pressure and associated post-release mortality is currently sustainable. Additionally, recent shark tournament data from the Northwest Atlantic, accounting for changes in effort, shows an increasing trend in abundance for common threshers. The ERA team acknowledged that due to the high quality of the meat, the majority of common threshers caught in recreational fisheries are kept, but these numbers are likely minor, especially compared to commercial catches. Thus, based on the best available information, the ERA team concluded that overutilization of common threshers in recreational fisheries is not likely a threat contributing significantly to the species' risk of extinction, now or in the foreseeable future.

Disease or Predation

We could find no information linking disease to declines in common thresher shark populations. Predation also does not appear to be increasing this species' risk of extinction, as the common thresher is a large shark with limited numbers of predators during all life stages. 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

We noted that some areas of the species' range have adequate measures in place to prevent overutilization, such as in the Eastern North Pacific, where U.S. fishery management measures to rebuild the common thresher population are helping to monitor the catch of common threshers and prevent any further population declines. These conservation and management measures (as discussed in detail in this Status Review) are viewed as adequate in decreasing the extinction risk to the common thresher shark by minimizing demographic risks (preventing further abundance declines) and the threat of overutilization (strictly managing and monitoring sustainable catch rates in both commercial and recreational fisheries) currently and in the foreseeable future. In the Northwest Atlantic, common threshers are managed under the pelagic species complex of the Atlantic HMS FMP, with commercial quotas imposed that restrict the overall level of common threshers 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 also subject to vessel upgrading restrictions. These regulations, as detailed in the 2006 Consolidated HMS FMP and described in this Status Review Report, help to monitor the catch of common threshers and prevent any further population declines in this portion of the species' range. The ERA agreed that under these existing regulatory mechanisms, longline effort in this portion of the species' range is unlikely to increase in the foreseeable future. However, inadequate regulations to control for overutilization of common threshers are evident in other parts of its range, particularly in the Mediterranean. However, the ERA noted that recent regulations implemented in 2010 by Spain, which is one of the largest shark landing nations in the Mediterranean, and responsible for a large majority of thresher catch in this region, strictly prohibit landings of all *Alopias* spp. This prohibition may be attributable to the significant decline in thresher landings by the EU reported to ICCAT since 2010, and has likely significantly reduced fishing pressure on common thresher sharks in the Atlantic. In addition, the ERA team agreed that overutilization of the species in the Mediterranean, which is a small portion of the species' global range, does not constitute an extinction risk for the global population. Inadequate regulatory mechanisms to control for overutilization of thresher species were also noted as problematic throughout the Indian Ocean. However, common threshers in particular do not appear to be caught in large numbers by fisheries in the Indian Ocean, likely a result of the species' more coastal, temperate distribution in areas where high seas longline fisheries operations are not as concentrated. In fact, it's quite possible that common thresher sharks do not occur in equatorial or tropical waters of the Indian Ocean at all (Romanov, 2015). As such, based on the best available information, inadequate regulatory measures to control for overutilization of the species in this portion of its range do not contribute significantly to the species' extinction risk.

Inadequate regulations to control for overutilization via the shark fin trade were also a concern initially, but we noted that common thresher sharks in particular may not be highly utilized in the fin trade, and the situation generally appears to be improving. For example, recent studies indicate that due to a waning interest in fins, as well as increased regulations to curb shark finning, the shark fin market is declining. 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 percent in 2011 but fell by 22 percent 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). Further, many other countries and RFMOs have also implemented shark finning bans or have prohibited the sale or trade of shark fins or products (see Status Review document for more details), further decreasing the demand for shark fins. In the U.S., for example, exports of dried shark fins significantly dropped after the passage of the Shark Finning Prohibition Act (which was enacted in December of 2000 and implemented by final rule on February 11, 2002; 67 FR 6194), and again in 2011, with the passage of the 2010 Shark Conservation Act and the ban on possession and trade of shark fins passed in several U.S. states. In fact, declining trends in landings of thresher sharks in both Hawaii and American Samoa are attributed to these regulations. Also in 2011, the price per kg of shark fin reached its highest (~$100/kg) and, as such, one would expect an increase in exports; however, as mentioned above, the opposite was true, suggesting that these types of finning and fin trade regulations are likely effective at discouraging U.S. fishers from fishing for sharks solely for the purpose of the fin trade. In 2012, the value of fins decreased indicating that perhaps the worldwide demand for fins may also be on a decline (NMFS, 2012, NMFS, 2013a). As a caveat to the decline in shark finning as a result of the numerous regulations and bans recently implemented, Dent and Clarke (2015) note that the demand for shark meat has increased annually by 4.5% from 2000-2011. However, given that thresher sharks have always been valued and retained for both their fins and meat, it is unlikely that this shift in demand will create new markets for the species. Overall, although the shark fin trade continues, and common thresher fins are likely utilized in the shark fin trade to some degree, the effect of the shark fin trade (from both legal and illegal harvest) on their extinction risk was not viewed as a significant threat. As such, based on the best available information, inadequate regulatory mechanisms to control for overutilization by the shark fin trade are not viewed as a significant threat to common thresher sharks. Additionally, as the supply and demand for shark fins continue to decrease (as demonstrated by the increase in finning regulations and decrease in shark fin price and consumption, respectively), so should the threat of finning and illegal harvest.

<u>Other Natural or Manmade Threats</u>
We did not identify effects of climate change (i.e., ocean warming, changes in currents and ocean circulation, changes in prey abundance and distribution, etc.) as a threat to common thresher sharks. We noted that common threshers are not reliant on estuarine habitats, which are thought to be one of the most vulnerable habitat types to climate change. Additionally, of the limited available information regarding effects to pelagic shark species from climate change, Chin (2010) determined that pelagic species have a low risk to climate change, and, although Hazen (2012) found that sharks had the greatest risk of losing current pelagic habitat in the North Pacific (i.e., changes in environmental factors such as SST would reduce the amount of suitable habitat), the highly migratory nature of common threshers allows them to modify their distributional range to remain in an environment conducive to their physiological and ecological needs. Thus, the ERA team concluded that threats from climate change are not likely significantly contributing to the species' risk of extinction, now or in the foreseeable future.

Overall Risk Summary

Guided by the results and discussions from the demographics risk analyses and threats assessments, we analyzed the overall risk of extinction to the global common thresher shark population. The following table gives the results of our likelihood point distributions. Likelihood points were tallied and the totals (n = 70) are presented for the overall level of extinction risk.

Table 4.

	Overall Level of Extinction Risk for the Common Thresher Shark		
	1 = Low risk	2 = Moderate risk	3= High risk
# of Likelihood Points	52.5	14.5	3

We were fairly confident in determining the overall level of extinction risk for the common thresher shark, placing the majority of our likelihood points in the "low risk" category. However, due to the lack of abundance trends and catch data for a large portion of the species' range (e.g., Western and Central Pacific and Indian Oceans), as well as significant declines observed in a small portion of the range (e.g., Mediterranean), we expressed some uncertainty by placing some of our likelihood points in the "moderate risk" and "high risk" categories as well. During discussions it was reiterated that in most areas, abundance trends are stable, increasing, or not discernable.

