Status Review Report:
Great Hammerhead Shark (*Sphyrna mokarran*)

2014

National Marine Fisheries Service
National Oceanic and Atmospheric Administration

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EXECUTIVE SUMMARY

This status review report was conducted in response to two petitions to list the great hammerhead shark under the Endangered Species Act (ESA) (petitioners: WildEarth Guardians on December 21, 2012; Natural Resources Defense Council on March 19, 2013). NMFS evaluated the petitions to determine whether the petitioners provided substantial information as required by the ESA to list a species. Additionally, NMFS evaluated whether information contained in the petitions might support the identification of a distinct population segment (DPS) that may warrant listing as a species under the ESA. NMFS determined that the petitions presented substantial scientific and commercial information, or cited such information in other sources, that the petitioned action may be warranted and, subsequently, NMFS initiated a status review of the great hammerhead shark. This status review report is comprised of two components: (1) the "Status Review" of the species, a document that compiles the best available information on the status of the great hammerhead shark as required by the ESA, and (2) the "Assessment of Extinction Risk" for the species, a document that provides the methods and conclusions of the NMFS Extinction Risk Analysis (ERA) team on the current and future extinction risk of the great hammerhead shark.

The great hammerhead shark (*Sphyrna mokarran*) is a circumtropical species that lives in coastal-pelagic and semi-oceanic waters. It occurs over continental shelves as well as adjacent deep waters, and may also be found in coral reefs and lagoons (Compagno 1984; Denham et al. 2007; Bester n.d.). Female great hammerhead sharks are viviparous (i.e., give birth to live young) and breed only once every two years (Stevens and Lyle 1989). Litter sizes range from 6 to 42 pups. Overall, great hammerhead shark exhibit life-history traits and population parameters that are intermediary among other shark species.

Unlike scalloped hammerhead sharks, great hammerheads are generally a solitary species and are rarely recorded in fisheries data. As such, very few studies have examined trends in *S. mokarran* abundance, and those that have are burdened with significant uncertainty in their results due to limited number of observations, large error bars, and highly sensitive models.

Based on a review of the best available information, the ERA team determined that there does not exist any population segment of the great hammerhead shark that would qualify as a distinct population segment (DPS), as defined by the joint U.S. Fish and Wildlife Service-NMFS interagency policy of 1996 on vertebrate distinct population segments under the ESA. As such, the ERA team evaluated the extinction risk of the global great hammerhead shark population.

The ERA team ranked the demographic parameters of abundance, growth/productivity, spatial structure and connectivity in terms of their risk to the species' continued existence. Naturally low abundance and life history traits (e.g., growth rate, late maturity, productivity rates, and low fecundity) were ranked as moderate risks to the species' continued existence, meaning these demographic parameters pose a significant risk to the species' continued existence, but only in combination with other demographic factors or threats (such as overutilization). Spatial structure/connectivity and diversity, however, were not found to pose significant risks to the great hammerhead shark's continued existence.

The ERA team also ranked the ESA section 4(a) threats to great hammerhead sharks, and concluded that overutilization and inadequately regulatory mechanisms are likely increasing the species' extinction risk, but only in combination with other threats or factors, whereas the other threats (habitat destruction, modification or curtailment, disease or predation, and other natural threats, such as the species' high at-vessel fishing mortality rates) were identified as having either unknown or no or very low effects on the extinction risk.

Based on an evaluation of abundance trends, growth and productivity, spatial structure, and diversity, as well as the ESA section 4(a)(1) threats listed above, the ERA team evaluated the species' current level of extinction risk as well as the species' extinction risk in the foreseeable future (which was defined as 50 years). For the current level of extinction risk, the ERA team expressed significant uncertainty, with little distinction between the identified risk categories of "no or very low risk", "low risk", and "moderate risk" of extinction. The ERA team reiterated that the great hammerhead shark is likely naturally low in abundance, and the available data is severely lacking or flawed, with no clear or consistent implication regarding the past or present status of the great hammerhead shark. In predicting the overall level of extinction risk through the next 50 years, the ERA team indicated increased confidence that the great hammerhead shark would be at a "no or very low" to "low" risk of extinction. The ERA team noted that the available information indicated that most of the observed declines occurred in the 1980s, before any significant management regulations. Since then, current regulatory measures in many parts of the great hammerhead range are minimizing the threat of overutilization, preventing further abundance declines in the foreseeable future and decreasing the likelihood of extinction of the global population. As such, the ERA team predicted that through the next 50 years, the species would be unlikely to be at risk of extinction due to demographic risks or threats to the point where the species would be influenced by stochastic or depensatory processes.

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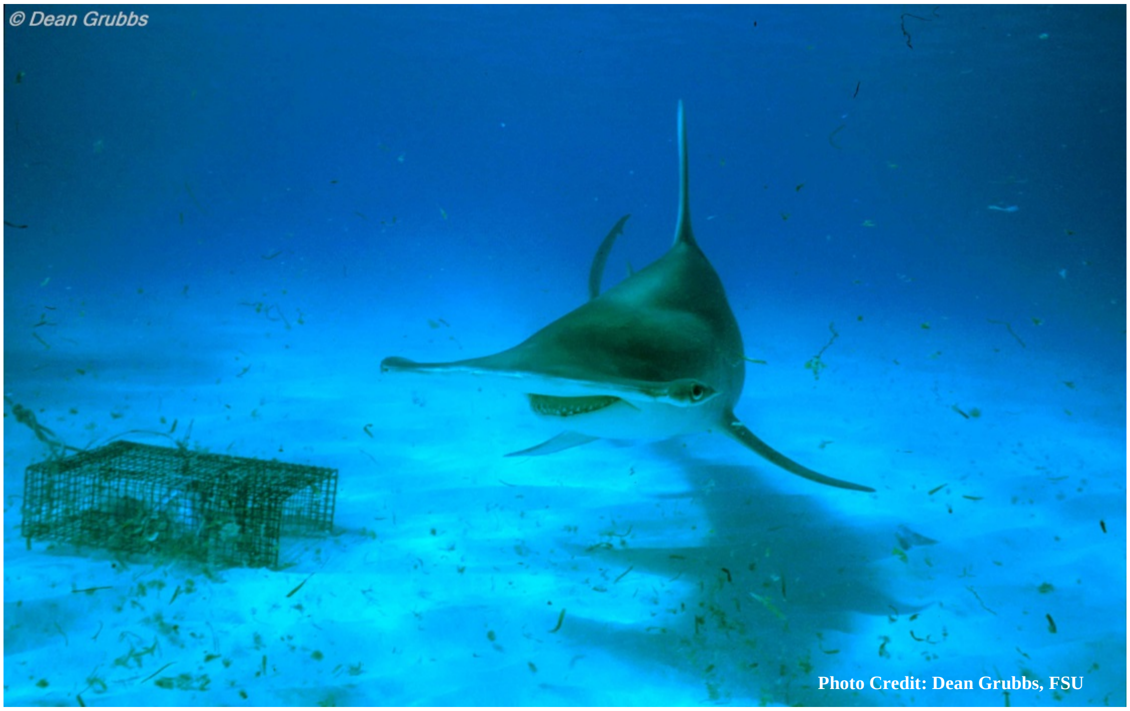

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INTRODUCTION

Scope and Intent of the Present Document

This document is the status review in response to two petitions[1] to list the great hammerhead shark under the Endangered Species Act (ESA). Under the ESA, if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted, a status review shall be promptly commenced (16 U.S.C. 1533(b)(3)(A)). The National Marine Fisheries Service (NMFS) decided that the petitions had sufficient merit for consideration and that a status review was warranted (78 FR 24701, April 26, 2013). The ESA stipulates that listing determinations should be made on the basis of the best scientific and commercial information available. NMFS appointed a contractor in the Office of Protected Resources Endangered Species Division to undertake a scientific review of the biology, population status and future outlook for the great hammerhead shark.

Key Questions in ESA Evaluations

In determining whether a listing under the ESA is warranted, two key questions must be addressed:

1) Is the entity in question a "species" as defined by the ESA?
2) If so, is the "species" threatened or endangered?

The ESA (section 3) defines the term "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." The term "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." NMFS considers a variety of information in evaluating the level of risk faced by a species in deciding whether the species is threatened or endangered. Important considerations include 1) absolute numbers of fish and their spatial and temporal distribution; 2) current abundance in relation to historical abundance and carrying capacity of the habitat; 3) any trends in abundance; 4) natural and human influenced factors that cause variability in survival and abundance; 5) possible threats to genetic integrity; and 6) recent events (e.g., a drought or a change in management) that have predictable short-term

[1] (1) WildEarth Guardians to U.S. Secretary of Commerce, Acting through the National Oceanic and Atmospheric Administration and the National Marine Fisheries Service, December 21, 2012, “Petition to list the great hammerhead shark (*Sphyrna mokarran*) under the U.S. Endangered Species Act” and (2) Natural Resources Defense Council, Before the Secretary of Commerce, March 19, 2013, “Petition to list the northwest Atlantic distinct population segment of great hammerhead sharks (*Sphyrna mokarran*) as threatened under the Endangered Species Act.”

consequences for abundance of the species. Additional risk factors, such as disease prevalence or changes in life history traits, may also be considered in evaluating risk to populations.

NMFS is required by law (ESA Sec. 4(a)(1)) to determine whether one or more of the following factors is/are responsible for the species' threatened or endangered status:

> (A) The present or threatened destruction, modification or curtailment of its habitat or range;
> (B) overutilization for commercial, recreational, scientific, or educational purposes;
> (C) disease or predation;
> (D) inadequacy of existing regulatory mechanisms; or
> (E) other natural or human factors affecting its continued existence.

According to the ESA, the determination of whether a species is threatened or endangered should be made on the basis of the best scientific and commercial information available regarding its current status, after taking into consideration conservation measures that are being made.

Summary of the Great Hammerhead Listing Petitions

A document titled "Petition to list the great hammerhead shark (*Sphyrna mokarran*) under the U.S. Endangered Species Act" was received by NMFS on December 21, 2012 from WildEarth Guardians (WEG). A second petition titled "Petition to list the northwest Atlantic distinct population segment of great hammerhead sharks (*Sphyrna mokarran*) as threatened under the Endangered Species Act" was received by NMFS on March 19, 2013 from Natural Resources Defense Council (NRDC). The joint U.S. Fish and Wildlife Service (USFWS)/NMFS *Endangered Species Act Petition Management Guidance* (1996) states that if NMFS receives two petitions for the same species, the requests only differ in the requested status of the species, and a 90-day finding has not yet been made on the earlier petition, then the later petition will be combined with the earlier petition and a combined 90-day finding will be prepared. As this was the case, NMFS responded by issuing a 90-day finding on both petitions to list the great hammerhead shark as threatened or endangered under the Endangered Species Act (78 FR 24701, April 26, 2013), and included a formal request for information.

The petitions state that commercial fishing, both targeted and bycatch, is the primary threat to the great hammerhead shark. The petitioners also assert that current habitat destruction, deposition of pollutants, lack of adequate regulatory mechanisms nationally and worldwide, global climate warming, as well the species' biological constraints, increase the susceptibility of the great hammerhead shark to extinction. According to the WEG petition, all five causal factors in section 4(a)(1) of the ESA are adversely affecting the continued existence of the great hammerhead shark. The focus of the NRDC petition is mainly on the northwest Atlantic population and it identified the threats of overutilization, inadequacy of existing regulatory mechanisms, and other natural or manmade factors that are affecting the great hammerhead sharks' continued existence. The petitions assert that listing of the great hammerhead shark would provide the species with much needed regulatory protection that will allow the population to recover.

LIFE HISTORY AND ECOLOGY

Taxonomy and Distinctive Characteristics

All hammerhead sharks belong to the family *Sphyrnidae* and are classified as ground sharks (Order Carcharhiniformes). Most hammerheads belong to the Genus *Sphyrna* with one exception, the winghead shark (*E. blochii*), which is the sole species in the Genus *Eusphyra*. The hammerhead sharks are recognized by their laterally expanded head that resembles a hammer, hence the common name "hammerhead." The great hammerhead shark (*Sphyrna mokarran*) is the largest of the hammerhead species and is distinguished from other hammerheads by a nearly straight anterior margin of the head and median indentation in the center in adults. The shark has strongly serrated teeth, strongly falcate first dorsal and pelvic fins, and a high second dorsal fin with a concave rear margin (Compagno 1984; Bester n.d.). The body of the great hammerhead is fusiform, with the dorsal side colored dark brown to light grey or olive that shades to white on the ventral side (Compagno 1984; Bester n.d.). Fins of adult great hammerheads are uniform in color, whereas the tip of the second dorsal fin of juveniles may appear dusky (Bester n.d.).

Range and Habitat Use

The great hammerhead shark is a circumtropical species that lives in coastal-pelagic and semi-oceanic waters from latitudes of 40°N to 31°S (Compagno 1984; Stevens and Lyle 1989; Cliff 1995; Denham et al. 2007). It occurs over continental shelves as well as adjacent deep waters, and may also be found in coral reefs and lagoons (Compagno 1984; Denham et al. 2007; Bester n.d.).

Great hammerhead sharks are generally solitary and highly mobile (Compagno 1984; Cliff 1995; Denham et al. 2007; Hammerschlag et al. 2011; Bester n.d.). In a review of shark tagging studies, Kohler and Turner (2001) examined three studies that looked at migrations of great hammerhead sharks (n = 220) and found maximum distance travelled to be 1180 km and a maximum time at liberty of 4 years. A more recent study tracked a great hammerhead shark migrating an even greater distance, with a minimum distance of 1200 km in 62 days, as it appeared to follow the Gulf Stream Current from the Florida Keys to 500 km off the coast of New Jersey (Hammerschlag et al. 2011). Some great hammerhead shark populations are thought to make poleward migrations following warm water currents, such as those found off Florida's coast (Heithaus et al. 2007; Hammerschlag et al. 2011), while others are thought to be residential populations with only seasonal incursions into cooler waters due to range expansions (not true migrations) (Taniuchi 1974; Stevens and Lyle 1989; Cliff 1995).

Great hammerhead sharks also appear to prefer warmer water temperatures above 20° C. For example, in waters off South Africa, great hammerhead shark females were rarely caught in waters less than 22° C, and males, although apparently more tolerant of cooler waters, became scarce when temperatures dropped below 20° C (Cliff 1995). Similarly, based on catch data around the Tampa Bay area of Florida, great hammerhead sharks are found primarily in water temperatures > 20°C (Hueter and Manire 1994). In the East China Sea, Taniuchi (1974) noted that great hammerheads are only abundant in parts of the sea that are influenced by the warm Kuroshio and Tsushima currents and likely reside in the surface to mid-water range. Although Heithaus et al. (2007) reported higher probabilities of encountering great hammerheads in cooler, deeper waters of the Florida Keys (with highest probability in temperatures of 17-18°C), the authors note that this may be due to the great hammerhead sharks' seasonal southward migration, as sampling was done primarily during the winter season.

The great hammerhead shark is also a high trophic level predator (trophic level = 4.3; Cortés 1999) and opportunistic feeder with a diet that includes a wide variety of teleosts, cephalopods, and crustaceans, with a preference for stingrays and other batoids (Compagno 1984; Strong et al. 1990; Denham et al. 2007). *Sphyrna mokarran* seems to be immune to stingray and catfish venom, sometimes found with barbs embedded in their mouths (Strong et al. 1990), and has been observed to use its uniquely shaped head, or 'cephalofoil' to pin down and prey upon stingrays. This type of prey handling may be unique to this species, but very few observations of predation events of great hammerheads or other *Sphyrnidae* have been made (Strong et al. 1990, Chapman and Gruber 2002). Stomach analysis of *S. mokarran* suggests that the species primarily feeds at or near the seafloor (Stevens and Lyle 1989; Cliff 1995; Bester n.d.).

Reproduction and Growth

Compared to the other hammerhead species, *S. mokarran* has a faster growth rate and thus matures at an earlier age, between 5 and 8.9 years (Piercy et al. 2010; Harry et al. 2011a; Piercy and Carlson, unpublished data). In terms of size, females attain maturity generally around 210-300 cm total length (TL) while males reach maturity at smaller sizes (generally around 187 – 269 cm TL) (see Table 1). However, in South Africa, Cliff (1995) documented markedly larger sizes at maturity, with 50% of females and males mature at sizes of 337 and 309 cm TL, respectively, and suggested possible geographical variation in maturity sizes.

Female great hammerhead sharks are viviparous (i.e., give birth to live young) with a yolk-sac placenta and breed only once every two years (Stevens and Lyle 1989), with a gestation period of 10-11 months (Stevens and Lyle 1989, Bester n.d.). Litter sizes range from 6 to 42 pups, with size at birth estimated at 500-700 mm TL (Table 1). Parturition occurs in the late spring or summer in the northern hemisphere (Ebert and Stehman 2013). In the southern hemisphere, birthing occurs between October and November off eastern Australia and between December and January off northern Australia (Stevens and Lyle 1989; Harry et al. 2011a). Although young of the year and juveniles may be found utilizing shallow inshore and coastal waters, pupping appears to occur farther offshore (Hueter and Tyminski 2007; Harry et al. 2011a).

In terms of size, the great hammerhead shark can reach lengths of over 610 cm TL (Compagno, 1984); however, individuals greater than 400 cm TL are rare (Stevens and Lyle 1989). Piercy et al. (2010) attributes the rarity of these larger great hammerhead sharks to growth overfishing, and estimated the oldest female and male great hammerhead sharks to be 44 and 42 years, respectively, with corresponding lengths of 398 cm TL (female) and 379 cm TL (male). Passerotti et al. (2010) aged two male great hammerhead sharks using bomb radiocarbon ageing methods, and found the sharks to be 42 years old (corresponding to 391 cm TL) and 36 years old (corresponding to 360 cm TL). Male great hammerhead sharks are thought to grow faster than females (with a growth coefficient, k, of 0.16/year for males and 0.11/year for females) but reach a smaller asymptotic size (335 cm TL for males versus 389 cm TL for females). In the northwestern Atlantic and Gulf of Mexico, von Bertalanffy growth parameters are estimated at L_∞ = 264.2 cm (fork length, FL), k=0.16 $year^{-1}$, t_0= −1.99 years for males, and L_∞ = 307.8 cm (FL), k=0.11 $year^{-1}$, t_0= −2.86 years for females (Piercy et al., 2010). Off the east coast of Australia, von Bertalanffy growth parameters are estimated at L_∞ = 402.7 cm (stretched total length) and k= 0.079 $year^{-1}$ for both sexes combined (Harry et al. 2011a). Based on data collected from the Indian Ocean, the length-weight relationship for female great hammerhead sharks is Total Weight (kg) = 0.00000380*FL^3.21084 and for males is Total Weight (kg) = 0.00002739*FL^2.8046 (Romanov and Romanova 2012).

Although there are very few age/growth studies for great hammerhead sharks, the available data indicate that great hammerhead sharks are a long-lived species and can be characterized as having low productivity (based on productivity parameters and categorizations in Musick (1999)), making them generally vulnerable to depletion and likely slow to recover from overexploitation.

Population Structure

It is unclear whether there are genetically distinct regional subdivisions of the great hammerhead shark. Due to sampling constraints, very few studies have examined the population structure of the great hammerhead shark. Naylor et al. (2012) suggested that there are two distinct clusters of great hammerhead sharks: one comprised of great hammerheads from the Atlantic, and a second comprised of great hammerheads from Australia and Borneo. This analysis, however, was based on only 22 specimens (9 from Gulf of Mexico, 7 from Northwest Atlantic, 1 from Borneo, and 5 from northern Australia).

Testerman and Shivji (2013) evaluated the genetic global population structure of *S. mokarran* *(*n=312) with both nuclear and mitochondrial data. Preliminary results showed statistically significant genetic partitioning between oceanic basins (mtCR ϕ_{ST} = 0.8745, nuclear F_{ST} = 0.1113) and shallow but statistically significant genetic structure within oceanic basins, although there were some differences between the two marker types in fine scale patterns involving northern Indian Ocean samples (Testerman and Shivji 2013). There is currently no evidence for sex-biased dispersal (D. Chapman, personal communication) as was found for scalloped hammerhead (Daly-Engel et al. 2013).

Demography

Overall, great hammerhead sharks exhibit life-history traits and population parameters that are intermediary among other shark species. In an ecological risk assessment study of sharks caught in Atlantic pelagic fisheries, Cortés et al. (2012) estimated productivity, determined as intrinsic rate of population increase, as 0.070 yr^{-1} (0.069-0.071 yr^{-1} lower and upper confidence limits) with a mean generation time of 27.1 years (see *Vulnerability to Fisheries in the Atlantic Ocean – Ecological Risk Assessment* section for further details). However, these estimates were based on an earlier assumed age of maturity of 20 years. Using updated life history parameters from the northwest Atlantic Ocean, productivity is now calculated at 0.096 $year^{-1}$ (median) within a range of 0.078-0.116 (80% percentiles) (Cortés unpublished). Median generation time (T) was estimated at 15.9 years, the mean age of parents of offspring of a cohort (μ_1) is 18.0 years and the mean age (Ã) of females bearing pups produced by a population at the stable age distribution is 14.3 years.

These demographic parameters place great hammerhead 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). These species generally have moderate potential to recover from exploitation.

Table 1. Compilation of *S. mokarran* life history characteristics from the published literature. (L_{50} represents length at 50% maturity and A_{50} represents age at 50% maturity)
*No specific sex identified.
** Length measurements are in stretched total length.
† Calculated from pre-caudal length using Piercy et al. (2007) and (2010)

Sampled Location	Maximum TL (cm, observed)		Maximum Age (observed)		TL at Maturity (cm)		Age at Maturity (year)	Litter Size	TL at Birth (cm)	von Bertalanffy Growth Coefficient (k)		Reference
	Female	Male	Female	Male	Female	Male				Female	Male	
Overall	> 610*				250-300	234-269		13-42	50-70			Compagno (1984)
NW Atlantic & GOM	415*		44	42	224 (L_{50})	187 (L_{50})	5.6 (male; A_{50}) 8.9 (female; A_{50})	15-23		0.11	0.16	Piercy et al. (2010), Piercy and Carlson (unpublished)
	414							13-41	67			Clark and von Schmidt (1965)
	370**	320**				~300						Heithaus et al. (2007)
		391		42								Passerotti et al. (2010)
		360		36								
West Africa (Senegal)	444							14-42	60-67			Cadenat and Blache (1981)
South Africa†	449	364			327	299						Cliff (1995)
Australia (N)	409	445			210 (L_{50})	225 (L_{50})		6-33	65			Stevens and Lyle (1989)
Australia (E)	439**	369**	39.1	31.7	228** (L_{50})		8.3 (A_{50})		70**	0.08 (combined)		Harry et al. (2011a)
		350				>252						Macbeth et al. (2009)
Japan (East China Sea)		327										Taniuchi (1974)

DISTRIBUTION AND ABUNDANCE

The great hammerhead shark can be found in coastal warm temperate and tropical seas worldwide. In the western Atlantic Ocean, the great hammerhead range extends from Massachusetts (although the species is rare north of North Carolina), in the United States, to Uruguay, including the Gulf of Mexico and Caribbean Sea. In the eastern Atlantic, it can be found from Morocco to Senegal, including in the Mediterranean Sea (although rare). The great hammerhead shark can also be found throughout the Indian Ocean and the Red Sea and in the Indo-Pacific region from Ryukyu Island south to New Caledonia and east to French Polynesia and the Pitcairn Islands (Bester n.d.; Froese and Pauly 2011). Although rare, there are also records of great hammerheads around the U.S. Hawaiian Islands (Randall 2007). Distribution in the eastern Pacific Ocean extends from southern Baja California, including the Gulf of California, to Peru (Compagno 1984) (Figure 1).

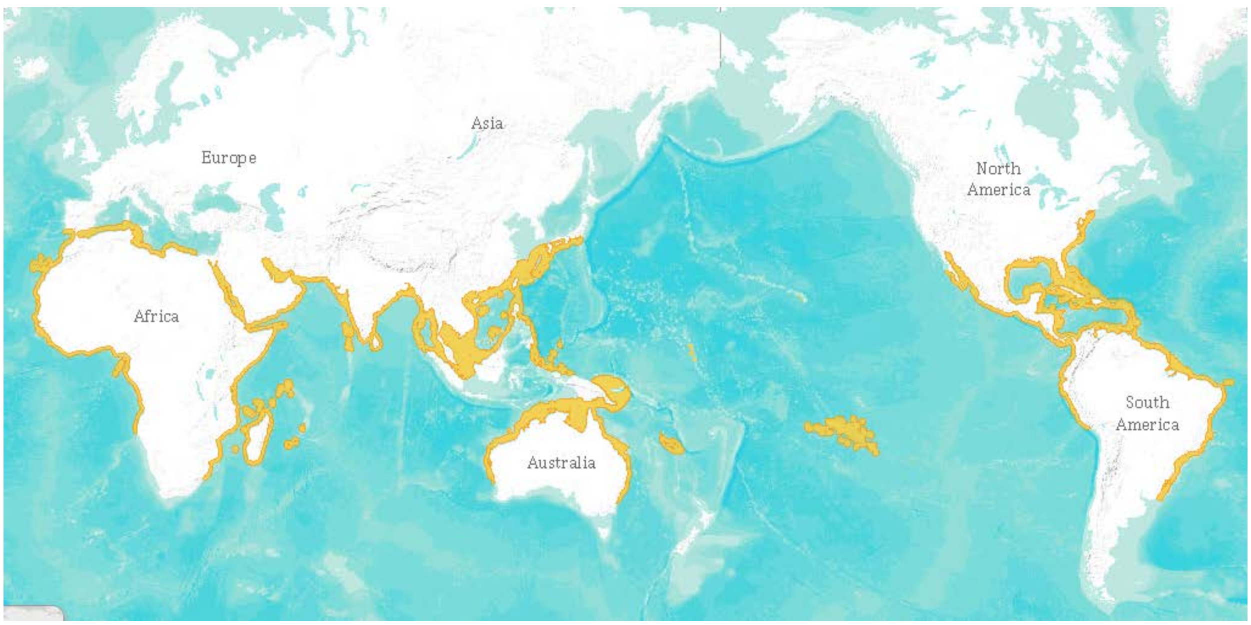

Figure 1. Distribution map of the great hammerhead shark (*Sphyrna mokarran*). (Source: adapted from IUCN 2014)

Description of the Fisheries and Current Catch Estimates

Great hammerhead sharks are caught in many global fisheries including bottom and pelagic longline tuna and swordfish fisheries, purse seine fisheries, coastal gillnet fisheries, and artisanal fisheries. As a primarily warm water species, great hammerheads are most often seen in the catches of tropical fisheries (Dudley and Simpfendorfer 2006; Zeeberg et al. 2006). They are generally not a target species, but due to their large fins with high fin needle content (a gelatinous product used to make shark fin soup), they are valuable as incidental catch for the international shark fin trade (Abercrombie et al. 2005; Clarke et al. 2006a).

There is very little information on the abundance of great hammerhead sharks, with only occasional mentions in historical records. Although more countries and regional fishery management organizations are working towards better reporting of fish catches down to species level, catches of great hammerheads have gone and continue to go unrecorded in many countries outside the U.S. Also, many catch records that do include hammerhead sharks do not differentiate between the *Sphyrna* species or shark species in general. These numbers are also likely under-reported as many catch records reflect dressed weights instead of live weights or do not account for discards (example: where the fins are kept but the carcass is discarded). Thus, given this type of data, species-specific population trends for great hammerheads worldwide are not readily available.

International Catch and Trade

Worldwide catches of sphyrnids, including great hammerhead sharks, are reported in the Food and Agriculture Organization of the United Nations (FAO) Global Capture Production dataset mainly at the family level. Total catches of the hammerhead family (*Sphyrnidae*) (Figure 2) have increased since the early 1990s, from 75 tonnes (mt) in 1990 to a peak of 6,313 mt in 2010. However, this FAO data does not include discard mortalities.

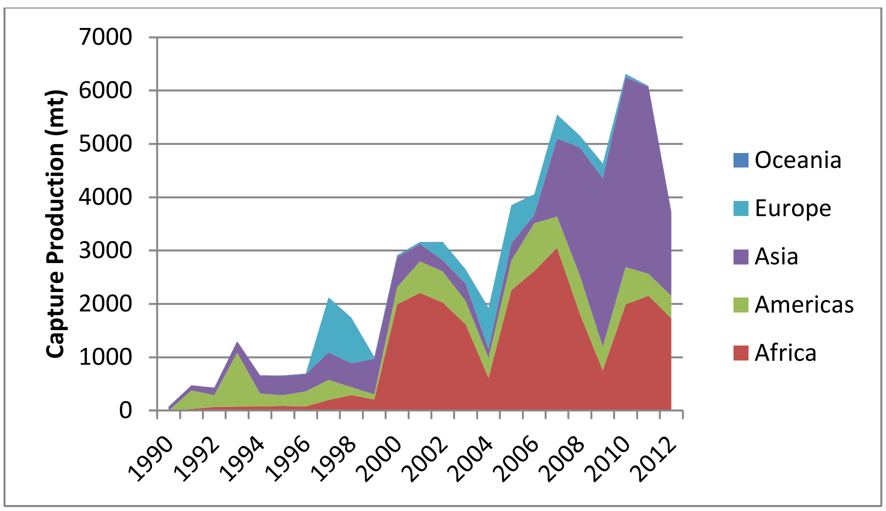

Figure 2. Global capture production (mt) of all hammerhead sharks (*Sphyrnidae*) from 1990-2012. (Source: FAO Global Capture Production; Accessed March 26, 2014)

In order to gain a better estimate of the global shark catch, Clarke et al. (2006a, 2006b) analyzed data from the Asian shark fin trade. According to shark fin traders, hammerheads (*Sphyrna* spp.) are one of the sources for the best quality fin needles for consumption, and fetch a high commercial value in the Asian shark fin trade (Abercrombie et al. 2005). In Hong Kong, the world's largest fin trade market, *S. mokarran* are found under the "Gu pian" market category and comprise approximately 1.5% of the total fins traded annually in the market (Clarke et al.

2006a). Applying a Bayesian statistical method to the Hong Kong shark fin trade data, Clarke et al. (2006b) estimated that around 375,000 great hammerhead sharks (with a 95% confidence interval = 130,000 – 1.1 million) are traded per year. The equivalent biomass is estimated to be around 21,000 mt.

