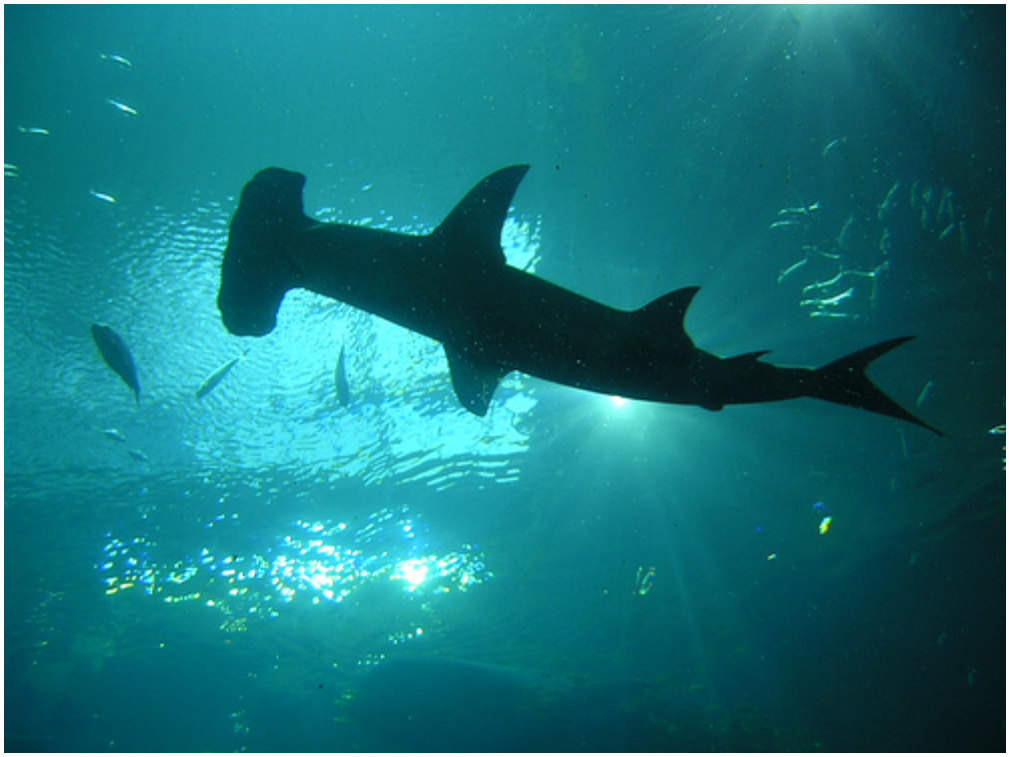
Before the Secretary of Commerce

Petition to List the Northwest Atlantic Distinct Population Segment of Great Hammerhead Shark (*Sphyrna mokarran*) as Threatened under the Endangered Species Act



Photograph by Tanjila Ahmed (CC BY 2.0)

March 15, 2013

Executive Summary

The great hammerhead shark, *Sphyrna mokarran*, is a long-lived, large coastal pelagic shark, the largest species of hammerhead shark of the Family Sphyrnidae. The great hammerhead shark, a generally solitary species, lives in coastal warm temperate and tropical waters, primarily in semi-oceanic waters near continental shelves but also in shallow coastal waters like bays and in passes and lagoons of coral reef atolls. In the spring and summer, some populations of great hammerhead sharks perform poleward migrations. This shark has a low reproductive potential, reproducing every two years. As an apex predator, the great hammerhead shark plays an important role in maintaining the long-term health of coastal marine ecosystems.

The northwest Atlantic population of great hammerhead sharks, which encompasses all great hammerhead sharks living in the Atlantic Ocean along the eastern U.S., as well as those in Caribbean waters and in U.S. and Mexican waters in the Gulf of Mexico, constitutes a distinct population segment (DPS) because it is both discrete and significant. The northwest Atlantic great hammerhead shark DPS is discrete because it is markedly separate from other populations based on both geographic separation and genetic evidence; it is significant because of the ecological uniqueness of its northwestern Atlantic Ocean habitat relative to the species as a whole, and because the loss of this population would result in a significant gap in the species' range.

The northwest Atlantic DPS of great hammerhead shark should be listed as threatened under the U.S. Endangered Species Act (ESA). The northwest Atlantic great hammerhead shark DPS is likely to become an endangered species within the foreseeable future for the following reasons:

First, the DPS is severely depleted. According to the best available scientific evidence, the current population of the northwest Atlantic great hammerhead shark DPS is estimated to be at less than 10% of its unfished abundance (Hayes 2007). This population level is alarming, given the species' very low natural intrinsic rate of population increase and the short time period over which the depletion has occurred.

Second, the DPS continues to face an unsustainable level of fishing mortality. The most recent scientific assessment found that great hammerhead sharks are overfished and undergoing overfishing (Hayes 2007). Although the United States has recently prohibited the retention of great hammerheads caught as bycatch in certain tuna fisheries (in accordance with a resolution by the International Commission for the Conservation of Atlantic Tunas (ICCAT)), the expected reduction in great hammerhead shark mortality associated with the rule is small. While new management changes have been proposed by the National Marine Fisheries Service (NMFS 2012b), they are unlikely to sufficiently reduce fishing-related mortality of great hammerheads.

Because of the DPS' highly depleted population level, the ongoing threats, and the insufficiency of current management and conservation measures, NMFS should designate the northwest Atlantic DPS of great hammerhead shark as threatened under the ESA. Alternatively, NMFS should designate the entire species of great hammerhead shark as threatened because the waters of the Gulf of Mexico, the U.S. Atlantic coast, and the Caribbean Sea constitute a significant

portion of its range (SPOIR), and the species is likely to become endangered in this SPOIR within the foreseeable future.

Notice of Petition

The Natural Resources Defense Council (NRDC) hereby petitions the Secretary of Commerce, through NMFS, to list the northwest Atlantic DPS of great hammerhead shark (*Sphyrna mokarran*) as threatened under the ESA and designate critical habitat to ensure its recovery pursuant to Section 4(b) of the ESA, 16 U.S.C. § 1533(b), section 553(3) of the Administrative Procedures Act, 5 U.S.C. § 533(e), and 50 C.F.R. § 424.14(a). In the alternative, NRDC petitions the Secretary to list the great hammerhead shark as threatened (and designate appropriate critical habitat) because the species is likely to become endangered in a significant portion of its range in the foreseeable future.

NRDC is a national not-for-profit conservation organization with approximately 1.3 million members and activists. One of NRDC's organizational goals is to further the ESA's purpose by preserving our national biodiversity. NRDC's members have a direct interest in ensuring the survival and recovery of northwest Atlantic great hammerhead sharks and in conserving the unique marine communities on which they rely and which they benefit.

NMFS has jurisdiction over this petition. This petition sets in motion a specific process, requiring NMFS to make an initial finding as to whether the petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533 (b)(3)(A). NMFS must make this initial finding "(t)o the maximum extent practicable, within 90 days after receiving the petition." *Id*. A petitioner need not demonstrate that listing is warranted, but rather shall present information demonstrating that such a listing *may* be warranted. While NRDC believes that the best available science demonstrates that listing the northwest Atlantic great hammerhead shark DPS (or great hammerhead shark as a whole) as threatened is in fact warranted, the available information clearly indicates that listing the DPS or species may be warranted. As such, NMFS should promptly make a positive finding on this petition and commence a status review as required by 16 U.S.C. § 1533 (b)(3)(B).

Respectfully submitted this 14th day of March, 2013.

Bradford H. Sewell, Senior Attorney
Natural Resources Defense Council
40 West 20th Street
New York, NY 10011
Tel: (212) 727-2700
bsewell@nrdc.org

Table of Contents

I. Species Account

A. Species Information

1. Taxonomy and description

The great hammerhead shark (also "great hammerhead"), *Sphyrna mokarran*, is the largest species of hammerhead shark of the Family Sphyrnidae. Hammerhead sharks are named for and easily distinguished from other sharks by their elongated and flattened hammer-shaped head, termed the cephalofoil. Hammerhead shark species, in turn, can be distinguished from one another by variations in their cephalofoil, among other characteristics. The great hammerhead is considered a "look-alike" species (CITES CoP15 2010) to the scalloped hammerhead (*S. lewini*) and the smooth hammerhead (*S. zygaena*). While the cephalophoil of the adult great hammerhead shark is nearly straight (with a shallow notch in the center), that of the scalloped hammerhead has a rounder anterior margin, a more pronounced center notch and bilateral notches, while the smooth hammerhead has a broad, flat and unnotched cephalophoil (Bester 2012). The great hammerhead can also be distinguished by its larger size and the curved (concave and falcate) rear margins of the pelvic fins (versus the straight margins of the scalloped hammerhead) (Bester 2012).

2. Diet

Great hammerhead sharks generally feed at dusk on the seafloor, and prey upon a wide variety of marine organisms, from invertebrates to bony fishes, rays, and sharks. Invertebrate prey include crabs, squid, octopus, and lobsters while commonly consumed bony fish are groupers, catfishes, jacks, grunts, and flatfishes. Great hammerheads have also been reported as cannibalistic, eating individuals of their own species (Bester 2012). As an apex predator, the great hammerhead shark plays an important role in maintaining the long-term health of coastal marine ecosystems (Myers *et al.* 2007).

3. Life history, longevity, and growth

Great hammerhead sharks are the largest species of hammerhead shark, growing to average sizes of 286.7 centimeters (cm) for males and 307.8 cm for females (Hueter *et al.* 2007; Piercy *et al.* 2010), and an average weight of 230 kilograms (kg) (maximum recorded sizes are 6.1 m and 450 kg) (Bester 2012) . Their average life span is approximately 32-39 years, with females living 7 years longer than males. A recent study found that great hammerheads have one of the oldest reported ages (44 years) for any elasmobranch (Hammerschlag *et al.* 2011: 111).

The species has a relatively fast early growth rate (compared to other large-bodied sharks) and the median age of maturity is between five and six years (Ebert and Stehmann 2013: 274). The great hammerhead reproduces every two years, giving birth during the spring or summer in the Northern Hemisphere to between thirteen and forty-two live pups after an eleven-month gestation period; it is considered to have a low reproductive potential (Castro *et al.* 1999; Hayes 2007: 55; Bester 2012; Ebert and Stehmann 2013).

4. Habitat

Great hammerhead sharks live in coastal warm temperate and tropical waters, generally in semi-oceanic waters near continental shelves (Hayes 2007: 55; Compagno 1984), but also in coastal pelagic waters, like island terraces, and in passes and lagoons of coral atolls (Ebert and Stehmann 2013: 273). Unlike the morphologically similar and geographically congruous scalloped hammerhead shark (Grace and Henwood 1997; Kohler *et al.* 1998), great hammerhead sharks are generally solitary and do not swim in schools (Castro *et al.* 1999). They inhabit waters from near the surface down to depths of at least 80 meters (m) (Denham *et al.* 2007). In contrast to most other species of sharks that reportedly mate at or near the bottom, great hammerhead sharks have been observed mating near the surface of the water (Bester 2012). The sharks may use shallow bays and coastal waters as nursery areas (FFWCC 2012).

5. Geographic range

Great hammerhead sharks are found globally in coastal warm temperate and tropical waters, mainly in waters over continental (and island) shelves (**Figure 1**). This shark inhabits both shallow coastal habitats as well as ranging far offshore (to deeper waters just beyond the shelves), and can be found in near-surface waters to depths over 80 m (Denham *et al*. 2007). This species typically avoids open-ocean and transoceanic movements (Compagno 1984; Hayes 2007), although some populations perform poleward migrations in the summer (Denham *et al*. 2007; Ebert and Stehmann 2013).