While common threshers experienced a significant historical decline as a result of overutilization in the North Eastern Pacific, a recent stock assessment shows that the species has recovered to more than 90% of pre-fished levels as a result of the implementation of management measures. In the Northwest Atlantic, an analysis of species-specific CPUE data indicates a stable (i.e., no) trend in abundance for common threshers since 1990, with reported landings stable over the last decade and averaging approximately 46,000 lbs (21 mt) per year. While the largest declines were detected in the Mediterranean, where common threshers are potentially targeted and heavily fished, we agreed that this area represents a small portion of their global range. Additionally, we noted that recent regulations implemented by Spain, one of the main landing nations in the Mediterranean, prohibit landings of all thresher species and are likely reducing fishing pressure on the common thresher in this portion of its range. We acknowledge that illegal fishing and discard and post-release mortality are a concern for the Mediterranean region; however, in other regions where these problems may exist, available trends show that the present level is sustainable. Further, mark/recapture data indicates that common threshers do not undertake trans-Atlantic migrations, which, when combined with the temperate range of the common thresher, separates the Mediterranean common threshers from other areas located throughout the world. As a result, overutilization of the species in the Mediterranean, which likely contributed to significant abundance declines of the species, does not present a significant threat of extinction to the global population.

We also emphasized that the common thresher's coastal and temperate distribution may limit the species' exposure to many high seas industrial fisheries operations throughout its range, particularly where fishing pressure is likely highest within the Indo-Pacific. This is evidenced by the fact that the species is rarely observed or caught throughout this portion of its range (including where regulations may be inadequate - which may reduce the impact of this potential threat on its contribution to the extinction risk of the species) and is notably absent from several genetic tests of shark fins throughout its range, indicating that the species may not comprise a large portion of the shark fin trade. In fact, recent inquiries into the distribution of common thresher indicate that the species likely does not occur in the equatorial and northern tropical Indian Ocean at all, and historical observations of the species are most likely misidentified pelagic and bigeye threshers (Romanov, 2015).

The available information indicates that most of the observed declines of common thresher occurred in the 1970s and 1980s, before any significant management regulations were in place. Since then, current regulatory measures in some parts of the common thresher range are reducing the threat of overutilization, preventing further abundance declines in the foreseeable future and decreasing the likelihood of extinction of the global population. Additionally, given that this species is relatively productive, it generally has some ability to recover from moderate levels of exploitation. In fact, under adequate management, this species has demonstrated significant resiliency, as evidenced by its rapid recovery after the implementation of management measures in the Eastern North Pacific. Thus, based on the best available information, we concluded that over the next 30 years, it is unlikely that the common thresher shark would be at risk of extinction across its range due to trends in its abundance, productivity, spatial structure, or diversity or influenced by stochastic or depensatory processes.

ERA Team's Extinction Risk Results and Conclusion for the Bigeye Thresher Shark

Evaluation of Demographic Risks

Out of the four demographic factors analyzed in this ERA, we identified abundance and growth rate/productivity as most concerning in terms of demographic risks that may contribute to the extinction risk of the bigeye thresher shark. The other factors, including spatial structure/connectivity and diversity, were not identified as demographic risks to the species. Below is a brief discussion of the rationale for our ERA team's conclusions regarding the demographic risk assessment for the bigeye thresher shark.

<u>Abundance</u>

Currently, there is a lack of reliable estimates of global population size, trends in abundance, and species-specific catch data for the bigeye thresher shark. When identified to species level, the bigeye thresher shark appears to comprise a significant portion of the direct or incidental shark catch in some areas of its range (e.g., Northwest Atlantic, Western and Central Pacific). Similar to catches, species-specific population assessments and trends in abundance for bigeye thresher shark are lacking. As previously noted, using a thresher complex or other thresher species as a proxy for bigeye thresher abundance could be erroneous because of the differences in the species' distributions as well as the proportions they make up in commercial catches. In most areas showing overall declines in Alopiids, it is uncertain which thresher species the declines are more likely attributable to, although most declines are likely attributable to either the bigeye or pelagic thresher rather than common threshers, with the exception of the Mediterranean. Additionally, there are also long-term misidentification issues between thresher sharks, which means historical data regarding thresher catch is likely not entirely accurate.

Bigeye thresher shark populations have likely exhibited historical declines in abundance relative to virgin biomass levels, but information regarding the magnitude of these declines is poor. In areas where more recent indicators of abundance for bigeye thresher are available (i.e., standardized CPUE trends), abundance trends are highly variable. In the Northwest Atlantic, it is likely that the bigeye thresher population suffered a significant historical decline; however, the ERA team questioned the magnitude of these declines, noting several issues with the available information, including the following: the data used were not species-specific, the time series ended in 2006, and the data were based on fisheries logbooks rather than observer data. The ERA team determined that observer data is likely more representative for bycatch species; thus, in order to determine the current relative abundance trends of bigeye thresher in the Northwest Atlantic, the ERA team analyzed recent species-specific observer data from the U.S. Northwest Atlantic Pelagic Longline Fishery from 1992-2013 and determined that the population of bigeye thresher shark in this area has likely stabilized.

In the Western and Central Pacific, where bigeye threshers are most commonly observed and likely most abundant, trends in abundance are unclear. An analysis of species-specific observer data from the Hawaiian Pelagic Longline Fishery indicates that abundance of bigeye thresher has been relatively stable and even potentially increasing in recent years. In contrast, fisheries data from the rest of the Western and Central Pacific region suggest thresher abundance may be on a decline, particularly in the last few years. However, the latter data from the rest of the Western and Central Pacific is not specific to bigeye thresher, and rather analyzes the thresher complex (all three *Alopias* spp). As such, interpreting this data is difficult. Given that bigeye thresher is typically the dominant thresher species in catch records from this region, the ERA team made the conservative assumption that the trends from the Western and Central Pacific are likely reflective of bigeye thresher; however, even given this assumption, the ERA team determined that the potential population declines in this region are not so significant such that the species' present level of abundance in this region contributes significantly to the species' risk of extinction globally.

Abundance information from other portions of the species' range is relatively poor and unreliable. In areas where data is lacking (e.g., Indian Ocean) it was difficult to discern if the population is stable or in decline. Given the high fishing pressure in the Indian Ocean, coupled with the species' high bycatch-related mortality rates and low productivity, it is likely that the species is experiencing some level of population decline in this region; however, we do not have enough information to determine the magnitude of this decline and whether this decline is significantly contributing to the extinction risk of the global population.