Although great hammerhead meat is considered essentially unpalatable (due to its high urea concentration), some countries still consume the meat domestically or trade it internationally. Hammerhead meat has been documented in fish markets in Trinidad and Tobago and eastern Venezuela (F. Arocha, personal communication), and in Kenya, it is dried and salted and actually identified as high quality meat (Vannuccini 1999). In Japan, hammerhead meat is consumed in steak form (Vannuccini 1999). However, it is likely that the current volume of traded meat and products is insignificant when compared to the volume of hammerhead fins in international trade (CITES 2010).

Regional Fishery Management Organizations (RFMOs)

RFMOs 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 the great hammerhead shark is a global, highly migratory species that crosses international boundaries, they are often caught as bycatch in the convention areas of those RFMOs for highly migratory fish stocks. Provided below are descriptions and information on these RFMOs and available catch data of hammerhead sharks from vessels operating in these convention areas.

International Commission for the Conservation of Atlantic Tunas (ICCAT)

ICCAT is the RFMO responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean and adjacent seas. In the Atlantic, great hammerhead shark catches have been reported by ICCAT vessels since 1992. In 2004, following the FAO International Plan of Action for Sharks, ICCAT published recommendation 04-10 requiring Contracting Parties, Cooperating non-Contracting Parties, Entities or Fishing Entities (CPCs) to annually report data for catches of sharks, including available historical data. In 2010, ICCAT adopted recommendation 10-08 prohibiting the rentention onboard, transshipment, landing, storing, selling, or offering for sale any part or whole carcass of hammerhead sharks of the family Sphyrnidae (except for *Sphyrna tiburo*) taken in the Converntion area in association with ICCAT fisheries. Combined reported catches of great hammerheads from ICCAT vessels in the Atlantic are shown in Figure 3. Around 52% of the total catch (n = 26 mt) from 1992-2011 was caught by longline gear. Fishing gear was not specified for the fleets operating under the Nigerian flag.

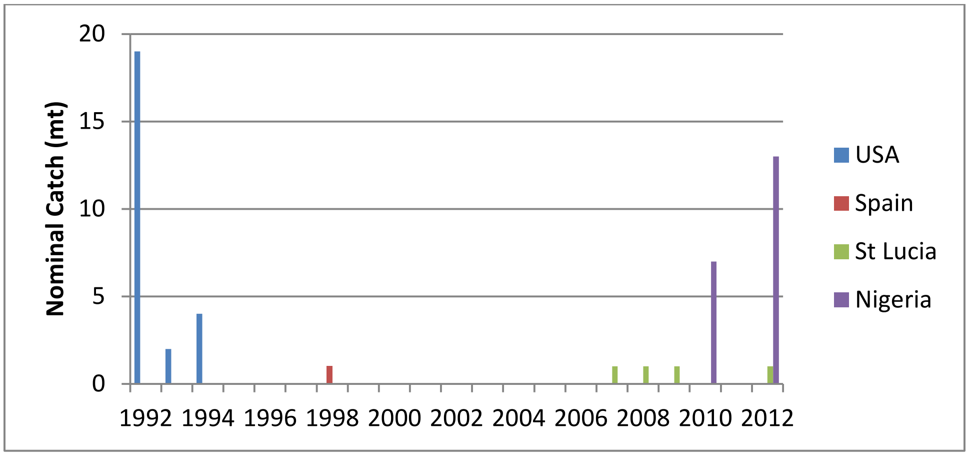

Figure 3. Nominal catches (mt) of *S. mokarran* reported to ICCAT by CPC vessel flag from 1992-2011. (Source: ICCAT nominal catch information: Task I web-based application, accessed December 2013)

Fleets operating under the U.S. flag reported the highest catches of great hammerhead sharks (25 mt), which occurred from 1992-1994. After 1994, no great hammerhead catches were reported to ICCAT by U.S. fleets. In 2010, fleets operating under the Nigerian flag reported 7 mt of great hammerhead catch and in 2012, this increased to 13 mt.

Western and Central Pacific Fisheries Commission (WCPFC)

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 data. 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 the tunas (Liu et al. 2009). All shark data collected before 2003 was recorded in the logbooks under the category "sharks." After 2003, species-specific information was recorded for the blue shark, mako shark, and silky shark, but all other sharks remained lumped in the category "other sharks" (Liu et al. 2009). Due to these data gaps, the WCPFC, the RFMO that seeks the conservation and sustainable use of highly migratory fish stocks in the western and central Pacific Ocean, recently revised their 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 hammerheads have not been provided to the WCPFC for a number of longline fleets. Table 2 provides the available aggregated hammerhead catch information as reported by Australia, Papua New Guinea, South Korea, and Cook Islands fleets to the WCPFC. Landings of hammerheads by vessels of the United States and its participating territories are lumped in an "Other Sharks" category and, as such, could not be pulled out for inclusion in Table 2. Table 3 provides the annual longline discards (in numbers) from 2006-2012 as reported by Australian fleets to the WCPFC.

Table 2: Annual catches (mt) of all hammerhead shark species by longliners in WCPFC Convention Area (compiled from Annual Reports to the Commission available at http://www.wcpfc.int/meetings/).

Country	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Australia	6.9	2.4	2.5	3.3	3.2	4.9	3.9
Papua New Guinea		32.9	18.7	36.6	39.2	22.3	
South Korea						<0.1	4
Cook Islands							58.1
TOTAL	6.9	35.3	21.2	39.9	42.4	27.3	66

Table 3: Annual longline discard estimates (in numbers) of all hammerhead shark species in WCPFC convention area by Australian fleets (compiled from Australia's Annual Reports to the Commission).

2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
101	23	8	41	33	140	180

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 over the past 6 years. In the mid-1980s, the purse seine fishery accounted for only 40% of the total tuna catch, but in 2010, this percentage had increased to 75% (Williams and Terawasi 2011). The majority of the purse seine catch has historically been attributed to Japan, South Korea, Chinese-Taipei and the USA fleets; however, recently an increased number of Pacific Islands fleets as well as new fleets (from China, Ecuador, El Salvador, New Zealand, and Spain) have entered the WCPFC tropical fishery (Williams and Terawasi 2011). These new additions have brought the number of purse seine vessels up to 280, the highest it has been since 1972 (Williams and Terawasi 2011); however, available data do not suggest great hammerheads are caught in large numbers by these purse seine fleets. For example, in 2010, the European Union (EU) estimated that its purse seine bycatch of great hammerhead sharks was only 0.08 mt in the WCPFC convention area (see EU's Annual Report to the Commission, available at http://www.wcpfc.int/node/3142). Analysis of WCPFC observer data from 1994 – 2009 also indicate that, in general, catches of hammerhead sharks are negligible in all WCPFC fisheries (Figure 4), but that longline sets pose more of a threat to non-target shark species than purse-seine sets in this convention area (SPC 2010). However, 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, observer coverage in the purse seine fleet has increased to 100% whereas observer coverage in the longline fishery remains below 2% (Clarke, 2013).

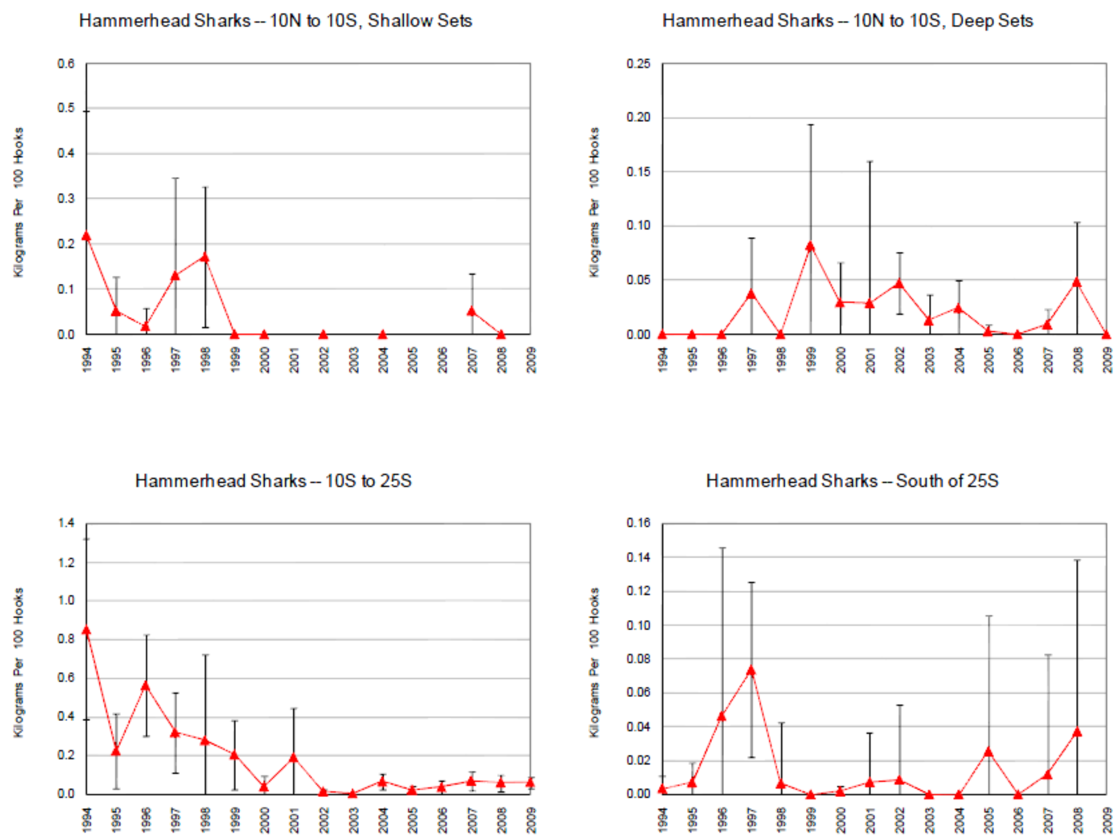

Figure 4: Nominal catch rates of hammerhead sharks determined from observer data collected onboard longliners in the Western and Central Pacific Ocean. (Source: SPC 2010)

Inter-American Tropical Tuna Commission (IATTC)

In the eastern Pacific, great hammerhead sharks are caught on a variety of gear, including longline and purse seine gear targeting tunas and swordfish. 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 (IATTC 2005). Since 1993, observers have recorded shark bycatch data onboard large purse seiners in the eastern Pacific. Unfortunately, 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. Román-Verdesoto and Orozco-Zöller (2005) used the program results and IATTC observer field notes to provide summaries of the spatial distributions, size composition, and species identification of the IATTC-observed bycatch of sharks in the eastern Pacific Ocean tuna purse-seine fishery. Bycatch for this report was defined as sharks that were discarded dead after being removed from the net and placed on the vessel, and was recorded from three types of purse-seine sets: 1) sets on tunas associated with dolphins ("dolphin sets"), 2) sets on tunas associated with floating objects ("floating-object sets"), and 3) sets on unassociated schools of tunas ("unassociated sets").

From 1993 – 2004, hammerhead sharks were caught in high numbers as bycatch in the purse seine fisheries (Figure 5) off the coast of South America, primarily between 80°W and 100°W Longitude and 10°N and 20°S Latitude (Figure 6).

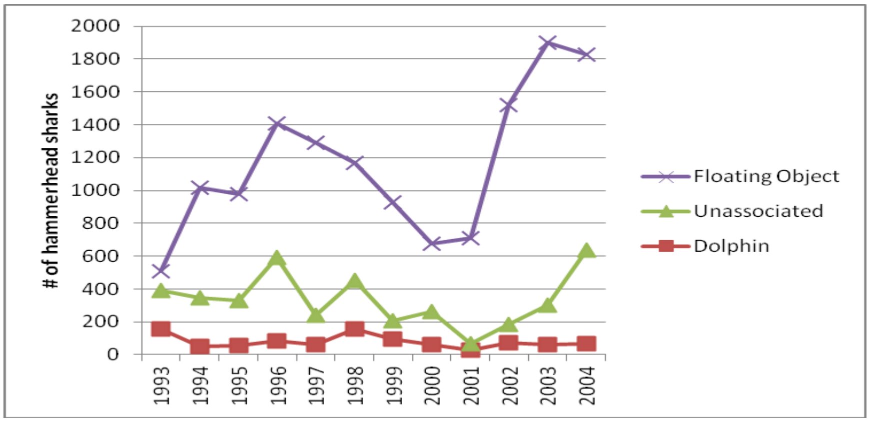

Figure 5. IATTC observed number of hammerhead sharks caught as bycatch from 1993-2004 in three types of purse-seine fishery sets in the Eastern Pacific: 1) sets on tunas associated with floating objects, 2) sets on unassociated schools of tunas, and 3) sets on tunas associated with dolphins. (Source: Román-Verdesoto and Orozco-Zöller 2005)

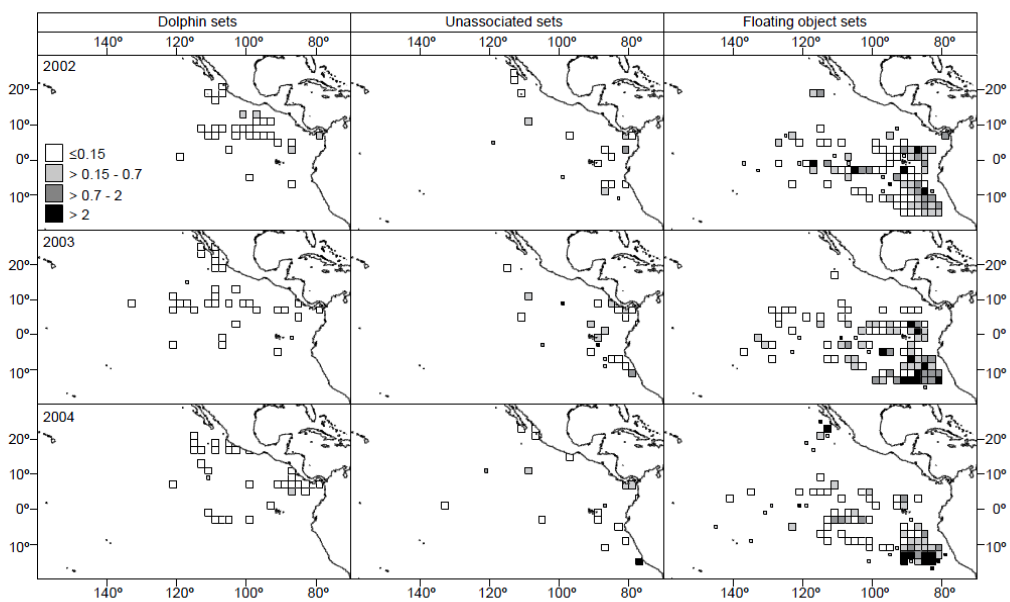

Figure 6. Observed hammerhead shark bycatch (in numbers) per set from 2002-2004. Small squares indicate five or fewer sets per 2º area and large squares indicate more than five sets. (Source: Román-Verdesoto and Orozco-Zöller 2005)

From 2001 to 2003, their observed numbers in the tuna purse seine sets increased by ~166% to reach a maximum of 1,898 individuals. Although the majority of hammerhead sharks were caught in the floating-objects type of purse seine set, they constituted a greater proportion of the shark bycatch in unassociated purse seine types (Table 4) (Román-Verdesoto and Orozco-Zöller 2005).

Table 4. Percentage of observed shark bycatch by species and set type, summed across years 1993-2004. (Source: Román-Verdesoto and Orozco-Zöller 2005)

	Percent by Set type			
Species	**Dolphin**	**Unasso-ciated**	**Floating object**	**Total**
Silky sharks "offshore"	52.5	35.1	59.4	56.0
Silky/Blacktip sharks "inshore"	2.7	9.1	0.2	1.4
Oceanic whitetip shark	10.3	5.8	24.7	21.0
Hammerhead shark	10.3	15.8	7.0	8.3
Other shark	13.0	24.6	2.7	6.3
Unidentified shark	11.3	9.5	6.0	7.0

Although specific data on great hammerhead numbers are unavailable, results from the one-year Shark Characteristics Sampling Program suggest that *S. mokarran* may comprise around 5% of the total hammerhead bycatch (Román-Verdesoto and Orozco-Zöller 2005). The IATTC observer data also revealed that the majority of the bycatch consists of large hammerhead individuals (>150 cm TL; Figure 7). This bycatch may or may not include mature great hammerheads since documented *S. mokarran* lengths at maturity are ~210-300 cm TL for females, and ~187 – 269 cm TL for males (see Table 1). Finer resolution of size and sex data, as well as species breakdowns, is needed to determine the actual effect on the great hammerhead population.

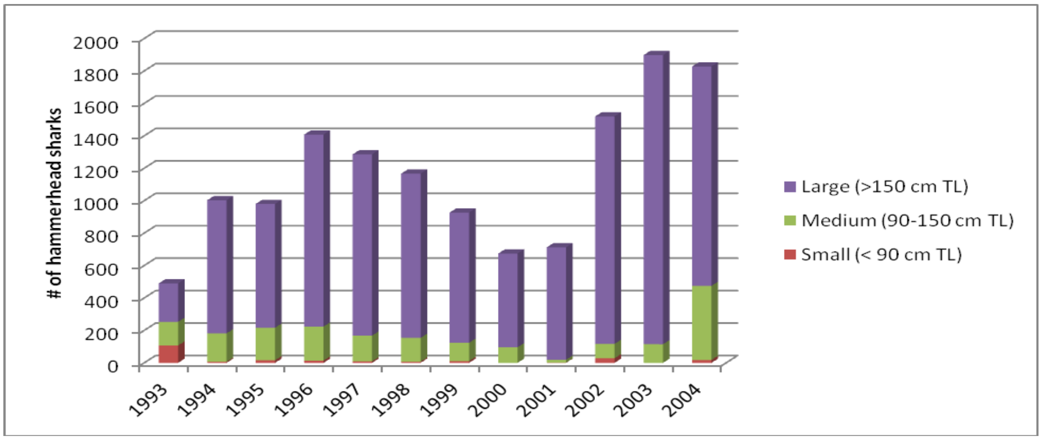

Figure 7. IATTC observed number and size of hammerhead sharks caught as bycatch from 1993-2004 in the eastern Pacific Ocean purse-seine fishery. (Source: Román-Verdesoto and Orozco-Zöller 2005)

Indian Ocean Tuna Commission (IOTC)

In the Indian Ocean, great hammerheads are caught as bycatch in pelagic longline tuna and swordfish fisheries and gillnet fisheries, and may also be targeted by semi-industrial, artisanal and recreational fisheries. The IOTC, the RFMO that manages tuna and tuna-like species in the Indian Ocean and adjacent seas, requires CPCs to annually report hammerhead shark catch data (see IOTC Resolutions 05/05, 11/04, 08/04, 10/03, 10/02); however, the current reported catches are thought to be incomplete and largely underestimated. The IOTC acknowledges that catches of sharks are usually not reported. When catch statistics are provided, they may not represent the total catches of the species but simply those retained on board, with weights that likely refer to processed specimens (IOTC 2011). Currently, the data in the IOTC public domain database does not contain catches for great hammerhead sharks, but does have reported catches of scalloped and smooth hammerheads from the *Sphyrna* family. Below is the nominal catch from 1986 – 2011 of scalloped and smooth hammerheads as reported to the IOTC (Figure 8). The trend in catch shows a significant increase and peak in the late 1990s/early 2000s, concurrent with the growth of the international shark fin trade (Clarke 2007), and then a subsequent and substantial decrease in catch in recent years (as much as 92% for scalloped hammerheads and 94% for smooth hammerheads), possibly indicating a decrease in abundance of the two species or effects of shark finning laws.

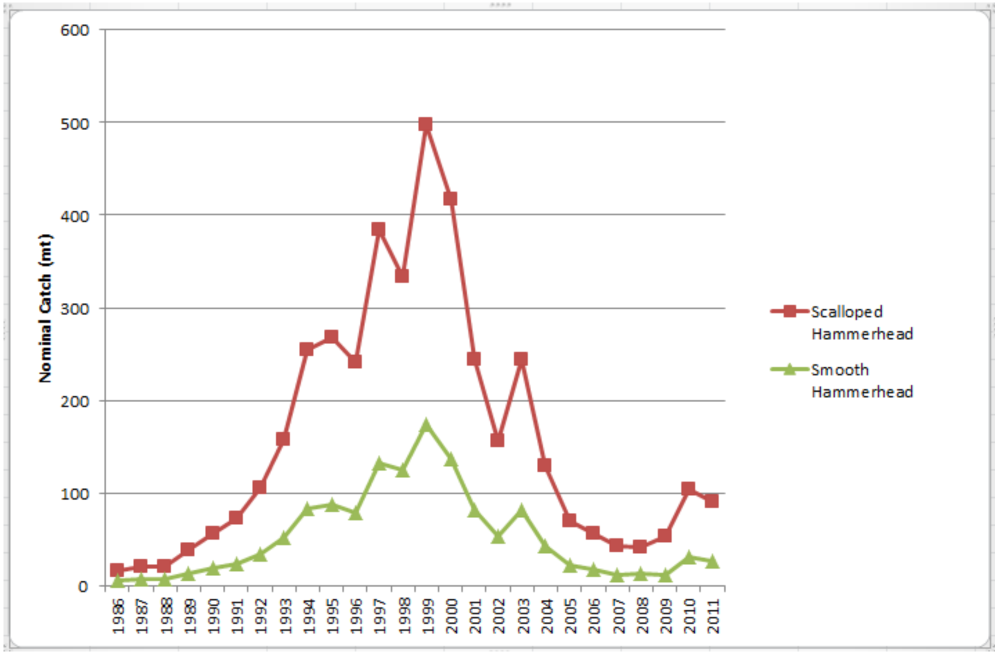

Figure 8. Total catches (mt) of scalloped and smooth hammerhead sharks as reported to the IOTC from 1986 – 2011. (Source: IOTC Nominal Catch Database, accessed June 4, 2013)

There is also a significant amount of illegal, unregulated, and unreported (IUU) fishing in the Indian Ocean that may be leading to the decline of hammerheads, both directly and indirectly, as great hammerhead sharks are not only targets for the fin trade but may also be losing many of their main prey items to these IUU practices (Dudley and Simpfendorfer 2006).

U.S. Fisheries

Great hammerheads are not caught in the U.S. west coast-based HMS fisheries, the U.S. Flag Pacific Island fisheries (American Samoa, Commonwealth of the Northern Mariana Islands, and Guam) or in the U.S. Hawaii-based longline fisheries as their primary range does not coincide with the areas of operation of these fisheries (see range map; Figure 1). The species has been recorded in Hawaii but is thought to be rare from a biogeographic perspective (Randall 2007; Walsh et al. 2009; Mundy 2005). Fisheries observers in the U.S. Hawaii-based longline fisheries (deep-set and shallow-set fisheries) have not recorded great hammerhead sharks in the catch since the inception of this program in 1990 (Stuart Arceneaux, NMFS PIRO Observer Program, pers. comm.). Additionally, total hammerhead shark catch in all commercial fishery sectors in Hawaii coastal and pelagic waters is extremely low, averaging 226 pounds per year over the time period 1953-2013, with no indication of a trend over time (Wendy Seki, State of Hawaii DLNR DAR, pers. comm.). It is also likely that most, if not all, of these hammerhead sharks are scalloped or smooth hammerheads.

In the U.S. Atlantic, great hammerhead sharks are mainly caught as bycatch in commercial longline and coastal gillnet fisheries, and by recreational fisheries using rod and reel. Below provides relevant information about the U.S. shark fisheries and great hammerhead catch, extracted primarily from the 2011, 2012, and 2013 Stock Assessment and Fishery Evaluation (SAFE) Reports for Atlantic Highly Migratory Species (HMS) (NMFS 2011a, 2012a, 2013) and the Amendment 2 to the U.S. 2006 Consolidated Atlantic HMS Fishery Management Plan (FMP) (henceforth referred to as the "Consolidated HMS FMP") (NMFS 2007):

U.S. Commercial Fisheries
The commercial shark fishery has been sporadic in nature. In the early 1900s, a Pacific shark fishery supplied limited demands for fresh shark fillets and fish meal as well as a more substantial market for dried fins of soupfin sharks. In 1937, the price of soupfin shark liver skyrocketed when it was discovered to be the richest source of vitamin A available in commercial quantities. A shark fishery in the Caribbean Sea, off the coast of Florida, and in the Gulf of Mexico developed in response to this demand (Wagner 1966). By 1950, the availability of synthetic vitamin A caused most shark fisheries to be abandoned (Wagner 1966).

In the late 1970s, however, the U.S. Atlantic shark fishery developed rapidly due to increased demand for their meat, fins, and cartilage. At the time, sharks were perceived to be underutilized as a fishery resource. The high commercial value of shark fins led to the controversial practice of finning, or removing the valuable fins from sharks and discarding the carcass. Growing demand for shark products encouraged expansion of the commercial fishery throughout the late 1970s and the 1980s. Tuna and swordfish vessels began to retain a greater proportion of their shark incidental catch, and some directed fishery effort expanded as well. As catches accelerated through the 1980s, shark stocks started to show signs of decline. Below describes the various gears that are used in the commercial shark fishery.

Pelagic Longline (PLL)
The pelagic longline (PLL) fishery for Atlantic HMS primarily targets 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 fishermen in the Atlantic are monitored every year and reported to ICCAT. From 1992-2000, elasmobranchs represented 15% of the total catch by the PLL fishery, with *S. mokarran* 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 93 great hammerhead sharks as caught on U.S. PLL gear between 1992 and 2005, representing 11% of the identified hammerhead species, 7% of all hammerhead catch, and 0.2% of all shark species caught (Baum and Blanchard 2010). Analysis of HMS 2005-2009 logbook data indicated that an average of 25 vessels landed 181 hammerhead sharks per year on PLL gear. An additional 1,130 sharks (annual average) were caught and subsequently discarded, with 780 individuals discarded alive and 350 discarded dead. In 2011, the shortfin mako led the shark species in largest amount of landings (in weight), with a total of ca. 372 mt, followed by thresher sharks (*Alopias* spp.), blue shark, and hammerhead sharks (*Sphyrna* spp.) with ca. 89, 65, and 3.8 mt, respectively (NMFS 2012b). The estimates for hammerhead shark landings declined by 1 mt from 2010 (NMFS 2011b). Since 2011, the United States has prohibited retaining, transshipping, landing, storing, or selling hammerhead sharks in the family *Sphyrnidae* (except for *Sphyrna tiburo*) caught in association with ICCAT fisheries (consistent with ICCAT Recommendations 09-07, 10-07, 10-08, and 11-08). During 2012, a total of 32 great hammerhead sharks were released from U.S. pelagic longline vessels (17 were released dead, 15 were released alive) (NMFS 2013a).

Bottom Longline (BLL)

The shark bottom longline fishery is active in the Atlantic Ocean from about the Mid-Atlantic Bight to south Florida and throughout the Gulf of Mexico. Bottom longline gear is the primary commercial gear employed for targeting large coastal sharks (LCS), which include great hammerhead sharks, in all regions. Gear characteristics vary by region and target species, but in general, BLL consists of a longline between 3 and 8 km (1.8 – 5 miles) long with 200-400 hooks attached and is set for 2 and 20 hours. Depending on the species being targeted, both circle and J hooks are used. Fishermen targeting sharks with BLL gear are opportunistic and often maintain permits for council-managed fisheries such as reef fish, snapper/grouper, tilefish, and other teleosts. Minor modifications to how and where the gear is deployed allow fishermen to harvest sharks and teleosts on the same trip. Currently 220 U.S. fishermen are permitted to target sharks (excluding spiny dogfish and smoothhound sharks) managed by the HMS Management Division in the Atlantic Ocean and Gulf of Mexico, and an additional 265 fishermen are permitted to land sharks incidentally.

Since 2002, shark BLL vessels are required to take an observer if selected; however, observations of the shark-directed BLL fishery in the Atlantic Ocean and Gulf of Mexico have been conducted since 1994. Comparisons of observed catches over the years should be made with caution as the number of participating vessels, hauls, and trips vary greatly by year. Based on the length frequency of the catch from 1994-2012 (Figure 9), the majority of great hammerheads caught in BLL trips are near or just over the size of maturity (using the assumption that great hammerheads mature at sizes ~200 cm FL). Since the inception of the observer program in 1994, the average size has increased over the time series but not substantially (although it is statistically significant), and the correlation of size with year is low ($p<0.001$, $r^2= 0.01$) (Figure 10).