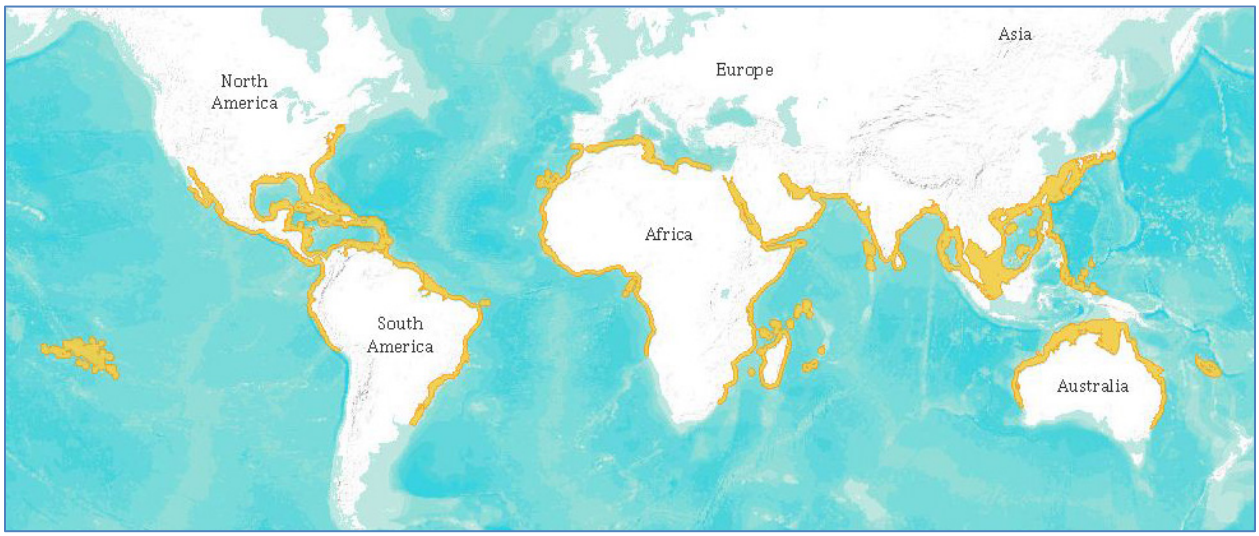


Figure 1. The global distribution of great hammerhead sharks (*Sphyrna mokarran*). Image from the IUCN Red List of Threatened Species, Version 2011.2 (http://maps.iucnredlist.org/map.html?id=39386).

In the western Atlantic Ocean, great hammerheads have been found as far south as Uruguay (Hammerschlag *et al.* 2011: 112). In the United States, the sharks range from the coastal to pelagic waters off New Jersey to southern Florida, and into the Gulf of Mexico (**Figure 2**; Grace and Henwood 1997; Kohler *et al.* 1998; Hammerschlag *et al.* 2011). Typically, great

hammerhead sharks spend time in the southerly portion of this range during the winter, and move north in the summer (Denham *et al.* 2007; Hammerschlag *et al.* 2011).

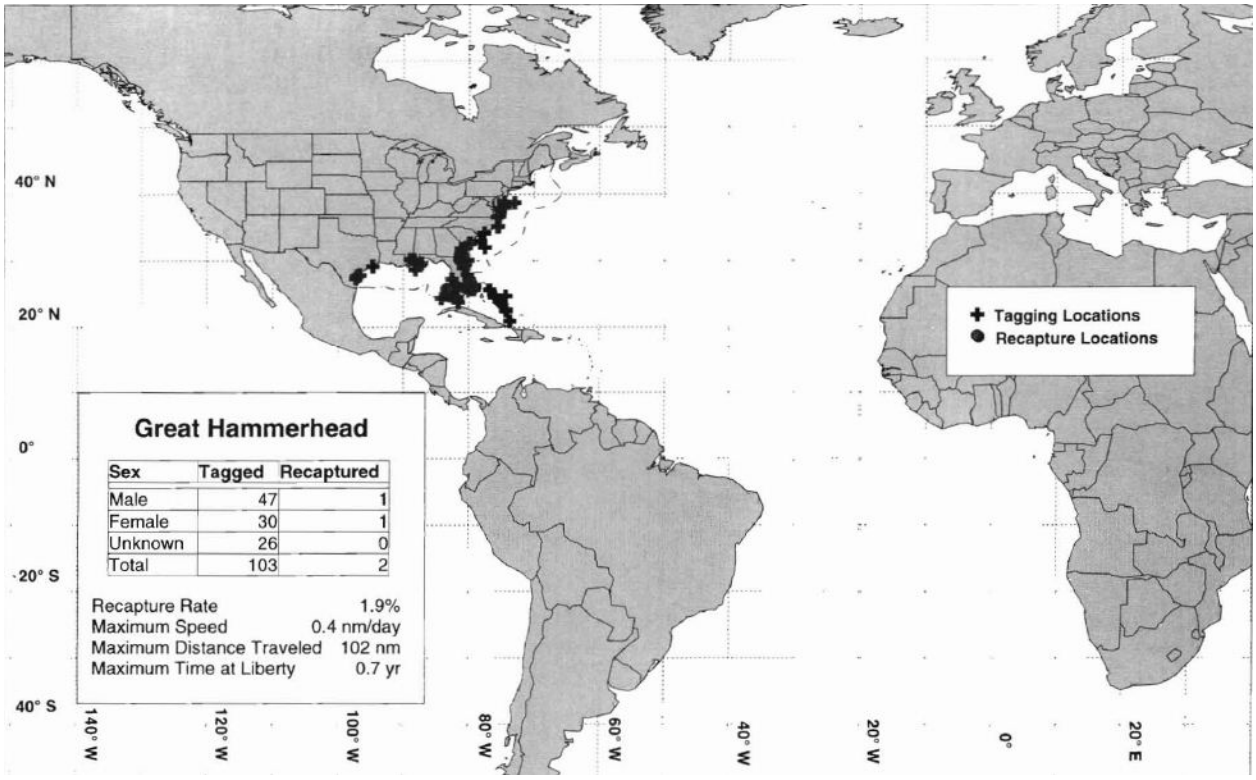


Figure 2. Atlantic distribution of tag and recapture locations for the great hammerhead, *Sphyma mokarran*, from the NMFS Cooperative Shark Tagging Program during 1962-93. The dotted-dashed line represents the U.S. EEZ. (Figure 141 from Kohler *et al.* 1998)

II. The northwest Atlantic population of great hammerhead sharks qualifies as a distinct population segment under the ESA.

The ESA provides for the listing of all species that meet the standards set forth for "endangered" and "threatened" species. The term "species" is defined broadly under the statute to include "any subspecies of fish or wildlife or plants and any distinct population segment of any species of vertebrate fish or wildlife with interbreeds when mature." 16 U.S.C. § 1532(16).

NMFS and the U.S. Fish and Wildlife Service (FWS) have published a policy to define a DPS for the purposes of listing, delisting, and reclassifying species under the ESA. *See* Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act, 61 Fed. Reg. 4722, (Feb. 7, 1996) ("DPS Policy"). 61 Fed. Reg. 4722 (February 7, 1996). Under this policy, a population segment must be found to be both "discrete" and "significant" before it can be considered for listing under the ESA.

For the reasons detailed below, the northwest Atlantic population of great hammerhead sharks is both discrete and significant and thus should be designated a DPS. For purposes of this petition,

the northwest Atlantic population encompasses sharks inhabiting waters along the Atlantic coast of the U.S. and the Gulf of Mexico.

A. Discreteness

Under the DPS Policy, a population segment of a vertebrate species is considered discrete if it satisfies either of the following conditions:

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors.
2. It is delimited by international governmental boundaries within which difference in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the ESA.

See DPS Policy at 4725. The northwest Atlantic population of great hammerhead sharks is markedly separate (discrete) from other populations based on both geographic range and genetics. The International Union for the Conservation of Nature (IUCN) lists four regional populations of great hammerhead sharks in its red list summary: West Africa (East Atlantic), Australia, Northwest Atlantic (which includes the Atlantic coast of the United States and the Gulf of Mexico), and the Southwest Indian Ocean. A portion of the northwest Atlantic population is managed in the United States as the South Atlantic and Gulf of Mexico population. The northwest Atlantic population is separated from the other populations by way of the Atlantic Ocean to the east and North and South America to the west (**Figure 1**). The U.S. Atlantic and Gulf of Mexico population is separated from the remainder of the Northwest Atlantic population to the south by way of the Yucatan peninsula and Caribbean islands including Cuba, which separate the Gulf of Mexico and Atlantic Ocean from the Caribbean Sea (**Figure 3**).

Figure 3: Geographic separations between the Atlantic Ocean, Gulf of Mexico and Caribbean Sea. (Available at http://www.worldatlas.com/aatlas/infopage/gulfofmexico.htm.)

Further support for the geographical discreteness of the northwest Atlantic population of great hammerhead sharks is found in tagging data from the NMFS Cooperative Shark Tagging Program (CSTP; http://na.nefsc.noaa.gov/sharks/tagging.html). Based on 22 years (1962-93) of tag and recapture data,[1] the documented range of great hammerhead sharks in the northwest Atlantic extends from New England south to the Caribbean Sea and the Gulf of Mexico no farther south than the Yucatan Peninsula (**Figure 2**) (Kohler *et al.* 1998). No great hammerheads were documented (in tagging or tag returns) outside of this range, despite the tagging effort encompassing the waters of 47 countries (in tag returns; 32 countries in initial tagging; Kohler *et al.* 1998: 5), and documentation of smooth hammerhead sharks in southwest Atlantic waters (Kohler *et al.* 1998: 81). In addition, while this species does perform seasonal migrations, it typically avoids open-ocean and transoceanic movements (Compagno 1984; Hayes 2007).

Scientists have determined that the Northwest Atlantic population of the morphologically similar and geographically congruous scalloped hammerhead sharks is genetically distinct from other scalloped hammerhead populations (Chapman *et al.* 2009). They have also identified genetic differences among three geographically distinct groupings of scalloped hammerhead sharks within the northwest Atlantic Ocean: the "northern" (comprised of U.S. Atlantic and Gulf of

[1] The majority of the tagging was conducted by rod-and-reel anglers. Biologists, NMFS fisheries observers, and commercial fishermen using primarily longlines, handlines, and nets (gill, trawl) accounted for the remainder. Conversely, commercial fishermen (50%) using longlines and net gear, and rod and reel anglers (40%) were responsible for the majority of the tag returns (Kohler *et al.* 1998: 4).

Mexico sharks, "central" (Belize and Panama), and the "southern" (Brazil) stocks (**Figure 4**) (Chapman *et al.* 2009: 225).