Overall, there is no evidence to suggest that present abundance levels are so low, such that depensatory processes are at work. As previously noted, although it is likely that the bigeye thresher shark has experienced declines of varying magnitudes throughout its range due to fishing mortality, recent relative abundance data included in this Status Review Report suggest that abundance trends are highly variable throughout the species' global range, with populations increasing, stable, slightly declining, or showing no clear trend. We noted that bigeye threshers are still captured regularly throughout their range and the range does not appear to have contracted. Thus, based on the best available information, we conclude that the current abundance of bigeye thresher throughout its range is not contributing significantly to the species' global risk of extinction, now or in the foreseeable future.

<u>Growth rate/productivity</u>
Bigeye thresher sharks exhibit life-history traits and population parameters that are on the low end of the spectrum among other shark species. The estimated growth coefficients confirm that the bigeye thresher is generally a slow-growing species. Relative to other thresher species, the bigeye thresher shark is the least fecund and productive, with a low intrinsic rate of population increase ($r = 0.009$ year^{-1}; Cortés et al. 2012). These demographic parameters place bigeye thresher shark towards the slower growing sharks along the "fast-slow" continuum of population parameters calculated for 38 species of sharks (see Appendix 2 of Cortés (2002)), which means this species generally has a low potential to recover from exploitation. In addition, based on several Ecological Risk Assessments, bigeye threshers have been found to be the most susceptible to pelagic longline fisheries in the Atlantic and Indian Oceans when compared to other shark species. Based on the best available information, including the fact that most species of elasmobranchs require many years to mature and have relatively low fecundity compared to teleosts, these life history characteristics could pose a risk to this species in combination with

threats that reduce its abundance, such as overutilization.

Spatial structure/connectivity

Like the common thresher, habitat characteristics that are important to the bigeye thresher are unknown, as are nursery areas. There is currently no evidence of female philopatry, 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. Thus, based on the best available information, there is insufficient information to support the conclusion that spatial structure and connectivity pose significant risks to this species.

Diversity

Similar to the common thresher, and based on the best available information, the ERA team concluded that the current level of information regarding the bigeye thresher shark's diversity is either unavailable or unknown, such that the contribution of this factor to the extinction risk of the species cannot be determined. Currently, there is no evidence to suggest the species is at risk due to a substantial change or loss of variation in genetic characteristics or gene flow among populations.

Threats Assessment

Out of the five ESA section 4(a)(1) factors, we identified overutilization and inadequate regulatory mechanisms as most concerning in terms of threats that may contribute to the extinction risk of the bigeye thresher shark. 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 bigeye thresher shark.

Habitat Destruction, Modification, or Curtailment

We noted that there is very little information on the species' habitat use and their exact pupping and nursery areas. As such, it is extremely difficult to assess the threat of habitat loss in terms of its contribution to the species' risk of extinction. Additionally, given that bigeye threshers are highly migratory pelagic species, it is very unlikely that the loss or degradation of any particular habitat type would have a substantial effect on the global bigeye thresher population. Given the best available information, the team reached consensus regarding this threat and concluded that the threat of habitat destruction, modification, or curtailment is not contributing significantly to the species' risk of extinction now or in the foreseeable future.

Overutilization

The ERA team assessed three different factors that may contribute to the overutilization of the bigeye thresher shark: bycatch in commercial fisheries (including at-vessel and post-release mortality rates), international shark trade (including fins and meat), and recreational fisheries. Because bigeye thresher sharks are considered valuable bycatch species, with high at-vessel mortality rates and low productivity, this species has an increased susceptibility to being overfished. While there is currently very little species-specific fisheries information on the catch or abundance of the bigeye thresher shark throughout its global range, fishing pressure on the species appears to be high, and overutilization (as indicated by decreases in average size of bigeye thresher caught in Pacific fisheries, as well as declines in CPUE in some areas of the Atlantic, Pacific, and Indian Oceans) has been observed in some parts of the species' range, providing evidence of the vulnerability of the species to commercial fisheries. However, current regulations may be mitigating this threat.

In the Northwest Atlantic, fisheries data show a significant historical decline in the thresher population (common and bigeye threshers combined), likely due to exploitation of the species. While this data is not species-specific, the bigeye thresher is thought to be the more common of the two species. However, as previously noted, a recent species-specific analysis of observer data from the Northwest Atlantic, which was deemed more reliable and accurate by the ERA team than logbook data for this species, indicates that the population has likely stabilized since 1990 at a diminished abundance (see Figure 41 in this Status Review document). This indicates that current levels of catch, bycatch, and associated mortality may be sustainable. Given the current level of fishing effort, combined with strict species-specific regulations in place for bigeye thresher in U.S. commercial and recreational fisheries, we determined that overutilization of bigeye thresher shark is not likely occurring in this portion of its range to the point that it contributes significantly to the species' global risk of extinction now or in the foreseeable future. As noted in the common thresher assessment, there is still uncertainty and we acknowledge that the problem could get worse if longline fishing effort increases. However, the stabilization of thresher shark populations in the 1990s coincided with the first Federal Fishery Management Plan for Sharks in the Northwest Atlantic Ocean and Gulf of Mexico, which included regulations on trip limits and quotas. Therefore, based on the best available information, the ERA team concluded that under current management measures, overutilization is not a threat that contributes significantly to the species' extinction risk, now or in the foreseeable future.

In the South Atlantic, the predominant longline fisheries responsible for the majority of thresher catches are from Brazil. Standardized CPUE trends from the prominent Brazilian Santos and Guaruja tuna longline fisheries showed only a slight decline for bigeye thresher from 1977 to 2006, with bigeye threshers disappearing from catch records altogether in 2006. However, as described in this Status Review Report, it appears these fisheries shifted effort to more temperate waters where bigeye threshers are less prevalent due to their more tropical distribution. Therefore, the ERA team agreed that the disappearance of bigeye threshers from catches in these particular fisheries from 2006 onwards was likely a result of a shift in the distribution of fishing effort rather than population declines. Total landings reported to ICCAT also significantly declined in 2009, which is the same year ICCAT enacted Recommendation 09-07 to specifically prohibit landings and retention of bigeye threshers. While we agreed that retention bans do not address bycatch-related mortality, the shift in fishing effort to temperate waters combined with a species-specific retention ban likely resulted in a reduction in fishing pressure in this portion of its range, as bigeye threshers were historically retained bycatch in this fishery. While bigeye threshers are reported as bycatch in other fisheries in the South Atlantic, and fishing pressure is reportedly high, catch rates and trends of bigeye thresher in these fisheries are largely unavailable or show no clear trend. Thus, based on the best available information, the ERA team concluded that overutilization of bigeye thresher sharks in commercial fisheries is not likely occurring in this portion of its range (South Atlantic) to the point that it contributes significantly to the species' global risk of extinction, now or in the foreseeable future.