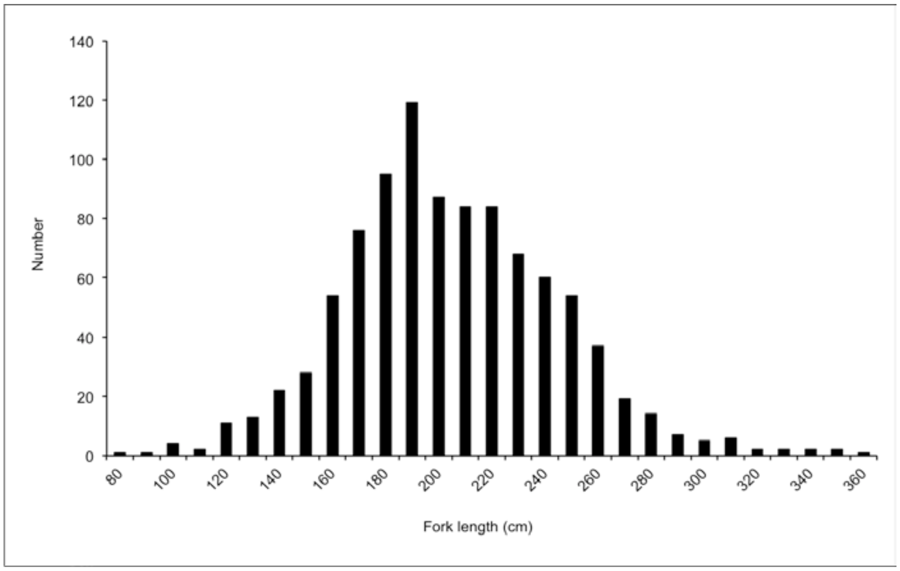

Figure 9. Length frequency (cm fork length) of great hammerhead sharks observed caught on bottom longline sets in the Gulf of Mexico and U.S. Atlantic Ocean 1994-2012. (Source: data from Gulak et al. 2013 and references therein)

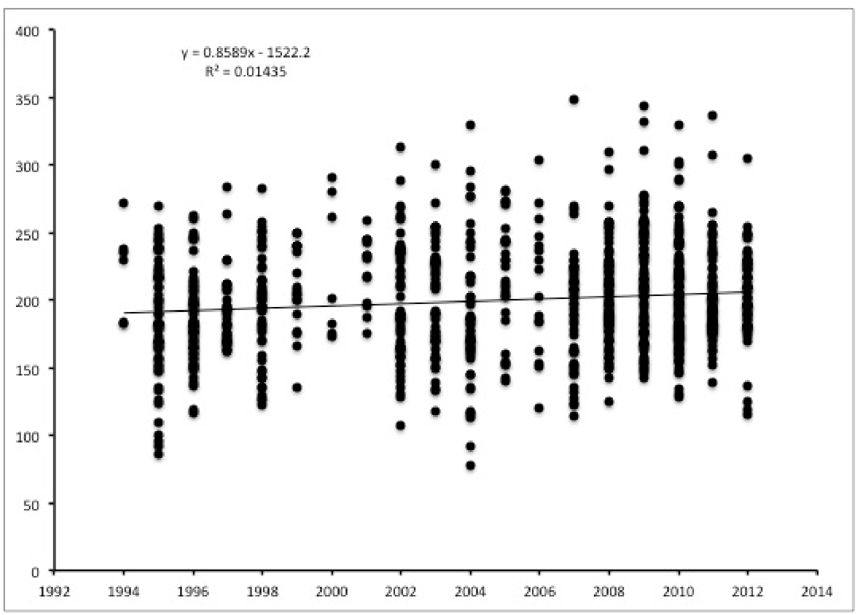

Figure 10. Lengths of great hammerhead sharks by year measured in the Shark Bottom Longline Observer Program, 1994–2012. The line indicates a linear regression fit to the data. (Source: data from Gulak et al. 2013 and references therein)

Gillnet Fishery

Since the implementation of Amendment 2 to the Consolidated Atlantic HMS FMP (NMFS 2007), the directed LCS gillnet fishery has been greatly reduced. The 33-head LCS trip limit (in effect from 2008-2012; increased to 36 LCS per trip in 2013) essentially ended the strike net fishery and limited the number of fishermen targeting LCS with drift gillnet gear. As a result, many gillnet fishers that historically targeted sharks are now targeting teleost species such as Spanish mackerel, king mackerel, and bluefish. Vessels participating in the Atlantic shark gillnet fishery typically possess permits for other Council and/or state managed fisheries and will deploy nets in several configurations based on target species including drift, strike, and sink gillnets. In 2011, a total of 402 sets by various gillnet fisheries in the Atlantic, including the Gulf of Mexico and Caribbean, were observed, with no great hammerheads reported as caught.

Commercial Handgear

Commercial handgears, including handline, harpoon, rod and reel, buoy gear and bandit gear, are used to fish for Atlantic HMS by fishermen on private vessels, charter vessels, and headboat vessels. Rod and reel gear may be deployed from a vessel that is at anchor, drifting, or underway (i.e., trolling). However, the shark commercial handgear fishery plays a very minor role in contributing to the overall shark landing statistics.

Commercial Fishery Data: Landings by Hammerhead Species

The following table (Table 5) shows domestic commercial landings of the hammerhead species which were compiled from the most recent stock assessment documents and updates provided by the NMFS Southeast Fisheries Science Center (SEFSC).

Table 5. Domestic commercial landings of hammerhead sharks in the Atlantic and Gulf of Mexico regions in pounds (lbs) of dressed weight (dw) from 2008- 2012 (kilograms are noted in parentheses). (Source: NMFS 2013a)

Large Coastal Shark	**2008**	**2009**	**2010**	**2011**	**2012**
Hammerhead, great	156 (71)	1,430 (649)	6,339 (2,875)	49 (22)	470 (213)
Hammerhead, scalloped	0	0	0	0	49,016 (22,233)
Hammerhead, smooth	0	4,025 (1,826)	7,802 (3,539)	110 (50)	3,967 (1,799)
Hammerhead, unclassified	56,963 (25,838)	158,503 (71,896)	94,494 (42,862)	104,327 (47,322)	17,622 (7,993)
TOTAL	57,119 (25,909)	163,958 (74,370)	108,635 (49,276)	104,486 (47,394)	71,075 (32,239)

From 2008 – 2012, the commercial landings of hammerhead sharks have been variable (Figure 11). Landings nearly tripled from 2008 to 2009 but subsequently decreased in the following years. For the most part, landings are lumped into an unclassified hammerhead category; however, it has been estimated that the majority (~59%) of the unclassified hammerhead landings are likely *S. lewini* (based on data from the Commercial Shark Fishery Observer Program; NMFS 2010).

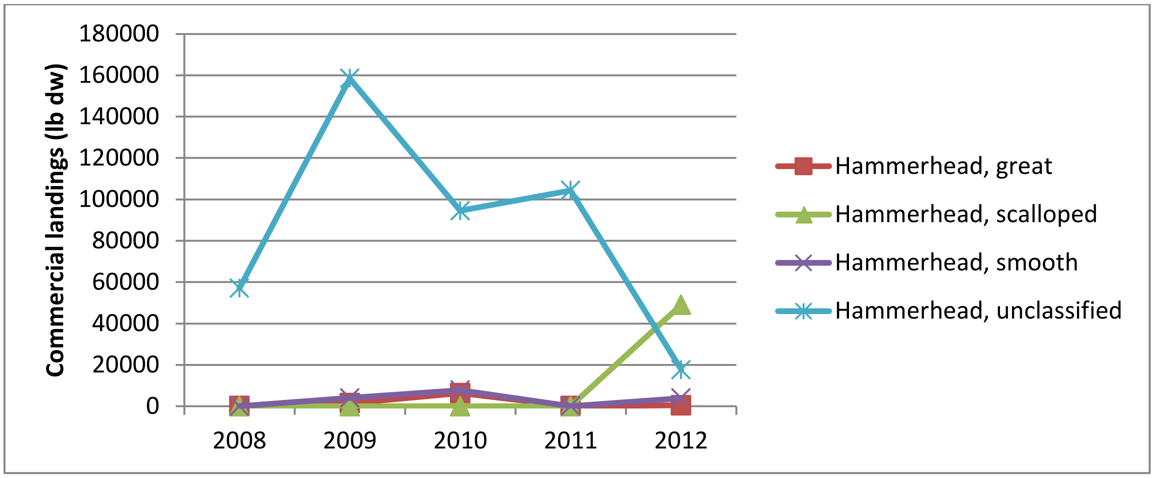

Figure 11. Atlantic commercial landings (lb dw) of hammerhead sharks from 2008-2012. (Source: NMFS 2013a)

Total Bycatch Estimates 2005-2006 (Source: NMFS 2011c)
Hammerhead shark bycatch estimates (by weight or number) were compiled from nine Southeast Region commercial fisheries for the NMFS 2006 U.S. National Bycatch Report. According to the report, bycatch estimates for hammerhead sharks in the various fisheries ranged from 15 individuals in the Gulf of Mexico Coastal Migratory Pelagic Troll, to 730 individuals in the Gulf of Mexico Reef Fish BLL fishery (with a coefficient of variation (CV) = 129.37) from 2005-2006. In the South Atlantic Coastal Migratory Pelagic Troll, the annual bycatch of hammerhead sharks was 6.15 individuals (CV = 36.74), whereas in the South Atlantic Snapper-Grouper Handline, this number was much larger, at 135.63 individuals (CV= 64.13). However, as shown by the large CVs, there is a high degree of uncertainty in these estimates.

Bycatch estimates specifically attributed to great hammerhead sharks were only available from the Atlantic and Gulf of Mexico Shark BLL fishery. According to the report, great hammerhead bycatch from 2005-2006 was estimated to be 191,774 lbs (CV = 0.25).

U.S. Recreational Shark Fishery
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 recreational shark fishery operating in the Atlantic Ocean, including the Gulf of Mexico and Caribbean, is managed using bag limits, minimum size requirements, and landing requirements (sharks must be landed with head and fins naturally attached). Since 2003, this recreational fishery has been limited to rod and reel and handline gear only. Similar state regulations along the Atlantic seaboard have been implemented through an Atlantic States Marine Fisheries Commission (ASMFC) interstate Shark FMP (ASMFC 2008). Currently, recreational fishermen are allowed one great hammerhead shark > 78” FL per vessel per trip. Table 6 provides a summary of recreational landings of great

hammerhead sharks as well as unidentified hammerhead sharks collected through three surveys: the NMFS Marine Recreational Fishery Statistics Survey (MRFSS), the NMFS Southeast Region Headboat Survey (SRHS), and the Texas Parks and Wildlife Department (TPWD) Marine Recreational Fishing Survey.

Table 6. Atlantic recreational harvest (# of individuals) of great hammerhead sharks and unclassified hammerhead sharks from 2002 – 2012. (Source: NMFS 2012a, NMFS 2013a)

Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Great Hammerhead Shark	4	47	9	55	98	786	13	128	3	126	42
Hammerhead, unclassified	5,247	0	0	2,676	1,099	807	0	0	0	0	0

Additionally, the Large Pelagic Survey (LPS) provided data from Maine through Virginia on the observed and reported numbers of hammerheads caught in the rod and reel fishery from 2002 - 2012. No great hammerhead sharks were observed or reported through the LPS; however, an unidentified hammerhead was reported as “kept” in 2004 and again in 2008. An additional 179 unidentified hammerheads were observed or reported in the rod and reel fishery from 2002-2012, but all were released (NMFS 2012a, 2013).

ANALYSIS OF THE ESA SECTION 4(A)(1) FACTORS

The ESA requires NMFS to determine whether a species is endangered or threatened because of any of the 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 great hammerhead shark.

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The ESA requires an evaluation of any present or threatened destruction, modification, or curtailment of habitat or range. Currently, great hammerhead sharks are found worldwide, residing in coastal warm temperate and tropical seas. They are usually observed in coastal waters and over continental shelves, but may also be found in adjacent deep waters and in coral reefs and lagoons.

In the U.S. exclusive economic zone (EEZ), the Magnuson-Stevens Act 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 Magnuson-Stevens Act defines EFH as habitat necessary for spawning, breeding, feeding, and growth to maturity and requires the identification of EFH in FMPs. Towards that end, 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 (COASTSPAN) Survey and the Cooperative Gulf of Mexico States Shark Pupping and Nursery (GULFSPAN) 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. Below (Figure 12) are the designated EFH areas along the U.S. coast that support EFH for great hammerhead sharks (note - at this time, insufficient data are available to differentiate EFH by size classes, therefore, EFH is the same for all life stages):

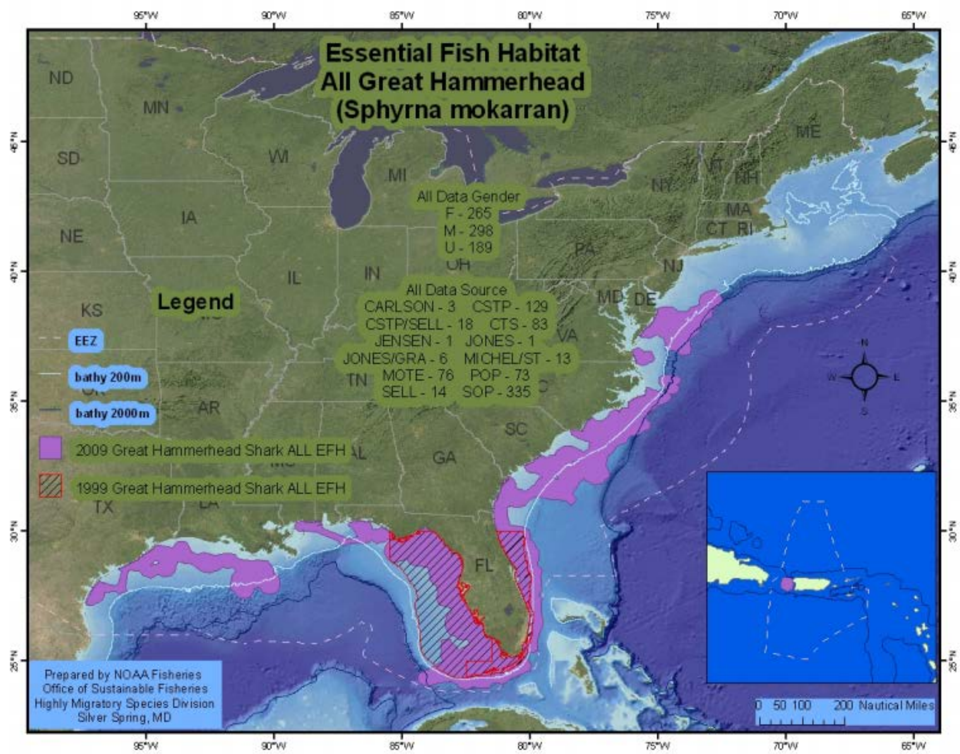

Figure 12. EFH (identified by the light purple area): Coastal areas throughout the west coast of Florida and scattered in the Gulf of Mexico from Alabama to Texas. Atlantic east coast from the Florida Keys to New Jersey and Eastern Puerto Rico. (Source: NMFS 2009)

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 the HMS EFH (which would include great hammerhead shark EFH) (NMFS 2006). Since the great hammerhead EFH is defined as the water column or attributes of the water column, there are anticipated to be minimal or no cumulative impacts from HMS and non-HMS fishing gears (NMFS 2006). However, a better understanding of the specific habitat types and characteristics that influence the abundance of great hammerheads within those habitats is needed in order to determine the effects of fishing activities on habitat suitability for *S. mokarran*.

In addition, the EFH regulations require that FMPs identify non-fishing related activities that may adversely affect EFH of managed species, either quantitatively or qualitatively, or both. Estuaries and coastal embayments have been identified as particularly important nursery areas for sharks, while offshore waters contain important spawning and feeding areas. All of 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. However, based on a comparison of *S. mokarran* distribution maps from 1984 and 2012 (Figure 13), there is no evidence to suggest a range contraction based on habitat degradation for the great hammerhead shark. In addition, as nursery areas for great hammerhead sharks remain unknown, the potential and threat of degradation of these areas cannot be assessed.

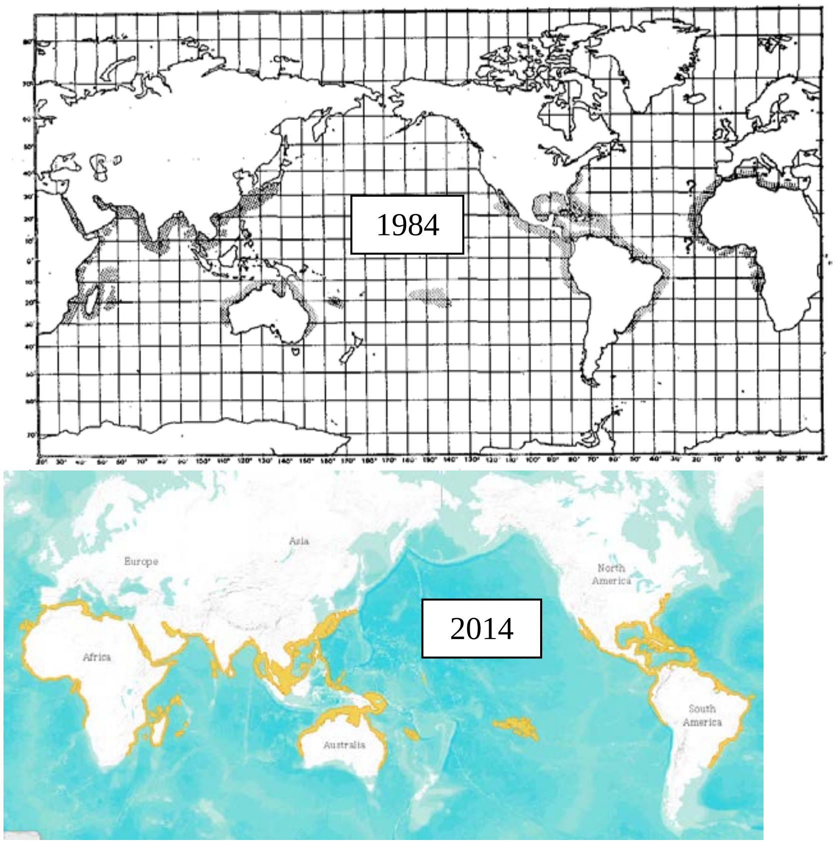

Figure 13. Known distribution of the great hammerhead shark in 1984 and 2014. (Source: Compagno 1984; IUCN 2014)

Because the great hammerhead range 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 pose a threat to this species. This threat was investigated specifically for great hammerhead sharks on Australia's Great Barrier Reef (GBR). Chin et al. (2010) conducted an integrated risk assessment for climate change to assess the vulnerability of great hammerhead sharks, as well as a number of other chondrichthyan species, to climate change on the GBR. 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. Great hammerhead sharks were considered in both the "coastal and inshore" ecological group and the "shelf" 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 coastal/inshore and reef ecological groups also showed relatively high risk, with moderate to high exposure to many of the climate change factors. However, two thirds of the species within the coastal/ inshore group 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 the climate change factors. Only a few of the climate change factors were thought to significantly alter the physiochemical environment or have substantial effects on the shelf and pelagic ecological groups (see Figure 14). Of the 133 GBR shark and ray species, the assessment identified 30 as being moderately or highly vulnerable to climate change. Great hammerhead sharks, however, were not one of these species. In fact, great hammerhead sharks were ranked as having a low overall vulnerability to climate change, with low vulnerability to each of the assessed climate change factors.

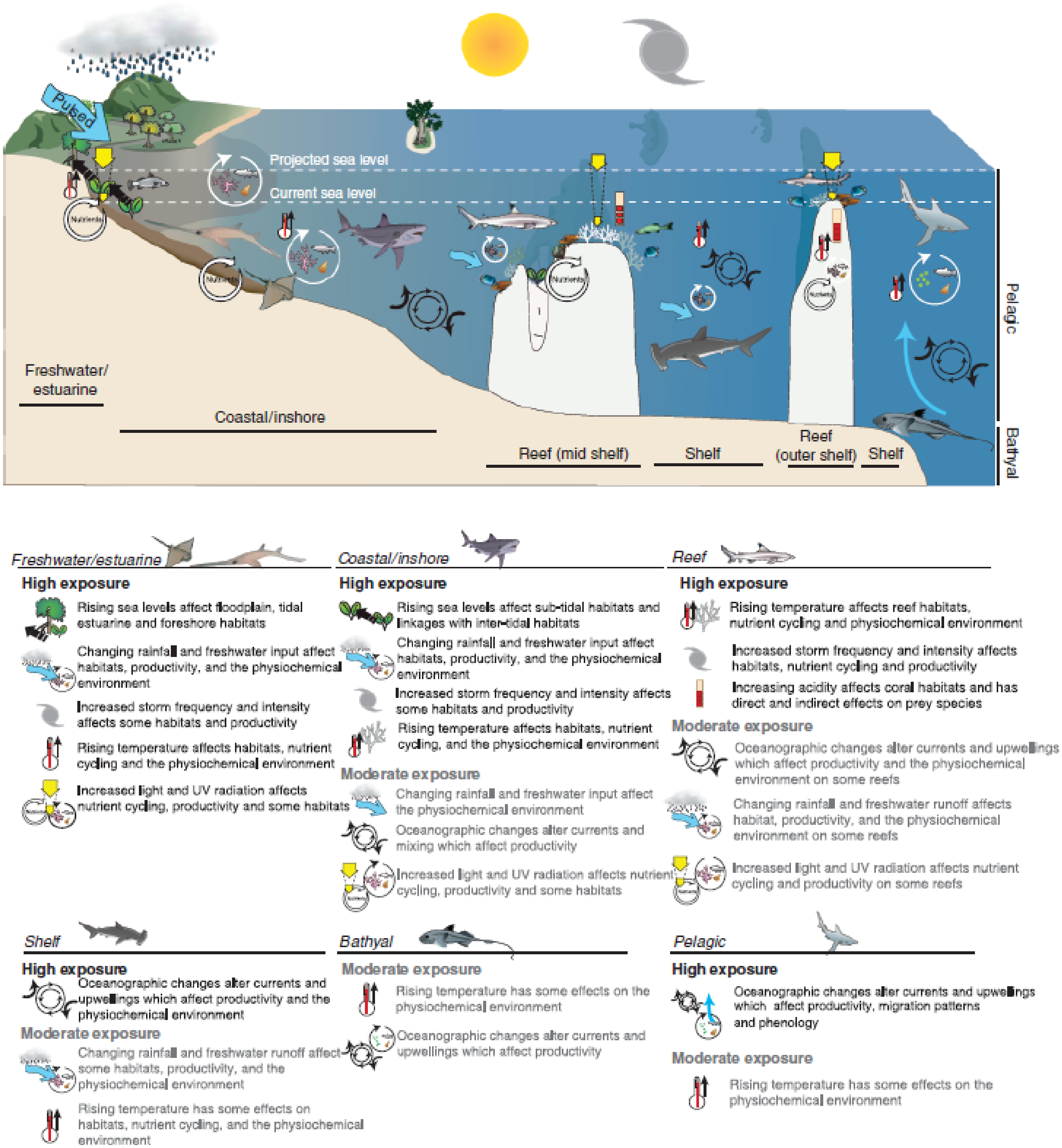

Figure 14. Exposure of GBR ecological groups to climate change factors. (Source: Chin et al. 2010)

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The ESA contains no guidance on how to assess overutilization, nor does it outline levels of population decline relative to an endangered or threatened status. For the purposes of this status review, population dynamic characteristics, such as current population size, abundance trends by regions, recruitment and depensation, and the effects of the shark fin trade on the population were considered for evaluating the status of the species. Much of the data come from localized study sites and over small periods of time and thus is difficult to extrapolate to the global population. In addition, data are often aggregated for the entire hammerhead complex.

Northwest Atlantic & Gulf of Mexico

Data from multiple sources indicate that great hammerhead sharks in the northwest Atlantic have experienced population declines over the past few decades. Unlike the scalloped hammerhead shark, NMFS has not yet conducted (or accepted) a stock assessment on the great hammerhead shark population in this region. However, two species-specific stock assessments (Hayes 2008 and Jiao et al. 2011) are available for review and inclusion in this report. Both stock assessments used surplus-production models, which are common for dealing with data-poor species, and are useful when only catch and relative abundance data are available (Hayes et al. 2009). Surplus-production models can also handle mixed-metric data. Unfortunately, given the limited amount and low quality of available data on great hammerhead sharks (assumed to be due to low abundance and limited sampling; Hayes 2008, Jiao et al. 2011), only two relative abundance indices were available as inputs for the great hammerhead stock assessment models: the NMFS Mississippi fishery-independent bottom longline shark survey (NMFS LL-SE), and the fishery-dependent commercial shark fishery observer program (CSFOP) index, which provided catch-per-unit-effort (CPUE) data. Catch time series data included recreational catches, commercial landings, and pelagic longline discards (see Figure 15). Both assessments found significant catches in the early 1980s, over two orders of magnitude larger than the smallest catches, but Hayes (2008) suggested that these large catches, which correspond mostly to the NMFS Marine Recreational Fishery Statistics Survey (MRFSS), are likely overestimated. Hayes (2008) also identified other data deficiencies that add to the uncertainty surrounding these catch estimates including: misreporting of the species, particularly in recreational fisheries, leading to overestimates of catches; underreporting of commercial catches in early years; and unavailable discard estimates for the PLL fishery for the period of 1982-1986.

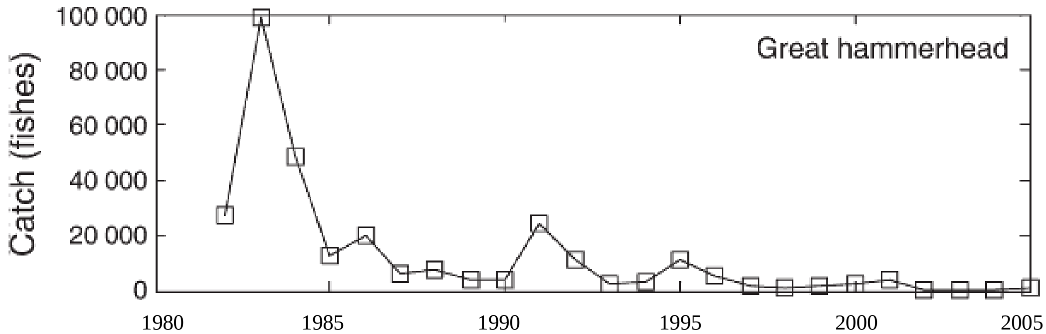

Figure 15. Catches (# of individuals, including recreational, commercial landings, and pelagic longline discards) of *S. mokarran* in the Northwest Atlantic and Gulf of Mexico from 1980-2005. (Source: Jiao et al. 2011)

In terms of abundance trends, the Hayes (2008) stock assessment found the models to be highly sensitive to the relative abundance index that was included. The best fit models (Schaefer and Fox models – see Hayes 2008) were based on the NMFS LL-SE series and indicated that the great hammerhead shark stock was depleted by 92% (Schaefer) or 96% (Fox) between 1982 and 2005. Specifically, the Schaefer model estimated a virgin population size (in 1982) of 190,000 (range = 140,000 – 290,000) and a population of 14,100 in 2005. The Fox model estimated a virgin population size of 230,000 (range = 210,000 – 380,000) and a population of 9,460 individuals in 2005. The Hayes (2008) stock assessment also showed variable fishing levels over the years but with fishing mortality and population size in 2005 that indicated that the stock was overfished and experiencing overfishing. Specifically, fishing mortality in 2005 was estimated to be 130% (Schaefer) or 220% (Fox) of fishing mortality associated with maximum sustainable yield (MSY), and population size was only 15% (Schaefer) or 11% (Fox) of the biomass that would produce MSY (Figure 16).

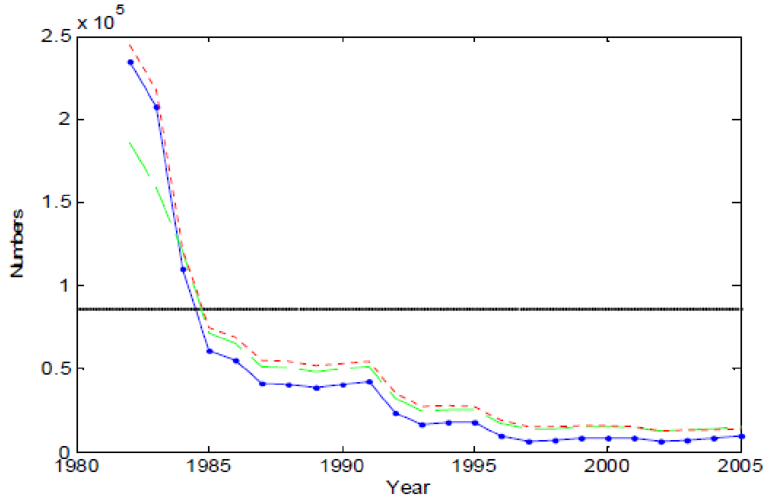

Figure 16. Hayes (2008) abundance trajectory for great hammerhead sharks. (Blue line = Fox model; Green line = Schaefer model; Red line = Pella-Tomlinson model; Black line = population size that produces MSY)

This is in contrast to the Jiao et al. (2011) stock assessment models, which indicated that after 2001, the risk of overfishing was very low and that the great hammerhead population was still overfished but no longer experiencing overfishing. However, both publications point out the high degree of uncertainty associated with the stock assessment models, with Jiao et al. (2011) warning that the stock assessment models should be "viewed as illustrative rather than as conclusive evidence of their present status," and Hayes (2008) reiterating the fact that the stock assessment model "had wide confidence intervals," and was "highly sensitive to the inclusion of certain abundance indices." For example, in a sensitivity analysis that considered a scenario that ignored catch data prior to 1995 in order to test the effect of catches in 1982-1994 (as the NMFS LL-SE index did not begin until 1995), the models showed a much less pessimistic status of great hammerhead sharks (with a higher productivity value and only a 57% depletion from virgin size). Estimates for discards were also questionable as they appeared to be the same as those used in the scalloped hammerhead shark stock assessment (Hayes et al. 2009). However, in the scalloped hammerhead stock assessment, discard estimates were calculated using a proportion that reflected scalloped hammerhead shark composition in the hammerhead complex (NMFS 2010). Thus, if based on proportions, the discard estimates used in the great hammerhead shark assessment should be different (and likely much lower) than those found in the scalloped hammerhead assessment. The high degree of uncertainty, sensitivity, and inclusion of certain data in these stock assessments should be taken into consideration when evaluating the extinction risk of this population.

In addition to the stock assessment, Hayes (2008) also examined the catch composition of hammerhead shark species (scalloped, great, and smooth) and noted that the relative proportion of each species in the catch has changed significantly since the early 1980s (Figure 17). Great hammerhead sharks, for example, constituted ~50% of the hammerhead shark catch in 1982 but their proportion has since decreased to < 30% of the species catch in 2005. This is in contrast to scalloped hammerhead sharks, which have increased in the catch composition from ~32% in 1982 to ~60% in 2005.

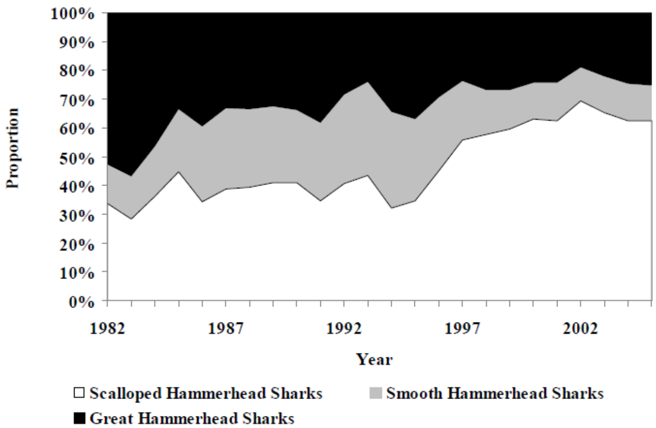

Figure 17. Proportion of scalloped, great, and smooth hammerhead sharks in the overall hammerhead catch from 1982 to 2005. (Source: Hayes 2008)

Hayes (2008) attributes this change in catch composition to the life histories of the hammerhead species, with the less productive species (smooth and great) being more susceptible to fishing pressure and thus disproportionately overexploited compared to the more resilient scalloped hammerhead shark. In terms of rebuilding, Hayes (2008) estimated that scalloped hammerhead sharks could rebuild within 30 years under 2005 catch levels, however, even under a "no catch" scenario, great hammerheads would only have a 56% probability of rebuilding within 30 years (see Table 7). However, given the new life history information available since Hayes (2008) it is likely that great hammerheads would have a higher likelihood of rebuilding (see **Demography** section).