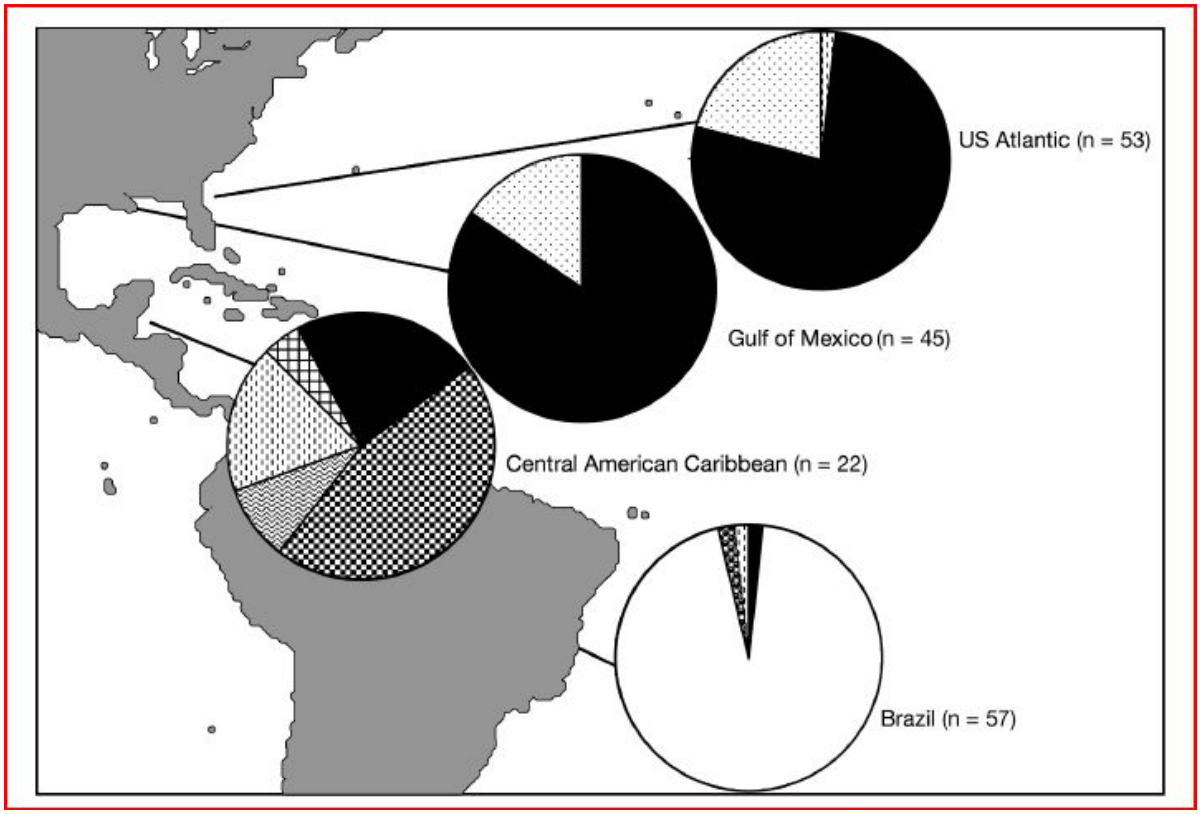


Figure 4: The frequency of various mitochondrial stocks in scalloped hammerhead sharks in different regions of the northern Atlantic Ocean. (Figure 3 in Chapman *et al.* 2009).

Although similar studies have yet to be completed for great hammerhead sharks, the existence of these mitochondrial distinctions in a morphologically similar hammerhead species with a similar geographic range (Grace and Henwood 1997; Kohler *et al.* 1998) suggests the existence of similar genetically distinct subpopulation of great hammerhead sharks in the western Atlantic Ocean and Gulf of Mexico.

The northwest Atlantic population of great hammerhead sharks is also discrete because it primarily inhabits U.S. waters, which offers the prospect of greater regulatory protection compared to many other jurisdictions globally where the species is found (see Section IV.B. below).

B. Significance

In order for a discrete population to be a DPS, it must also be significant. A population segment is considered significant based on one or more of the following:

1. Persistence of the discrete population in an ecological setting unusual or unique to this taxon;

2. Evidence that loss of the discrete population would result in a significant gap in the range of a taxon;
3. Evidence that the discrete population represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range; and
4. Evidence that the discrete population differs markedly from other populations of the species in its genetic characteristics.

See DPS Policy at 4725. The northwest Atlantic population of great hammerhead sharks meets three of the four criteria discussed above.

First, the northwest Atlantic continental shelf and adjacent ocean waters including the Gulf of Mexico represent a unique ecological setting; the area is markedly different in terms of bathymetry, hydrography, productivity, and trophic relationships from other areas that serve as habitat for great hammerhead sharks around the world (*see* **Figure 1)** (Sherman and Hempel 2008). Looking at those four factors, the United Nations Environment Program (in collaboration with three other national and international ocean management organizations – National Oceanic and Atmospheric Administration (NOAA), the Intergovernmental Oceanographic Commission, and the International Union for the Conservation of Nature (IUCN)) distinguished 64 unique large marine ecosystems (LMEs) around the world. The 64 LMEs included four unique LMEs in the northwest Atlantic great hammerhead shark DPS habitat: portions of the Caribbean Sea, the Gulf of Mexico and the Northeast U.S. Continental Shelf LMEs, and the entire Southeast U.S. Continental Shelf LME (UNEP acknowledged linkages between the Gulf of Mexico and Southeast U.S. Continental Shelf LMEs) (Sherman and Hempel 2008: 689-90; NMFS 2011: 143).

The wealth and variety of tropical to warm temperate habitats contained within these ecosystems support a variety of marine species, from wide-ranging pelagics to coral reef communities (NMFS 2011: 143). The many commercially important fisheries in the area reflect the very diverse fauna of the region, with relatively few large fisheries, and many small fisheries (NMFS 2011: 143). These areas are also defined in part by a relationship to the Gulf Stream, which flows from the Gulf of Mexico, along the U.S. Southeast Continental Shelf LME, and delineates the outer edge of the Northeast U.S. Continental Shelf LME. Great hammerhead sharks are known to follow the Gulf Stream during seasonal poleward migrations (Hammerschlag *et al.* 2011). Tagging and recapture studies showing that great hammerhead sharks captured in these areas stay within them further support the determination that these areas provide a unique ecological setting for the species, one which provides the range of habitats and conditions required to fulfill their life history needs (**Figure 2**) (Kohler *et al.* 1998).

Second, the loss of the northwest Atlantic population of great hammerhead sharks would result in a significant geographic gap in the range of great hammerhead sharks worldwide. This population encompasses all great hammerhead sharks living in the Atlantic Ocean along the eastern U.S., as well as those in Caribbean waters and in Mexican waters in the Gulf of Mexico, *compare* **Figure 1** *with* **Figure 3**. The population is also significant because it is predominantly found in U.S. waters, which, as noted above and discussed more below, provides it with greater opportunities for regulatory protection. Given the significantly declining population trends for

the species in other areas of the world (Denham *et al.* 2007) and the lack of regulation in many areas outside of U. S. waters, the loss of the U. S. Atlantic and Gulf of Mexico population of great hammerhead sharks would also represent a significant loss in the species' range.

Third, as discussed above, a recent genetic study clearly supports a genetic distinction between the northwestern Atlantic population of scalloped hammerhead sharks and other populations of scalloped hammerhead sharks around the world (**Figure 4**) (Chapman *et al*. 2009). In this study, scientists also identified genetic differences among three geographically distinct groupings of scalloped hammerhead sharks within the northwest Atlantic Ocean: the "northern" (comprised of U.S. Atlantic and Gulf of Mexico animals, "central" (Belize and Panama), and the "southern" (Brazil) stocks (**Figure 4**) (Chapman *et al.* 2009: 225). Given their similar geographic range, habitat, and movement patterns between great and scalloped hammerheads, it is likely that great hammerhead sharks will show equivalent genetic population distinctions.

Because it is both discrete and significant, the population of great hammerhead sharks in the northwestern Atlantic Ocean should be designated a DPS pursuant to the ESA.

III. Population status and abundance trends of the Northwest Atlantic population of great hammerhead sharks

A. Population trends

There is little data available on the northwest Atlantic population outside of the United States, including for landings and catch effort in Central America and the Caribbean. Between 1983 and 1991, the Cuban-directed shark fishery (longline) recorded great hammerhead sharks (subadults and juveniles) as one of 23 species caught (Denham *et al.* 2007). In Mexico (Tamaulipas, Veracruz, Tabasco, Campeche and Yucatan), 901 vessels were monitored every day between November 1993 and December 1994, and great hammerhead sharks represented 86% of the total catch (Denham *et al.* 2007).

Several studies have examined population trends of hammerhead sharks associated with the pelagic longline fisheries in U.S. Atlantic and Gulf of Mexico waters, and all have concluded that there have been substantial declines ranging from 72-89% over the last few decades. A standardized catch-rate index of hammerhead shark species (*i.e.*, scalloped, great, and smooth hammerheads) from commercial fishing logbook data in the United States pelagic longline fishery between 1986 and 2000 and from observer data between 1992-2005 estimated a population decline of 89% (Baum *et al.* 2003). Using catch and population trend data from multiple studies, Jiao (*et al.* 2009) found a 72% decline in abundance from 1981 to 2005. Baum and Blanchard (2010), using model estimates, came up with an almost identical 76% decline in the relative abundance from 1992 to 2005.

Hayes (2007) is the only species-specific assessment of great hammerhead shark. The study included full stock assessments of scalloped, great and smooth hammerhead sharks, both individually and as a complex. Although the author noted data limitations, this study represents the best available scientific information with respect to the population status of U.S. Atlantic and Gulf of Mexico population of great hammerhead sharks and fishing mortality on this population.

The Hayes stock assessment of great hammerhead shark used three production models and recreational, commercial, and pelagic discard data to estimate catch and relative abundance. Abundance in 2005 was estimated to be less than 10% of the unfished population (**Figure 4**).

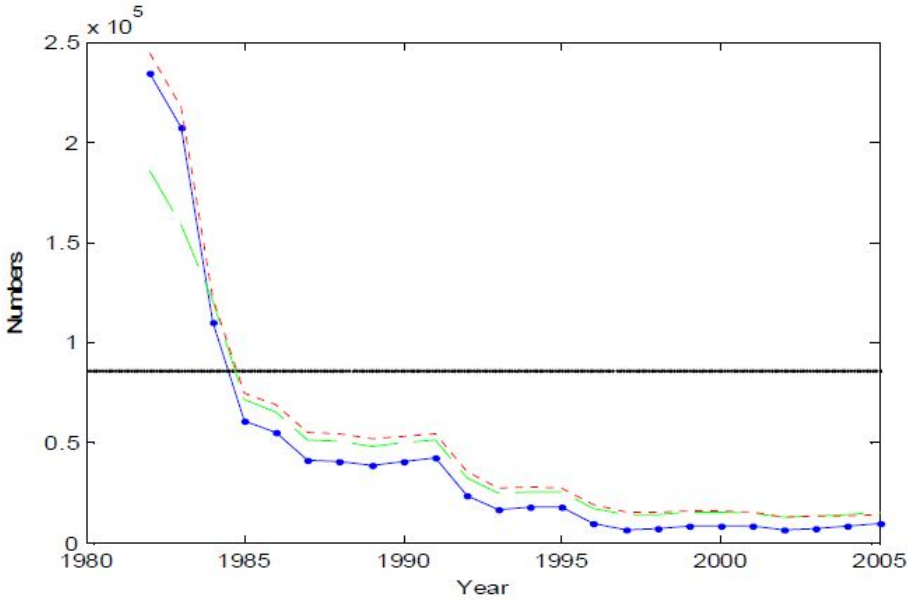


Figure 4. Abundance trajectory of great hammerhead sharks, 1982-2005. The solid blue line represents estimated abundance from the Fox model, the long green dotted line represents abundance from the Schaefer model, and the short orange dashed line represents abundance from the Pella-Tomlinson model. N_{MSY} from the Fox model is indicated as a solid horizontal black line (Figure 3.5A. in Hayes 2007).

Hayes determined that the U.S. Atlantic and Gulf of Mexico population of great hammerhead sharks had experienced and was likely continuing to experience overfishing; in 2005, estimated fishing mortality was between 130% and 220% of F_{MSY}, and the population size in 2005 was between 15% and 11% of N_{MSY}, based on two models (**Figure 5**) (Hayes 2007: 63). Simulations estimated that even with no removals, great hammerhead sharks had only a 56% probability of recovery within 30 years; this estimate, based on available catch data, may be an underestimate because unreported catches would result in a more pessimistic status (Hayes 2007: 66-7).