Some data is available from the Western and Central Pacific, where threshers are regularly caught as bycatch in longline fisheries throughout the region. Historically, the thresher complex reportedly declined by approximately 83% in this region (Ward and Myers, 2005); however, the ERA team pointed out several issues with this study, including variation in locations between surveys and differences in data sources (e.g., fishery independent data vs fishery dependent data) and seriously questioned its conclusions. Few other recent studies are available, and either analyze the thresher complex (all *Alopias* spp.) or show no clear trend. Based on the best available information, the ERA team agreed that the catch composition in the Western and Central Pacific is likely dominated by bigeye threshers, particularly due to the rarity of common thresher sharks in catch records and genetic tests of shark fins throughout the Pacific and Indian Oceans, as well as documented misidentifications between thresher species. Therefore, as previously noted, we assumed that the trends in these areas are likely reflective of bigeye thresher. Some reliable fisheries data from the Western and Central Pacific is from Japanese longline observer data, in which bigeye thresher was the second most commonly caught shark species from 1992-2006, comprising 10.9% of the total shark catch (Matsunaga and Yokawa, 2013). Catch estimates indicate that removals have been stable over the last decade, and some analyses indicate slight increases in catch rates of thresher sharks in certain areas, although no clear temporal trend was detected (Lawson, 2011, Clarke, 2011). Other reliable fisheries data in the Western and Central Pacific comes from the U.S. Hawaii pelagic longline fishery, in which the bigeye thresher is the third most frequently caught elasmobranch in Hawaii tuna fisheries. The U.S. Hawaii longline fishery has observed an increase in the number of bigeye threshers caught as bycatch on tuna targeted trips. While participation, number of hooks, and number of tuna targeted trips have been slowly increasing since 2010 (PIFSC, 2014), standardized CPUE derived from observer data indicates that abundance of bigeye thresher has been relatively stable since 1994, with a potentially substantial increase in recent years. Bigeye threshers are also an important species in Taiwan longline fisheries targeting tuna, and comprise approximately 5% of the total shark catch (Liu and Tsai, 2011). Although catches of bigeye threshers have increased over time in Taiwanese longline fisheries, information regarding corresponding effort is not available to discern abundance trends.

Overall, standardized CPUE data for the Western and Central Pacific, where longline fishing effort has been steadily increasing since 1995 primarily in the South Pacific, and nearly half the effort occurs in tropical and equatorial waters where bigeye threshers have shown the highest CPUEs (Rice et al., 2015, Matsunaga and Yokawa, 2013), show a slightly decreasing trend for the thresher complex from 2011-2013. Of note is that the use of wire leaders in Western and Central Pacific fisheries has generally been declining since 2004 (Lawson, 2011), which may account for some declines in CPUE as sharks are more capable of biting through monofilament line and escaping. In fact, the use of wire leaders or shark lines was recently banned throughout the Western and Central Pacific by the WCPFC in July 2015, which should help reduce shark bycatch rates in the region. While the last three years of both the standardized and nominal thresher CPUEs show a more significant decline, the standardized CPUE from the thresher complex is difficult to interpret as the second most commonly reported thresher species is the general “thresher shark" category. Additionally, while it appears the thresher shark complex is declining sharply at the last data point, this is based on relatively few data, which may not be robust and may exaggerate the trend in the last year. Overall, despite increasing fishing pressure over the past 20 years, focused predominantly in tropical areas where all life stages of bigeye thresher would likely occur (including potential nursery areas), available abundance indices have not shown any significant population decline. Based on this information, the ERA team did not deem the declining trend in the last three years to be so significant to conclude that overutilization is occurring in the entire Western and Central Pacific. The ERA team emphasized that the present level of fishing pressure on bigeye thresher in this region is highly variable, both spatially and temporally, as evidenced by increasing trends in Hawaiian fisheries compared to slightly declining trends for the rest of the Western and Central Pacific. Thus, based on the best available information, the ERA team concluded that overutilization of bigeye thresher sharks from commercial fisheries is not likely occurring throughout the entirety of the Western and Central Pacific to the point that it contributes significantly to the species’ global risk of extinction, now or in the foreseeable future.

While there are no abundance trends for bigeye thresher in the Indian Ocean, the IOTC acknowledges, and the ERA team agreed, that bycatch rates of bigeye thresher shark are likely high in Indian Ocean longline fisheries. Landings data reported to the IOTC are reported for the thresher complex and not identified to species, thus it is difficult to interpret this information with respect to bigeye thresher specifically. However, given the bigeye thresher’s high hooking mortality rate and potentially significant presence in the shark fin trade, fishing pressure is likely contributing to the overutilization of the species in the Indian Ocean. We note that this threat may also be exacerbated by the species’ relatively high vulnerability to fisheries due to its slow growth and low productivity. Thus, in the absence of any trend data, we concluded that overutilization in the form of bycatch-related fishing mortality may be contributing to population declines and increasing this species’ risk of extinction in the Indian Ocean in the foreseeable future, although there are significant uncertainties. However, it should also be noted that longline fishing effort in the Indian Ocean appears to be declining as well as shifting to more temperate waters (Ardill et al., 2011) where bigeye threshers are less prevalent, which could potentially reduce fishing pressure on the species. Overall, based on the best available information, the ERA team agreed that overutilization of bigeye thresher in the form of indirect and direct fishing pressure is likely occurring in the Indian Ocean, but also noted that overutilization of the species in one particular region does not necessarily equate to a risk of extinction to the global population.

As previously described, the thresher complex has been reported as comprising between 2.3% of the shark fin trade; however, the proportion of bigeye thresher in the fin trade is unknown. Based on genetic analyses of fins in markets of major shark fin exporting countries throughout the range of the species, including Taiwan, Indonesia, and UAE, bigeye thresher fins have commonly been identified as present. In fact, bigeye thresher fins comprised approximately 7% of fins in numerous markets across Indonesia, which is one of the largest shark catching nations in the world. However, overall, the ERA team concluded that thresher sharks as a whole represent a relatively small portion of the fin trade, and the situation regarding the fin trade may be improving, as evidenced by a decline in both price and demand for fins. In fact, landings of bigeye thresher in particular have declined in both Hawaii and American Samoa, which has been attributed to regulations prohibiting shark finning in the U.S. Therefore, although the bigeye thresher shark is likely prevalent in the shark fin trade, the ERA team concluded that based on the best available information, finning for the shark fin trade is not a threat contributing to the overutilization of the species to the point where it is contributing significantly to the species' global risk of extinction, now or in the foreseeable future.

We did not identify recreational fisheries as a threat that is presently contributing to the overutilization of the species. While bigeye thresher sharks, like common threshers, are prized game fish in recreational fisheries due to their large size and fighting abilities, information regarding recreational fisheries data for bigeye threshers are severely lacking outside of the U.S., where recreational fishing for bigeye thresher is largely prohibited and presumably only few are taken each year, as evidenced by sparse records of bigeye thresher in recreational fisheries data.

Disease or Predation

We could find no information linking disease to declines in bigeye thresher shark populations. Predation also does not appear to be increasing this species' risk of extinction, as the bigeye thresher is a large shark with limited numbers of predators during all life stages. Therefore, based on the best available information, we concluded that neither disease nor predation is increasing the species' extinction risk.