Table 7. Probability (in %) of the *S. mokarran* stock rebuilding under different time frames and catch scenarios. (Source: Hayes 2008)

Time horizon	No Catch	C_{2005}	200% of C_{2005}	300% of C_{2005}
10 Years	27	24	21	17
20 Years	44	32	25	22
30 Years	56	40	29	24

Recent studies have re-examined great hammerhead shark abundance throughout the northwest Atlantic and Gulf of Mexico. Shepherd et al. (2005) analyzed great hammerhead abundance trends from the northern Gulf of Mexico shelf waters (between 10 and 100 m depth) using bycatch data from shrimp/groundfish research trawl surveys. The authors estimated a negative rate of change in abundance for great hammerheads, with the species last observed in the dataset in 1979; however, the trend was not significant and based on very small sample sizes (Shepherd et al. 2005). Looking at the entire hammerhead complex, Jiao et al. (2009) estimated a decline of approximately 72% in abundance from 1981 to 2005 using a Bayesian hierarchical surplus production model and various NMFS fisheries data. Likewise, Baum and Blanchard (2010) found a similar decline of 76% in relative hammerhead abundance from 1992 to 2005 using generalized linear mixed models and U.S. PLL logbook and observer data.

Using a generalized linear modeling (GLM) approach, a relative abundance index for great hammerhead was derived using more recent observer data (from 1994 to 2011) from the U.S. commercial BLL fishery operating in the Atlantic Ocean and Gulf of Mexico (Carlson et al. 2012; Carlson, unpublished). Trends in abundance indicated a 9% increase over the length of the time series (Figure 18). However, data from the NMFS Mississippi Laboratory fishery independent bottom longline survey indicated no clear trend likely owing to the low number of observations in the data series (Adam Pollock, personal communication; Figure 19). The abundance of juvenile great hammerhead sharks captured in an inshore fishery independent survey conducted by Mote Marine Laboratory from 1995 to 2004 showed a slight decline over the time series (Figure 20).

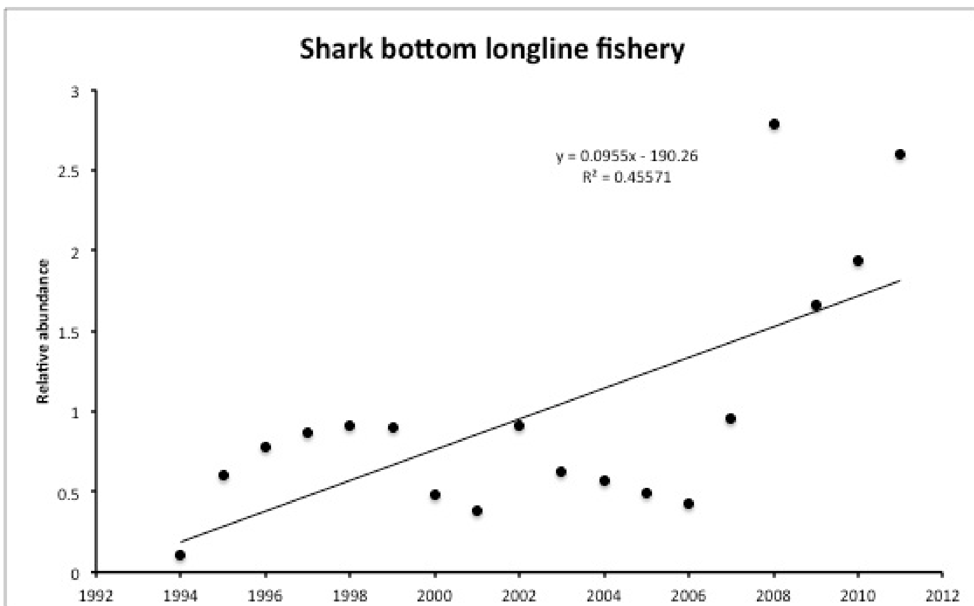

Figure 18. Mean relative index (index divided by mean of index) of annual abundance estimates from 1994 to 2011 for great hammerhead shark from the shark bottom longline fishery.

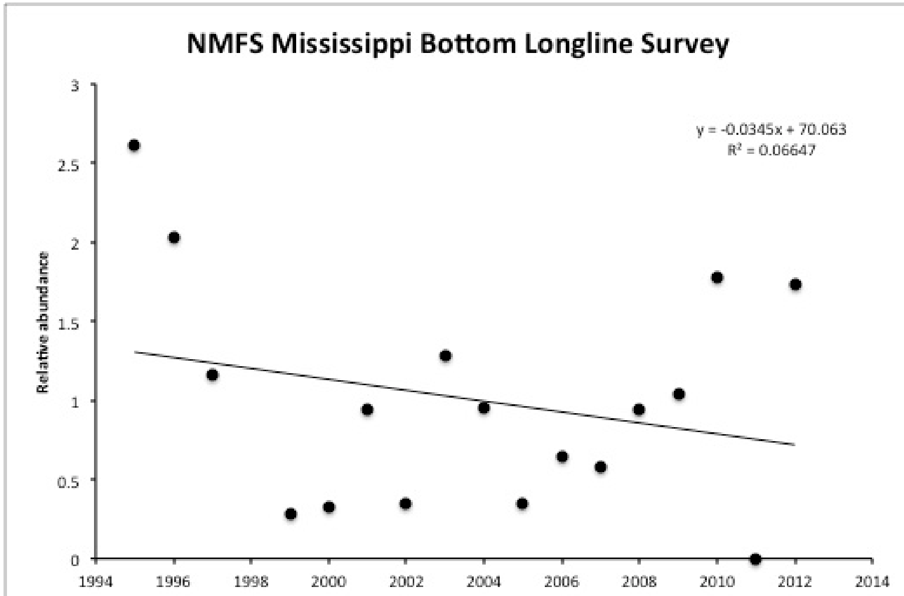

Figure 19. Relative nominal index of annual abundance estimates from 1995 to 2012 for great hammerhead shark from the Mississippi Bottom Longline Survey.

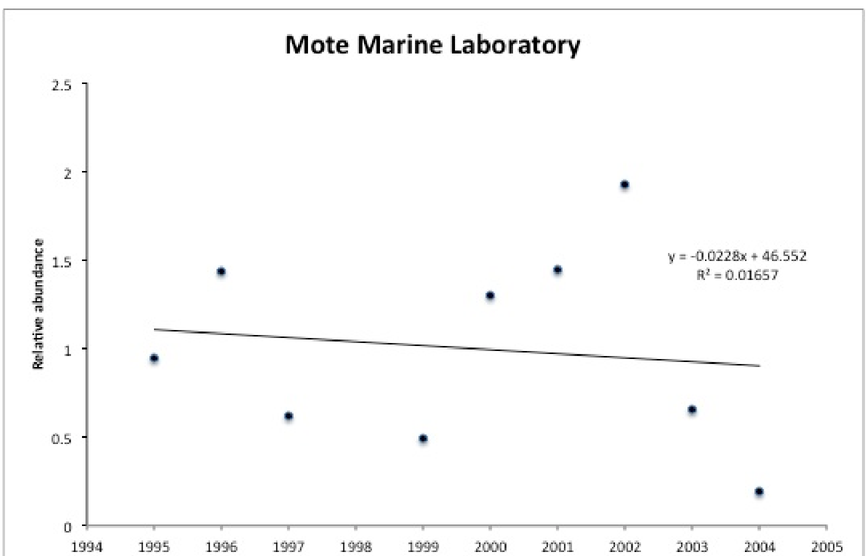

Figure 20. Nominal index of annual abundance estimates from 1995 to 2004 for great hammerhead shark from the Mote Marine Laboratory gillnet survey.

Farther south, in Mexico, the shark fishery is an important source of food and jobs on both coasts, where up to 90% of the Mexican shark production is consumed domestically. Average annual shark catches in the Gulf of Mexico from 1976-1995 represented one-third of the total national shark production (Castillo-Géniz et al. 1998). A one-year study that monitored catch and effort of a Mexican artisanal coastal shark fishery found that landings peaked in October

(CPUE = 27.2 sharks per trip) and were lowest in the month of April (CPUE = 4.46 sharks per trip), with an overall average CPUE of 9.45 (± 1.92) sharks per trip. Of the 84,717 sharks caught from 1993-1994, less than 2% (actual percentage not identified) were great hammerhead sharks (Castillo-Géniz et al. 1998). In a review of elasmobranch fisheries, Bonfil (1994) identified *S. mokarran* as an important and main species in commercial catch in Mexican fisheries operating in the Gulf of Mexico and Caribbean. As many of the shark nursery areas in this region are also important fishing grounds for the local communities (Castillo-Géniz et al. 1998), the species is heavily exploited in its juvenile and sometimes newborn stage in parts of its range (Bonfil 1994).

<u>Central America & Caribbean</u>

Few data are available from this region. The population abundance in the Caribbean is unknown as catch reporting is sporadic and not normally recorded down to the species level. According to a personal observation (R. T. Graham) provided to the International Union for Conservation of Nature (IUCN) (Denham et al. 2007), hammerheads were heavily fished by longlines off the coast of Belize in the 1980s and early 1990s. This heavy exploitation subsequently led to an observed decline in the abundance and size of hammerheads, a shifting of *S. mokarran* distribution from coastal waters to barrier reefs (Kyne et al. 2012; based on personal communication from R. T. Graham), and prompted a halt in the Belize-based shark fishery (Denham et al. 2007). Fishing pressure on hammerheads still continues as a result of Guatemalan fishermen entering Belizean waters. However, the IUCN notes (but does not provide a citation) that catch records from the Cuban directed shark fishery show a small increase in the mean size of great hammerheads since 1992, suggesting partial recovery of the species in this region (Denham et al. 2007).

Off Venezuela, observers note that great hammerheads are mostly concentrated around the oceanic islands and near the edge of the continental shelf (Figure 21).

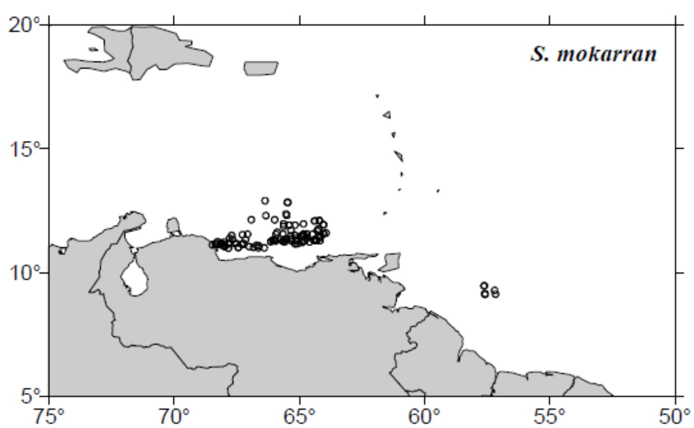

Figure 21. Observed great hammerhead catches by the Venezuelan longline fleet from 1994-2000. (Source: Arocha et al. 2002).

From 1994 to 2000, observers from the Venezuelan Pelagic Longline Observer Program recorded 149 great hammerheads caught by the Venezuelan longline fleet targeting tuna and swordfish in the Caribbean Sea and central Atlantic. Great hammerhead sharks were the 4th most commonly caught shark species on the longline gear and made up 7.9% of the total shark catch (and 47% of the hammerhead species catch) (Arocha et al. 2002). Tavares and Arochoa (2008) examined the dataset extended out to year 2003 and found that although great hammerheads remained the 4th most commonly caught species (n=177), their percentage in the catch decreased to 6.8%, likely explained by the fact that no great hammerheads were caught during the last year of the time series. From 1994 to 2003, CPUE for the species declined (but the trend was not significant) and ranged between 1.33 sharks/1000 hooks and 8.70 sharks/1000 hooks, with an average of 2.9 (± 1.58) sharks/1000 hooks (Tavares and Arocha 2008). The observed *S. mokarran* sharks ranged in size from 86 cm to 213 cm TL, with females dominating the catch. The majority of the catch was comprised of immature individuals (between 130 and 190 cm TL; Figure 22).

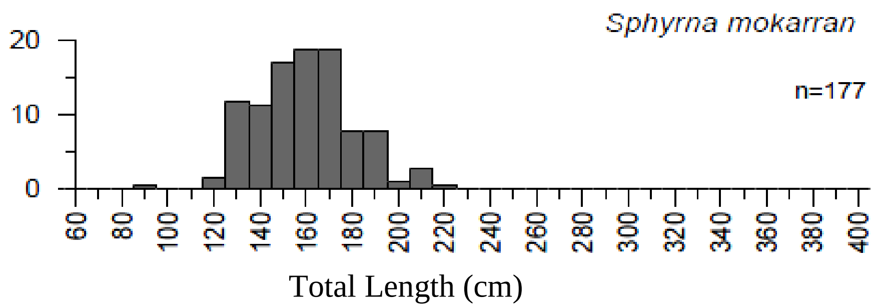

Figure 22. Total length (cm) of the observed great hammerhead catch by the Venezuelan longline fleet from 1994-2003. (Source: Tavares and Arocha 2008)

<u>Southwest Atlantic</u>

In the ports of Rio Grande and Itajai, Brazil, annual landings of hammerhead sharks have fluctuated over the years. In 1992, reported landings were ~ 30 t but increased rapidly to 700 t in 1994. From 1995 to 2002, catches decreased and fluctuated between 100-300 t (Baum et al. 2007). Information from surface longline and bottom gillnet fisheries targeting hammerhead sharks off southern Brazil indicates declines of more than 80% in CPUE from 2000 to 2008, with the targeted hammerhead fishery abandoned after 2008 due to the rarity of the species (FAO 2010). In a study on the removal of shark species by São Paulo State tuna longliners off the coast of Brazil, Amorim et al. (1998) documented significant catches of smooth and scalloped hammerhead sharks from 1974 – 1997 (mainly on the southern continental slope). However, great hammerhead sharks were only very rarely caught by these Santos, São Paulo longliners and represented ≤ 5% of the hammerhead species catch. In a follow up study, conducted from 2007-2008, Amorim et al. (2011) found no records of *S. mokarran* in the São Paulo State surface longline data, although 376 smooth and scalloped hammerheads were recorded as caught (Figure 23). As shown below, the area of operation for the longline fisheries (Figure 24) and catch locations (Figure 23) overlaps with the great hammerhead shark range.

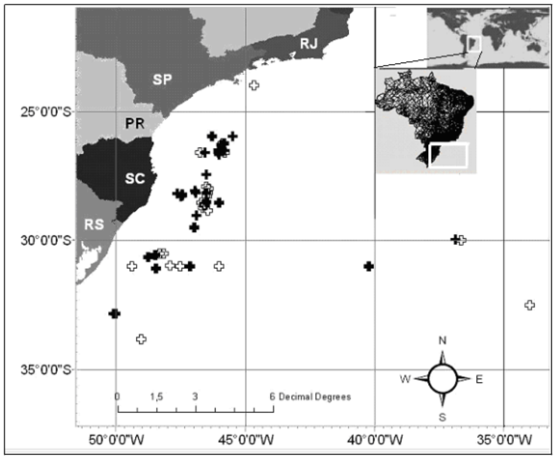

Figure 23. Catch locations of scalloped and smooth hammerheads as reported by Santos longliners (white crosses = scalloped, black crosses = smooth). (Source: Amorim et al. 2011)

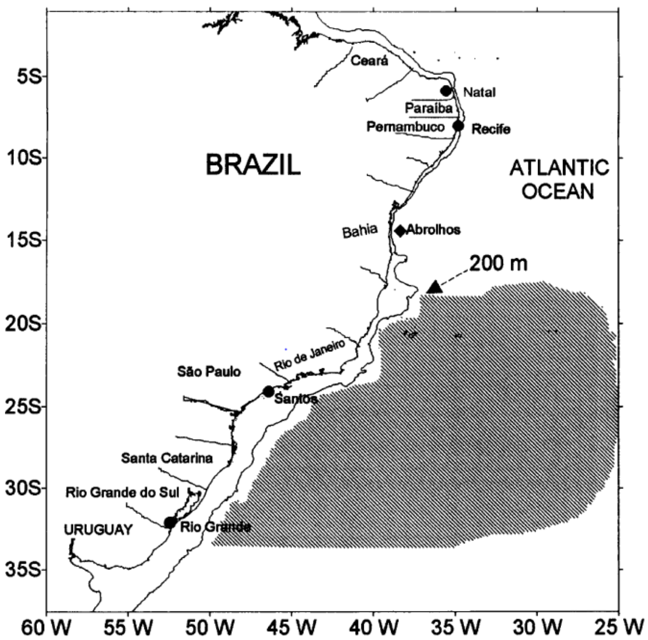

Figure 24. Santos longliners area of fisheries operation. (Source: Amorim et al. 1998)

<u>Eastern Atlantic & Mediterranean Sea</u>

Great hammerhead sharks are rare in the Mediterranean Sea and considered an alien species. Only one specimen has been recorded in the western Mediterranean (Camogli, Ligurian Sea; Boero and Carli 1977) and was thought to be introduced via Gibraltar (Bradai et al. 2012). Although Ferretti et al. (2008) has been referenced as a study that estimated a decline of >99.99% in *Sphyrna* spp. abundance and biomass, the authors acknowledge that they could only assess *S. zygaena*, and, as such, this study is not a good proxy for other hammerhead species' abundance trends in this region (FAO 2013).

Great hammerhead sharks can be found farther south in the Eastern Atlantic, off the coast of West Africa. They were once documented ranging from Mauritania to Angola, with periods of high abundance observed in October in waters off Mauritania, and from November to January in waters off Senegal (Cadenat and Blache 1981). In the 1940s, they were described as reaching large sizes (6 m TL). However, with the targeted exploitation of this species, especially in the Senegalese and Gambian fisheries, there has been a significant and ongoing decrease in shark landings in these waters, with an observed scarcity of large hammerhead sharks (Diop and Dossa 2011). Data from Senegal's annual fisheries reports show a decrease of more than 50% in hammerhead landings from 2006 to 2010 (see Figure 25). Landings data and scientific surveys conducted in Mauritanian waters also show that CPUE and yields of great hammerhead sharks have fluctuated over the years, but since 2006, have shown a downward trend (Dia et al. 2012). In 2009, the total catch of sharks in Mauritanian waters was 2,010 mt, with great hammerheads constituting only 1.15% of the shark catch (or 23 mt) (Dia et al. 2012). In 2011, 77 fishermen were surveyed for 4 weeks from four landing ports in Orango National Park in Guinea-Bissau in order to obtain an idea of annual shark catches in this area. Over those four weeks, a total of 6.31 mt of sharks were caught, of which 0.65 mt were great hammerhead sharks (Betunde 2011).

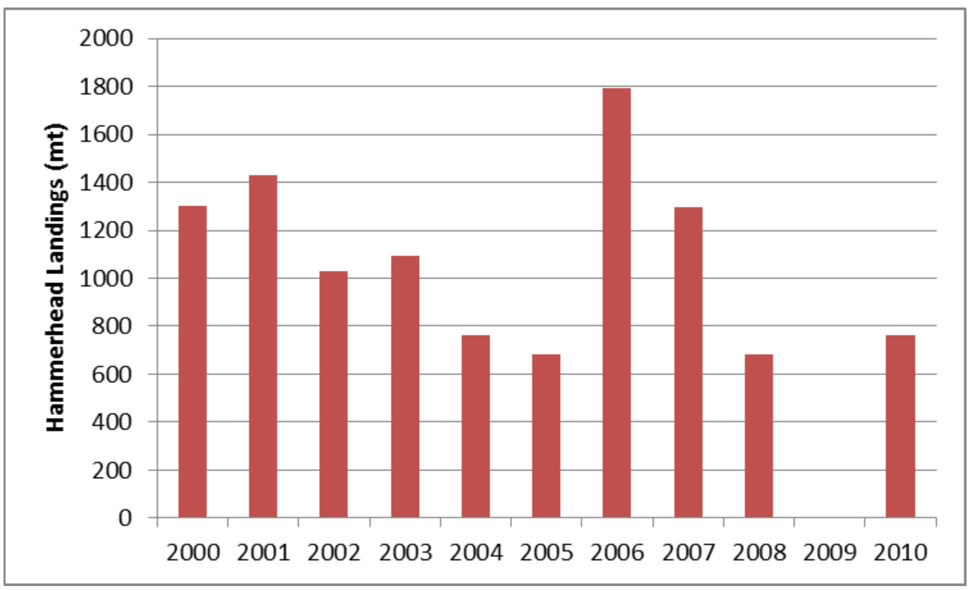

Figure 25. Annual hammerhead landings as documented in Senegal Marine Fisheries Reports.

According to a review of shark fishing in the Sub Regional Fisheries Commission (SRFC) member countries (Cape-Verde, Gambia, Guinea, Guinea-Bissau, Mauritania, Senegal, and Sierra Leone), Diop and Dossa (2011) state that shark fishing has been occurring in this region for around 30 years. Shark fisheries and trade in this region first originated in Gambia, but soon spread throughout the region in the 1980s and 1990s, as the development and demand from the worldwide fin market increased. From 1994 to 2005, shark catch reached maximum levels, with a continued increase in the number of boats, with better fishing gear and people entering the fishery, especially in the artisanal fishing sector. Before 1989, artisanal catch was less than 4,000 mt. However, from 1990 to 2005, catch increased dramatically from 5,000 mt to over 26,000 mt, as did the level of fishing effort (Diop and Dossa 2011). Including estimates of bycatch from the industrial fishing fleet brings this number over 30,000 mt in 2005 (however, discards of shark carcasses at sea were not included in bycatch estimates, suggesting bycatch may be underestimated) (Diop and Dossa 2011). In the SRFC region, an industry focused on the fishing activities, processing, and sale of shark products became well established. From 2005 to 2008, shark landings subsequently dropped by more than 50 percent, to 12,000 mt (Diop and Dossa, 2011). In 2010, the number of artisanal fishing vessels that landed elasmobranches in the SRFC zone was estimated to be around 2,500 vessels, with 1,300 of those specializing in catching sharks (Diop and Dossa 2011).

As mentioned earlier, large hammerheads are scarce in this region, which is likely a result of the historical targeted fishing of this species and the continued removal of these sharks before they can attain maximum sizes. As such, many of the hammerheads that are currently caught in the fisheries operating in the Eastern Atlantic are juveniles. Bycatch data from the European pelagic freezer-trawler fishery, which operates off Mauritania, provide evidence of this age dominance. Between October 2001 and May 2005, 42% of the retained pelagic megafauna bycatch from over 1,400 freezer-trawl sets consisted of hammerhead species (*S. lewini, S. zygaena,* and *S. mokarran*), with around 75% of the hammerhead catch juveniles of 0.50 – 1.40 m in length (Zeeberg et al. 2006). In addition, analysis of Mauritania landings data of the closely related scalloped hammerhead shark also shows a recent predominance of juveniles in the catch (for the period of 2003 - 2011) and a decline in the average size of the species (Figure 26; Dia et al. 2012). Scientific research survey data, collected from 1982-2010, also show a sharp drop in yields, especially since 2005, and in 2010, virtually no *Sphyrna* spp. (*S. lewini* and *S. zygaena*) were caught during the survey (Figure 27; Dia et al. 2012).

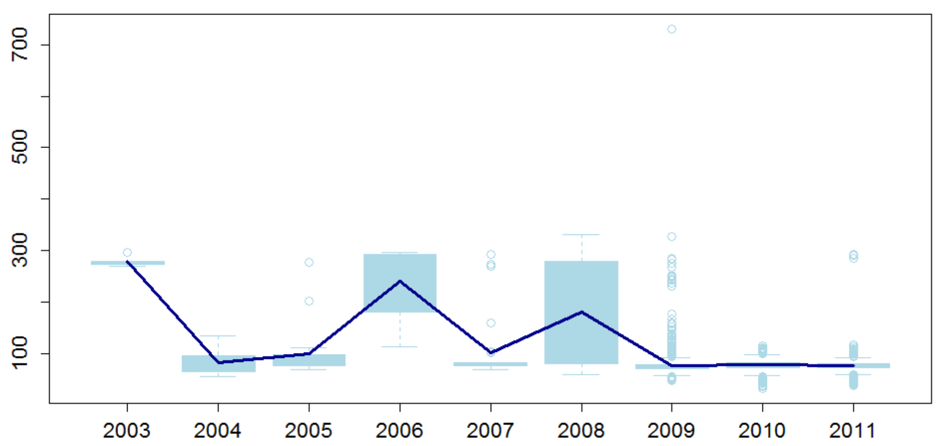

Figure 26. Change in average size (cm) of *Sphyrna lewini* in landings in Mauritanian waters. (Source: Dia et al. 2012)

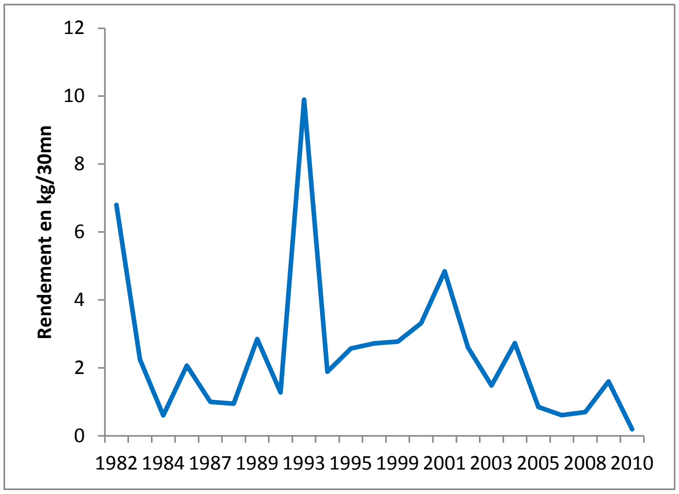

Figure 27. Change in average abundance indices (Kg/30min) of genus *Sphyrna* spp. in research surveys in Mauritanian waters from 1982 to 2010. (Source: Dia et al. 2012)

Although there are no stock assessments for great hammerhead sharks from the Eastern Atlantic region, most of the pelagic stocks and demersal fish that have been evaluated are considered fully exploited to overexploited due to historical and current fishing practices (FAO 2012). For example, many of the shrimp stocks range between fully and overexploited and the commercially important octopus and cuttlefish stocks in this region are deemed overexploited. Some stocks, such as the white grouper in Senegal and Mauritania, are even considered to be in severe condition. Driving this exploitation is the increasing need for protein resources in this region, both as a trade commodity and as a dietary staple. In fact, many people in Sub-Saharan Africa depend on fish for protein in their diet, with fish accounting for around 22% of their protein intake (Heck and Béné 2005). This proportion increases to over 50% in many of the poorer African countries, where other animal protein is scarce, and in West African coastal countries, where fishing has driven the economy for many centuries (Heck and Béné 2005). For example, fish accounts for 47% of protein intake in Senegal, 62% in Gambia, and 63% in Sierra Leone and Ghana (Heck and Béné 2005). With population growth in the SRFC predicted to increase from 35 million (in 2007) to around 76 million by 2050 (Diop and Dossa 2011), and with 78.4% of the population living within 100 km of the coast, there will likely be higher demand and fishing pressure on marine resources in future years (Diop and Dossa 2011). Already, the FAO reports that ‘‘the Eastern Central Atlantic has 43% of its assessed stocks fully exploited, 53% overexploited and 4% non-fully exploited, a situation warranting attention for improvement in management’’ (FAO 2012). Thus, given the high demand for dietary protein in this region and the apparent decline and current rarity of great hammerheads (especially of large individuals) in fisheries data from the Eastern Atlantic, the available information suggests that the great hammerhead population is likely overexploited. The historical and current fishing pressure on the species, especially on juveniles, may be hindering recruitment and causing depensatory effects (whereby a decrease in spawning stock leads to reduced likelihood of finding a mate).

Vulnerability to Fisheries in the Atlantic Ocean – Ecological Risk Assessment

In an effort to evaluate the vulnerability of specific shark stocks to pelagic longline fisheries in the Atlantic Ocean, Cortés et al. (2012) conducted an Ecological Risk Assessment using observer information collected from a number of ICCAT fleets. Ecological Risk Assessments are popular modeling tools that take into account a stock's biological productivity (evaluated based on life history characteristics) and susceptibility to a fishery (evaluated based on availability of the species within the fishery's area or operation, encounterability, post capture mortality and selectivity of the gear) in order to determine its overall vulnerability to overexploitation (Cortés et al. 2012; Kiska 2012). Productivity and susceptibility scores are normally plotted on an x-y scatter plot and an overall vulnerability or risk score is calculated as the Euclidean distance from the origin of x-y scatter plot. For example, a species with low productivity and high susceptibility would be at a high risk to overexploitation by the fishery. In this way, vulnerability scores can be ranked and compared between species. Ecological Risk Assessment models are useful because they can be conducted on a qualitative, semi-quantitative, or quantitative level, depending on the type of data available for input.

Results from the Cortés et al. (2012) Ecological Risk Assessment indicate that great hammerheads face a relatively low risk in ICCAT fisheries. Out of the 20 assessed shark stocks, great hammerheads ranked 14th in terms of their susceptibility (S) to pelagic longline fisheries in the Atlantic Ocean. The population's estimated productivity (P) value (r = 0.070) ranked 10th; however, this was based on older life history information and recent data suggests great hammerheads are more productive (see **Demography** section). The authors then calculated overall vulnerability (v) scores using three methods: the Euclidean distance, a multiplicative index (defined as v=P(1-S)), and the arithmetic mean of the productivity and susceptibility ranks. Using the Euclidean distance method, great hammerheads ranked 14th in terms of their overall vulnerability to the PLL fisheries in the Atlantic Ocean. For the other two methods, their vulnerability rankings were lower, but not by much (v = 10 using multiplicative index; v = 13 using arithmetic mean).

Indian Ocean

There are currently no quantitative stock assessments or basic fishery indicators available for great hammerhead sharks throughout the entire Indian Ocean, and thus the stock status is highly uncertain. According to a review by de Young (2008), the status of general shark populations within the Indian Ocean, off the coasts of Egypt, India, Iran, Oman, Saudi Arabia, Sudan, United Arab Emirates, and Yemen, are currently unknown. Off the coasts of Maldives, Kenya, Mauritius, Seychelles, South Africa, and United Republic of Tanzania, sharks are presumed to be fully to over-exploited (de Young 2006).