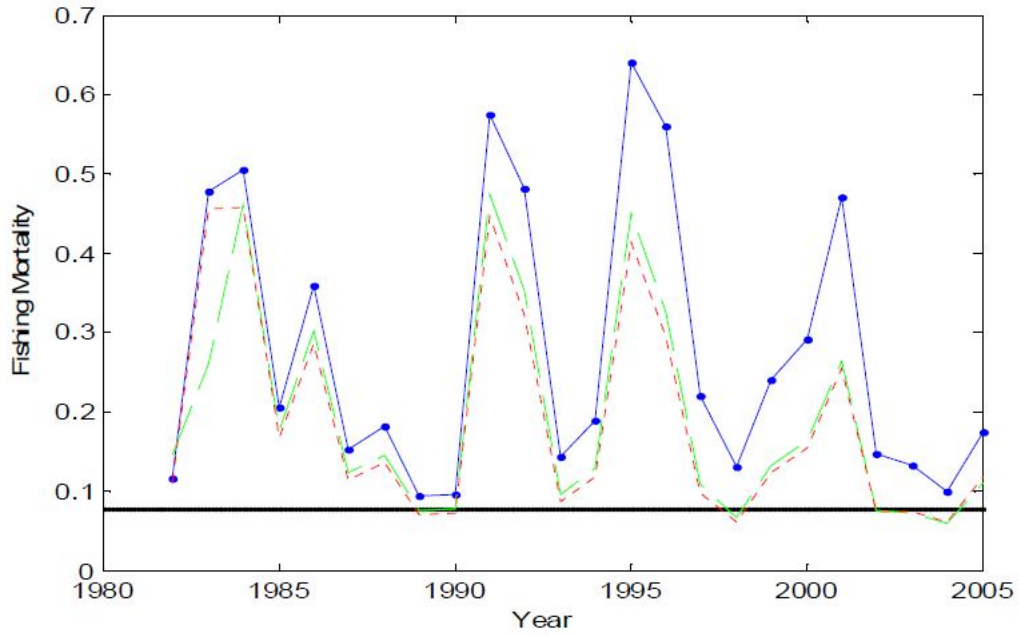


Figure 5. Fishing mortality from 1982 through 2005 for great hammerhead sharks. The solid blue line represents estimated fishing mortality from the Fox model, the long green dotted line represents fishing mortality in the Schaefer model, and the short orange dashed line represents fishing mortality from the Pella-Tomlinson model. F_{MSY} from the Fox model is indicated as a solid horizontal black line (Figure 3.4A. in Hayes 2007).

Hayes (2007) also indicated that decreasing population trends for great hammerhead sharks were more pronounced than those for scalloped hammerhead sharks (**Figure 6**), and that as a result, the composition of hammerhead shark species in the catch has shifted. Whereas great hammerhead sharks used to make up approximately 50% of the hammerhead shark catch in 1982, by 2005 they accounted for only 20% of the catch (**Figure 7**). Scalloped hammerheads, on the other hand, increased from around 30% in 1982 to around 60% in 2005. This may be due to the greater reproductive potential of scalloped hammerhead sharks, which may make them able to withstand fishing pressure better than the less productive great hammerhead shark.

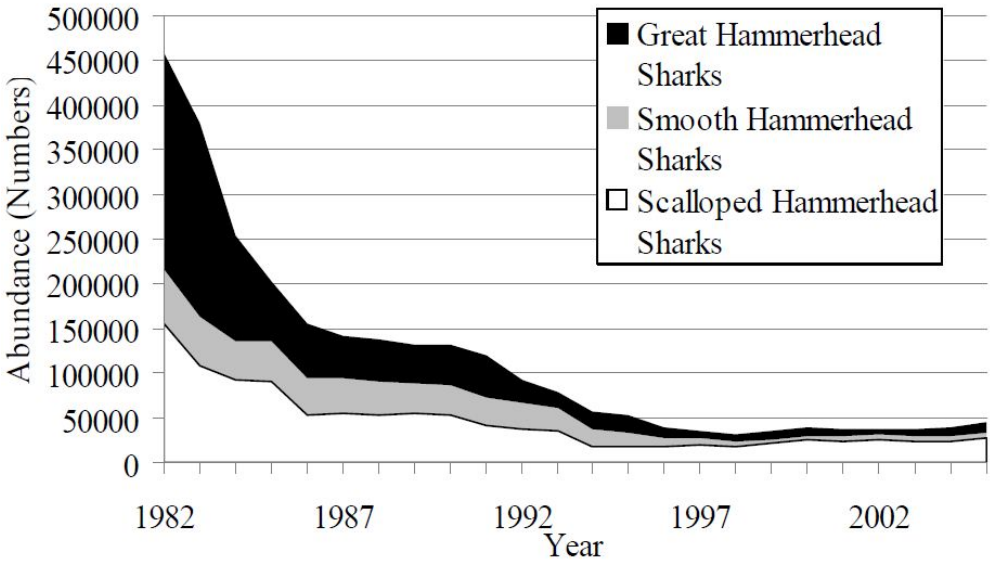


Figure 6. Population abundance estimates of scalloped (white), smooth (grey), and great (black) hammerhead sharks from individual stock assessments (Figure 4.4B. in Hayes 2007).

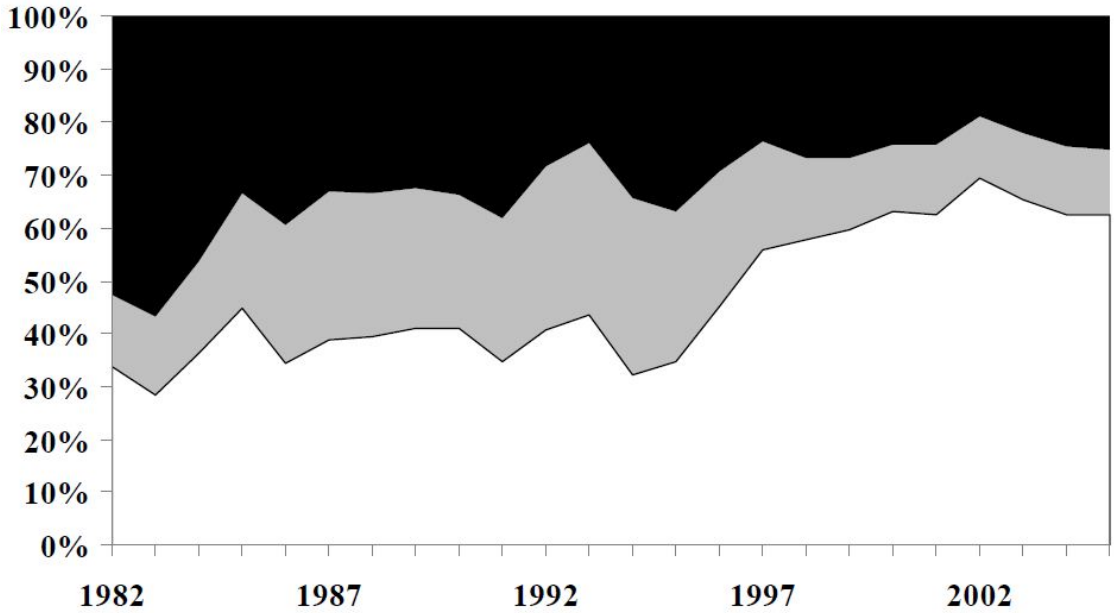


Figure 7. Species composition of the hammerhead shark complex based on individual stock assessments. Using a t-test, significant ($p < 0.01$) trends in changes of proportions of scalloped (white) and great (black) hammerhead sharks exist, and are a little weaker but still significant for smooth (grey) hammerhead sharks ($p = 0.04$) (Figure 4.5. in Hayes 2007).

B. Conservation status

The IUCN has determined that great hammerheads are endangered both as a species and as regional populations (Denham *et al.* 2007). In the northwest Atlantic, this species is considered endangered based on a suspected decline of more than 50% over the past 10 years (Denham *et al.*

2007). This designation for the regional population did not consider the most recent species assessment (Hayes 2007), which only bolsters the determination of endangered status. In the eastern Atlantic (West Africa), these sharks are considered critically endangered because of a suspected population decline of 80% in the last 25 years, and because fisheries in this region remain largely unmonitored and unmanaged (Denham *et al.* 2007). In the southwest Indian Ocean, the sharks are considered endangered based on a 79% decline in catch rates and the active targeting of this species for its fins. And in northern Australia, although population data are considered deficient, the status of great hammerhead sharks is of concern because of a large increase in illegal, unregulated and unreported (IUU) fishing in the recent years (Denham *et al.* 2007).

IV. Identified threats to the species: criteria for listing

A species is endangered under the ESA if it "is in danger of extinction throughout all or a significant portion of its range." *See* 16 U.S.C. § 1532(6). A species is threatened under the ESA if it "is likely to become an endangered species within the foreseeable future." *See id. at* § 1532(20). To determine whether a species is endangered or threatened, NMFS must consider five statutorily prescribed factors:

- The present or threatened destruction, modification, or curtailment of its habitat or range;
- Overutilization for commercial, recreational, scientific, or educational purposes;
- Disease or predation;
- The inadequacy of existing regulatory mechanisms; and
- Other natural or manmade factors affecting its continued existence.

See 16 U.S.C. § 1533(1)(a). The agency must consider each of the listing factors singularly and in combination with the other factors. *See Carlton v. Babbitt*, 900 F. Supp. 526, 530 (D.D.C. 1995). Each factor is equally important and a finding by the Secretary that a species is negatively affected by just one of the factors warrants a non-discretionary listing as either endangered or threatened. *See Nat'l Wildlife Fed. v. Norton*, 386 F. Supp. 2d. 553, 558 (D. Vt. 2005) (*citing* 50 C.F.R. § 424.11(c)). Likewise, a species must be listed if it is endangered or threatened because of a combination of factors. *See, e.g.*, 50 C.F.R. § 424.11(c).

As discussed below, the northwest Atlantic population of great hammerhead sharks – which represents a significant portion of the range of great hammerhead sharks worldwide – is likely to become endangered within the foreseeable future as a result of at least three of the statutorily-prescribed factors.

A. Overutilization for commercial, recreational, scientific, or educational purposes

Overexploitation by way of directed fisheries and bycatch (and high bycatch mortality rates) in fisheries targeting other species has been the primary cause of continuing declines in great hammerhead sharks in the northwest Atlantic (Denham *et al*. 2007; Hayes 2007). According to

the best available scientific evidence, the population of hammerhead sharks in the northwest Atlantic (U.S. Atlantic and Gulf of Mexico) has undergone fishery-related substantial declines, ranging from 72-89%, over the last few decades (Baum *et al.* 2003; Jiao *et al.* 2009; Baum and Blanchard 2010). According to the most recent scientific assessment, the northwest Atlantic DPS of great hammerhead sharks is overfished and undergoing overfishing (Hayes 2007: 63). Hayes (2007) estimated the abundance of the U.S. Atlantic and Gulf of Mexico population of great hammerhead sharks to be less than 10% of the unfished population (Hayes 2007).

1a. Commercial fisheries

In 1982, estimated catches (including commercial catch in the pelagic longline fishery (PLL) targeting tunas and swordfishes) of great hammerhead sharks peaked at approximately 100,000 fish in the U.S. Atlantic and Gulf of Mexico (Hayes 2007: Figure 3.1A & 57-8 (for a discussion of the data on which the figure is based)). Catch in 2005 (recreational and commercial) was estimated to be 1,319 great hammerhead sharks, a decrease due to both population declines (Baum and Blanchard 2010) and increased regulation and reduction in quotas in U.S. shark fisheries (Hayes 2007: Appendix 2A).

In the **U.S. Atlantic PLL fishery** between 1992 and 2005, great hammerhead sharks accounted for 11% of the landings of hammerhead sharks that were identified to species (a total of 850 hammerhead sharks were identified to species; another 442 were unidentified; Baum and Blanchard 2010: Table 1). From 2005 through 2009, on average, 25 vessels/year kept hammerhead sharks, and less than 2 percent of the total PLL trips kept hammerhead sharks (76 FR 53652: 53657). On average, 1,299 hammerhead sharks were caught; an average of 181 of these was landed while an average of 780 was released alive and 350 were discarded dead (76 FR 53652: 53654).