Inadequacy of Existing Regulatory Mechanisms

We noted that some areas of the species' range do have adequate measures in place to prevent overutilization, such as in the Northwest Atlantic where U.S. fishery management measures prohibit bigeye thresher landings in commercial and recreational fisheries to help rebuild populations and prevent any further population declines. These conservation and management measures (as detailed in the 1999 FMP for Atlantic Tunas, Swordfish, and Sharks and explained in this Status Review) are viewed as adequate in decreasing the extinction risk to the bigeye thresher shark by minimizing demographic risks (preventing further abundance declines) and the threat of overutilization (strictly prohibiting landings and monitoring sustainable catch and discard rates) currently and in the foreseeable future. Although we recognize that bigeye threshers are still caught and discarded in these fisheries, the ERA team determined that current levels may be sustainable as evidenced by a continuing stable CPUE trend based on observer data, which accounts for bycatch-related mortality. Additionally, the significant decline in thresher landings by the EU reported to ICCAT since 2010 may be attributable to other international regulations, including ICCAT's recommendation 09-07, which specifically prohibits the retention, transshipping, landing, storing, selling, or offering for sale any part or whole carcass of bigeye thresher sharks, as well as Spain's prohibition on landings of all *Alopias* spp. Thus, these regulations have likely significantly reduced fishing pressure on bigeye thresher sharks in the Atlantic. In addition, the recent listing of bigeye thresher under Appendix II of the Convention of Migratory Species now encourages international cooperation towards conservation of the species. We recognize that regulations for bigeye thresher are likely inadequate in other parts of its range, including in the South Atlantic (although Brazil recently banned gillnets) and especially throughout the Indian Ocean where, despite prohibitions on landings of *Alopias* spp. implemented in 2010, reported landings have continued to increase. However, based on the best available information, overutilization in these portions of the species' range is either not likely occurring (i.e., South Atlantic), or is likely occurring, but does not in and of itself contribute significantly to the species' risk of global extinction (i.e., Indian Ocean).

Inadequate regulations to control for overutilization via the shark fin trade were also a concern initially, as the bigeye thresher was identified to species in several genetic tests of fins in various portions of its range, and seemed to comprise a large portion of fins in markets across Indonesia (one of the largest shark catching countries in the world). However, we noted that overall, thresher fins do not make up a large portion of the shark fin trade (~2.3%) relative to other species, such as blue sharks, makos, and hammerheads. Additionally, thresher shark fins are not considered highly valued or "first choice" among traders. Finally, the situation regarding the fin trade appears to be improving (refer back to the common thresher - Inadequacy of Existing Regulatory Mechanisms section of this ERA). In fact, a decrease in landings of bigeye thresher was reported in Hawaii and American Samoa, which has been attributed to regulations that prohibit shark finning in the United States, and may also be indicative of the efficacy of these regulations. Overall, although bigeye thresher shark fins are utilized in the shark fin trade to some degree, the effect of the shark fin trade (from both legal and illegal harvest) on their extinction risk was not viewed as a significant threat. Additionally, as both the supply and demand for shark fins continues to decrease (as demonstrated by the increase in finning regulations and decrease in shark fin consumption and price, respectively – see Inadequacy of Existing Regulatory Mechanisms section for common thresher above), so should the threat of finning and illegal harvest. While an increase in the demand for shark meat is apparent in recent years, it is unlikely that new markets will develop for bigeye thresher, as its meat is not as desirable as other shark species due to its mushy texture.

<u>Other Natural or Manmade Threats</u>

We noted that information regarding effects of climate change (i.e., ocean warming, changes in currents and ocean circulation, changes in prey abundance and distribution, etc.) to pelagic shark species is extremely limited and difficult to quantify. Given the limited amount of information available, the ERA concluded that effects of climate change are unlikely to contribute significantly to the species' risk of extinction. Like common threshers, we noted that bigeye threshers are not reliant on estuarine habitats, which are thought to be one of the most vulnerable habitat types to climate change. Of the limited available information regarding impacts to pelagic shark species from climate change, Chin et al. (2010) determined that pelagic species have a low risk to climate change, and, although Hazen et al. (2012) found that sharks had the greatest risk of losing current pelagic habitat in the North Pacific (i.e., changes in environmental factors such as SST would reduce the amount of suitable habitat), the highly migratory nature of bigeye threshers gives them the ability to shift their range or distribution to remain in an environment conducive to their physiological and ecological needs.

Overall Risk Summary

Guided by the results and discussions from the demographics risk analyses and threats assessments, we analyzed the overall risk of extinction to the global bigeye thresher shark population. The following table gives the results of our likelihood point distributions. Likelihood points were tallied and the totals (n = 70) are presented for the overall level of extinction risk.

Table 5.

	Overall Level of Extinction Risk for the Bigeye Thresher Shark		
	1 = Low risk	2 = Moderate risk	3= High risk
# of Likelihood Points	34.5	30.5	5

We showed considerable uncertainty in determining the overall level of extinction risk for the bigeye thresher, dividing our likelihood points almost evenly between the “low risk” and “moderate risk” categories, with a slight majority in the “low risk” category. Due to a lack of abundance trends and catch data for a large portion of the species’ range, we expressed uncertainty by spreading our likelihood points across all categories. During discussions it was reiterated that across the species’ range, regional abundance trends are highly variable, with no clear trend for the global population.

Although the global abundance of bigeye thresher shark is highly uncertain, none of the available studies that reported recent standardized CPUEs (Northwest Atlantic, South Atlantic, Hawaii, Western and Central Pacific), and give some insight into the species’ current abundance, show a significant and continued decline such that demographic risks are significantly contributing to the species’ risk of extinction. Based on most recent fisheries data, the ERA team concluded that at least some populations of bigeye thresher are not overutilized and current fishing pressure and associated mortality on these populations may be sustainable. We recognized that the bigeye thresher’s tropical distribution may increase the species’ exposure to many high seas industrial fisheries operations throughout its range, particularly where fishing pressure is likely highest within the Indo-Pacific. This is evidenced by the fact that the species is commonly observed or caught throughout this portion of its range (including where regulations may be inadequate - which may increase the impact of this potential threat on its contribution to the extinction risk of the species) and is present in several genetic tests of shark fins throughout its range, indicating that the species may be prevalent in the shark fin trade. Thus, while the bigeye thresher may be experiencing some degree of population decline in the Western and Central Pacific and Indian Oceans, the magnitude of decline is uncertain because available CPUE and landings data is reported for the thresher complex (all three *Alopias* spp.) and are not species-specific. However, the ERA team agreed that the potential declines of bigeye thresher in these portions of its range are not likely to be so severe such that it contributes significantly to the species’ global risk of extinction, now or in the foreseeable future.