In northern Madagascar, Robinson and Sauer (2011) documented an artisanal fishery that operates mainly in water shallower than 100 m and targets sharks primarily for their fins. Based on access point surveys and observation data collected from 2001 to 2004, Carcharhinidae species accounted for 69% of the landings and *Sphyrnidae* (*S. lewini* and *S. mokarran*) accounted for 24%. Of the *Sphyrnidae* landings, *S. lewini* was the most common species, comprising ~96% of the landings. Only 7 *S. mokarran* sharks were landed during the survey period, of which 5 were immature.

Similarly, landings of great hammerhead sharks were also rare in the shark fisheries operating in Antongil Bay in northeastern Madagascar, which again commonly land only fins rather than whole sharks. Based on genetic sampling of 239 fin snips, collected through cooperative programs with fishers and from market surveys in 2001 and 2002, the scalloped hammerhead shark was the most represented species in the shark fishery (Doukakis et al. 2011). Conversely, only one great hammerhead shark specimen was found, and it was collected from the marketplace (rather than a fisher) (Doukakis et al. 2011).

Off the coast of South Africa, significant decreases in catch rates of great hammerhead sharks have been observed, indicating potential local population declines. In fact, analysis of fishery-independent data from the KwaZulu-Natal beach protection program revealed declines in the catch rates of *S. mokarran* since the late 1970s. Specifically, from 1978 – 2003, annual CPUE of *S. mokarran* significantly declined by 79%, from 0.44 to 0.09 (sharks per km of net) (Figure 28; Dudley and Simpfendorfer, 2006). The majority of the catch (greater than 64%) consisted of immature great hammerhead sharks (Dudley and Simpfendorfer, 2006).

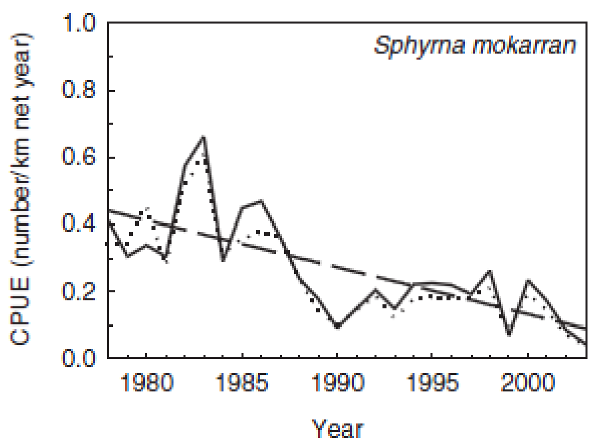

Figure 28. Annual CPUE of great hammerhead sharks caught in the KwaZulu-Natal beach protection program nets between 1978 and 2003 (solid line). (Source: Dudley and Simpfendorfer 2006)

In Pakistan, sharks are caught in large quantities as bycatch by the tuna fisheries. In fact, it is estimated that 55% of the total Pakistan shark landings come from tuna gillnet boats (which fish using surface and driftnet gillnets). Since 1999, shark landings have steadily decreased, from ~32,500 mt to ~8,000 mt in 2007 (Shahid 2012). Although hammerhead sharks are not one of the dominant bycatch species, they are represented in the composition (Shahid 2012).

Likewise, great hammerhead sharks can be found at various fish landings sites in Indonesia, but only in low numbers. Between 2001 and 2006, White et al. (2008) visited six fish landing sites in Indonesia and recorded 21,651 sharks. Of this total, only 3.5% were sphyrnid species, the majority of which were scalloped hammerhead sharks. Great hammerhead sharks comprised only 0.1% of the total number of recorded sharks and constituted 0.4% of the total biomass.

In Australian waters, sharks are caught by commercial, recreational and traditional fishers as targeted catch, retained catch, and bycatch. Almost all sharks landed in Australia are used for domestic consumption. According to Bensley et al. (2010), the annual commercial Australian shark catch from 1996 to 2006 ranged from about 8,600 mt to 11,500 mt; however, the reporting of catch weights varied due to the state of processing (e.g., whole weight, processed weight, landed weight, etc.).

Australia – Northwest Coast

Hammerhead sharks, specifically, are caught in the shark fisheries operating off the northwest coast of Australia. The 'northern shark fisheries,' as they are called, comprise the state-managed Western Australia North Coast Shark Fishery (WANCSF) which operates in the Pilbara and western Kimberley, and the Joint Authority Northern Shark Fishery (JANSF) in eastern Kimberly. The northern shark fisheries have targeted a variety of species including sandbar, blacktip, and lemon sharks, and retained others, such as hammerheads and tiger sharks (Heupel and McAuley 2007). The fisheries historically used demersal longline gear and pelagic gillnetting in the JANSF. According to Heupel and McAuley (2007), significant reductions in hammerhead catches in this fishery occurred between 1998 and 1999, when CPUE declined from a high of 0.18 kg/hook to 0.07 kg/hook (Heupel and McAuley 2007). After 1999, CPUE remained low, varying between 0.05 and 0.11 kg/hook until 2005 (Heupel and McAuley 2007). However, fishing practices also underwent major changes during this period. In the late 1990s, the major source of fishing effort transitioned from mainly pelagic gillnetting to demersal longlining. Around 2002-2003, larger longliners who used to fish in pelagic waters entered the fishery, expanding the spatial distribution of fishing effort. After mid-2003, reporting efforts changed as research funding ended, calling into question the accuracy of catches. In June 2005, new management practices were introduced and the northern shark fishing effort has since been low and infrequent. Even with these fishery management changes, Heupel and McAuley (2007) suggest that the available northern shark fishery CPUE data from 1996-2005 provides a good indication of the hammerhead abundance. The authors reason that because hammerheads are widely distributed and were never truly targeted by the fishery, they were less likely affected by the fishing practice changes noted above (Heupel and McAuley 2007). Provided these assumptions are true, then the analysis of the CPUE data from 1996-2005 suggests declines of 58-76% in hammerhead abundance in Australia's northwest marine region (Heupel and McAuley 2007). The *State of the Fisheries and Aquatic Resources Report 2010/11* provides more recent CPUE data for the northern shark fishery, extending the dataset to 2010 (Figure 29; McAuley and Rowland 2012). Specific catches of hammerhead sharks in this fishery from 2001-2009 are shown in Figure 30. Although the data suggest that hammerhead population abundance has declined since the late 1990s, recent management measures and regulations have essentially halted operations in this fishery (see "Evaluation of adequacy of existing measures" section), thereby greatly minimizing the threat of overutilization that this fishery poses to the population in this region.

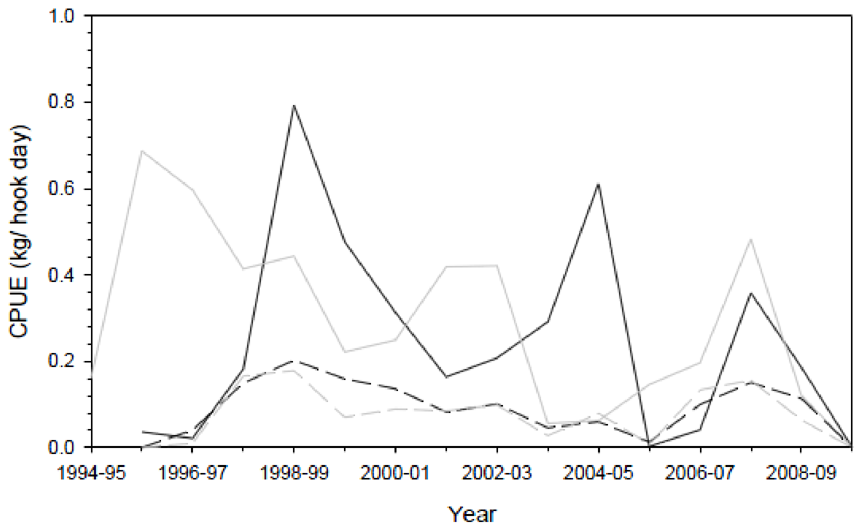

Figure 29. Nominal CPUE of indicator and secondary target shark species in Australia's northern shark fisheries (WANCSF and JANSF) from 1994 – 2010. Solid black line is sandbar sharks, solid grey line is blacktip sharks, dashed black line is tiger shark, and dashed grey line is hammerhead sharks. (Source: McAuley and Rowland 2012)

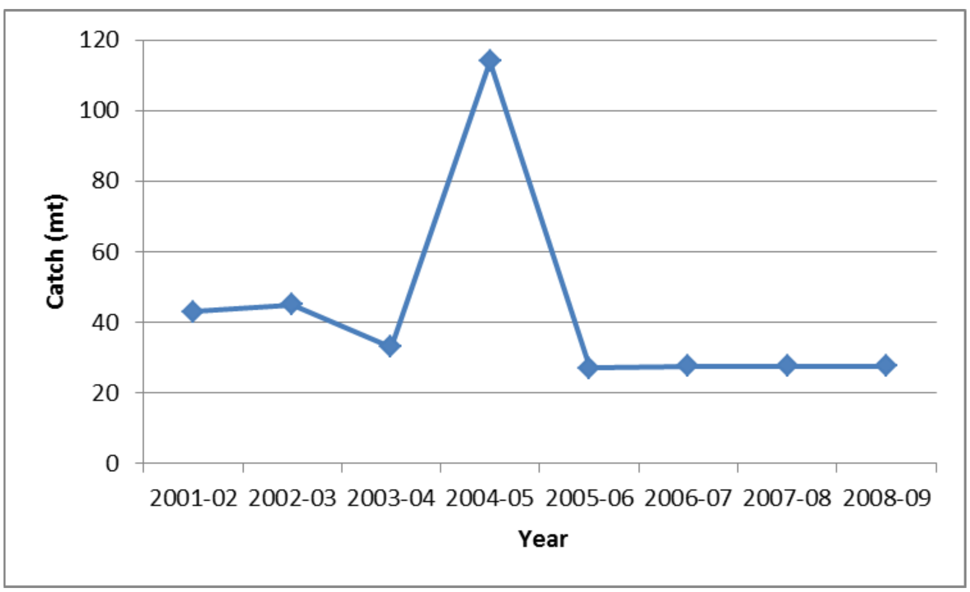

Figure 30. Catch (mt) of hammerhead sharks (Sphyrnidae) from Australia's northern shark fisheries' (WANCSF and JANSF). Data for 2006 to 2009 are averaged due to confidentiality of records. (Source: McAuley 2008; McAuley and Rowland 2012)

Although not targeted, hammerhead sharks may also be caught as bycatch in Australia's Northern Prawn Fishery (NPF), as their distribution overlaps with the fishery's area of operation. In a study that examined the fishing impact of the NPF on elasmobranch bycatch species, great hammerhead sharks were found to be potentially at risk from the fishery based on fishing mortality estimates (Zhou and Griffiths 2008). Specifically, the results showed that the estimated fishing mortality from the fishery was greater than the maximum sustainable fishing mortality for *S. mokarran*, and the 95% confidence interval for the fishing mortality estimate included the estimated minimum unsustainable fishing mortality for the species (Zhou and Griffiths 2008). However, these estimates should be viewed with caution as the estimated relative abundance of *S. mokarran* was highly uncertain due to low detection rates in the study (only 12 individuals were detected in surveys conducted from 1979 to 2003; Zhou and Griffiths 2008).

The Northern Territory Offshore Net and Line (NTONL) fishery, which targets black-tip sharks and grey mackerels, operates off the coastline of Australia's Northern Territory and uses longlines or pelagic set nets (bottom set nets are prohibited). Other shark species, including hammerheads, are recorded as bycatch. Based on NTONL observer data from 2002 to 2007 (during 49 days at sea), great hammerhead sharks constituted 1.6% of the total catch of elasmobranch species (Field et al. 2013). Their relative abundance was calculated at 1.51 individuals per day (Field et al. 2013). In 2011, hammerhead sharks constituted 12% of the total bycatch (141 mt), exceeding the trigger reference point established for byproduct species. Because of this, the management advisory committee for the fishery will review the trigger breach and provide advice to the Executive Director of Fisheries for necessary action (Northern Territory Government 2012). It is unclear how many great hammerhead sharks were caught as the estimates were for all *Sphyrna* spp. However, based on the observer data (Field et al. 2013), the ratio of scalloped hammerheads to great hammerheads in the bycatch is approximately 1.8:1.

Vulnerability to Fisheries in the Indian Ocean – Ecological Risk Assessments
Recently, two Ecological Risk Assessments have been conducted which provide a geographically broader look at the impact of Indian Ocean fisheries on the great hammerhead shark population. The first Ecological Risk Assessment looked at the impact of artisanal fisheries of the SW Indian Ocean on mammals, sea turtles, and elasmobranchs (Kiszka 2012). The assessment was based on interview survey data and examined shark bycatch and utilization in artisanal fisheries using multifilament and monofilament drift gillnets, bottom set gillnets, beach seines and handlines. The artisanal fisheries that were surveyed had areas of operation off Kenya, Mozambique, Tanzania, and Mauritius. Results from the Ecological Risk Assessment indicate that scalloped and great hammerheads face a high risk (most vulnerable) in drift gillnet fisheries (based on their low productivity scores and high susceptibility scores) (Kiszka 2012). The hammerhead species show a more moderate risk in bottom set gillnets, beach seines and handlines. The author ultimately concluded that coastal artisanal fisheries in the Indian Ocean are likely to have a significant impact on hammerhead sharks (Kiszka 2012).

The second Ecological Risk Assessment looked at the impact of IOTC industrial tuna fisheries (both longline and purse seiners) on sharks. Although the IOTC gillnet fleet is responsible for catching the majority of sharks (representing 68% of the total IOTC fisheries shark catch), the susceptibility analysis was unable to be conducted on this fleet due to a lack of effort distribution information and observer data. The IOTC fleet that catches the second highest number of sharks is the longline fleet, representing 16% of the total shark catch, followed by the purse seiners with less than 1% of the shark catch. In the IOTC fisheries data, sharks are for the most part reported as a “shark group” or by main shark species caught (examples: blue, mako). The Ecological Risk Assessment was conducted for 17 shark species and used available data from the combined IOTC longline fleet, including the Soviet Union research longline, the Portuguese, Japanese, Korean, La Reunion Island, and Chinese longline fleets, and for the combined IOTC purse seiner fleet. Based on the observer data used in the study, only a few great hammerheads were bycaught in the IOTC longline fisheries and none were observed in the purse seine fisheries (H. Murua, personal communication). The Ecological Risk Assessment results revealed that the great hammerhead shark ranked 9 out of 17 in terms of its overall vulnerability to the IOTC longline fisheries compared to the other identified species (Table 8). The great hammerhead shark was characterized by low productivity but also lower susceptibility compared to the other vulnerable species. Post capture mortality was estimated to be 100% for great hammerheads. In terms of vulnerability to purse seines, it was ranked as #4 out of the 17 assessed species (with low numbers being more vulnerable); however, its susceptibility estimate was significantly lower than that calculated for longlines. In other words, when comparing across fisheries, the species is much less likely to be impacted by purse seines than longlines (Table 8) (Murua et al. 2012).

Table 8. Productivity and susceptibility analysis for *S. mokarran* caught by fisheries operating in the IOTC convention area.

	Productivity	**Susceptibility**					**Vulnerability**	
IOTC Fishery	Lambda	Availability	Encounterability	Selectivity	Post-capture mortality	Susceptibility	Vulnerability	RANK (out of 17)
Pelagic LL	1.098 (1.079-1.115)	0.925	1	0.622	1	0.575	0.436	9
Purse Seine	1.098 (1.079-1.115)	0.667	1	0.273	1	0.182	0.824	4

Western Pacific

Information on hammerhead shark utilization in the Western Pacific is mainly available from Australian fisheries operating in these waters. Hammerhead sharks are specifically caught in a number of fisheries operating off the eastern coast of Australia, including the New South Wales (NSW) Ocean Trap & Line (OTL) fishery, the East Coast Tuna and Billfish Fishery as well as the West Coast Tuna and Billfish Fishery. Fisheries-independent data from protective shark meshing programs in this region, off beaches in Queensland and NSW, suggest significant declines in these hammerhead populations. Data from the Queensland Shark Control Program (QSCP) indicate declines of around ~83% in hammerhead shark abundance between 1985 and 2012 (with *S. lewini* making up the majority of this catch) (Figure 31 and Figure 32; Queensland Department of Employment, Economic Development and Innovation (QLD DEEDI), 2013).

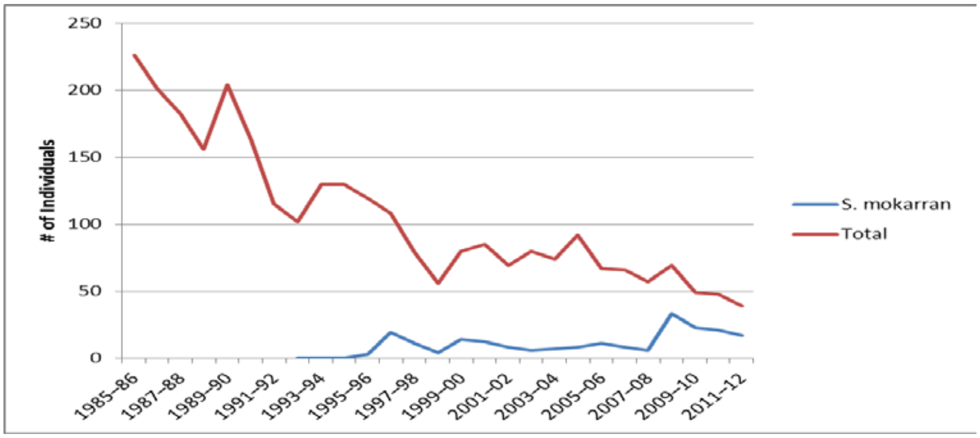

Figure 31. Total number of hammerhead sharks (*Sphyrna* spp.) caught in QSCP nets from 1985-2012, and the total number of great hammerhead sharks caught from 1992 – 2012.

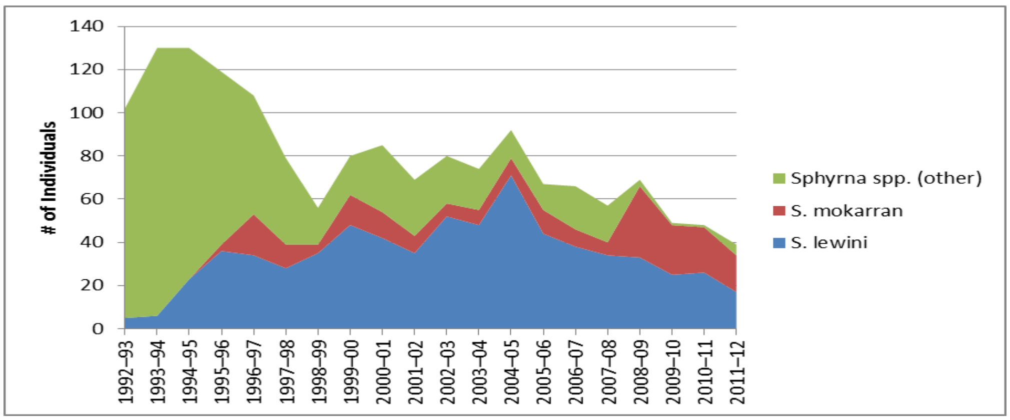

Figure 32. Number of great hammerhead (*S. mokarran*), scalloped hammerhead (*S. lewini*) and other hammerhead (*Sphyrna* spp.) sharks caught in the QSCP nets from 1992 – 2012.

Although the significant drop in the number of hammerhead sharks caught in the QSCP may suggest historical overutilization of this complex, a similar statement is difficult to make based upon analysis of only the great hammerhead shark data. *S. mokarran* abundance in the Queensland shark control nets has fluctuated over the years, with no clear trend (Figure 31 and Figure 32). In fact, catch has remained below 20 individuals until 2008/2009, when a peak of 33 individuals was caught in the nets (QLD DEEDI 2013). Abundance has since declined by around 48% to 17 individuals in 2011/2012 (QLD DEEDI 2013). However, compared to the other observed shark species, great hammerhead sharks appear to only rarely be caught by the QSCP nets, averaging < 2% of the total shark catch over the years. As such, this dataset may not be a good indicator of great hammerhead shark abundance trends, at least in raw data form.

In reviewing this status review document, the Extinction Risk Analysis team (see **Assessment of Extinction Risk**) attempted to extract additional temporal patterns for the QSCP great hammerhead time series and their results are presented here. The first step taken was to examine the fraction of total hammerhead sharks that were identified as great hammerhead sharks (Figure

33). From this information, it was clear that there was an extended time period (following 4 years of transitional data) where the fraction was relatively stable (mean value from 1996-2007 = 0.1222). The next step was to apply this mean fraction to the aggregate hammerhead shark catch from 1985-1995 (Figure 34). This results in an apparent decline in great hammerhead shark catch during the 1980s and 1990s followed by an apparent increase over the more recent decade. It should be noted that this is the pattern of catch only, and not a measure of abundance such as CPUE. Spatial and temporal variability in beach net effort and other factors would need to be carefully considered, but if effort were relatively static then the time series might be indicative of great hammerhead shark abundance for this region. It should be further noted that, as with the raw data, great hammerhead sharks are relatively rare in the reconstructed QSCP catch, averaging ~2% numerically over the entire data series.

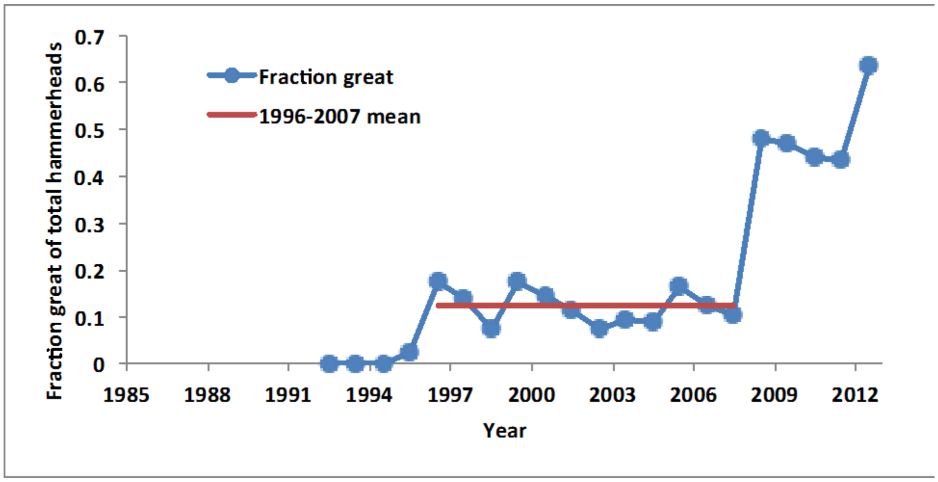

Figure 33. Fraction of total hammerhead shark catch in the Queensland Shark Control Program identified as great hammerhead sharks. The mean fraction for the time period 1996-2007 is indicated. 1992-1995 data are assumed to be transitional data and are not included in the mean.

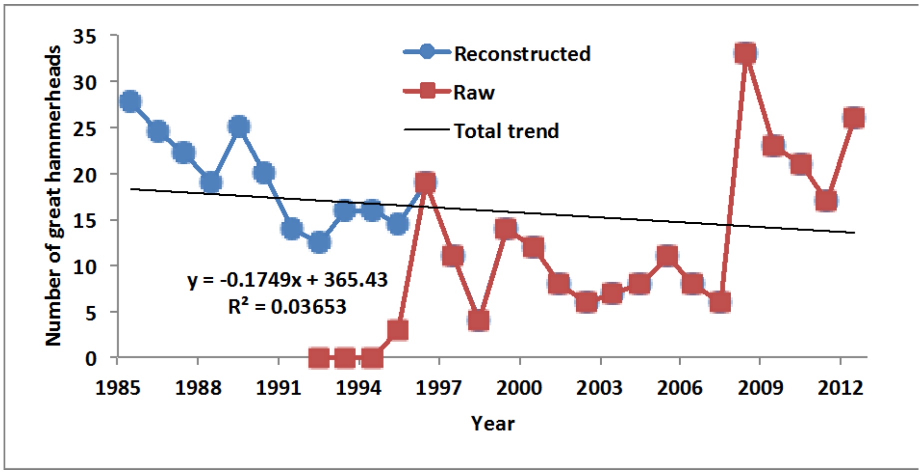

Figure 34. Time series of great hammerhead shark catch in the Queensland Shark Control Program. The reconstructed segment of the time series uses the mean fraction for the time period 1996-2007. 1992-1995 species-specific catch data are assumed to be transitional data and are replaced by the reconstructed estimates for this time period using the total hammerhead shark catch and the mean fraction. Regression for the entire series is shown for illustrative purposes only.

Similarly, data from a three-year observer survey of small-scale commercial gillnet vessels in the East Coast Inshore Finfish Fishery (which operates in the Great Barrier Reef World Heritage Area off Queensland) also suggests that *S. mokarran* are not commonly caught in the inshore coastal areas of this region. Out of the total number of elasmobranchs observed in the gillnet catch (n = 6,828), great hammerhead sharks comprised only 1.5% of the catch (n=102) (Harry et al. 2011b). This is in contrast to the scalloped hammerhead shark, which is likely the most abundant hammerhead species off the coast of Queensland (Taylor et al. 2011), and was the 4th most abundant elasmobranch in the gillnet catch (making up 8.8% of the total catch, n=604) (Harry et al. 2011b). However, when the data were analyzed by weight for the carcharhiniform shark catch, great hammerhead sharks ranked third, due to their large mean size at capture (~154 cm; still immature) compared to the other species (Harry et al. 2011b).

In addition to the QCSP, hammerhead sharks are caught in the NSW Shark Meshing Program (SMP). This program annually deploys a series of bottom-set mesh nets between September 1st and April 30th along 51 ocean beaches from Wollongong to Newcastle. Since the 1950s, at least 16,064 animals have been caught in these nets, consisting mostly of hammerhead sharks (29%), rays (18.9%), whalers (which could include up to 10 species of the genus *Carcharhinus*; 18.4%), and angel sharks (14.4%) (Green et al. 2009). Prior to 1972, whalers and angel sharks were the dominant species in the SMP, but their numbers have declined and hammerheads have become a larger proportion of the catch (Figure 35). In fact, from 1972 to 2008, hammerheads averaged approximately 50% of the annual catch (range 34% - 67%) (Green et al. 2009). However, Green et al. (2009) notes that in the past few years (from 2002 – 2008), their average has declined to 35% (range 20-42%).

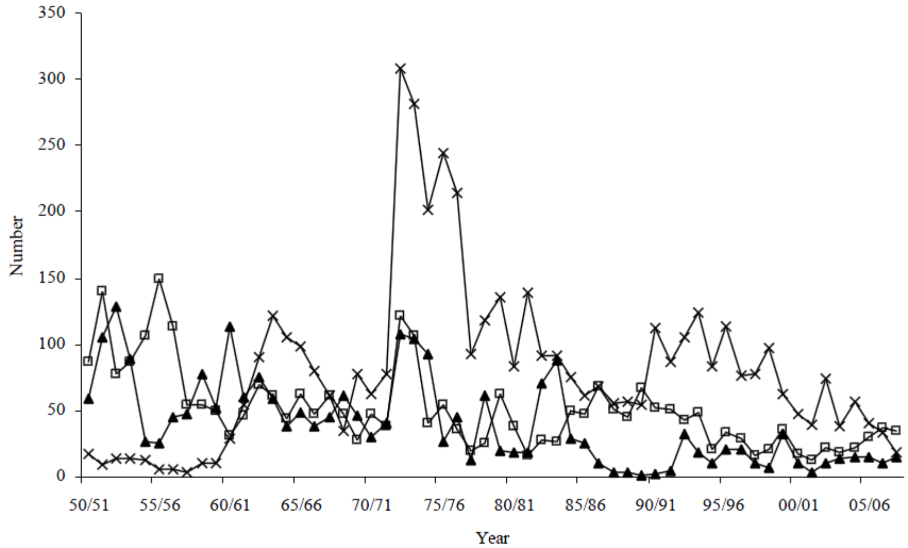

Figure 35. Annual catches of hammerhead sharks (X), whalers (□), and angel sharks (▲) in the NSW SMP from 1950 – 2008. (Source: Green et al. 2009)

Although there was no significant trend for the CPUE of hammerhead sharks over the entire 1950 – 2008 period (Figure 36; Reid et al. 2011), since the 1970s, the number of hammerheads caught per year in NSW beach nets has decreased by more than 90%, from over 300 individuals in 1973 to less than 30 in 2008 (Williamson 2011). Unlike the QCSP data, the SMP did not break out the hammerhead complex by species but noted that the majority of the hammerhead catch are likely smooth hammerhead sharks (*S. zygaena*) (Reid et al. 2011; Williamson 2011), as they are the hammerhead species most tolerant of temperate waters (Compagno 1984).

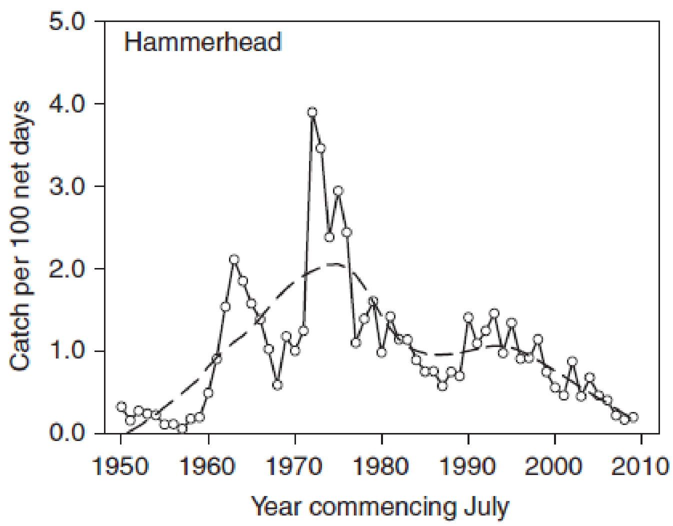

Figure 36. CPUE of hammerhead sharks in the NSW SMP from 1950 – 2010. (Source: Reid et al. 2011)

In the NSW commercial fisheries, sharks have historically been a bycatch species. However, since 2004, there has been a significant increase in targeted fishing for sharks in specific areas (Green et al. 2009). For example, in the NSW Ocean Trap and Line (OTL) fishery, annual catch of sharks increased by ~200% between 2004-2005 and 2006-2007, mainly due to the high value of shark fins in the market. Faced with the threat of overexploitation, the Industry & Investment NSW (I&I NSW) implemented new restrictions on shark fishing in the OTL fishery in 2009 and allowed observers onboard OTL vessels. From September 2008 to May 2009 they collected data from 81 fishing trips. Results from the observer data show that great hammerhead sharks, although a targeted species, represent only a very small percentage (0.5%) of the total number of (targeted) shark species (n = 1,383). Again, likely due to the area of operation of this fishery in more temperate waters, *S. mokarran* was rarely observed in the OTL catch, with only 9 total sharks caught. This translates to a mean catch rate of around 0.02 ± 0.01 sharks per 100 hooks per setline deployment (Macbeth et al. 2009). Likewise, reported landings by NSW commercial fishers also indicate that hammerheads are not a dominant species in the catch (see Table 9).