Recent U.S. regulations (discussed below in Section IV.B.) have prohibited or restricted landings of great hammerhead sharks in certain fisheries; however, fishing remains the primary threat to this species, largely because of significant ongoing bycatch and/or bycatch mortality. Moreover, there remain significant directed fisheries internationally, including illegal fisheries, in part fueled by the increasing demand for shark fins.

1b. Recreational fisheries

Reported recreational catches of great hammerhead sharks has varied greatly in recent years – from a low of three sharks in 2010 to a high of 786 in 2007 (NMFS 2012b: Table 3.8). In some years, "unclassified" hammerhead shark catches could add significantly to total great hammerhead sharks recreationally harvested; total unclassified hammerhead shark caught in the recreational fishery ranged as high as > 5,000 sharks (in 2002) (NMFS 2012b: Table 3.8).

2a. Bycatch (discarded catch)

In the U.S. Atlantic and Gulf of Mexico, great hammerhead sharks are taken as bycatch, *i.e.*, catch that is discarded, in a variety of gear types, including PLL, bottom longlines (BLL), and gillnets (**Table 1**) (NMFS 2011).

In 2005-06, estimated bycatch of great hammerhead sharks on **BLL** in the U.S. Atlantic and Gulf of Mexico (*i.e.*, the NMFS Southeast Region; NMFS 2011: 143) was close to 200,000 pounds, the highest level for any hammerhead shark species (**Table 1**).

Table 1. Annual bycatch estimates and coefficients of variation (CVs, where available) of hammerhead sharks for southeast region fisheries. Bycatch estimates are in live pounds or number of individuals, and reflect the average from the years identified. Data were compiled from the most recent U.S. National Bycatch Report (NMFS 2011).

Common Name	Year (s)	Bycatch	Unit	CV	NMFS Region[A]	Fishery
Hammerhead shark	2005	14.7	#		Southeast: Gulf of Mexico	Coastal Migratory Pelagic Troll
	2005-06	730.4	#	129.4	Southeast: Gulf of Mexico	Reef Fish Bottom Longline
	2005-06	6.2	#	36.7	Southeast: Atlantic	Migratory Pelagic Troll
	2005-06	135.6	#	64.1	Southeast: Atlantic	Snapper-Grouper HandLine
Great hammerhead	2005-06	191,774.4	lbs.	0.3	Southeast: Atlantic & Gulf of Mexico	Shark Bottom Longline*
Scalloped hammerhead	2005	139.5	#	1.1	Southeast: Atlantic	Large and Small Coastal Shark Aggregates (Drift, Strike, and Bottom Gillnet)
	2005-06	116,989.2	lbs.	0.4	Southeast: Atlantic & Gulf of Mexico	Shark Bottom Longline*
TOTAL Hammerhead sharks	**2005-06**	**1,026.3, 308,763.5**	**#, lbs.**		**Southeast: Atlantic & Gulf of Mexico**	**All gears**

[A]The NMFS Southeast Region includes eight coastal states (North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas) that border the northwestern Atlantic Ocean and Gulf of Mexico. The Commonwealth of Puerto Rico and the territory of the U.S. Virgin Islands are also included within the Southeast Region's management jurisdiction (NMFS 2011: 143)

*NMFS (2011) notes that bycatch estimates for the shark bottom longline are currently being refined due to discrepancies in the calculation of total effort.

In the **U.S. Atlantic PLL fishery**, logbook data indicate that, between 2005 and 2009, 87 percent of hammerheads caught on PLL were discarded (76 FR 53652: 53654). On an annual basis, an

average of 780 hammerhead sharks was released alive and 350 were discarded dead (76 FR 53652: 53654).

Underreporting of bycatch species in logbooks is a serious concern and inadequate compliance and misreporting contributes to underestimating of the magnitude of the bycatch problem (NMFS 2011: 52). While observer programs are a more reliable source of data, there is still bias in these data (NMFS 2011: 50), and observer coverage occurred relatively recent (starting in 1992 and 1994 for the PLL and BLL fisheries, respectively) and remains limited (5-13% and 4-6% for the PLL and BLL fisheries, respectively) (NMFS 2011: 153, Table 4.2.2). In conjunction with the recognized problem of the recording of great hammerhead sharks in the generic hammerhead shark category, the above bycatch estimates understate the true extent of the bycatch problem.

2b. Bycatch mortality

At-vessel mortality is exceptionally high for all age groups of great hammerhead sharks caught on BLL, the primary source of bycatch for great hammerheads (**Table 1**). Between 1994 and 2005, at-vessel mortality rates of juvenile and adult great hammerhead sharks caught in commercial BLL averaged 93.8%, and were highest with the longest soak time and coldest bottom water temperatures (Morgan and Burgess 2007). In addition, at-vessel mortality rates were extremely high (> 90%) in all age classes (78-330 cm), indicating that great hammerhead sharks would not benefit from size-based regulations (*i.e*., size limits) (Morgan and Burgess 2007). As a result of this exceptionally high capture mortality rate, even when great hammerhead sharks are not directly targeted, virtually any incidental capture of this species, even if promptly released, contributes to fishing mortality.

Information on at-vessel mortality for great hammerhead sharks on PLL is limited, based only on observer and logbook data in limited years and for an aggregated hammerhead shark group. According to these data, at-vessel mortality of hammerhead sharks between 2005 and 2009 was between 23 and 31% (76 FR 53652: 53655, 53657). NMFS does not have estimates of at-vessel mortality of hammerhead sharks by recreational vessels, but believes that it is low (76 FR 53652: 53654).

3. Illegal fisheries

In many parts of the world, lack of regulatory enforcement is a major impediment to conservation of sharks (Biery and Pauly 2012). Lack and Sant (2008) recently compiled an assessment of IUU fishing for sharks from a review of the available literature. The authors found that the hammerhead shark is one of the two most frequently cited shark species taken in illegal fishing. In U.S. waters, illegal take of hammerheads has been recorded off the coast of Texas by Mexican fishermen using gillnets and longlines (Lack and Sant 2008). On the Pacific coast of Costa Rica (at Cocos Island Marine Reserve, known for its hammerhead populations), the majority of illegal fishing of sharks targets great hammerheads, which are typically finned and discarded at sea (Lack and Sant 2008). As recently as 2011, illegal fishing and finning of hammerhead sharks was documented in the Galápagos Marine Reserve, a UNESCO World

Heritage site, demonstrating that despite recent international advances in shark conservation and awareness, illegal fishing is an ongoing problem (Carr *et al*. 2013).

4. Shark fin trade

Hammerhead fins are highly valued because of their large size and high needle count (Abercrombie *et al.* 2005; Dulvy *et al.* 2008; Camhi *et al.* 2009), and can be distinguished by their relatively light color (Clarke *et al*. 2006a). Information on the trade of shark fins in recent decades has been obtained by examining the Hong Kong Fin Market, where trade in fins represented 65-80% of the global market from 1980 to 1990 (Clarke 2008) and 44-59% of the market from 1996 to 2000 (Clarke 2004).

In the Hong Kong shark fin market, great hammerhead shark fins are sold as "Gu Pian" (sometimes mislabeled as "Chun Chi," for scalloped hammerhead) and represent approximately 1.5-1.8% of the fin trade (Clarke *et al.* 2006a). Using commercial data on traded weights and sizes of fins, coupled with DNA and Bayesian statistical analysis to account for missing records, Clarke (*et al.* 2006a, 2006b) estimated that 300,000 to 700,000 great hammerhead sharks, equivalent to a biomass of 20,000-35,000 tons, were being harvested for the fin trade each year, at least as of 2005 (**Figure 8**) (Clarke *et al.* 2006b). Genetic techniques have also been used to determine that substantial proportions of these fins often come from areas where populations are considered endangered by the IUCN (*e.g.*, 21% of scalloped hammerhead fins came from the western Atlantic) (Chapman *et al.* 2009).

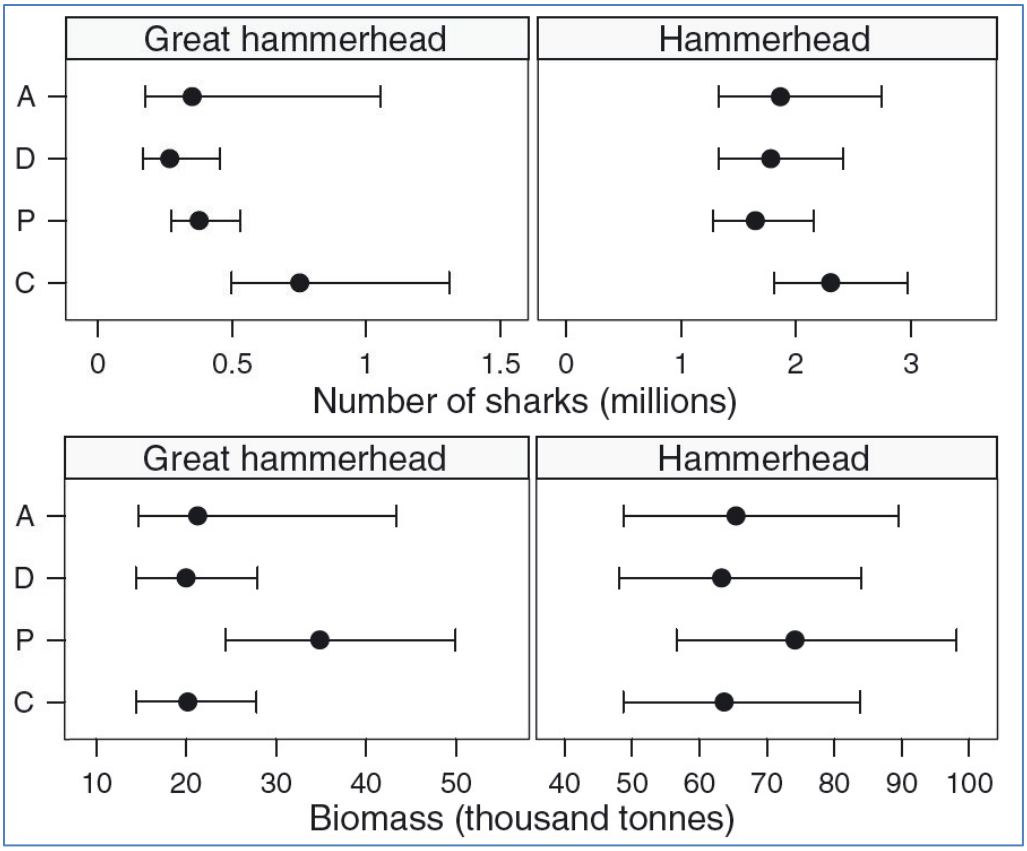


Figure 8. Estimates of the number (top panel) and biomass (bottom panel) of great hammerhead (left) and unspecified hammerhead shark species (right) utilized per year in the shark fin trade worldwide. Medians (circles) and 95% probability intervals (lines) are shown. Fin positions are abbreviated as: dorsal (D), pectoral (P), caudal (C) and all fin positions from a mixture distribution (A). Modified from Clarke *et al.* 2006b.

B. The inadequacy of existing regulatory mechanisms

The catch and harvest of great hammerhead sharks in the northwest Atlantic Ocean, including the Gulf of Mexico, is managed by multiple countries and governmental entities. The existing management measures put in place by these entities have failed to stop the ongoing population decline of the northwest Atlantic DPS of great hammerhead sharks.