The available information indicates that most of the observed declines occurred historically, before any significant management regulations were in place. Since then, current regulatory measures in some parts of the bigeye thresher range are reducing the threat of overutilization, preventing further abundance declines in the foreseeable future and decreasing the likelihood of extinction of the global population. The ERA team acknowledged that given the species' low productivity and high bycatch-related mortality rates, it is generally more vulnerable to unsustainable levels of exploitation. However, given the best available information, we concluded that over the next 50 years, it is unlikely that the bigeye thresher shark would be at risk of extinction throughout its global range due to current trends in its abundance, productivity, spatial structure, or diversity or influenced by depensatory processes, effects of environmental stochasticity, or catastrophic events.

SIGNIFICANT PORTION OF ITS RANGE ANALYSIS

As noted in the **Introduction** above, the definitions of both "threatened" and "endangered" under the ESA contain the term "significant portion of its range" (SPR) as an area smaller than the entire range of the species which must be considered when evaluating a species' risk of extinction. Under the final SPR policy announced in July 2014, should we find that the species is of low extinction risk throughout its range, we must go on to consider whether the species may have a higher risk of extinction in a significant portion of its range (79 FR 37577; July 1, 2014). Specifically, we were asked to identify any SPRs for the common and bigeye thresher shark with the understanding that a portion of the range of a species is "significant" if its contribution to the viability of the species is so important that, without that portion, the species may not survive.

After a review of the best available information, we concluded that the data did not indicate any portion of the common or bigeye thresher sharks' range as more significant than another. Both species of thresher shark are highly mobile, with global distributions, and very few restrictions governing their movements. Although there is preliminary evidence of possible genetic partitioning between ocean basins, this was based on one study with a limited sample size (see Trejo (2005)). We recognized that the Mediterranean region and Indian Ocean likely have more concentrated threats than other regions of the common and bigeye thresher's range, respectively. However, the ERA team concluded that the Mediterranean represents a small portion of the global range of the common thresher, and the loss of that part of the species' range would not constitute an extinction risk to the global species. Thus, the Mediterranean would not qualify as "significant" under the SPR Policy. Likewise, the ERA team concluded that loss of the Indian Ocean population of bigeye thresher would not necessarily constitute a risk of extinction for the global species. In particular, we did not find substantial evidence to indicate that the loss of genetic diversity from one portion (such as loss of an ocean basin population) would result in the remaining population lacking enough genetic diversity to allow for adaptations to changing environmental conditions. Similarly, we did not find that loss of any portion would severely fragment and isolate the common or bigeye thresher population to the point where individuals would be precluded from moving to suitable habitats or have an increased vulnerability to threats. As previously mentioned, both species of thresher shark are highly mobile, globally distributed, and have no known barriers to migration. Loss of any portion of its range would not likely isolate the species to the point where the remaining populations would be at risk of extinction from demographic processes. In fact, we found no information that would suggest that the remaining populations could not repopulate the lost portion, and, if for some reason the species could not repopulate the lost portion, it would still not constitute a risk of extinction to the remaining populations. Areas exhibiting source-sink dynamics, which could affect the survival of the species, were not evident in any part of the common or bigeye thresher shark range. There is also no evidence of a portion that encompasses aspects that are important to specific life history events but another portion that does not, where loss of the former portion would severely impact the growth, reproduction, or survival of the entire species. There is also little to no information regarding nursery grounds or other important habitats utilized by the species that could be considered limiting factors for the species' survival. In fact, we found evidence that there are likely reproductive grounds and nursery areas in all three major ocean basins (Benjamin et al., 2015, Fernandez-Carvalho et al., 2015a, Matsunaga and Yokawa, 2013). In other words, the viability of the species does not appear to depend on the productivity of the population or the environmental characteristics in any one portion. Overall, we did not find any evidence to suggest that any specific portion of the species' range had increased importance over another with respect to either species' survival.

Appendix 1

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

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
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.
Guinea-Bissau	2009	Ban on shark fishing in Marine Protected Areas (two parks covering 2,077 km^2).
Indonesia	2010	No shark fishing in Raja Ampat
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	2015	Passed legislation (Public Law No. 18-108) in early 2015 to establish the Micronesia Regional Shark Sanctuary, which covers the country's full EEZ and encompasses nearly 3 million square kilometers (1.1 million square miles) in the western Pacific Ocean. The measure 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.
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.
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	Created world's largest shark sanctuary. 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.
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 2

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. 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	2013	Shark finning is prohibited by all vessels fishing in EU waters and on all EU vessels fishing in oceans worldwide. Sharks must be landed with fins naturally attached.
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 & Caribbean Seas.
Namibia	2003	Generally prohibits the discards of harvested or bycaught marine resources. Prohibits 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.
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.
Venezuela	2012	Sharks caught in Venezuelan waters must be brought to port with fins naturally attached.

Appendix 3

Summary of RFMO Shark Regulations pertinent to Thresher Sharks

RFMO	Date	Shark Regulations
International Commission for the Conservation of Atlantic Tunas (ICCAT)	2009	Developed recommendation 09-07 which specifically prohibits the retention, transshipping, landing, storing, selling, or offering for sale any part or whole carcass of bigeye thresher sharks (*A. superciliosus*) in any fishery with exception of a Mexican small-scale coastal fishery with a catch of less than 110 fish; CPCs should strongly endeavor to ensure that vessels flying their flag do not undertake a directed fishery for species of thresher sharks of the genus *Alopias* spp.
General Fisheries Commission of the Mediterranean (GFCM)	2012	Adopted ICCAT recommendation 09-07 on thresher sharks; bigeye threshers cannot be retained on board, transhipped, landed, transferred, stored, sold or offered for sale; CPCs should strongly endeavor to ensure that vessels flying their flag do not undertake a directed fishery for species of thresher sharks of the genus *Alopias* spp.
Indian Ocean Tuna Commission (IOTC)	2010	Developed recommendation 10-05 which specifically prohibits the retention, transshipping, landing, storing, selling or offering for sale any part or whole carcass of thresher sharks of all the species of the families Alopiidae; Requires CPC vessels flying their flag to promptly release unharmed, to the extent practicable, thresher sharks when brought along side for taking on board the vessel; Recreational and sport fishing shall release alive all caught animals of thresher sharks of all the species of the families Alopiidae. The CPCs shall ensure that both recreational and sport fishers carrying out fishing with high risk of catching thresher sharks are equipped with instruments suitable to release alive the animals
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). WCPFC also adopted a CMM 2014-05 (effective July 2015) that requires each national fleet to ban the use of
Inter-American Tropical Tuna Commission (IATTC)	2005	
North Atlantic Fisheries Organization (NAFO)	2005	
Southeast Atlantic Fisheries Commission	2006	

(SEAFO)		wire trace as branch lines or leaders
Western and Central Pacific Fisheries Commission (WCPFC)	2008	
North East Atlantic Fisheries Commission (NEAFC)	2007	

Appendix 4

Status and Development of National Plan 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 & 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 Province of China	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
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

The following section describes the relevant regulatory mechanisms in countries that catch common and bigeye threshers that also ranked in the top 26 shark-catching countries as identified by the FAO in Fischer et al. (2012). It is important to note that these summaries were compiled in 2012 and are not exhaustive; thus, they may not reflect the most recent regulatory updates.