Table 9. Reported NSW commercial landings (mt) for select shark groups from 2001-2008. (Source: Green et al. 2009)

SHARK GROUPING	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Hammerheads	7.73	4.18	2.83	2.16	2.61	4.11	2.41
Whalers	184.82	172.35	134.75	148.14	226.82	429.23	224.3
Angel sharks	44.45	32.9	45.32	40.11	50.17	53.39	28.57
Port Jacksons	0.08	0.89	0.48	0.84	0.01	0.39	
Tigers	3.44	0.8	1.98	1.44	6.55	4.92	2.03
Makos	4.66	2.23	1.52	2.28	2.95	6.42	1.73
Wobbegongs	99.05	91.83	87.44	71.33	73.85	53.27	41.1
Total	**341.68**	**305.18**	**274.32**	**266.30**	**362.96**	**551.73**	**300.14**

Values represent estimated whole weights in tonnes
(Source: DPI Comm. Catch data extract Sept 2008)

In terms of recreational fisheries catch of hammerheads in this region, data are available from the NSW Gamefish Tournament and Monitoring Program. Over the period of 1993 – 2005, a total of 445 hammerhead sharks were reported caught, with over 87% (n = 389) tagged and released back into the water. Again, given the composition of the catch data from the commercial fisheries, it is likely that the majority of this recreational hammerhead catch are smooth hammerhead sharks. (Green et al. 2009).

In the tropical waters of the Pacific, there are very limited data available on the threat of overutilization of great hammerhead sharks by fisheries. One study that looked at operational-level logsheet and observer data of fleets operating in the Republic of the Marshall Islands EEZ found only three reports of observed *S. mokarran* individuals from 2005-2009 (although estimates of total annual longline catches of sharks ranged from 1,583 to 2,274 t $year^{-1}$) (Bromhead et al. 2012).

Eastern Pacific

In the Pacific, the central Mexican shark fishery began in the early 1940s and grew from catches of less than 5000 tons in the early 1960s to catches of 25,000 tons in the late 1970s, and reached maximum exploitation in the 1980s and 1990s (Pérez-Jiménez et al. 2005). Although *S. lewini* has been documented as an important shark species that was routinely caught off the Pacific coast of Mexico and in the Gulf of California, with studies that have shown its importance in artisanal fisheries (Pérez-Jiménez et al. 2005; Bizzarro et al. 2009; Smith et al. 2009), reports of *S. mokarran* in the fisheries data are extremely rare. In the Gulf of Tehuantepec, *S. lewini* is the second most important species in the shark fishery, comprising around 29% of the total shark catch from this area (INP 2006), whereas *S. mokarran* is ranked 11th (out of 21 species) and comprises < 4.7% of the catch (when grouped with other shark species). From 1996-2001, CPUE of all sharks in the Gulf of Tehuantepac declined by around 46% (INP 2006); however, CPUE specifically for great hammerhead sharks was not calculated (INP 2006).

In Costa Rica, shark catches reported by the artisanal and longline fisheries have shown a dramatic decline (~50%) after reaching a maximum of 5000 tonnes in 2000 (SINAC 2012). Observations of the relative abundance of all pelagic sharks in the Costa Rica EEZ indicate dramatic declines of ~58% between 1991 and 2002 (Arauz et al. 2004). Although this region is documented as part of the great hammerhead range, their observance in fishery data is rare. For example, there are no records of great hammerhead sharks in observer data from Costa Rica's Pacific mahi-mahi targeted longline fishery (217 sets observed between 1999 and 2008), although catches of both *S. lewini* and *S. zygaena* were reported. The majority of the fishing effort was, however, concentrated in pelagic waters (from 19.5 to 596.2 km offshore; see Figure 37) but also overlapped with the documented range of the great hammerhead shark (Whoriskey et al. 2011).

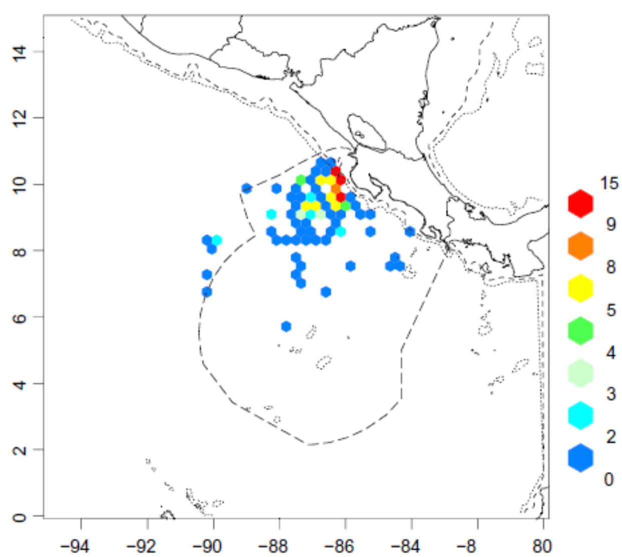

Figure 37. Observed mahi-mahi targeted pelagic longline fishing effort in number of sets between 1999 and 2008 (Source Whoriskey et al. 2011).

Farther south, in Ecuador, sharks are mainly caught as "incidental catch" in a variety of fishing gear, including pelagic and bottom longlines, and drift and set gill nets, with hammerhead sharks used primarily for the fin trade. Catch records for the hammerhead complex (*S. lewini, S. mokarran*, and *S. zygaena*) indicated a peak in landings of around 1000 t in 1996, followed by a decline through 2001 (CITES 2012). However, from 2004 to 2010, the catch records show no clear trend. Landings in 2004 were approximately 149 t. In 2005, landings decreased by about 67% to 49 t but subsequently increased in the following years to reach a peak of 327 t in 2008. In 2009, landings decreased again by around 71% but tripled the following year to reach approximately 304 t in 2010 (INP 2010).

Effect of the Shark Fin Trade

Shark fins are a top commodity in Asia and fetch a high price, up to 1,000 € per fin or 80 € per bowl of shark fin soup. Shark meat, on the other hand, sells for considerably less, approximately 10 €/kilo for meat compared to 500 €/kilo for fins (Oceana 2010). Because of this stark difference in price, the practice of "finning," whereby fishers sever shark fins and return the remaining carcass to the sea, continues to occur as fishermen targeting sharks prefer to keep only the valuable fins onboard their boats for trade (Oceana 2010). In Ecuador, for example, Jacquet et al. (2008) calculated that the weight of fin exports exceeded the weight of reported mainland landings of sharks by 44% from 1998-2004. On average, 3,850 mt of unaccounted for fins were exported per year (Jacquet et al. 2008). Many of these fins are subsequently exported to Hong Kong and sold in the world's largest fin trade market. In 2008, around 10 million kg (10,000 t) of shark fins were imported into Hong Kong from 87 countries and regions worldwide (Oceana 2010). Spain (2,646 t), Singapore (1,201 t), Taiwan (991 t), Indonesia (681 t), and the United Arab Emirates (511 t) were the world's top exporters of shark fins (both frozen and dried; calculated using Hong Kong Census Trade Statistics) (Oceana 2010). Costa Rica ranked as 6th, with 327 exported tonnes of shark fins to Hong Kong. However, compared to numbers in the early 2000s, Costa Rica has seen a dramatic reduction in shark fin production and catch by the national fleet and artisanal longline fisheries (SINAC 2012). Likewise, global data from FAO's Fishery Commodities and Trade Database also reflects a recent decrease in shark fin exports since 2007; however, the export of all shark products has substantially increased since the early 1990s and appears to be continuing on that trend (Figure 38).

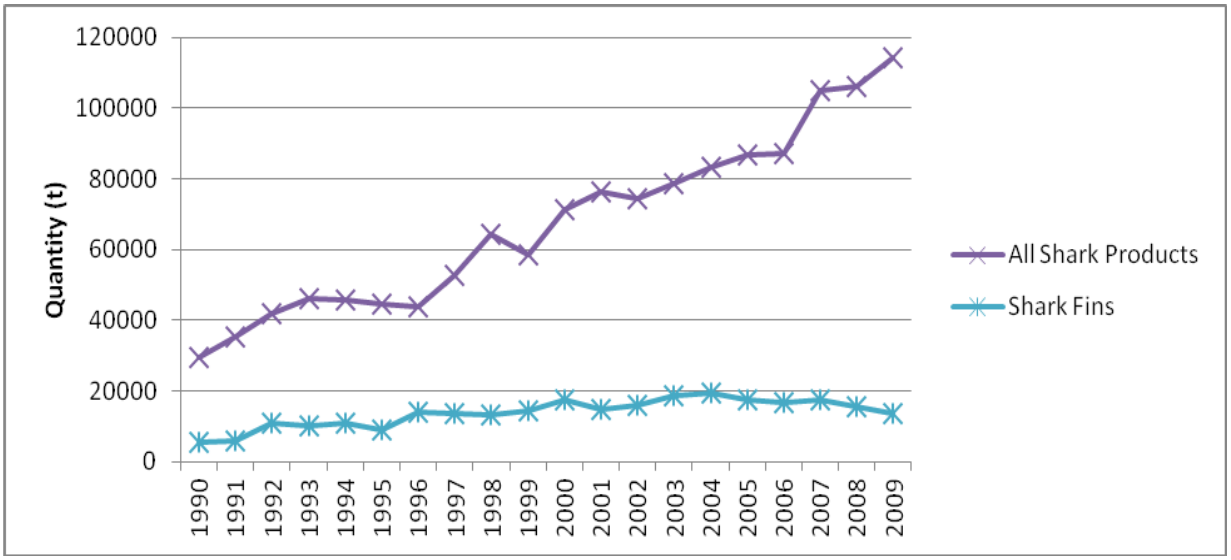

Figure 38. Global exports of shark products from 1990-2009, as reported in the FAO Fishery Commodities and Trade Database. Shark Fins include: shark fins dried, unsalted, salted, in brine but not dried or smoked, frozen, prepared or preserved. All Shark Products include: all shark fins (above); shark fillets, frozen; shark fillets, fresh or chilled; shark oil; shark liver oil; sharks nei, fresh or chilled; sharks nei frozen; sharks, rays, chimaeras nei, frozen; sharks, rays, etc., dried, salted or in brine; sharks, rays, chimaeras, skates, nei fillets frozen; sharks, rays, skates, fresh or chilled, nei ("nei" = not elsewhere included).

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. Instead, Clarke et al. (2006b) 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 the great hammerhead shark, along with scalloped and smooth hammerheads, is one of the most popularly traded species in the Asian fin market. Because of their large fins with a high fin needle content (a gelatinous product used to make shark fin soup), *S. mokarran* fetch a high commercial price in the market, around $135/kg for the average, wholesale, unprocessed fin, the most for any of the hammerhead fins (Abercrombie et al. 2005). Great hammerhead sharks comprise approximately 1.5% of the total fins traded in Hong Kong, which translates to an annual estimate of 375,000 individuals (95% CI: 130,000 – 1.1 million) (Clarke et al. 2006a, 2006b).

Clarke et al. (2006b) also used the shark fin trade data to estimate the total number of sharks traded worldwide. According to the study, 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 tonnes/year (range: 1.21 - 2.29 million tonnes/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 tonnes /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. By reconstructing catches of small-scale and industrial fishers using government reports and grey literature, Jacquet et al. (2008) estimated Ecuador mainland shark landings to be 6,868 t (average) per year from 1979-2004, with small-scale fisheries representing 93% of the total landings. For the period of 1991-2004, the reconstructed estimates were 3.6 times greater than what was reported to the FAO (Jacquet et al. 2008). These studies indicate that the FAO database, the only source for current international catch statistics, may be drastically under-representing global shark catches.

Disease or Predation

The ESA requires an evaluation of disease and predation factors as they affect great hammerhead sharks. No information has been found to indicate that disease is a factor in great hammerhead shark abundance. These sharks likely carry a range of parasites, such as external copepods (*Alebion carchariae*, *A. elegans*, *Nesippus crypturus*, *N. orientalis*, *Eudactylina pollex*, *Kroyerina gemursa*, and *Nemesis atlantic)*(Bester, n.d.); however, no data exist to suggest these parasites are affecting *S. mokarran* abundance.

Hammerhead sharks may also accumulate brevotoxins, heavy metals, and polychlorinated biphenyls in their liver, gill, and muscle tissues; however, the lethal concentration limit of these toxins and metals is currently unknown (Lyle 1984; Storelli et al. 2003; Flewelling et al. 2010). It is hypothesized that these apex predators can handle higher body burdens of these anthropogenic toxins due to the large size of their livers which "provides a greater ability to eliminate organic toxicants than in other fishes" (Storelli et al. 2003) or may even be able to limit their exposure by sensing and avoiding areas of high toxins (like during *K. brevis* red tide blooms) (Flewelling et al. 2010). Currently, the impact (and prevalence) of toxin and metal bioaccumulation in great hammerhead shark populations is unknown.

Predation is also not thought to be a factor influencing great hammerhead abundance numbers. The most significant predator on great hammerhead sharks is likely humans; however, larger sharks, including adult *S. mokarran*, are known to prey upon injured or smaller great hammerheads. However, the extent of predation of juveniles in nursery areas is currently unknown. In addition, because great hammerhead sharks are apex predators and opportunistic feeders, with a diet composed of a wide variety of items, including teleosts, cephalopods, crustaceans, and rays (Compagno 1984; Bester, n.d.), it is unlikely that they are threatened by competition for food sources. Although there may be some prey species that have experienced population declines, no information exists to indicate that depressed populations of these prey species are negatively affecting the great hammerhead shark abundance.

Evaluation of the Inadequacy of Existing Regulatory Mechanisms

The ESA requires an evaluation of existing regulatory mechanisms to determine whether they may be inadequate to address threats to the global great hammerhead population. Existing regulatory mechanisms may include Federal, state, and international regulations. Below is a description and evaluation of current domestic and international management measures that affect the great hammerhead shark.

Domestic Authorities

The U.S. fisheries are managed under the authority of the Magnuson-Stevens Act, 16 U.S.C. 1801 *et seq.* 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), 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 (16 U.S.C. 951 *et seq*.) and potentially the U.S.-Canada Albacore Treaty.

Atlantic Tunas Convention Act

The Atlantic Tunas Convention Act of 1975 (ATCA) authorizes the Secretary of Commerce to administer and enforce all provisions of the International Convention for the Conservation of Atlantic Tunas (ICCAT). Pursuant to this goal, the Secretary cooperates with the duly authorized officials of the government of any party to the Convention as well as any other Federal department or agency or any State. Under ATCA, the Secretary shall promulgate such regulations as may be necessary and appropriate to carry out ICCAT recommendations. However, regulations promulgated under ATCA are, to the extent practicable, to be consistent with FMPs prepared and implemented under the Magnuson-Stevens Act.

The authority to issue regulations to implement the recommendations from ICCAT has been delegated from the Secretary to the Assistant Administrator for Fisheries, NOAA. On August 29, 2011, NMFS finalized the implementation of ICCAT recommendation 10-08. This regulation prohibits the taking of great, smooth, and scalloped hammerhead sharks and affects the U.S. commercial HMS PLL fishery and recreational fisheries for tunas, swordfish, and billfish in the Atlantic Ocean, including the Caribbean Sea and Gulf of Mexico (76 FR 53652; August 29, 2011).

Tuna Conventions Act

The Tuna Conventions Act of 1950 provides limited Federal authority to regulate activities of U.S. fishing vessels in the Eastern Pacific Ocean. Under this authority, NMFS promulgates regulations to implement recommendations of the IATTC that have been approved by the U.S. Department of State. The FMP for U.S. West Coast fisheries for HMS provides a mechanism that can be used to implement or supplement recommendations of the IATTC or other international fishery management bodies, particularly for U.S. fisheries based on the West Coast.

Magnuson-Stevens Fishery Conservation and Management Act

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.

Management of U.S. Pacific Fisheries for HMS:
Within the U.S., HMS fishery management in the Pacific is the responsibility of adjacent states as well as three regional fishery management councils which were established by the Magnuson-Stevens Act: the Western Pacific Fishery Management Council (WPFMC), North Pacific Fishery Management Council (NPFMC) and Pacific Fishery Management Council (PFMC). The WPFMC manages HMS fisheries pursuant to the Fishery Ecosystem Plan (FEP) for Pacific Pelagic Fisheries of the Western Pacific Region (Pelagics FEP; serves as an FMP). 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 Pelagics FMP) 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 NPFMC does not manage HMS, except that sharks, including some migratory species, are included in the Gulf of Alaska Groundfish FMP as well as the Bering Sea and Aleutian Islands Groundfish FMP. The PFMC has jurisdiction over the EEZ off Washington, Oregon and California, and manages HMS in this region. 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. Then, in 2004, the FMP for U.S. West Coast Fisheries for HMS was developed by the PFMC in response to the need to coordinate state, Federal, and international management. NMFS, on behalf of the U.S. Secretary of Commerce, partially approved the FMP on February 4, 2004. The majority of the FMP implementing regulations became effective on April 7, 2004. Reporting and recordkeeping provisions became effective on February 10, 2005. Since its implementation, this FMP has been amended twice, once in 2007, and again 2011. Species that are managed under FMPs or FEPs are called management unit species and typically include those species that are caught in quantities sufficient to warrant management or specific monitoring by NMFS and the Council. In the FMPs and FEPs for U.S. fisheries in the Pacific, great hammerhead sharks are not considered to be a management unit species and thus are not directly managed.

Management of U.S. Atlantic HMS 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 fishermen, as a condition of their permit, the fishermen 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). This interstate shark FMP became effective in 2010.

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 (71 FR 58058, NMFS 2006). Since 2006, this FMP has been amended six times, with three more amendments currently under development. Amendment 2, finalized in June 2008, required 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). Amendment 5a, which was finalized in July 2013 (78 FR 40318; July 3, 2013) is especially relevant as it implements conservation and management measures to address the recent NMFS "overfished" and "overfishing" status determination of the scalloped hammerhead stock (76 FR 23794; April 28, 2011). These measures include separating the commercial hammerhead quotas from the large coastal shark (LCS) complex quotas and linking the Atlantic hammerhead shark quota to the Atlantic aggregated LCS quotas, and the Gulf of Mexico hammerhead shark quota to the Gulf of Mexico aggregated LCS quotas. In other words, if either the aggregated LCS or hammerhead quota is reached, then both the aggregated LCS and hammerhead management groups will close. These quota linkages were implemented as an additional conservation benefit for the hammerhead shark complex due to the concern of hammerhead bycatch and additional mortality from fishermen targeting other sharks within the LCS complex. In addition, the separation of the hammerhead species for quota monitoring purposes from other sharks within the LCS management unit will allow NMFS to better manage the specific utilization of the hammerhead complex. For the recreational fisheries, NMFS has increased the minimum size limit for hammerheads from 54 inches FL (4.5 feet; 137 cm) to 78 inches FL (6.5 feet; 198 cm) to ensure that primarily mature individuals are retained.

Below are additional applicable federal commercial and recreational fishing regulations for U.S. Atlantic HMS fishermen:

Commercial Shark Fishing Regulations:
Any fisherman who fishes for, retains, possesses, sells, or intends to sell, great hammerhead sharks needs a Federal Atlantic Directed or Incidental shark limited access permit. These permits are administered under a limited access program and NMFS is no longer issuing new shark permits. A directed shark permit allows fishermen to retain 36 LCS sharks, which includes great hammerhead sharks, per vessel per trip. An incidental permit allows fishermen to retain up

to 3 LCS sharks, which includes great hammerhead sharks, per vessel per trip. Authorized fishing gear types for great hammerhead sharks include gillnet, rod and reel, handline, bottom longline, or bandit gear. There are no restrictions on the types of hooks that may be used to catch hammerhead sharks, and there is no commercial minimum size limit. All fins must remain naturally attached.

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. As mentioned previously, the hammerhead shark quota is split 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 fishermen with a federal commercial shark permit. In addition, fishermen may be selected to carry an observer onboard, and some fishermen are subject to vessel monitoring systems depending on the gear used and where they fish. Starting in 2011, fishermen using pelagic longline gear and dealers buying from vessels that have pelagic longline gear onboard have been prohibited from retaining onboard, transshipping, landing, storing, selling, or offering for sale any part or whole carcass of hammerhead sharks of the family *Sphyrnidae* (except for the *Sphyrna tiburo*).

Recreational Shark Fishing Regulations:
Great hammerhead sharks may be retained recreationally as long as tunas, swordfish, or billfish are also not retained. Authorized fishing gear includes 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. Great hammerheads that are kept must have a minimum size of 78 inches (6.5 feet; 198 cm) fork length. Sharks that are under the minimum size must be released. One great hammerhead 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. Recreational retention of hammerhead sharks is prohibited on recreational trips that also possess a tuna, swordfish or billfish (76 FR 53652; August 29, 2011).

U.S. Shark Conservation Act
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 Magnuson-Stevens Fishery Conservation and Management Act 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.

State Fishery Management Regulations

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 fishermen along the Atlantic coast and in the Gulf of Mexico and Caribbean, fishermen 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 (Table 10). States in the Gulf of Mexico and territories in the Caribbean Sea have also implemented regulations that are mostly the same as the Federal regulations for sharks (although these do not reflect the recent Amendment 5a implementation regulations for hammerhead sharks). However, the state of Florida, which has the largest marine recreational fisheries in the United States and the greatest number of HMS angling permits, recently went even further than Federal regulations to protect the great hammerhead shark by prohibiting the harvest, possession, landing, purchasing, selling, or exchanging of any or any part of a hammerhead shark (including scalloped, smooth, and great hammerheads) caught in Florida's waters by Florida fishermen (Florida Fish and Wildlife Conservation Commission, effective January 1, 2012). The Florida regulations explicitly allow for federal fishermen fishing in federal waters to land and sell hammerhead sharks to permitted dealers in Florida ports. 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 (Table 10).

Table 10. Current and relevant shark regulations by U.S. state and territory. (Source: NMFS 2011a; NMFS 2013a)

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 (ASMFC 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.

<table>
<tr><td>Rhode Island</td><td rowspan="7">Fishermen must abide by the Interstate FMP for Atlantic Coastal Sharks adopted by the ASMFC (ASMFC 2008). This FMP requires that all sharks harvested by commercial or recreational fishermen within state waters have the tail and fins attached naturally to the carcass. Commercial fishermen may only land a maximum of 36 LCS (which includes hammerhead sharks). ASFMC opens and closes the hammerhead fishery when NOAA Fisheries opens and closes the corresponding federal fisheries. Recreational fishermen may only catch sharks with a fork length of at least 78 inches (6.5 feet; 198 cm) 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 (including great hammerheads) per calendar day. Recreational fishing vessels are allowed a maximum harvest of one shark from the federal recreationally permitted species (including great hammerheads), per trip, regardless of the number of people on board the vessel.

Fishermen are prohibited from possessing great hammerheads in the state waters of Virginia, Maryland, Delaware and New Jersey from May 15 through July 15—regardless of where the shark was caught. Fishermen 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.

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.</td></tr>
<tr><td>Connecticut</td></tr>
<tr><td>New York</td></tr>
<tr><td>New Jersey</td></tr>
<tr><td>Delaware</td></tr>
<tr><td>Maryland</td></tr>
<tr><td>Virginia</td></tr>
<tr><td>North Carolina</td><td>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.</td></tr>
<tr><td>South Carolina</td><td>Adopted the ASMFC Coastal Shark Interstate FMP. Additionally, defers to federal regulations. Gillnets may not be used in the shark fishery in state waters.</td></tr>
</table>

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. Additionally, no person shall harvest, possess, land, purchase, sell, or exchange any or any part of the great hammerhead shark. However, the prohibitions on harvest shall not apply to lawful harvest in federal waters when such harvest is transported directly through state waters with gear appropriately stowed.
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 fishermen 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) with a minimum size of 64” TL (163 cm) for great hammerheads.

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.
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.
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.
Hawaii	Unlawful to possess, sell, offer for sale, trade, or distribute shark fins. Includes exemptions for education and research.
Illinois	Bans the possession, sale, or distribution of detached shark fins.
U.S. 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.
American Samoa	Prohibits the possession, delivery, or transportation of any shark species or shark body party. Includes an exemption for research.
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 Adequacy of Domestic Regulatory Mechanisms

Commercial fisheries:

Many recent U.S. regulations have been implemented that help protect hammerhead sharks caught in U.S. fisheries. As mentioned previously, on August 29, 2011, NMFS finalized the implementation of ICCAT recommendation 10-08, which prohibits the retention, transshipping, landing, sorting, or selling of scalloped, smooth, and great hammerhead sharks by the U.S. commercial HMS PLL fishery and recreational fisheries for tunas, swordfish, and billfish in the

Atlantic Ocean, including the Caribbean Sea and Gulf of Mexico. (76 FR 53652; August 29, 2011). NMFS estimated that this prohibition would result in an additional 100 hammerhead sharks that are released alive annually (76 FR 53652; August 29, 2011). Amendment 5a implementation will also help prevent the direct and indirect overutilization of the species by specifically monitoring hammerhead catches in the other fisheries and closing the management group when the quota of either the hammerhead or aggregated LCS management group is reached. In this way, the additional mortality of hammerheads as bycatch on fishing gear for other LCS will be reduced.

In addition, NMFS recently published Amendment 4 to the Consolidated HMS FMP which 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), NMFS 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 the local U.S. Caribbean market; collects HMS landings data through existing territorial government programs; authorizes specific gears; is restricted to vessels less than or equal to 45 feet (13.7 m) length overall; and may not be held in combination with any other Atlantic HMS vessel permits. However, at this time, fishers 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 great hammerhead sharks, but only within the U.S. EEZ around Puerto Rico and the U.S. Virgin Islands and from fishers under U.S. jurisdiction.

Recreational Fisheries:
Currently, the state of Florida has the largest marine recreational fisheries in the United States. It also has the greatest number of HMS angling permits, with 4,035 permitted individuals in 2011, and the second highest number of HMS Charter/Headboat permits (639) (NMFS 2011a). From 2008-2009, NMFS conducted a telephone survey of HMS Angling permit and Atlantic Tunas General permit holders to estimate fishing effort and total catches for private angler recreational HMS trips in Florida. Results indicated that most recreationally caught sharks were not caught on directed trips but rather occurred as bycatch during non-HMS targeted trips and trips targeting other HMS groups (MRIP 2010). In addition, analysis of catch dispositions revealed that more than 99% of shark catches were released (MRIP 2010). With retention and at-vessel mortality rates of hammerhead sharks by recreational vessels believed to be low (NMFS 76 FR 53653), these data indicate that recreational fisheries may not be a significant threat to great hammerhead sharks in the northwest Atlantic and Gulf of Mexico. Furthermore, Florida recently passed legislation prohibiting the landing of hammerhead sharks in Florida waters, providing substantial

conservation benefits for great hammerhead sharks in an area where they are commonly found in the western Atlantic.

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 Atlantic shark fins significantly dropped (Figure 39), which was expected. In 2011, with the passage of the U.S. Shark Conservation Act and closure of loopholes from the previous Act, exports of dried Atlantic shark fins dropped again, by 58%, to 15 mt, the second lowest export amount since 2001 (Figure 39). 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.

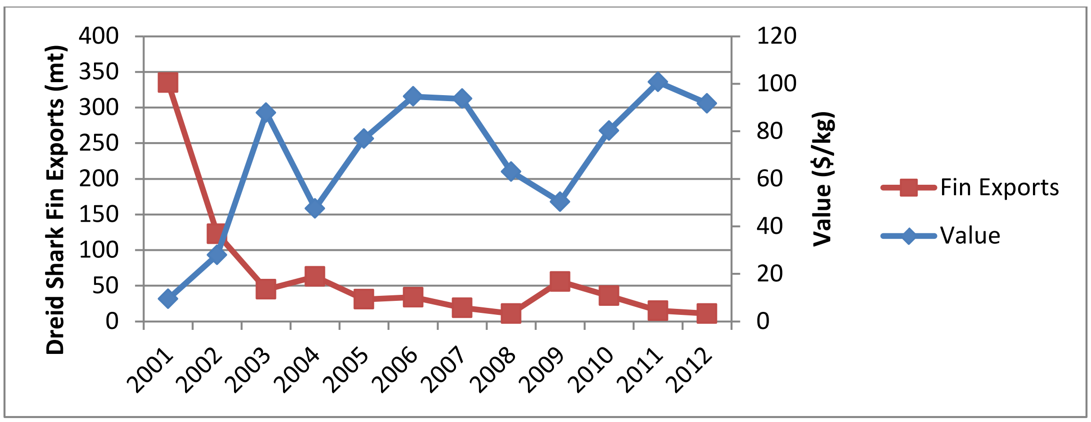

Figure 39. Amount and value of U.S. Atlantic shark fin exports from 2001 to 2011. (Source: NMFS 2012a, NMFS 2013a)

Similarly, many U.S. states, especially on the west coast, and U.S. Flag Pacific Islands 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 (54% decrease, from 374 to 171 tonnes) as Hawaii could no longer be used as a fin trading center for the international fisheries operating and finning in the Central Pacific (Figure 40) (Clarke et al. 2007).