1. U.S. regulatory mechanisms - State

In U.S. Atlantic coastal waters, individual states' management of ocean waters from their shorelines to three miles offshore (nine miles in the case of Florida's Gulf of Mexico coastline) is coordinated by the Atlantic States Marine Fisheries Commission (ASMFC) (ASMFC 2008). The ASMFC was formed in 1942 and has the authority, pursuant to the 1993 Atlantic Coastal Fisheries Management Act and its 2000 amendments, 16 U.S.C. Ch. 71 *et seq.*, to develop and implement interstate fishery management plans (FMPs) for inshore fisheries; the FMPs are then administered by state agencies, and the ASMFC helps coordinate such management with

management in federal waters (ASMFC 2009). ASMFC member states are Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida.

As of January 1, 2010, management measures approved by the ASMFC:

- prohibited recreational and commercial anglers from possessing great hammerhead sharks in the state waters of Virginia, Maryland, Delaware and New Jersey from May 15 through July 15—regardless of where the shark was caught;
- prohibited recreational anglers from possessing any shark species that is illegal to catch or land by recreational anglers in federal waters and required the closure of commercial shark fisheries when they are closed in federal waters;
- required that all sharks retained by recreational and commercial anglers have head, tail, and fins attached to their carcasses;
- instituted size limits for retained sharks in recreational fisheries and required the implementation of annually specified possession limits (with some exceptions) in commercial fisheries;
- limited the gear that recreational anglers can use when targeting sharks to handlines and rod and reel; and
- limited the gear that commercial fishers can use to rod and reel, handlines, small mesh gillnets, large mesh gillnets, trawl nets, shortlines, pound nets/fish traps, or weirs (states are required to implement shortline and gillnet bycatch reduction measures) (ASMFC 2008).

Additional requirements in ASMFC states include a prohibition on commercial fishing for large coastal sharks (Connecticut); additional line length restrictions in shark fisheries (North Carolina); and gill net prohibitions (South Carolina and Georgia) (NMFS 2012b: Table 3.1). Florida, effective January 1, 2012, prohibited the commercial harvest, possession and landing of hammerhead sharks (scalloped, smooth and great hammerheads) in state waters (three miles off the Atlantic coast and nine miles off the Gulf coast). Recreational fisheries for these species are allowed to continue, as long as such fisheries are "catch and release."

States bordering the Gulf of Mexico that are not ASMFC member states – Texas, Alabama, Mississippi, and Louisiana – do not have regulations specific to great hammerhead sharks, but do regulate fishing for great hammerhead sharks caught in state waters, three miles off the coastline in Alabama, Mississippi, and Louisiana, and nine miles off Texas (NMFS 2012b: Table 3.1). Alabama and Louisiana have recreational and commercial catch and size limits, Alabama prohibits shark fishing on weekends, and Louisiana requires shark fins to remain attached to shark carcasses until they are landed (NMFS 2012b: Table 3.1). Texas has length, possession and harvest limits for recreational and commercial shark fisheries (NMFS 2012b: Table 3.1). Mississippi has size and possession limits for recreational and commercial shark fisheries and prohibits shark finning (NMFS 2012b: Table 3.1)

2. U.S. regulatory mechanisms - Federal

In the U.S. EEZ, NOAA, through the Highly Migratory Species (HMS) Management Division of NMFS, regulates fishing for great hammerhead sharks. NMFS also regulates tuna, swordfish and billfish fisheries, as well as other shark fisheries, in which great hammerhead sharks may be caught as bycatch.

NMFS Rule Implementing International Commission for the Conservation of Atlantic Tunas
In August 2011, NMFS adopted a rule (76 Fed. Reg. 53652) based on the recommendations (10-08) of ICCAT. This rule prohibits the retention of hammerhead sharks by Atlantic HMS commercially permitted vessels that have PLL gear on board, and recreational fishers fishing with a General Category permit when participating in a HMS tournament or fishing under an HMS Angling or Charter/Headboat permit when tunas, swordfish, and/or billfish are also retained (NMFS 2012b: 3-4). An analysis of the 2005 through 2009 HMS logbook data covering the Atlantic HMS PLL fishery indicates that, on average, a total of 181 hammerhead sharks per year were kept by fishermen using PLL gear (76 FR 53652: 53653), which would mean 20 great hammerhead sharks if catch proportions (*i.e.*, 11% of the catch identified as great hammerhead sharks; **Table 2**, Baum and Blanchard 2010) have been consistent in the past 20 years (and assuming the logbook data is accurate, a major question mark as discussed above). NMFS estimated that prohibiting retention would result in an additional 100 hammerhead sharks released alive annually (76 FR 53652: 53653), or about 11 great hammerhead sharks.

NMFS did not prohibit retention of sharks in fisheries that are not associated with ICCAT fisheries. These include commercial shark BLL, gillnet, or handgear fisheries, and shark recreational fisheries when tunas, swordfish, and billfish are not retained (NMFS 2012b: 3-4). As reported in the most recent U.S. bycatch report (NMFS 2011), great hammerhead sharks make up a substantial proportion of bycatch in BLL and other unregulated gears (including bottom gill net, hand line and drift strike gear) (**Table 1**).

NMFS Shark Finning Rules
NMFS first banned finning of all sharks in the U.S. Atlantic Ocean as part of a 1993 fishery management plan for sharks; the ban was extended by federal law in 2000 (NMFS 2004: 2; Shark Finning Prohibition Act of 2000, Public Law 106-557). According to the prohibition, sharks must be landed whole, with fins attached, by boats fishing in U.S. waters and by vessels registered in the U.S. (but not foreign-registered vessels not fishing in the U.S. Exclusive Economic Zone (EEZ)).

Magnuson-Stevens Fishery Conservation and Management Act (MSA)
NMFS manages federal fisheries in partnership with regional fishery management councils pursuant to the Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. §§ 1801 et seq. National Standard One of the MSA requires that NMFS and councils prevent and end overfishing. Pursuant to Section 304(e) of the statute, when federally-managed fish stocks are declared as overfished or approaching an overfished condition, management measures must be implemented within two years that immediately end overfishing and rebuild the fishery. The measures must include a rebuilding plan that rebuilds the fishery within the shortest time possible, not to exceed ten years with certain limited exceptions.

In 1989, several regional fishery management councils requested that NMFS take the lead in developing a FMP for sharks under its authority (NMFS 1993: 1). In response to that request, NMFS completed the first FMP for sharks in 1993 (NMFS 1993). The plan was renamed the combined FMP for Atlantic Tunas, Swordfish, and Sharks in 1999 and then the Consolidated Atlantic Highly Migratory Species FMP in 2006 (2006 HMS FMP) when the management of billfish was added to the plan (NMFS 1999: 150; NMFS 2006). The great hammerhead shark is managed as one of three hammerhead species (others are scalloped and smooth hammerhead) in the Atlantic Large Coastal Shark Complex (LCS) in 2006 HMS FMP, which includes commercial shark quotas and recreational retention limits.

In 2012, NMFS proposed new management measures via an amendment (draft Amendment 5) to the 2006 HMS FMP (NMFS 2012b). Although a schedule presented in March 2012 indicated that the proposed rule (amendment) and related environmental impact statement would be published in mid-2012 they were not released until November 2012 (NMFS 2012c). This means that the schedule presented in March indicating that a final environmental impact statement would be published in late 2012 or early 2013 and that the rule would be finalized in early 2013 (NMFS 2012b) is no longer accurate.

The law is clear that NMFS may not consider future plans in a decision whether to list a species under the ESA.[2] This is particularly true in situations like that here – where there is significant uncertainty about what conservation measures may be included in Amendment 5 and ongoing delays in the development of Amendment 5.

Moreover, none of the measures proposed in draft Amendment 5 are likely to stop declines in the northwest Atlantic population of great hammerhead sharks. First, draft Amendment 5 is not designed to address the fishing-related mortality of great hammerhead sharks specifically. Rather, it seeks to address overfishing of scalloped hammerhead sharks (*e.g.*, the discussion of the preferred alternative begins with the assessment of scalloped hammerhead sharks in Hayes *et al.* (2009) (NMFS 2012b: 2-8)). For purposes of reducing fishing-related mortality of scalloped

[2] *See Oregon Natural Resources Council v. Daley*, 6 F. Supp. 2d 1139, 1153-55 (D. Or. 1998) (NMFS's decision not to list the Oregon Coast evolutionarily significant unit of coho salmon improperly relied on future and voluntary measures); *Center for Biological Diversity v. Morgenweck*, 351 F. Supp. 2d 1137, 1140 (D. Colo. 2004) ("the law is clear that FWS cannot consider future conservation efforts in its review of the Petition"); *Southwest Center for Biological Diversity v. Babbitt*, 939 F. Supp. 49 (D.D.C 1996) (remanding action to Secretary and instructing him to eliminate the promises of proposed future actions of the Forest Service from the listing determination); *see also* FWS & NMFS, Endangered Species Petition Management Guidance (July, 1996) at 9 (listing must be based on the "here-and-now of a species' current status" and cannot be rejected "on the basis of an unproven promise of future favorable management"); Department of the Interior Fish and Wildlife Service and Department of Commerce National Oceanic and Atmospheric Administration, Policy for Evaluation of Conservation Efforts When Making Listing Decisions, 68 Fed. Reg. 15100-02, 15115 (Mar. 28, 2003) ("conservation efforts that are not sufficiently certain to be implemented and effective cannot contribute to a determination that listing is unnecessary or a determination to list as threatened rather than endangered").

hammerheads, draft Amendment 5's preferred alternative would cap total hammerhead shark landings at levels that represent only a one to two percent decrease from recent annual average landings in both the Atlantic Ocean and the Gulf of Mexico (NMFS 2012b: 4-31). Great and smooth hammerheads are included in the TAC only because of the difficulty in "differentiating among the species, especially when dressed" (NMFS 2012b: 2-8).[3] Draft Amendment 5 contains no discussion or analysis regarding whether and how any of the proposed alternatives will help reduce or end overfishing of great hammerhead sharks and/or rebuild the species.

To similar effect, NMFS offers no assessment of the effects of the proposed increases in recreational size limits on great hammerhead sharks. NMFS bases its proposal to increase the recreational size limit on the size at which female dusky sharks reach reproductive maturity (93 inches, or just under the proposed eight foot size limit), noting that the 96 inch size limit may also benefit scalloped hammerhead sharks because scalloped hammerhead sharks larger than 96 inches are rarely caught recreationally and because female scalloped hammerheads also reach maturity at less than 96 inches (at approximately 78 inches) (NMFS 2012b: 2-17; 4-10). Female great hammerhead sharks, by contrast, mature at 250 to 300 cm (98 – 118 inches) and grow to at least 550 cm (18 feet) (Ebert & Stehmann 2013: 274). Moreover, great hammerhead sharks are the largest species of hammerhead shark, growing to average sizes of 286.7 cm (about 112 inches) for males and 307.8 cm (about 121 inches) for females (Hueter *et al.* 2007; Piercy *et al.* 2010).

In addition, the approach in draft Amendment 5 overlooks the nature of the hammerhead shark fishery, in which NMFS has indicated that hammerhead sharks appear to be retained more as incidental catch than as a directly targeted species in the fisheries in which they are captured (NMFS 2012a: 45).[4] Although draft Amendment 5 subtracts a current estimate of discards from the catch limit (NMFS 2012b: 2- 9) before allocating the remainder among different fisheries, it fails to evaluate that hammerhead shark discards will likely increase over time as fishermen respond to the new catch limit by discarding hammerheads they catch. The discard (at-vessel) mortality rates for hammerhead sharks in BLL fisheries are extremely high – often well over 90 percent (NMFS 2012a: 24; Morgan and Burgess 2007).

3. International regulatory mechanisms

The harvest of great hammerhead sharks in the northwest Atlantic Ocean outside of U.S. waters and ICCAT fisheries is generally allowed. Limited exceptions are Mexico's ban, instituted in

[3] In the HMS logbooks and coastal fisheries logbooks (CFL), fishermen typically report "unidentified hammerhead sharks" and do not list the individual hammerhead shark species (NMFS 2012b: 4-23).