Indonesia: The Ministry of Marine Affairs and Fisheries is responsible for the implementation of fishery management measures in Indonesia. The activities and regulations issued by the Ministry of Marine Affairs and Fisheries are based on Fisheries Law No. 31/2004 (amended by Law No. 45/2009) which includes provisions for fishing gear and technical measures, total allowable catches (TACs) and quotas, entry controls and registers, MCS, enforcement, etc. An important by-law is Regulation No. 60/2007 on the Conservation of Fishery Resources, which deals with the conservation of ecosystems, fish species and fish genetics. Existing shark regulations are only those necessary to conform to international agreements (e.g., trade controls for species listed by CITES (e.g. whale shark), and those prescribed by RFMOs of which Indonesia is a member).

India: In India, authority to enact laws is divided between the Central Government and Indian states. Ultimately, the Ministry of Agriculture via the Department of Animal Husbandry, Dairying and Fisheries is responsible for fisheries in India's EEZ. Relevant legislation includes the 1897 Fisheries Act, the 1986 Environment Protection Act, the 1978 Marine Fishing Regulation Act and the 1991 Coastal Regulation Zone Notification. India has developed a comprehensive marine fishing policy on the principle of stakeholder participation (led by an interministerial empowered committee). Measures consist of entry controls and technical measures (including 33 marine protected areas covering about 6,271 km^2). Currently, India is instituting a more effective MCS and enforcement scheme that includes a vessel monitoring system (VMS). To date, India has not adopted any shark finning regulations.

Spain: Fisheries in Spain are essentially regulated under Law No. 3/2001. Regulations are implemented under the umbrella of the Common Fisheries Policy of the European Union (Member Organization), which includes application of the precautionary principle and is moving towards an ecosystem approach to fisheries. Management is based on TACs complemented by technical conservation measures. Spain has established 17 national and regional marine protected areas and 12 artificial reefs for the protection and regeneration of marine resources. A shark finning ban is in place (Orden APA 1126/2002). In addition, a number of shark-specific regulations and prohibitions exist, including a prohibition to catch thresher sharks (family Alopiidae) under Real Decreto 139/2011. There is also a regulation on fishing of highly migratory species, Regulation of recreational fisheries, List of Wild Species under Special Protection Rules and of the National Catalogue of Threatened Species.

Taiwan Province of China: The Council of Agriculture is the competent authority on agricultural, forestry, fishery, animal husbandry, and food affairs in Taiwan Province of China. Fisheries are regulated under the Domestic Fisheries Act and Wildlife Conservation Act (1929, last amendment 200843). The Act deals with entry controls, technical measures, MCS and enforcement schemes and recreational fisheries. A shark finning measure in the EEZ and territorial waters has gradually been implemented since 2012 under Executive Yuan under Order No. Nung-sou-yu 1011330088. In addition, Taiwan's NPOA-Sharks states that all parts of sharks landed in Taiwan Province of China are fully utilized.

Mexico: The agency responsible for fisheries management, monitoring and enforcement in Mexico is the Comisión Nacional de Acuacultura y Pesca (National Commission of Aquaculture and Fisheries). Fisheries are regulated by Article 27 of the Political Constitution of the United Mexican States, by the 2007 General Fishing Law for Sustainable Fisheries and Aquaculture by the Regulations rooted in its predecessor (1992). The 2007 Law uses an integrated sector development approach; it establishes entry controls, technical measures, TACs and quotas, and MCS and enforcement (recently strengthened, implemented through the National Commission of Aquaculture and Fisheries), etc. Mexico regulates shark finning and prohibits the exclusive use of shark fins and landing of fins without the bodies on board. Three shark species are listed as threatened by the Rule on Environmental Protection. In addition, the Rule on Responsible Fisheries of Sharks and Rays from 2006 prohibits retention of 12 species, and defines protected areas and seasons, gear restrictions and reporting requirements. This rule was amended in 2011 with spatial closures for shark fisheries along the Pacific coast and the Gulf of Mexico.

United States: Refer back to Domestic Authorities in this section.

Malaysia: The agencies responsible for fishery matters in Malaysia include the Department of Fisheries Malaysia and the Fisheries Development Authority of Malaysia. The Fisheries Act 1985 and the regulations adopted under the act provide the legal framework for the management of fishery resources and aquaculture. Marine waters are divided into four fishing zones and access regulations apply accordingly. Management of Malaysia's offshore fisheries in the EEZ includes regulation of fishing effort, TACs and individual quotas, MCS and enforcement measures. Additionally, a series of marine protected areas has been established in the coastal waters. There are no shark fin measures in place, but Malaysia reports that all retained sharks are fully utilized. Other relevant regulations are the zoning of fishing areas and a trawling ban in the near-coast zone.

Japan: The Ministry of Agriculture, Forestry and Fisheries is the responsible agency for fisheries management in Japan. The Fisheries Law (1949, revised in 1962) regulates fisheries and aquaculture activities in Japan. In 2001, Japan established the new Basic Law on Fisheries seeking to secure sustainable utilization of fishery resources, stable supply of fish and fishery products for the nation and sound development of the Japanese fishing industries as well as improvement and revitalization of fishing communities. Coastal fisheries are co-managed by the industry. Offshore and distant-water fisheries are regulated through a fisheries licensing system. The 1997 Preservation and Management of Living Marine Resources Law introduced the TAC system. In compliance with measures by RFMOs (tuna), shark finning regulations apply for all Japanese tuna fisheries (including coastal and near shore operations). Japan also reports that all parts of sharks are utilized. Fisheries targeting sharks or causing substantive shark bycatch are strictly controlled by a licensing system.

France: The main authority in charge of fisheries and aquaculture is the Agriculture and Food Industry Ministry. Since 1983, French marine fisheries policies have been guided by the Common Fisheries Policy (CFP) of the EU, which covers all aspects of the sector including access to fishing areas, technical measures, TACs and quotas, monitoring of resources and fishing activities, control and enforcement, and marketing and international relations. Shark finning is regulated by EU Regulation (EC) 1185/2003 which prohibits the dumping of finned shark carcasses at sea in its waters and for its vessels wherever they may fish. Currently, a 5% fin-to-body weight ratio is required for sharks landed with separated fins, but the shark finning measure from 2003 is under revision with the objective to ban the finning of sharks on board vessels (landing of sharks with fins attached).

Thailand: Fisheries are managed under the Thai Fisheries Act (1947, revised in 1953 and 1985), which includes technical measures (e.g. area and seasonal closures, gear restrictions) and entry controls. Other relevant pieces of legislation are the Act Governing the Right to Fish in Thai Waters (1939), the Thai Vessel Act (1938), the Wildlife Reservation and Protection Act (1992) and the Enhancement and Conservation of National Environmental Quality Act (1992). Currently, Thailand has no shark finning ban or other fin regulations in place.