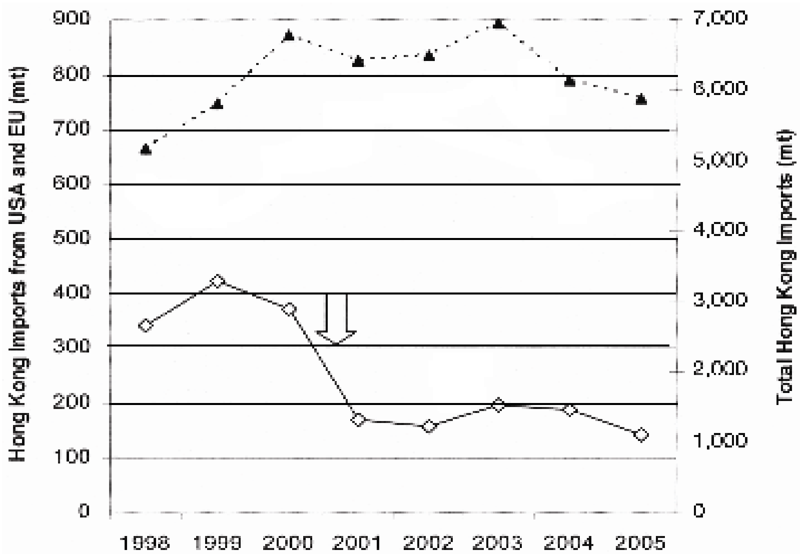

Figure 40. Annual imports of shark fin to Hong Kong from the U.S. (◊) and total Hong Kong imports (▲). The clear arrow indicates the implementation of finning regulations in the state of Hawaii. (Source: Clarke et al. 2007)

International Authorities

Finning bans have also been implemented by a number of countries including the European Union (EU), as well as by nine RFMOs (Tables 11 and 12). These finning bans range from requiring fins remain attached to the body to allowing fishermen 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. A number of countries have also enacted complete shark fishing bans (Table 13), with the Bahamas, Marshall Islands, Honduras, Sabah (Malaysia), and Tokelau (an island territory of New Zealand) adding to the list in 2011, and the Cook Islands in 2012. Shark sanctuaries 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, and French Polynesia.

In addition, all hammerhead sharks (*Sphyrnidae*) are listed on Annex I, Highly Migratory Species, of the United Nations Convention on the Law of the Sea, in recognition of the importance of collaborative management for these sharks. Scalloped, smooth (*Sphyrna zygaena*), and great hammerheads are also listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES is an international agreement between governments that regulates international trade in wild animals and plants. It encourages a proactive approach and the species covered by CITES are listed in appendices according to the degree of endangerment and the level of protection provided. Appendix I includes species threatened with extinction; trade in specimens of these species is permitted only in exceptional circumstances. Appendix II includes species not necessarily threatened with extinction, but for which trade must be controlled to avoid exploitation rates incompatible with species survival. Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade. In March 2013, at the CITES Conference of the Parties meeting in Bangkok, member nations, referred to as "Parties," voted in support of listing these three species of hammerhead sharks in CITES Appendix II – an action that means increased protection, but still allows legal and sustainable trade. This CITES listing will go into effect on September 14, 2014. At that time, export of their fins will require permits that ensure the products were legally acquired and that the Scientific Authority of the State of export has advised that such export will not be detrimental to the survival of that species. Four Party members have already entered reservations (Canada, Guyana, Japan, and Yemen), which means that those countries will be formally treated as non-Party members with respect to trade in the hammerhead species.

Also of relevance is the FAO International Plan of Action for the Conservation and Management of Sharks, which recommends that RFMOs carry out regular shark population assessments and that member States cooperate on joint and regional shark management plans. In November 2010, ICCAT adopted recommendation 10-08 prohibiting the retention, transshipment, landing, storing, or offering for sale any part or carcass of hammerhead sharks of the family *Sphyrnidae* (except for bonnethead shark). Many of the other RFMOS have passed resolutions for the purpose of collecting better data on catches of shark species, including the great hammerhead shark. In 2005, the IATTC passed Resolution C-05-03, which calls for a more comprehensive data collection system, with each CPC annually reporting data for catches, effort by gear type, landing and trade of sharks by species, and available historical data. The IOTC requires CPCs to annually report shark catch data and provide statistics by species for a select number of sharks, including hammerhead sharks (Resolutions 05/05, 11/04, 08/04, 10/03, 10/02). In December 2010, WCPFC adopted a Conservation and Management Measure for sharks (CMM 2010-07), which requires Commission Members, Cooperating non-Members, and participating Territories (CCMs) to include key shark species (including great hammerhead shark) 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 hammerhead sharks from longline, troll, purse seine and pole and line (in weight) fisheries. The IATTC, IOTC, and WCPFC also encourage the live release of sharks, especially juveniles or pregnant females, caught incidentally (and not used for food or other purposes) in fisheries for tunas and tuna-like species.

Table 11. International regulations that prohibit shark finning by implementing country. (Source: HSI 2014)

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. In May 2012, the state of New South Wales (NSW) listed *S. mokarran* as a vulnerable species, making it illegal to catch and keep, buy, sell, possess or harm the great hammerhead without a specific permit, license or other appropriate approval.
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. Allows artisanal fishers to target hammerheads with longlines within 10 nm from the shore and reduces the competition with larger commercial longline vessels, which are subsequently restricted to waters 20 nm or more from the shore.
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		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.

Table 12. Regional Fisheries Management Organization (RFMO) shark regulations. (Source: HSI 2014)

RFMO	**Date**	**Shark Regulations**
International Commission for the Conservation of Atlantic Tunas (ICCAT)	2011	Developed recommendation 10-08 which specifically prohibits the retention, transshipping, landing, sorting, or selling of hammerhead sharks, other than bonnethead sharks, caught in association with ICCAT fisheries. However, there is an exception for developing coastal nations for local consumption as long as hammerheads do not enter into international trade.
General Fisheries Commission of the Mediterranean (GFCM)	2012	Hammerheads cannot be retained on board, transhipped, landed, transferred, stored, sold or displayed or offered for sale.
Commission for the Conservation of Antarctic Marine living Resources (CCAMLR)	2006	Directed fishing on shark species in the Convention Area, for purposes other than scientific research, is prohibited. Any bycatch of shark, especially juveniles and gravid females, taken accidentally in other fisheries, shall, as far as possible, be released alive.
Inter-American Tropical Tuna Commission (IATTC)	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.
Indian Ocean Tuna Commission (IOTC)	2005	
North Atlantic Fisheries Organization (NAFO)	2005	
Southeast Atlantic Fisheries Commission (SEAFO)	2006	
Western and Central Pacific Fisheries Commission (WCPFC)	2008	
North East Atlantic Fisheries Commission (NEAFC)	2007	

Table 13. International regulations that prohibit shark fishing by implementing country. (Source: HSI 2014)

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.
Colombia	1995	Shark fishing is prohibited in the Malpelo Wildlife Sanctuary
Cook Islands	2012	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	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).
Honduras	2011	Moratorium on commercial shark fishing in Honduran waters, effectively creating a shark sanctuary which encompasses all 240,000 square kilometers (92,665 square miles) of the country's EEZ on its Pacific and Caribbean coasts.
Israel	1980	Banned shark fishing.
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.
Mauritania	2003	Created a 6000 km^2 coastal sanctuary for sharks and rays (Banc d'Arguin National Park - PNBA). Targeted shark fishing is prohibited (however *S. lewini* may be taken as bycatch in nets).
Micronesia	2012	In the process of developing a regional sanctuary where shark fishing is prohibited and authorizing the development of a regional ban on the possession, sale, and trade of shark fins. 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.

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.
Raja Ampat, Indonesia	2010	Banned shark fishing.
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, including the great hammerhead shark, 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.

Countries that prohibit the sale or trade of shark fins or products:

- 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

Analysis of Adequacy of Existing International Regulatory Mechanisms

Given the lack of data reporting on hammerhead catches, it is difficult to measure the adequacy of current regulatory mechanisms as they relate to the global population of great hammerhead sharks. *S. mokarran* is a highly migratory species found worldwide and thus requires protections in every ocean basin.

In Atlantic waters, ICCAT has afforded the species protection from fishing by ICCAT vessels by adopting Recommendation 10–08 prohibiting the retention of hammerheads caught in association with ICCAT-managed fisheries. Each Contracting Party to ICCAT is responsible for implementing this recommendation. ICCAT Recommendation 10–08 also includes a special exception for developing coastal States, allowing them to retain hammerhead sharks for local consumption provided that they report their catch data to ICCAT, endeavor not to increase catches of hammerhead sharks, and take the necessary measures to ensure that no hammerhead parts enter international trade. As this exception allows hammerheads to be retained under certain circumstances, it may provide a lesser degree of protection for hammerhead sharks in the developing coastal States that choose to take advantage of the exception. However, according to ICCAT data (Figure 3), vessels under the U.S. flag accounted for 86% of the great hammerhead catch from 1992-2010.

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. 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). Unfortunately, enforcement of these regulations is weak, with many reports of illegal and unregulated 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.

On the other side of the Atlantic, 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. 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. 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. The EU officially adopted this strict finning ban in July 2013.

In the 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).

In the Indian and Pacific Oceans, the RFMOs which regulate these waters prohibit fins onboard that weigh more than 5% of the weight of sharks. These regulations are aimed at curbing the practice of shark finning, but do not prohibit the fishing of sharks. In addition, these regulations may not even be effective in stopping finning of great hammerheads as a recent study found the great hammerhead shark to have an average wet-fin-to-round-mass ratio of only 1.95% (±0.25; n = 11) (Biery and Pauly 2012). This ratio suggests that fishing vessels operating in these RFMO convention areas would be able to land more great hammerhead shark fins than bodies and still pass inspection.

Although, there are no great hammerhead-specific RFMO management measures in place for the Pacific or Indian Ocean populations, many of these RFMOs have developed additional shark conservation and management measures that aim to further reduce shark waste and promote the live release of all shark species, yet it is unclear how effective these measures have been. For example, in a review of the existing WCPFC shark conservation and management measures (CMM), 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 outcomefocused objectives of the CMM requirements, which increases the difficulty in verifying compliance and creates difficulties for data monitoring and review. The author 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 contracted (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 (objective # 1) in both purse seine and longline fisheries do not appear to be decreasing. In the purse seine fisheries, Clarke (2013) estimated that finning rates are lower than before the CMM effective date, but are currently greater than 20% (and are not declining), and in longline fisheries, finning rates are greater than 30%. In terms of great hammerhead sharks, the observer data show that when incidentally caught, this species is very likely to be finned (83% of *S. mokarran* discards were finned, one of the highest shark finning percentages observed; 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 great hammerheads, have been found to suffer high mortality rates when caught in purse seine nets and on longline gear. Additionally, the poor observer coverage of the longline fisheries and the variable implementation rates by CCMs of the data provision requirements (estimated at 50% in 2012) impedes the success of achieving objective #3 and creates difficulties for sustainably managing shark stocks. Thus, the expected benefit from implementation of these CMM measures appears to be negligible (Clarke 2013). Going forward, Clarke (2013) recommends focusing on: “a) improving the Commission’s ability to confirm compliance with existing measures; b) maximizing the effectiveness of the existing measures; and c) creating a framework within which the effectiveness of all measures (existing or proposed [such as mitigation measures]) can be judged on their ability to control fishing mortality for overfished shark stocks.”

In Australia, the states and territories have implemented various shark regulations that are likely to protect the species when inside Australia’s EEZ. For example, finning bans exist in all waters of Australia, although the strictness of the ban (i.e., based on fin ratio or requires fins attached) varies by state. In May 2012, the state of New South Wales (NSW) listed *S. mokarran* as a vulnerable species, making it illegal to catch and keep, buy, sell, possess or harm the great hammerhead without a specific permit, license or other appropriate approval. In Australia’s northern shark fisheries (JANSF and WANCSF), hammerhead catches saw a significant decline from their peak in 2004/05 following the implementation of stricter management regulations in 2005 (including area closures and longline and gillnet restrictions in WANCSF). In 2008, the JANSF’s export approval was revoked over concerns about the ecological sustainability of the fishery. In 2009, the WANCSF export approval expired. As such, no product from either fishery can currently be legally exported. As the northern shark fisheries rely upon shark fin exports for the majority of their income, these export losses have effectively shut down the fisheries, and, consequently, from 2009-2011 there was no reported activity in the northern shark fisheries (McAuley and Rowland 2012).

Other shark fishing countries in the Indian and Pacific Oceans include Indonesia, India, Taiwan, and Costa Rica. Indonesia, which is the top shark fishing nation in the world, currently has no 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), nor are their vessels likely to have insulated fish holds or refrigeration units (Tull 2009), 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 illegal, unregulated, and unreported (IUU) fishing). 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. Following the noticeable decline in shark species, Indonesian fishermen targeting shark fins began moving south in the late 1990s, from the South China Sea and Gulf of Thailand to waters of northern Australia (Field et al. 2009). After 2001, Australian Customs patrol reported a large increase in the number of IUU vessel sightings (Figure 41), mainly from Indonesia, with a peak occurring in late 2005 and early 2006.

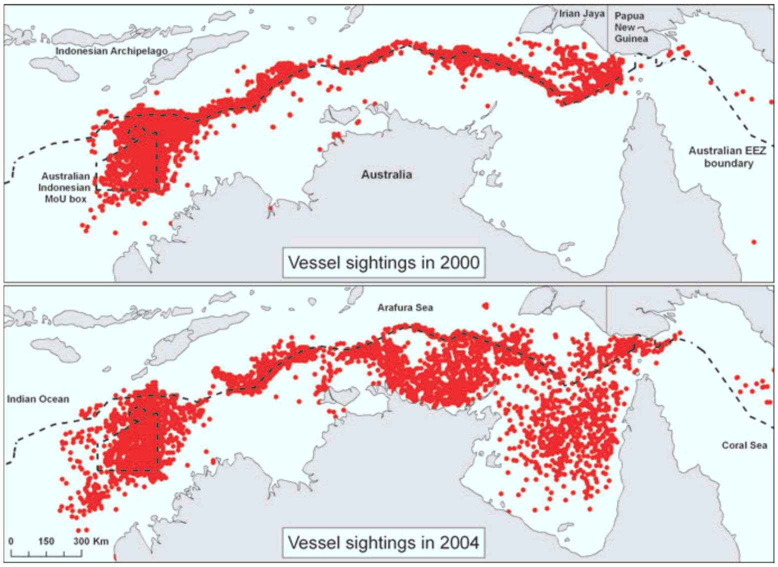

Figure 41. Coastwatch sightings of IUU foreign fishing vessels bordering and within the Australian EEZ in 2000 and 2004. (Source: Field et al. 2009)

Since 2006, there has been a decline in IUU fishing in Australian waters, thought to be due to exhaustion of stocks in easily accessible regions near the Australian EEZ, as well as international government agreements and domestic policies (Field et al. 2009). Between July 2008 and June 2012, only 60 Indonesian vessels targeting sharks were apprehended (Lack and Sant 2012). Because illegal shark fishing is often unreported, there is a lack of information available on the species composition of the IUU shark catch. However, using a small collection of shark fins that were confiscated from IUU fishers in northern Australian waters, the Commonwealth Scientific and Industrial Research Organisation identified that 4.8% of the fins (the 6th largest source) belonged to *S. mokarran* (Lack and Sant 2008).

Reports of IUU fishing are also prevalent in the waters off West Africa and account for around 37% of the region's catch, the highest regional estimate of illegal fishing worldwide (Agnew et al. 2009; EJF 2012). From January 2010 to July 2012, the UK-based non-governmental organization Environmental Justice Foundation (EJF) conducted a surveillance project in southern Sierra Leone to determine the extent of IUU fishing in waters off West Africa (EJF 2012). The EJF staff received 252 reports of illegal fishing by industrial vessels in inshore areas, 90 percent of which were bottom trawlers, with many vessels exporting their catches to Europe and East Asia (EJF 2012). The EJF (2012) surveillance also found these pirate industrial fishing vessels operating inside exclusion zones, using prohibited fishing gear, refusing to stop for patrols, attacking local fishers and destroying their gear, and fleeing to neighboring countries to avoid sanctions. Due to a lack of resources, many West African countries are unable to provide effective or, for that matter, any enforcement, with some countries even lacking basic monitoring systems. These deficiencies further increase the countries' susceptibility to IUU fishing, resulting in heavy unregulated fishing pressure and likely overexploitation of their fisheries.

In 2013, NMFS published a report to Congress that identified nations that engaged in IUU fishing, based on violations of international conservation and management measures during 2011 and/or 2012, and identified three Colombian, one Ecuadorian, one Panamanian, and two Venezuelan-flagged vessels that violated IATTC resolutions and illegally finned sharks, discarding the carcasses at sea (NMFS 2013b). The following are additional documented cases of IUU fishing as compiled by Paul (2009). In 2008, off the coast of Africa, a Namibian-flagged fishing vessel was found fishing illegally in Mozambican waters, with 43 mt of sharks and 4 mt of shark fins onboard. In 2009, a Taiwanese-flagged fishing trawler was found operating illegally in the South Africa EEZ with 1.6 mt of shark fins onboard without the corresponding carcasses. Also in 2009, 250 trawlers were found to be poaching sharks in coastal areas in the Bay of Bengal with the purpose of smuggling the sharks to Myanmar and Bangkok by sea. There are also reports of traders exploiting shark populations in the Arabian Gulf due to the lack of United Arab Emirates enforcement of finning regulations. In the Western Pacific, in 2007, a Taiwanese-flagged tuna boat was seized in Palau for IUU fishing and had 94 shark bodies and 650 fins onboard. In 2008, a Chinese-flagged fishing vessel was arrested by the Federated States of Micronesia (FSM) National Police for fishing within the FSM's EEZ. Based on the number of fins found onboard, there should have been a corresponding 9,000 bodies, however only 1,776 finned shark bodies were counted.

In Somalia, it is estimated that around 700 foreign-owned vessels are operating in Somali waters without proper licenses, and participating in unregulated fishing for highly-valued species like sharks, tunas, and lobsters (HSTF 2006). A study that provided regional estimates of illegal fishing (using FAO fishing areas as regions) found the Western Central Pacific (Area 71) and Eastern Indian Ocean (Area 57) regions to have relatively high levels of illegal fishing (compared to the rest of the regions), with illegal and unreported catch constituting 34 and 32% of the region's catch, respectively (Agnew et al. 2009). The annual value of high seas IUU catches of sharks worldwide has been estimated at $192 million (HSTF 2006). Annual worldwide economic losses from all IUU fishing is estimated to be between $10 billion and $23 billion (NMFS 2013c).

In the U.S., reports of IUU fishing by Mexico, a top shark fishing nation accounting for nearly 4.1% of the global shark catch, has been ongoing for the past decade. Since the mid-1990s, the United States Coast Guard (USCG) has documented Matamoros Mexican vessels illegally fishing in the area surrounding South Padre Island, Texas (Brewster-Geisz and Eytcheson 2005). The Mexican IUU fishermen use gillnet and longline gear for shark and red snapper, which are believed to be more prevalent in the U.S. EEZ off Texas than in the Mexican EEZ near Matamoros. The sharks, the majority of which are blacktips and hammerheads, are finned and the fins sold. Based on data from 2000-2005, Brewster-Geisz and Eytcheson (2005) estimated that Mexican fishermen are illegally catching anywhere from 3 to 56% of the total U.S. commercial shark quota, and between 6 and 108% of the Gulf of Mexico regional commercial quota (with the percentage dependent upon the assumptions of the number of sharks per incursion and the average weight per shark). Updated data since 2005 show a decrease in the number of detected incursions (Brewster-Geisz et al. 2010); however, the extent of IUU fishing on the Gulf of Mexico *S. mokarran* population is unknown.

High levels of IUU fishing have also been reported off Central/South America and in the Western and Central Pacific Ocean (WildAid 2003; Lack and Sant 2008). In these areas, longlining and gillnetting are the most frequently cited methods used in illegal shark fishing, with hammerhead sharks a main target (Lack and Sant 2008). In Belém, Brazil, in May 2012, the Brazilian Institute of Environmental and Renewable Natural Resources (IBAMA) seized around 7.7 mt of illegally obtained dried shark fins intended for export to China (Nickel 2012). A few months later, IBAMA confiscated more than 5 mt of illegal shark fins in Rio Grande do Norte (Rocha de Medeiros 2012), suggesting current regulations and enforcement are not adequate to deter or prevent illegal shark finning. In fact, it is estimated that illegal fishing constitutes 32 percent of the Southwest Atlantic region's catch (based on estimates of illegal and unreported catch averaged over the years of 2000 – 2003; Agnew et al. 2009). In the ETP, there is evidence of illegal fishing by both local fishermen and industrial longliners within many of the marine protected areas (WildAid 2003; Hearn et al. 2010; Bessudo et al. 2011). In Ecuador, concern over illegal fishing around the Galapagos Islands prompted a 2004 ban on the exportation of fins but only resulted in the establishment of new illegal trade routes and continued exploitation of hammerhead sharks (CITES 2010). In 2007, a sting operation by the Ecuadorian Environmental Police and the Sea Shepherd Conservation Society resulted in a seizure of 19,018 shark fins that were being smuggled over the border on buses from Ecuador to Peru. The fins were believed to come from protected sharks in the Galapagos Islands (Paul 2009). More recently, in November 2011, Colombian environmental authorities reported a large shark massacre in the Malpelo wildlife sanctuary, an area where divers reported sightings of schools of more than 200 hammerhead sharks. The divers counted a total of 10 illegal Costa Rican trawler boats in the wildlife sanctuary and estimated that as many as 2,000 sharks may have been killed for their fins (Brodzinsky 2011). A few months later, thousands of pounds of shark products were confiscated in the Marshall Islands, with the Marshall Islands Marine Resource Authority fining a Japanese tuna transshipment vessel $125,000 for having sharks on board in a designated shark sanctuary (AFP 2012). In Palau, a Taiwanese vessel was spotted by Palau law enforcement officials fishing and finning sharks in its protected waters, and was fined $65,000 and banned from Palauan waters for a year (Turagabeci 2012). Unfortunately, like most of these Pacific Island countries, Palau is small, and patrolling its large oceanic territory is difficult without adequate resources (Bromhead et al. 2012). Currently, Palau has only one patrol boat to enforce fishing regulations in 604,000 km^2 of ocean waters (Turagabeci 2012).

Other Natural or Manmade Factors Affecting the Great Hammerhead Shark's Continued Existence

Many sharks are thought to be biologically vulnerable to overexploitation based on their life history parameters. The use of demographic analyses is a common and popular tool for assessing this vulnerability (Musick and Bonfil 2005). The main parameter estimated in the demographic analysis is the intrinsic rate of increase (r), or the measure of potential for growth rate in a population. A small value for r (<0.14) indicates that the shark has low productivity and thus may be slow to recover from overexploitation (based on FAO's productivity indices for exploited fish species). Cortés (unpublished) estimated r = 0.096 for *S. mokarran* with a generation time of 15.9 (see **Demography** section), whereas Hayes et al. (2008) calculated a higher value, with r = 0.14 (using NMFS LL-SE index); however, both estimates indicate a species with low productivity.

Contributing to the great hammerhead's biological vulnerability is the fact that these sharks are obligate ram ventilators and suffer very high at-vessel fishing mortality in bottom longline fisheries (Morgan and Burgess 2007; Morgan et al. 2009). From 1994-2005, NMFS observers calculated that out of 178 great hammerheads caught on commercial bottom longline vessels in the northwest Atlantic and Gulf of Mexico, 93.8% were dead when brought aboard. Size did not seem to be a factor influencing susceptibility as 100% of the young (0-80 cm FL; n=1), 93% of the juveniles (101-189 cm FL; n=71), and 94.3% of the adults (>190 cm FL; n=106) suffered at-vessel fishing mortality. Soak time of the longline had a positive effect on the likelihood of death whereas bottom water temperature had a negative effect (Morgan and Burgess 2007). Morgan et al. (2009) also documented over 90% at-vessel mortality rates for great hammerhead sharks for soak times ranging anywhere from <4 hours to over 24 hours, indicating that management measures which target soak times of bottom longlines may not be effective in reducing mortality of great hammerhead sharks caught on this type of fishing gear.

In a study that examined the physiological stress responses to being caught in fishing gear and post-release survival, great hammerhead sharks were once again found to be extremely vulnerable to capture stress and mortality (Gallagher et al. *in press*). The study specifically compared five shark species (blacktip, bull, lemon, great hammerhead, and tiger) and their responses to being caught on drum lines. Fight times on the hooks were recorded, blood samples taken, reflexes tested, and satellite tags were deployed on a select number of sharks. Results from the study showed that blood lactate levels (which were positively correlated with fight time) were significantly higher in great hammerhead sharks compared to the other species (Gallagher et al. *in press*). Previous studies have demonstrated a positive relationship between blood lactate levels and likelihood of post-release mortality, with lactate values of around 16-20 mmol/l associated with moribund sharks (Gallagher et al. *in press*). In great hammerhead sharks, the blood lactate values averaged 17.00 mmol/l (±2.78) after fight times of 17-131 minutes (Gallagher et al. *in press*). One tagged great hammerhead, which had a 24 minute fight time and lactate value of 19 mmol/l, was released alive but died after less than 10 minutes. Compared to the other shark species, the great hammerhead also had the lowest tag reporting rate, which the authors suggest could be an indication of low post-release survival (Gallagher et al. *in press*).

In addition to line gear, *Sphyrna* spp. also suffer high mortality in beach net programs (Reid and Krogh 1992; Dudley and Simpfendorfer 2006). In a study examining the protective shark mesh program in New South Wales, Australia, *Sphyrna* spp was the taxonomic group with the lowest net survival rates. The nets used in the protective mesh program were 150 m long and 6 m deep, with a mesh size of 50-60cm and soak time generally between 12 and 48 hours. Out of the 2,031 hammerheads caught by this program (from 1972-1990), only 1.7% were alive when cleared from the nets (Reid and Krogh 1992).

These biological characteristics of low productivity and high at-vessel mortality (on certain fishing gear) may increase the great hammerhead sharks' vulnerability to overexploitation and should be considered in context of other threats to the species.

ASSESSMENT OF EXTINCTION RISK FOR THE GREAT HAMMERHEAD SHARK (*SPHYRNA MOKARRAN*)

Conducted by the Extinction Risk Analysis (ERA) Team in December 2013

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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 Protected Resources office, 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 the great hammerhead shark now and in the foreseeable future.

DISTINCT POPULATION SEGMENT ANALYSIS

Consideration of the Species Question

In determining whether to list a species, the first issue is whether the petitioned subject is a valid species. The petitioned subject, the great hammerhead shark, or *Sphyrna mokarran* (Rüppell, 1837), is a valid species for listing. The taxonomic breakdown of *S. mokarran* is as follows:

Kingdom: Animalia
Phylum: Chordata
Class: Chondrichthyes
Subclass: Elasmobranchii
Order: Carcharhiniformes
Family: Sphyrnidae
Genus: *Sphyrna*
Species: *mokarran*

Criteria for Identification of Distinct Population Segments

After determining whether the petition identifies a species, the next issue is whether any petitioned populations qualify as DPSs within the species. The joint policy of the USFWS and NMFS provides guidelines for defining DPSs below the taxonomic level of species (61 FR 4722;

February 7, 1996). The policy identifies two elements to consider in a decision regarding whether a population qualifies as a DPS: discreteness and significance of the population segment to the species.

<u>Discreteness</u>

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

<u>Significance</u>

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

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

Furthermore, we were provided with additional guidance outlined below regarding the designation of DPSs:

As stated in the joint DPS policy, Congress expressed its expectation that the Services would exercise authority with regard to DPSs sparingly and only when the biological evidence indicates such action is warranted.

The best available information must be used in determining that a population meets the DPS Policy criteria. At the same time, the DPS Policy allows for flexibility in identifying DPSs. DPSs need not be identified at the lowest level of distinction possible, especially if this will not provide a conservation benefit to the species.

The ERA team will determine whether a conservation benefit might result if the species under review was divided into Distinct Population Segments (DPSs) by considering the following factors:

1) Are some populations of a species or subspecies more at risk, or not at risk?
2) Can we better preserve genetic integrity by listing as DPSs?
3) Would ESA protections be expedited by focusing on one or more DPSs instead of the entire species' range?
4) Will processing multiple actions associated with multiple DPSs take away from protection of this or other species?

5) If dividing an already-listed species with critical habitat in place into DPSs, can statutory requirements to designate critical habitat for each new DPS be met on a timely basis so that the species is not left without a critical habitat designation (i.e., can a new critical habitat designation be published simultaneously with the new DPS listing(s)?
6) Will mixing of individuals among DPSs make it difficult to quantify and monitor take if we list separate DPSs instead of one taxonomic species or subspecies?
7) Will the need to redo any section 4(d) regulations for newly listed DPSs of a species previously listed range-wide result in lapses in protections (i.e., can a new section 4(d) regulation be published simultaneously with the new DPS listing(s)?
8) Would recovery be expedited by focusing on DPSs instead of entire species' range or vice versa?
9) Would delisting a DPS of a listed species negatively impact the recovery of the rest of the species (presumably made up of several additional DPSs)?

Distinct Population Segment Analysis – ERA Team Results

Proposed DPSs by Petitioners
NMFS received two petitions to list the great hammerhead shark under the ESA. The first petition, submitted by WildEarth Guardians, requested NMFS to list the great hammerhead shark throughout its range or as DPSs if NMFS could identify any. The second petition, submitted by NRDC, specifically requested NMFS to designate the Northwest Atlantic population of great hammerhead shark as a DPS and list it as threatened under the ESA. Below is an evaluation of whether this subpopulation and any other population segments of great hammerheads meet the criteria of a DPS using the guidance provided above.

Evaluation of DPSs
First, we evaluated the best available biological evidence for information regarding the discreteness of great hammerhead population segments. We reviewed an abstract of a study that examined the genetic global population structure of *S. mokarran* (n = 312) with both nuclear and mitochondrial data (Testerman and Shivji 2013). According to the abstract, the preliminary results showed statistically significant genetic partitioning between oceanic basins (mtCR ϕ_{ST} = 0.8745, nuclear F_{ST} = 0.1113) and shallow but statistically significant genetic structure within oceanic basins, although there were some differences between the two marker types in fine scale patterns involving northern Indian Ocean samples (Testerman and Shivji 2013). However, since this was only an abstract and we were not given access to further details regarding the study, such as the range/locations of the samples, a comparison of the results between the nuclear and mitochondrial DNA, or further information regarding the resultant genetic structure and between and within oceanic basins, we concluded that not enough information was available from this abstract to make an informed decision regarding discreteness of great hammerhead populations based on genetic differences. We also reviewed a study by Naylor et al. (2012), which suggested that there are two distinct clusters of great hammerhead sharks: one comprised of great hammerheads from the Atlantic, and a second comprised of great hammerheads from Australia and Borneo. This analysis, however, was based on only 22 specimens from 4 locations, with

only 6 of the samples collected outside of the Atlantic (9 from Gulf of Mexico, 7 from Northwest Atlantic, 1 from Borneo, and 5 from northern Australia). Given the small sample size from a limited number of locations, we also did not find this to be substantial evidence of discreteness based on genetic differences.