[4] Hammerhead sharks do not appear generally to be targeted in the Gulf of Mexico and Atlantic Ocean. According to CFL data from 2008 – July 2011, approximately 16 percent of the total shark catch reported was made up of all hammerhead sharks (smooth and great hammerhead landings combined are, in recent years, generally between 1/3 and 1/2 of scalloped hammerhead landings in the U.S. waters) (NMFS 2012a: 45; NMFS 2012b: Tables 2.13-2.16). These landings mainly come from fishing trips using BLL and gillnet gear, and suggest that hammerhead sharks are retained more as incidental catch than as a directly targeted shark species in those fisheries (NMFS 2012a: 45).

2011, on shark fishing from May-August each year and the Bahamas' ban on all shark fishing, as well as sale and trade in shark products (HSI 2013; Shark Savers UD). Shark finning has been prohibited in Mexico since 2007 (Shark Savers UD), and by ICCAT (in accordance with the 5% rule)[5] in northwest Atlantic Ocean tuna fisheries since 2004 (Shark Savers UD).

ICCAT

In 2010, ICCAT adopted ICCAT Recommendation 10-08 which prohibits the retention, transshipping, landing, storing, or selling of hammerhead sharks in the family Sphyrnidae (except for *Sphyrna tiburo*) caught in association with ICCAT fisheries (NMFS 2012b: 3-4).

The Convention on Trade in Endangered Species (CITES)

One hundred and seventy five countries are parties to CITES, an international treaty designed to control and regulate international trade in certain animal and plant species that are or may be threatened with extinction (NMFS 2012b: 3-4, 3-5). Listed species are included in Appendices to CITES, and parties meet every two to three years to consider amendments to the lists of species in Appendices I and II and other issues (NMFS 2012b: 3-4, 3-5). CITES indicates that an Appendix II listing is appropriate where a species may become threatened with extinction unless trade is closely controlled and may include "look-alike species," *i.e.*, species of which the specimens in trade look like those of species listed for conservation reasons (*see* Article II, paragraph 2 of the Convention). International trade in specimens of Appendix II species may be authorized by export permits or re-export certificates (*see* Article IV of the Convention).

In 2010, the U.S. and Palau proposed the scalloped, great, and smooth hammerhead sharks for listing on CITES Appendix II (CITES CoP15 2010). While the proposal received support from a majority of Parties, it did not receive the two-thirds' majority required for adoption (Los Angeles Times 2010). In 2012, Costa Rica listed the scalloped hammerhead shark in CITES Appendix III, thereby requiring CITES export permits for all scalloped hammerhead products leaving Costa Rica, and a certificate of origin for scalloped hammerhead imports from all other CITES Parties. In March 2013, Brazil, Costa Rica, and Honduras successfully proposed listing scalloped hammerhead sharks, and "look-alike species" great and smooth hammerhead sharks for listing on CITES Appendix II (CITES CoP16 2013). The effective inclusion of these hammerhead sharks in CITES Appendix II will be delayed 18 months due to required resolution of technical and administrative issues.

United Nations' Convention on the Law of the Sea

While the great hammerhead shark is listed on Annex I, Highly Migratory Species, of the United Nations' Convention on the Law of the Sea, urging international cooperation and management of this species, no such management yet exists (Denham *et al.* 2007).

[5] The majority of current international shark finning regulations are ratio-based, *i.e.*, landed weight of fins may not exceed 5% of carcass weight. However, a recent study shows that this 5% level is insufficient for many species, including great hammerhead sharks (Biery and Pauly 2012). The mean (± standard error) wet-fin-to-round-mass ratio for great hammerhead shark is 1.96%, which means that a 5% ratio would allow fishers to land extra shark fins without needing to keep or report the carcasses, and without consequences (Biery and Pauly 2012).

C. Other natural or manmade factors affecting the great hammerhead shark's continued existence

1. Global climate warming

Global climate warming poses additional threats to the continued existence of the great hammerhead shark population in the northwest Atlantic. According to NMFS (2009: 74 Fed, Reg. 29344, 29356), "[s]ince the 1970s, there has been a historically significant change in climate (Greene *et al.* 2008). Climate warming has resulted in increased precipitation, river discharge, ocean temperatures, and glacial and sea-ice melting (Greene *et al.* 2008)." The Intergovernmental Panel on Climate Change (IPCC) (2007) has concluded that global warming caused by humans is already impacting the habitats and life history of species worldwide. Furthermore, such effects are occurring faster than scientists had previously predicted (Boesch *et al.* 2007). Impacts of global climate warming on northwest Atlantic great hammerhead sharks will be largely indirect, such as the result of food web disruptions, adverse modification of nursery and adult habitat, and distributional shifts that will impact vulnerability to fishing mortality.

Between 1948 and 1998, global ocean temperatures increased by 0.31° C on average in the upper 300 m (Levitus *et al.* 2000). Locally, some ocean regions are experiencing even greater warming (Bindoff *et al.* 2007). Notably, the largest increases in global ocean temperature have occurred in the upper ocean where primary production is concentrated and warming appears to be affecting global ocean productivity (Behrenfeld *et al.* 2006). The IPCC (2007: 275) stated that it has a high level of confidence that "[r]egional changes in the distribution and productivity of particular fish species are expected due to continued warming and local extinctions will occur at the edges of ranges." In a recent NMFS study, clear shifts in spatial distribution were linked to ocean temperatures in multiple fish stocks on the northeast U.S. continental shelf (Nye *et al.* 2009: 124). Twenty-four of the 36 stocks studied displayed statistically significant changes consistent with warming, as indicated by a poleward shift in the center of biomass, an increase in mean depth of occurrence, and/or an increase in mean temperature of occurrence (Nye *et al.* 2009: 124). As mentioned above, great hammerhead sharks occur in tropical and warm temperate waters, preferring water temperatures of 13 to 29 °C (Grace and Henwood 1997; Hoffmayer *et al.* 2011). As ocean temperatures warm, changing water temperature distributions may affect the sharks' migratory range, including shifts in their preferred breeding, nursery, and foraging habitats. Furthermore, because of the influence of temperature as a migratory and reproductive cue (Castro *et al.* 1999; Bester 2012; Hoffmayer *et al.* 2011; Ebert and Stehmann 2013), increased temperatures may alter reproductive timing and possibly reproductive success (Kerr *et al.* 2009).

Shifts in spatial distribution of great hammerhead sharks also threaten to undermine management. First of all, a shift (*e.g.*, northern expansion) of the shark's range may expose the species to increased bycatch threats from additional fisheries. Distributional shifts will also decrease the efficacy of existing and proposed management measures (including quotas and time/area closures) unless these measures are flexible and linked to up-to-date distribution data.

In addition, global climate warming poses a threat to habitats used by great hammerhead sharks. These include both the coral reef habitats (*e.g.*, coral atolls, lagoons, and island terraces) where great hammerhead sharks roam and feed, as well as the shallow bays and coastal waters they use as nursery areas (FFWCC 2012). Global warming is already adversely impacting coastal and coral reef ecosystems along the U.S. Atlantic coast. Specifically, climate warming has lead to increased incidences of coral bleaching and other thermal stress, disease, damage from storms, and algal overgrowth, among other detrimental effects (Hughes 1994; Hoegh-Guldberg *et al.* 2007; Alvarez-Filip *et al.* 2009). Climate warming is also causing increased precipitation in many coastal estuarine systems, including the eastern U.S. (Wake and Markham 2005: 16-17; Kerr *et al.* 2009). Greater precipitation results in greater discharges of nutrient pollution into rivers, estuaries and out to coastal waters, leading to increased eutrophication and hypoxic conditions (Howarth *et al.* 2006). Further, global warming increases the occurrence of and/or severity of hypoxic conditions in estuaries, bays, and rivers (Boesch *et al.* 2007). These effects have been accelerating in recent years and are expected to continue to accelerate (Howarth *et al.* 2006). These climate-related threats to coastal habitats like bays and coral reefs in the northwest Atlantic will likely limit the quantity and quality of habitats for great hammerhead sharks.

Ocean surface warming as a result of global climate warming is also believed to have caused recent sharp declines in phytoplankton levels, which are down by 40% since the 1950s (Beherenfeld *et al.* 2006; Borenstein 2010). A sustained decline of phytoplankton threatens the health of the entire marine food web that depends on forage fish species to convert energy from zooplankton and phytoplankton to sustain larger predatory species. As an apex predator, the great hammerhead shark is particularly vulnerable to reductions in the productivity and carrying capacity of marine ecosystems.

The ability of the great hammerhead shark to adapt to climate change and other threats is limited by the species' low natural intrinsic rate of population increase. While exploitation is the primary threat to this inherently vulnerable shark, the threats associated with climate warming substantially increase the risk of extinction for great hammerhead sharks in the northwest Atlantic.

V. Requested Listing

NMFS must list a species as "threatened" under the ESA if the species is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." See 16 U.S.C. § 1532(20).

Appropriate Time Frames

In choosing a time frame, *e.g.*, what is the "foreseeable future" in which a species is likely to become endangered for classification purposes, NMFS must choose a time frame that is reasonable, given the species' characteristics and the nature of the threats. *Cf.* Black's Law Dictionary, 8th ed. 2004 (definition of foreseeable is "reasonably anticipatable"). The time frame should also ensure protection of the petitioned species, and give the benefit of the doubt regarding any scientific uncertainty to the species.

The time frame for great hammerhead shark should be similar to that used for other long-lived species. Because fishing mortality and global warming are the foremost threats to great hammerhead shark, NMFS should also use a timeframe that is appropriate for such impacts. The minimum time period that meets these criteria is 100 years.

The 100 year time frame has been used for fish with shorter lifespans, such as Columbia River steelhead, Chinook salmon, and, most recently, the Gulf of Maine DPS of Atlantic Salmon (NMFS 2009: 74 Fed. Reg. 29344, 29356). Courts have approved the use of the 100 year timeframe for multiple other species as well. *See Western Watersheds Project v .United States Fish and Wildlife Service*, 535 F. Supp. 2d 1173, 1184 (D. Id. 2007) (To be a "threatened species under the ESA, the sage-grouse must be likely 'to be in danger of extinction' within 100 years"); *Southwest Center for Biological Diversity v. Norton*, 2002 WL 1733618, at *12 (D.D.C. July 29, 2002) (for the Queen Charlotte goshawk, the FWS determined that the goshawk would be "threatened" if at any point in the next 100 years there is a 20% chance that the species would become extinct); *Western Watersheds Project v. Foss*, 2005 WL 2002473, at *15 (D. Id., Aug. 19, 2005) (court ruled that FWS's decision not to list a plant with 64 percent chance of extinction within 100 years as threatened was untenable).

The IUCN species classification system also uses a timeframe of 100 years. For example, a species must be classified as "vulnerable" under the IUCN system if there is a probability of extinction of at least 10% within 100 years. Further, a species must be listed as "endangered" if the probability of extinction is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).

Most recently, NMFS defined the year 2100 as the foreseeable future in proposed listing determinations for 82 candidate coral species (77 FR 73220: 73226). This was based on NMFS agreement with a scientific review committee's "judgment that the threats related to global climate change (e.g., bleaching from ocean warming, ocean acidification) pose the greatest potential extinction risk to corals and have been assessed with sufficient certainty out to the year 2100." (77 FR 73220: 73226).

In planning for species recovery, agencies also routinely consider a 75-200 year foreseeable future threshold (Suckling 2006). For example, the FWS used 100 years in connection with recovery of the Steller's Eider (*e.g.*, the Alaska-breeding population of the species will be considered for delisting from threatened status when it has <1% probability of extinction in the next 100 years, and certain populations have <10% probability of extinction in 100 years and are stable or increasing) and 200 years in connection with recovery of the Utah prairie dog, and NMFS used 150 years in connection with the recovery of the Northern right whale (Suckling 2006).