Sri Lanka: The Ministry of Fisheries and Aquatic Resources is the responsible agency for fisheries management, which is based on the Fisheries and Aquatic Resources Act No. 2 of 1996. It provides for entry controls, technical measures, fishing reserves and export/import regulations. Sri Lanka passed a shark finning ban in 2011, and also passed Thresher Shark Regulations 2012 under the Fisheries and Aquatic Resources Act, No 2 of 1996. This act effectively prohibits catching, possessing or trading in thresher sharks.

New Zealand: The Fisheries Management Directorate of the Ministry of Primary Industries is responsible for managing fishery resources based on the Fisheries Act 1996. It provides the framework for the New Zealand Quota Management System under which transferable quotas are allocated to individuals based on the proportion of the total allowable commercial catch (TACC) they own. In addition, a number of technical measures are implemented for different fisheries. New Zealand also has in place a comprehensive MCS and enforcement scheme. Live shark finning is banned by the Animal Welfare Act 1999. A number of fisheries plans are relevant for sharks, in particular for deepwater, inshore and highly migratory species. A code of practice (2001, updated 2010) codifies the safe handling, processing and unloading of sharks in the tuna fishery. New Zealand has a relatively high level of observer coverage in a range of shark-targeted and bycatch fisheries generating information on sea fishing practices.

Portugal: Within the Ministry of Agriculture, Sea, Environment, and Spatial Planning, the Directorate-General of Natural Resources, Security and Marine Services is mainly responsible for fisheries management in Portugal. Regulations are implemented under the umbrella of the CFP, which includes application of the precautionary principle and is moving towards an ecosystem approach to fisheries (EAF). Management is based on TACs complemented by technical measures. Like other EU countries, shark finning is regulated by EU Regulation (EC) 1185/2003 which prohibits the dumping of finned shark carcasses at sea in its waters and for its vessels wherever they may fish. Currently, a 5% fin-to-body weight ratio is required for sharks landed with separated fins, but the shark finning measure from 2003 is under revision with the objective to ban the finning of sharks on board vessels (landing of sharks with fins attached).

United Kingdom: The Department of Environment, Food and Rural Affairs is responsible for policy and regulations on the marine environment, biodiversity and fisheries. The fisheries policy and management of the United Kingdom of Great Britain and Northern Ireland are implemented under the umbrella of the CFP, which includes application of the precautionary principle and is moving towards an EAF. Management is based on TACs complemented by technical conservation measures. As an EU member, shark finning is regulated by EU Regulation (EC) 1185/2003 which prohibits the dumping of finned shark carcasses at sea in its waters and for its vessels wherever they may fish. Currently, a 5% fin-to-body weight ratio is required for sharks landed with separated fins, but the shark finning measure from 2003 is under revision with the objective to ban the finning of sharks on board vessels (landing of sharks with fins attached).

Republic of Korea: The Ministry for Food, Agriculture, Forestry and Fisheries is the responsible authority for the management of fisheries in the Republic of Korea. Management is based on the 2009 Fisheries Act and the 2009 Fisheries Resources Management Act. Measures applied include entry controls, technical measures, TACs and quotas; emphasis is given to an effective MCS and enforcement scheme and a participatory, community-based fisheries management approach. Relevant regional and international obligations are implemented through the 2008 Distant Water Fisheries Development Act. In 2005, the Republic of Korea established the ecosystem-based Fish Stock Rebuilding Plan. The Republic of Korea has not adopted finning measures in its EEZ but complies with relevant high seas regulations. Area restrictions for purse seine fisheries are intended to minimize incidental catches of sharks.

Peru: Fisheries management is the responsibility of the Ministry of Production through the Office of the Deputy Minister of Fisheries. It is mainly based on the General Fisheries Law – Decree Law No. 25 977 and numerous by-laws. Measures deal with fishery entry regimes, fleet and processing capacities, technical measures, TACs, scientific assessments and MCS. Shark finning is not prohibited in Peru, although the draft NPOA contains the objective of complete utilization of shark bodies. Peru has a number of various shark-specific regulations, including minimum sizes for certain elasmobranchs and mesh size for catching coastal rays and sharks; bycatch for three Chondrichthyes; a permanent Multi-sector Working Group on Oceanic Matters comprised of representatives from environmental protection NGOs to advise on and coordinate relevant obligations under the UN system; identify the relation between highly migratory resources and national fishing opportunities for management purposes (specifically considers *A. vulpinus*)[13]; and fisheries management of tuna and similar species.

Australia: Australian fishery resources are managed under both commonwealth and state/territory legislation. The Commonwealth of Australia has jurisdiction over foreign fisheries, offshore fisheries or fisheries extending to waters adjacent to more than one state or territory or

[13] Resolución Ministerial No. 058-2002-PE

fisheries by agreement with individual states. All commonwealth fisheries are managed by the Australian Fisheries Management Authority under the Fisheries Management Act of 1991. At both the state and the commonwealth levels, management is highly participatory with various joint industry/government bodies established to advise on fisheries management issues. These bodies also often include community, indigenous and/or conservation representatives. Specific management strategies used by the Australian Fisheries Management Authority and the states are based on publicly available FMPs that have been developed through these various management advisory and consultative committees. Fisheries management measures include access controls, technical measures, TACs and quotas, as well as an MCS and enforcement scheme that incorporates logbook reporting and routine surveillance. Australia has imposed a shark finning ban in waters under its jurisdiction; however, shark regulations vary within Australian states and territories. Some states and territories follow the shark fin ban policy or require a shark fin-to-body weight ratio or prohibit the dumping of finned carcasses at sea; others (e.g. South Australia and Victoria) allow the removal of non-dorsal fins. Additional commonwealth and state/territory regulatory measures include gear restrictions, spatial closures, prohibited species and size limitations for all or specific shark fisheries as well as catch limitations within and outside the Australian EEZ. For example, the Western and Eastern Tuna and Billfish Fisheries set a maximum catch of 20 sharks within the EEZ, and a maximum catch of 100 pelagic sharks outside the EEZ, per vessel per trip. Of those 100 pelagic sharks, a maximum limit of 20 is set specifically for *A. vulpinus*. The Environment Protection and Biodiversity Conservation (EPBC) Act lists 11 shark species as endangered or vulnerable and it is automatically updated following CMS and CITES listings; however, although *A. vulpinus* was listed under Appendix II of CMS in 2014, Australia did not subsequently list *A. vulpinus* under the EPBC Act. The common thresher shark was previously nominated for assessment as threatened under the EPBC Act in 2011, but the species was not prioritized for assessment due to insufficient data/information.

Overall, the most commonly adopted management measures for sharks are regulations regarding shark fins; but, other regulations have also been implemented such as closed areas and season, by-catch/discard regulations, protected species, total allowable catches (TAC) and quotas, special reporting requirements and others. Large marine protected areas that prohibit fishing as well as specific shark sanctuaries are also increasing in popularity around the globe.

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