We also reviewed the information provided in the petition on specific DPSs but found the information did not support a DPS designation based on the DPS policy criteria. The NRDC petition cited tagging studies by Kohler et al. (1998) as evidence of geographical discreteness. Although Kohler et al. (1998) tagged 103 great hammerhead sharks from 1962-1993, only 2 were recaptured. Given the very low recapture number, and the subsequent general lack of information regarding the behavior of the other tagged sharks, we did not find that this study showed or supported geographical discreteness of the Northwest Atlantic population of great hammerhead sharks.

The petition also cited genetic information about scalloped hammerheads as a surrogate for great hammerhead genetic distinction, claiming that since these species are morphologically and geographically congruous, then it is likely that they also have similar genetic structure. We did not find that this was applicable for a DPS analysis given the above guidance and the information in the DPS policy. Under the DPS Policy, the population segment of a species is considered discrete if it is markedly separate from other populations <u>of the same taxon</u> as a consequence of physical, physiological, ecological, or behavior factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation – but the presence of this genetic discontinuity refers to the population of the species in question, not as evidenced in a similar species. Therefore, we concluded that genetic differentiation in scalloped hammerheads could not be used to satisfy the discreteness criterion for great hammerhead sharks.

Finally, the petition mentions that the northwest Atlantic population is discrete because it primarily inhabits U.S. waters, which offers it greater regulatory protection compared to other populations. We did consider if populations could be delimited by international governmental boundaries due to differences in regulations that may influence the conservation status of the population segment. However, we referred back to our guidance that states that DPSs should be used sparingly, and need not be identified at the lowest level of distinction possible, especially if this will not provide a conservation benefit to the species. At this time, we do not have enough information to allow us to accurately delimit DPSs based on international governmental boundaries or evidence that this would provide an increased conservation benefit to the overall species. Basic fisheries data, behavioral and also abundance information are lacking for this species throughout its range. Without this information, we did not feel that we completely understood the impacts of different governmental regulations on the extinction risk of specific populations, especially to be able to draw specific boundary lines that would provide a greater conservation benefit to the species.

Based on the above analysis, we concluded that the best available information does not indicate that any population segment of the great hammerhead shark would qualify as a DPS under the

DPS policy. As such, we conducted the extinction risk analysis on the global great hammerhead shark population.

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. The phrase has never been formally interpreted by NMFS. Recently, NMFS and FWS published a draft policy on interpretation of the phrase (76 FR 76987; December 9, 2011). While the Draft Policy remains in draft form, we were asked to consider the interpretations and principles contained in the Draft Policy with regards to the great hammerhead shark. Specifically, we were asked to identify any SPRs for the great hammerhead 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 great hammerhead sharks' range as being more significant than another. Great hammerhead sharks are highly mobile, with a global distribution, and very few restrictions governing their movements. Although there was preliminary evidence of possible genetic partitioning between ocean basins, this was based on an abstract with no accompanying data or information that we could evaluate, and a study with a limited sample size (see DPS Analysis). Based on these deficiencies, we did not find the evidence to be substantial enough 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 great hammerhead population to the point where individuals would be precluded from moving to suitable habitats or have an increased vulnerability to threats. As previously mentioned, the great hammerhead shark is highly mobile, with diffuse abundance, and 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. Areas exhibiting source-sink dynamics, which could affect the survival of the species, were not evident in any part of the great hammerhead 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 great hammerhead sharks that could be considered limiting factors for the species' survival. 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 its range had increased importance over another with respect to the species' survival. As such, when we considered the extinction risk of the species, we considered it throughout the species' entire range.

EXTINCTION RISK ANALYSIS

Often the ability to measure or document risk factors is limited, and information is not quantitative and very often lacking altogether. Therefore, in assessing risk, 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 great hammerhead shark after conducting a demographic risks analysis. Likewise, the ERA team performed a threats assessment for the species by scoring the severity of current threats to the species as well as predicting whether the threat will increase, decrease, or stay the same in 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 are provided below.

Foreseeable future – ERA team discussion

For the purpose of this extinction risk analysis, the term "Foreseeable future" was defined as the timeframe over which threats can be predicted reliably to impact the biological status of the species. In determining an appropriate "foreseeable future" timeframe, we first considered the life history of the great hammerhead shark. Longevity is estimated to be around 44 years, although it has only been validated up to 42 years. Generation time, which is defined as the time it takes, on average, for a sexually mature female great hammerhead shark to be replaced by offspring with the same spawning capacity, is estimated to be around 16 years. As a late-maturing species, with relatively slow growth rate 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. As such, and taking into account the longevity of the species, we agreed that a biologically reasonable foreseeable future timeframe would be three generation times, or approximately 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.

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 1 (no or low risk) to 3 (high risk). Below are the definitions that the team used for each ranking:

> 1 = No or low risk: It is unlikely that this demographic factor poses a significant risk to the species' continued existence, either by itself or in combination with other demographic factors or threats
>
> 2 = Moderate risk: It is likely that this demographic factor poses a significant risk to the species' continued existence but only in combination with other demographic factors or threats.
>
> 3 = High risk: It is likely that this factor, by itself, poses a significant risk to the species' continued existence.

The team members were given a template to fill out and asked to rank the risk of the demographic factors. If the demographic factor was ranked as a moderate risk, then the team members were asked to identify those other demographic factors or potential threats that would work in combination with the demographic factor to present a moderate risk to the species (Table 2). After scores were provided, the team discussed the range of perspectives for each of the demographic risks 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) and reviewed by the ERA team and considered in making the overall risk determination. 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. 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 2. 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 (1-3)

Abundance

Comments:

Other Demographic Factors or Potential Threats (only applies if Score = 2):

Growth rate/productivity

Comments:

Other Demographic Factors or Potential Threats (only applies if Score = 2):

Spatial structure and connectivity

Comments:

Other Demographic Factors or Potential Threats (only applies if Score = 2):

Diversity

Comments:

Other Demographic Factors or Potential Threats (only applies if Score = 2):

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 to rank the effect that the threat was currently having on the extinction risk of the species. If the threat was identified as having a small or moderate effect on the species' extinction risk, then the ERA team member was asked to identify the other threat(s) or demographic factor(s) that it was interacting with to increase the species' extinction risk by checking the interacting threat/factor box (Table 3). Below are the specific definitions of the threat effect levels:

No effect on extinction risk: It is unlikely that this threat is increasing the species' extinction risk, either by itself or in combination with other threats.

Small effect: It is unlikely that this threat, by itself, is increasing the species' extinction risk, but some concern that it may in combination with other threats or factors.

Moderate effect: It is likely that this threat, in combination with other threats or factors, is increasing the species' extinction risk.

Significant effect: It is likely that this threat, by itself, poses a significant risk to the species' continued existence.

Unknown: There is not enough information to determine effect that this threat has on the species' extinction risk.

To allow individuals to express uncertainty in determining the overall level of extinction risk facing the species, the ERA team adopted the "likelihood point" (FEMAT) method (see Table 4 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 five threat effect levels. After scores were provided, the team discussed the range of perspectives for each of the threats, 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) and reviewed by the ERA team and considered in making the overall risk determination.

Table 3. Template for the threats assessment used in ERA team deliberations.

						Interaction with other threats/factors									
						Threats					Demographic				
Threat	**No effect**	**Small**	**Moderate**	**Significant**	**Unknown**	H	O	D/P	I	OT	A	G	SS	D	**NOTES**
Habitat destruction, modification or curtailment (H)															
Overutilization (O)															
Disease or predation (D/P)															
Inadequacy of existing regulatory mechanisms (I)															
Other (OT)															

Overall Level of Extinction Risk Analysis

Guided by the results from the demographics risk analysis as well as threats assessment, the ERA team members used their informed professional judgment to make an overall extinction risk determination for the species now and in the foreseeable future. For these analyses, the ERA team defined five levels of extinction risk:

> 1 = No or very low risk: It is unlikely that this species is at risk of extinction due to projected threats or trends in abundance, productivity, spatial structure, or diversity.
>
> 2 = Low risk: It is unlikely that this species is at risk of extinction due to trends in abundance, productivity, spatial structure or diversity; however, current threats (or projected threats) may be (or will be) altering those trends but not yet by enough to cause the species to be influenced by stochastic or depensatory processes.
>
> 3 = Moderate risk: The species exhibits a trajectory indicating that it is approaching a level of abundance, productivity, spatial structure, and or/diversity that places its current or future persistence in question. A species may be at moderate risk of extinction due to declining trends in abundance, productivity, spatial structure, or diversity and current or projected threats that inhibit the reversal of these trends.
>
> 4 = High risk: The species is at or near a level of abundance, productivity, spatial structure, and or/diversity that places its current or future persistence in question. Similarly, it faces clear and present threats that are likely to create such demographic risks.
>
> 5 = Very high risk: The species is strongly influenced by stochastic or depensatory processes, facing current threats exacerbating the demographic risks, and indicating imminent extinction.

Again, the team adopted the “likelihood point” (FEMAT) method to allow individuals to express uncertainty in determining the overall level of extinction risk facing the species (Table 4). 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 species should be listed as threatened or endangered. Rather, the ERA team drew scientific conclusions about the overall risk of extinction faced by the species under present conditions and in the foreseeable future based on an evaluation of the species’ demographic risks and assessment of threats.

Table 4. Template for the overall level of extinction risk analysis used in ERA team deliberations.

Overall level of extinction risk NOW					
	1 = No or Very low risk	2 = Low risk	3= Moderate Risk	4 = High risk	5 = Very high risk
Number of likelihood points					

Overall level of extinction risk through the foreseeable future (50 years)					
	1 = No or Very low risk	2 = Low risk	3= Moderate Risk	4 = High risk	5 = Very high risk
Number of likelihood points					

ERA Team's Extinction Risk Results and Conclusion for the Great Hammerhead Shark

Evaluation of Demographic Risks

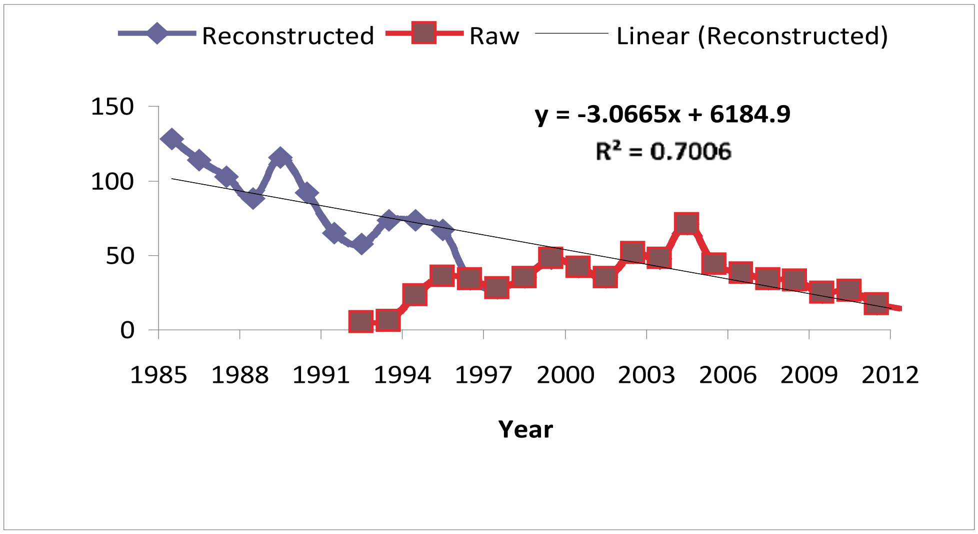
Abundance

Our ERA team scores for abundance of the global great hammerhead population ranged from 1 to 2, with a modal score of 2. A score of 2 represents moderate risk, meaning that it is likely that abundance poses a significant risk to the species' continued existence but only in combination with other demographic factors or threats. Currently, there is a lack of reliable estimates of population size and there is some evidence to suggest that this species may be naturally low in abundance, such as their rarity in fisheries data. If this is the case, these low levels of abundance may pose significant risk to the species in combination with other factors, such as overutilization, since a species that is already at naturally low levels may not be able to withstand heavy fishing pressure.

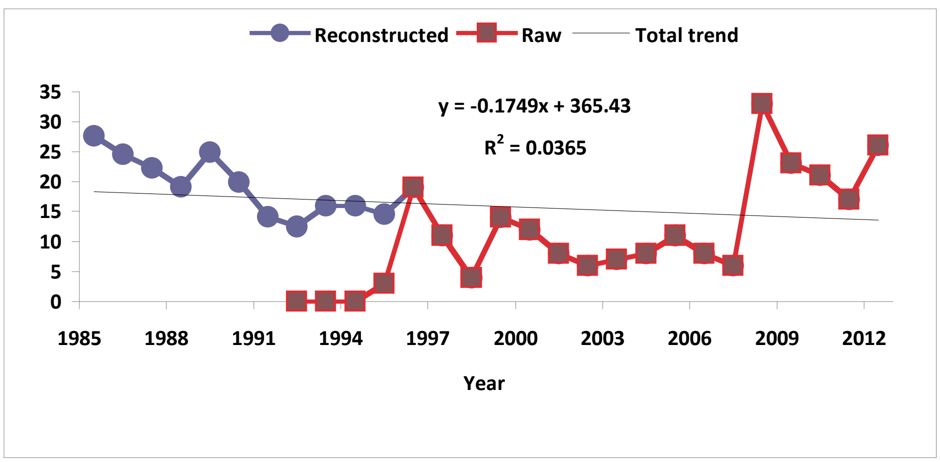
Presently, there is no evidence to suggest depensatory processes are at work. In addition, the available indicators of massive abundance declines appear to be flawed, localized, or both. While it is likely that great hammerheads have declined like some other species of sharks, their overall decline may not be as severe as in other species. For example, using the information from the Queensland shark control program time series data, when one compares catch rates of the two species over time, results show clear differences in the severity of declines experienced by scalloped and great hammerhead sharks. As explained in the Status Review document, we extracted additional temporal patterns from the Queensland shark control program time series data. We extracted catches identified to species levels for the time period of 1985-2012 for both scalloped and great hammerhead sharks. 1992-1995 species-specific catch data are assumed to be transitional data and are replaced by reconstructed estimates for this time period using the total hammerhead shark catch and the mean fraction of the species for the time period of 1996-

2007. Below are the extracted catches identified to species levels for the time period of 1985-2012 for both scalloped and great hammerhead sharks. Regression for the entire series is shown for illustrative purposes.

Scalloped Hammerhead Catches (data extracted from QLD DEEDI (2013)):



Great Hammerhead Catches (data extracted from QLD DEEDI (2013)):



Likewise, severe declines in scalloped hammerhead populations have been noted in other areas (such as off Brazil, Indonesia, Oman, Mauritania, and Pacific Mexico – see Miller et al. 2013), but there is no information or evidence to show that this is also the case for great hammerhead populations.

When identified to species level, great hammerhead sharks are not a significant part of the direct or incidental shark catch in most of their range, with the exception of coastal fisheries in the eastern Atlantic off Africa, areas off Venezuela, and likely some coastal areas of the Indian Ocean. Similar to catches, species-specific population assessments and trends in abundance for great hammerheads are lacking. To use a hammerhead complex or other hammerhead species as a proxy for great hammerhead abundance could be erroneous because of the large difference in the proportions they make up in commercial and artisanal catch. Usually great hammerheads comprise <10% of the sphyrnid catch, see Román Verdesoto and Orozco-Zöller (2005) and Amorim et al. (1998) for examples of commercial non-directed shark fisheries; Castillo-Geniz et al. (1998), Robinson and Sauer (2011), and Doukakis et al. (2011) for examples of artisanal shark fisheries; and Dia et al. (2012), Dudley and Simpfendorfer (2006), and White et al. (2008) for other examples where data are not from a fishery, or the fishery is not identified. Although higher great hammerhead proportions have been identified in a few other fisheries (see Venezuelan longline fleet bycatch data – 47%, Arocha et al. 2002; observed U.S. BLL catch - 32% from 1994-2011, Carlson personal communication; and observed NTONL bycatch - 34%; Field et al. 2013), the majority of the sphyrnid catch remains dominated by the more abundant and susceptible schooling scalloped hammerhead shark.

In areas where great hammerhead shark data are available, some trends show large declines (e.g. NW Atlantic) but most of these studies have high degrees of uncertainty and, in some cases, alternate analyses indicate different results (e.g. Hayes (2008) vs. Jiao et al. (2011)). As previously noted, it is likely that great hammerhead sharks have declined due to fishing mortality but recent relative abundance data included in the Status Review document suggest the population is either stable, shows no clear trend, or may be increasing in some areas.

Growth rate/productivity

Our ERA team scores for growth rate and productivity of the global great hammerhead population ranged from 1 to 2, with a modal score of 2. A score of 2 represents moderate risk, meaning that it is likely that growth rate and productivity poses a significant risk to the species' continued existence but only in combination with other demographic factors or threats.

Great hammerhead sharks exhibit life-history traits and population parameters that are intermediary among other shark species. Productivity = 0.096/year (median) within a range of 0.078-0.116 (80% percentiles) (Cortés unpublished). These demographic parameters place great hammerhead 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 Ecological Risk Assessments, great hammerheads have been found to be less susceptible to pelagic longline fisheries in the Atlantic and Indian Ocean when compared to other shark populations. However, primarily based on the fact that most species of elasmobranchs take 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

Individually, we all scored spatial structure/connectivity for the great hammerhead shark as a 1. A score of a 1 represents no or very low risk, meaning that it is unlikely that spatial structure or connectivity poses a significant risk to the species' continued existence, either by itself or in combination with other demographic factors or threats.

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. Thus, there seems to be insufficient information that would support the conclusion that spatial structure and connectivity pose significant risks to this species.

Diversity

Individually, we all scored diversity as a 1 for the great hammerhead shark. A score of a 1 represents no or very low risk, meaning that it is unlikely that diversity poses a significant risk to the species' continued existence, either by itself or in combination with other demographic factors or threats.

There is no evidence the species is at risk due to a substantial change or loss of variation in genetic characteristics or gene flow among populations. This species is found in a broad range of habitats and appears to be well-adapted and opportunistic.

Threats Assessment

The following table gives the results of our ERA team's analysis of the effect of threats to the global great hammerhead shark population. Likelihood points were tallied and the totals (n = 40) are presented for each ESA section 4(a) factor. In addition, interacting threats and demographic factors are identified as well as the modal forecasts for the foreseeable future.

						Interaction with other threats/factors								
						Threats					**Demographic**			
Threat	**No effect**	**Small**	**Moderate**	**Significant**	**Unknown**	H	O	D/P	I	OT	A	G	SS	D
Habitat destruction, modification or curtailment (H)	10	12	1	0	17		X							
Overutilization (O)	1	9	18	3	9				X	X	X	X		
Disease or predation (D/P)	35	1	0	0	4									
Inadequacy of existing regulatory mechanisms (I)	1	13	13	6	7		X			X	X	X		
Other (OT)	0	15	4	0	21		X		X		X			

Out of the five ESA section 4(a) factors, we identified overutilization and inadequate regulatory mechanisms as having moderate effects on the extinction risk of the species, whereas the other factors were identified as having either unknown or no or very low effects on extinction risk. Below is a brief discussion of the rationale for our ERA team's conclusions regarding the threats assessment.

Habitat Destruction, Modification, or Curtailment

We noted that there is very little information on habitat use and little is known about their exact pupping and nursery areas. As such, it is extremely difficult to assess the threat of habitat loss. We reflected this uncertainty, with 43% of our likelihood votes represented in the "Unknown" threat effect level. The effect level that received the second highest number of votes was the "Small effect" category as we acknowledged that while habitat specificity is not greatly defined for the species, there may be other natural and anthropogenic impacts to the environment that could have some effect on its pelagic habitat. We considered global warming as a possible habitat modification, but noted that the Chin et al. (2010) study described in the Status Review document did not find *S. mokarran* to be a vulnerable species to global warming. Given the available information, we concluded that the effect that habitat destruction, modification, or curtailment is having on the species' extinction risk cannot be determined at this time.

Overutilization

We identified overutilization as a threat with a moderate effect on the extinction risk of the species, which means it is likely increasing the species' extinction risk but only in combination with other threats or factors. Because great hammerhead sharks are highly prized for their fins, this makes the species a popular fishing target as both catch and bycatch and increases its susceptibility to being overfished. However, there is currently very little fisheries information on the catch or abundance of the great hammerhead shark. For example, in the Eastern Atlantic, there is little species-specific data with mainly anecdotal reports of a decline in large hammerheads due to IUU fishing, industrial, and artisanal fishing. In the Northwest Atlantic, fisheries data show a decline in the great hammerhead population, likely due to historical overfishing of the species. However, since 2005 (the last year of the fisheries data from the Jiao et al. (2011) and Hayes (2008) analyses), the trend is unclear, with some evidence that the population may be stable or increasing (see Figures 18 – 20 in Status Review document). In addition, some members were concerned about the accuracy of species identification in the historical fisheries data. Hayes (2008) notes that the relative proportion of great hammerhead sharks in the hammerhead catch has changed significantly since the early 1980s, decreasing from ~50% in 1982 to <30% in 2005, however team members argued that species identification for hammerhead sharks in landings data prior to 2007 was highly inaccurate and question the validity of these percentages. (Since January 1, 2007, NMFS has required all pelagic longline, bottom longline, and gillnet vessel owners who hold shark permits and operators of those vessels to attend a Protected Species Safe Handling, Release, and Identification Workshop; and all Federally permitted shark dealers are required to attend Atlantic Shark Identification workshops.) Hayes (2008) also identifies many data deficiencies that have increased the uncertainty in his estimates, including the misreporting of the species, particularly in recreational fisheries, which has likely led to overestimations of catches. In other studies that discriminate between hammerhead species, great hammerheads tend to comprise <10% of the total hammerhead complex. Only recently has identification of sharks, down to species level, become a priority for national and international fishery managers (including many RFMOs), with the publication of shark and fin guides available for fishermen in order to more accurately report shark catches down to the species level.

Very little data is available from the Pacific and Indian Oceans, with only one study that specifically shows a significant decline in the great hammerhead population (from a localized area – Dudley and Simpfendorfer (2006)). The other studies either analyze the hammerhead complex (of which scalloped hammerheads usually predominate the composition) or show no clear trend. We reflected our uncertainty in evaluating the threat of overutilization by placing 23% of our likelihood votes in the "Unknown" threat effect level. In addition, the range of the effect levels varied from no effect to significant effect, also a reflection of our uncertainty. We note that this threat may be tempered by the species' relatively low vulnerability to fisheries due to its diffuse abundance, wide range, and lack of schooling behavior. Overall, we concluded that overutilization in combination with other factors, such as a lack of regulatory mechanisms in some of the largest shark fishing nations in the world, and demographic risks such as naturally low abundance, is likely increasing this species' risk of extinction.

<u>Disease or Predation</u>

We identified disease and predation as factors that are unlikely to increase the species' extinction risk now or in the foreseeable future. In terms of disease, it was noted that since the species prefers benthic prey (example: sting rays), it might be susceptible to contaminants that accumulate on the sea floor; however, there is currently no evidence to suggest the great hammerhead is at an increased risk of extinction from disease. Predation also does not appear to be increasing this species' risk of extinction. The great hammerhead shark is an apex predator and opportunistic feeder and does not appear to be in competition for food sources. Therefore, based on the best available information, we concluded that neither disease nor predation was increasing the species' extinction risk.

<u>Inadequacy of Existing Regulatory Mechanisms</u>

We identified the lack of adequate regulatory measures as a threat with a small to moderate effect on the extinction risk of the species, which means it may be or is likely increasing the species' extinction risk but only in combination with other threats or factors. We placed an equal number of likelihood points in both effect levels. The other factors that were identified as working in conjunction with this threat to increase extinction risk were overutilization (as a result of inadequate regulatory measures and IUU fishing), demographic risks such as low abundance, and biological vulnerability to fishing gear.

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 to rebuild the scalloped hammerhead populations are helping to monitor the catch of great hammerheads and preventing any further population declines. These conservation and management measures (as detailed in Amendment 5a to the Consolidated HMS FMP (78 FR 40318; July 3, 2013) and explained in the Status Review) are viewed as adequate in decreasing the extinction risk to the great hammerhead shark by minimizing demographic risks (preventing further abundance declines) and the threat of overutilization (strictly managing and monitoring sustainable catch rates) currently and in the foreseeable future. Regulations specific to great hammerheads, however, are lacking in parts of Central and South America (although Brazil recently banned gillnets) and especially off the coast of West Africa and throughout the Indian

Ocean. However, this species does not appear to be caught in large numbers by fisheries so additional regulatory measures may not significantly decrease the species' extinction risk.

In terms of international trade of the species, the recent CITES listing of great hammerhead sharks on Appendix II should increase monitoring and potential management actions as CITES party members must ensure that trade of the species will not be detrimental to the survival of the species. However, the CITES listing will not go into effect until September 14, 2014. As data reporting, with emphasis on species' discrimination, was noted as a significant inadequacy in current regulatory measures adding to the uncertainty in the extinction risk of the species, this CITES listing and subsequent management measures should help decrease this uncertainty and provide a greater understanding of the extinction risk faced by the species.

Finning and illegal harvest were also a concern, but we noted that the situation appears to be improving. For example, China (a large consumer of shark fins) recently prohibited shark fins at all official reception dinners (Ng 2013). Clarke et al. (2007) documented that shark fin traders cite hammerheads as the sources of the best quality fin needles for consumption at banquets so the prohibition could decrease the global demand for hammerhead fins. 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 United States, for example, exports of dried Atlantic 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. 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. fishermen 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 2012a, NMFS 2013a).

In addition, unlike the scalloped hammerhead shark, which may be caught in large numbers by IUU vessels, the great hammerhead shark is less susceptible to overutilization from illegal harvest due to its solitary behavior and diffuse abundance. Although many of the IUU fishing reports in the Status Review document do not identify fins down to species, the IUU fishing occurred in known "hot spots" of scalloped hammerhead sharks. These are areas where large numbers of scalloped hammerheads have been known to aggregate and school, such as around the Galapagos, Malpelo, Cocos and Revillagigedo Islands in the Eastern Tropical Pacific. Thus, it is likely that many of the fins belonged to *S. lewini*. The status review also mentions a study that did examine a small collection of fins confiscated from IUU fishers in northern Australian waters, and found that the number of fins identified as scalloped hammerheads were almost double those that belonged to great hammerhead sharks (Lack and Sant 2008). In fact, the scalloped hammerhead shark was the 2nd highest source of illegal fins (behind the Whitecheek shark – *Carcharhinus dussumieri*). In 2007, a sting operation that confiscated a total of 19,018 illegal fins at the border between Ecuador and Peru also identified the fins down to species, and found that the fins represented four species of sharks: bigeye thresher, pelagic thresher, sandbar, and scalloped hammerhead (O'Hearn-Gimenez 2007). Based on the location of many reported

IUU fishing occurrences, and the representation of *S. lewini* in identified fin hauls, it seems likely that the vast majority of hammerhead sharks that are harvested by IUU fishing vessels are the schooling scalloped hammerhead shark.

Although great hammerhead fins are one of the most prized in the shark fin trade, 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 the demand for shark fins continues to decrease (as demonstrated by the increase in finning regulations and decrease in shark fin price), so should the threat of finning and illegal harvest.

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

We identified biological vulnerability in the form of high at-vessel fishing mortality as a potential factor that may increase the species risk of extinction. However, when we evaluated this factor, we noted that the extent of this vulnerability on the species extinction risk is unknown and hard to quantify. Fisheries information is lacking and it is likely that most of the fishing mortality on this species is through capture in gillnets, where its biological vulnerability would not present an issue as the species would not likely be released after capture. However, given the uncertainties, we placed 53% of our likelihood votes in the "Unknown" threat effect level. The effect level that received the second highest number of votes was the "Small effect" category as we acknowledged that there may be some concern that its biological vulnerability could exacerbate extinction risk when coupled with other threats or demographic risks.

Overall Risk Summary

Guided by the results and discussions from the demographics risk analysis and threats assessment, we analyzed the overall risk of extinction to the global great hammerhead shark population. The following tables give the results of our likelihood point distribution. Likelihood points were tallied and the totals (n = 40) are presented for the overall level of extinction risk now and through the foreseeable future.

	Overall Level of Extinction Risk NOW				
	1 = No or Very low risk	2 = Low risk	3= Moderate Risk	4 = High risk	5 = Very high risk
# of Likelihood Points	13	15	11	1	0

	Overall Level of Extinction Risk through the Foreseeable Future (50 years)				
	1 = No or Very low risk	2 = Low risk	3= Moderate Risk	4 = High risk	5 = Very high risk
# of Likelihood Points	16	18	6	0	0

For the current level of extinction risk of the great hammerhead shark, we expressed our uncertainty, based on the data limitations, by placing an almost equal distribution of likelihood points in the "no or very low risk," "low risk," and "moderate risk" categories, however the majority of points fell into the "low risk" category. During discussions, it was reiterated that the great hammerhead shark is likely naturally low in abundance. It is also not present in fisheries data, either due to lack of reporting or simply not present in common fishing grounds (or susceptible to the fishing gear). There is only one scientifically-robust study that has shown large declines in the population using fisheries-independent data, and this study was conducted in a small, localized area (off South Africa – Dudley and Simpfendorfer (2006)). We noted flaws in the other studies cited within the Status Review document, including questionable species discrimination within the data (as only recently has more attention been paid to accurately identifying hammerheads down to species), models that are highly sensitive to data series, differences in the complexity of models, large error bars in results data, short time series or small number of observations used in the studies.

However, we were more confident in predicting the overall level of extinction risk through the next 50 years, placing more likelihood points in the “no or very low risk” and “low risk” categories. The available information indicates that most of the observed declines occurred in the 1980s, before any significant management regulations. Since then, current regulatory measures in many parts of the great hammerhead range are minimizing the threat of overutilization, preventing further abundance declines in the foreseeable future and decreasing the likelihood of extinction of the global population. Thus, we predicted that through the next 50 years, the species would be unlikely to be at risk of extinction due to trends in its abundance, productivity, spatial structure, or diversity or influenced by stochastic or depensatory processes.

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