Perhaps most importantly, the time period that NMFS uses in its listing decision must be long enough so that actions can be taken to ameliorate the threats to the petitioned species and prevent extinction. For all these reasons, Petitioner recommends a minimum of 100 years as the time frame for analyzing the threats to the continued survival of great hammerhead shark.

Significant Portion of Its Range
A "significant portion of [a species'] range" (SPOIR) can include both current and historical habitat. *See, e.g., Northwest Ecosystem Alliance v. United States Fish and Wildlife Serv.,* 475 F.3d 1136, 1148 (9th Cir. 2007) ("major geographical areas in which it is no longer viable but once was"), *citing Defenders of Wildlife v. Norton*, 258 F.3d 1136, 1145 (9th Cir. 2001). A danger of extinction to a species within a SPOIR is sufficient to require listing. 16 U.S.C. § 1532(6); *Defenders*, 258 F.3d at 1141-42.

Cumulative Impacts of Stressors
Consistent with the ESA's requirements, while each factor and each individual stressor may be discussed separately, they must be considered together in making listing decisions. To only consider them "piecewise, one or two at a time . . . is flawed because the interaction among components may yield critical insight into the probability of extinction. . . . the synergism among processes – such as habitat reduction, inbreeding depression, demographic stochasticity, and loss of genetic variability – is exactly what will be overlooked by viewing only the pieces." *Boyce* (1992: 495-6); *see also Western Watersheds Project v. Fish and Wildlife Serv.*, 535 F. Supp. 2d 1173, 1179 (D. Id. 2007) ("It is the cumulative impacts of the disturbances, rather than any single source, [that] may be the most significant influence on the trajectory of sagebrush ecosystems."). NMFS has considered cumulative risk in prior listing determinations (NMFS 2009: 74 Fed. Reg. 29344, 29382-83).

A. The Northwest Atlantic Great Hammerhead Shark DPS Should be Listed as a Threatened Species

For the reasons set forth in this petition, NMFS should list the northwest Atlantic DPS of great hammerhead sharks as a threatened species because this DPS is likely to become endangered in the foreseeable future throughout all or a significant portion of its range. The precipitous and sustained decline of the northwest Atlantic DPS of great hammerhead sharks despite efforts to stabilize this population indicate that it is necessary to use the protections available under the ESA to save and recover this population.[6]

B. The Great Hammerhead Shark Should be Listed as a Threatened Species Because It Is Likely to Become Endangered Within the Foreseeable Future in a Significant Portion of Its Range.

In the alternative, NMFS should designate the great hammerhead shark as threatened because the species is threatened throughout a significant portion of its range – throughout the habitat of the northwest Atlantic population of great hammerhead sharks, an area spanning the eastern coastline of the U.S. and adjacent ocean waters and the Gulf of Mexico. For the reasons discussed above, this area constitutes a significant portion of the species' range in which the species is likely to become an endangered species within the foreseeable future.

[6] Similar concerns recently led NMFS to issue a positive ESA 90-day finding on a Petition for the morphologically similar, geographically congruous, and equivalently imperiled scalloped hammerhead shark (76 FR 72891).

VI. Recovery Plan Elements

NMFS should establish a recovery plan for the great hammerhead sharks in the northwest Atlantic Ocean that addresses fishing-related mortality, particularly resulting from bycatch, climate change, and other key threats, and including the following components:

- Changes in fisheries management, including improved bycatch monitoring, gear changes and restrictions, time/area closures, and bycatch caps;

- Research aimed at reducing bycatch and bycatch mortality, including research relating to gear modifications;

- Measures to address the current and future effects of global warming on great hammerhead sharks, including measures to protect coastal habitats used as nursery and foraging areas; and

- Enhanced implementation and enforcement of fishery restrictions.

VII. Critical Habitat Designation

Petitioner requests the designation of critical habitat for great hammerhead sharks in the northwest Atlantic Ocean concurrent with the requested listings, as required by 16 U.S.C. § 1533(b)(6)(C). *See also* 16 U.S.C. § 1533(a)(3)(A). Critical habitat should encompass all coastal and marine habitats in which great hammerhead shark are known to forage and reproduce.

Critical habitat is defined by Section 3 of the ESA as: (i) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species. *See* 16 U.S.C. § 1532(5).

The designation and protection of critical habitat is one of the primary ways to achieve the fundamental purpose of the ESA, "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." *See* 16 U.S.C. § 1531(b). In adding the critical habitat provision to the ESA, Congress clearly saw that species-based conservation efforts must be augmented with habitat-based measures: "It is the Committee's view that classifying a species as endangered or threatened is only the first step in insuring its survival. Of equal or more importance is the determination of the habitat necessary for that species' continued existence . . . If the protection of endangered and threatened species depends in large measure on the preservation of the species' habitat, then the ultimate effectiveness of the

Endangered Species Act will depend on the designation of critical habitat." *See* House Committee on Merchant Marine and Fisheries, H.R. Rep. No. 887, 94th Cong. 2nd Sess. at 3 (1976).

The great hammerhead shark will benefit from the designation of critical habitat in all of the ways described above. Designated critical habitat will allow NMFS to identify reasonable and prudent alternatives to activities that are impeding recovery but not necessarily causing immediate jeopardy to the continued survival of the species. For these reasons and as already stated, we request critical habitat designation concurrent with species listing.

VIII. Conclusion

For all of the reasons discussed in this petition, NMFS should list the northwest Atlantic DPS of great hammerhead shark as a threatened species under the ESA. In the alternative, NMFS should list great hammerhead shark as threatened because it is likely to become endangered in the foreseeable future throughout a significant portion of its range.

IX. Literature Cited

Abercrombie, D.L., Clarke, S.C., and M.S. Shivji. 2005. Global-scale genetic identification of hammerhead sharks: application to assessment of the international fin trade and law enforcement. Conservation Genetics 6: 775–788. Available at: http://nsuweb.acast.nova.edu/ocean/ghri/forms/abercrombie05.pdf

Alvarez-Filip, L., Dulvy, N.K., Gill, J.A., Côté, I.M., and A.R. Watkinson. 2009. Flattening of Caribbean coral reefs: region-wide declines in architectural complexity. Proceedings of the Royal Society B 276: 3019-3025. Available at: http://rspb.royalsocietypublishing.org/content/276/1669/3019.full.

Atlantic States Marine Fisheries Commission (ASMFC). 2008. Interstate Fisheries Management Plan for Coastal Sharks. Available at: http://www.asmfc.org/speciesDocuments/coastalSharks/fmps/interstateFMPforAtlanticCoastalSharks.pdf.

ASMFC. 2009. Interstate Fisheries Management Program Charter. Available at: http://www.asmfc.org/.

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

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

Behrenfeld, M.J., O'Malley, R.T., Siegel, D.A., McClain, C.R., Sarmiento, J.L., Feldman, G.C., Milligan, A.J., Falkowski, P.G., Letelier, R.M., and E.S. Boss. 2006. Climate-driven trends in contemporary ocean productivity. Nature 444: 752-755.

Bester, C. 2012. Ichthyology at the Florida Museum of Natural History: Great Hammerhead. Available at: http://www.flmnh.ufl.edu/fish/gallery/descript/greathammerhead/ghammerhead.html.

Biery, L., and D. Pauly. 2012. A global review of species-specific shark-fin-to-body-mass ratios and relevant legislation. Journal of Fish Biology **80**: 1643–1677.

Bindoff, N.L., J. Willebrand, V. Artale, A, Cazenave, J. Gregory, S. Gulev, K. Hanawa, C. Le Quéré, S. Levitus, Y. Nojiri, C.K. Shum, L.D. Talley and A. Unnikrishnan. 2007. Observations: Oceanic Climate Change and Sea Level. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)] (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 2007). Available at: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch5.html

Boesch, D. F., Coles, V.J., Kimmel, D.G. and W.D. Miller. 2007. Coastal Dead Zones and Global Climate Change: Ramifications of Climate Change for Chesapeake Bay Hypoxia. Excerpted from the full report, Regional Impacts of Climate Change: Four Case Studies in the United States. Prepared by University of Maryland Center for Environmental Science for the Pew Center on Global Climate Change.

Camhi, M.D., Valenti, S.V., Fordham, S.V., Fowler, S.L. and C. Gibson. 2009. The Conservation Status of Pelagic Sharks and Rays: Report of the IUCN Shark Specialist Group Pelagic Shark Red List Workshop. IUCN Species Survival Commission Shark Specialist Group. Newbury, UK. x + 78p. Available at: http://cmsdata.iucn.org/downloads/ssg_pelagic_report_final.pdf

Carr, L.A., Stier, A.C., Fietz, K., Montero, I., Gallagher, A.J., and J.F. Bruno. 2013. Illegal shark fishing in the Galápagos Marine Reserve. Marine Policy 39: 317-321.

Castro, J.I., Woodley, C.M., and R.L. Brudek. 1999. A preliminary evaluation of the status of shark species. FAO Fisheries Technical Paper. No. 380. Rome, Italy. 72p. Available at: http://www.fao.org/docrep/003/X2352E/x2352e00.htm

Chapman, D.D., Pinhal, D., and Shivji, M.S. 2009. Tracking the fin trade: genetic stock identification in western Atlantic scalloped hammerhead sharks *Sphyrna lewini*. Endangered Species Research 9: 221-228. Available at: http://www.int-res.com/articles/esr2009/9/n009p221.pdf.

Convention on International Trade in Endangered Species of Wild Fauna and Flora: Fifteenth meeting of the Conference of the Parties (CITES CoP15). 2010. Prop. 15: Proposal to include Hammerhead, Sandbar, and Dusky Sharks in Appendix II. Fifteenth meeting of the Conference of Parties, 13-25 March 2010. Available at: http://www.cites.org/eng/cop/15/prop/E-15-Prop-15.pdf.

Convention on International Trade in Endangered Species of Wild Fauna and Flora: Sixteenth meeting of the Conference of the Parties (CITES CoP16). 2013. Prop. 43: Proposal to include Scalloped Hammerhead, Great Hammerhead and Smooth Hammerhead in Appendix II. Sixteenth meeting of the Conference of Parties, 3-14 March 2013. Available at: http://www.cites.org/eng/cop/16/prop/E-CoP16-Prop-43.pdf

Clarke, S. 2004. Understanding pressures on fishery resources through trade statistics: a pilot study of four products in the Chinese dried seafood market. Fish and Fisheries 5: 53-74.

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

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

Clarke, S.C., McAllister, M.K., Milner-Gulland, E.J., Kirkwood, G.P., Michielsens, C.G., Agnew, D.J., Pikitch, E.K., Nakano, H., and M.S. Shivji. 2006b. Global estimates of shark catches using trade records from commercial markets. Ecology Letters **9** (10): 1115-1126.

Compagno, L.J.V. 1984. FAO species catalog. Vol 4. Sharks of the world. An annotated and illustrated catalog of shark species known to date. Part 2. Carcharhiniformes. FAO Fisheries Synopsis 125: 251-655. Available at: http://www.fao.org/docrep/009/ad123e/ad123e00.htm

Cortés, E., Brooks, L., and G. Scott. 2002. Stock assessment of large coastal sharks in the U.S. Atlantic and Gulf of Mexico. Sustainable Fisheries Division Contribution SFD-02/03-177. NOAA, National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City, FL. 133 pp.

Denham, J., Stevens, J., Simpfendorfer, C.A., Heupel, M.R., Cliff, G., Morgan, A., Graham, R., Ducrocq, M., Dulvy, N.D, Seisay, M., Asber, M., Valenti, S.V., Litvinov, F., Martins, P., Lemine Ould Sidi, M., Tous, P. and D. Bucal. 2007. *Sphyrna mokarran. In*: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>. Downloaded on 13 March 2012. Available at: http://www.iucnredlist.org/apps/redlist/details/39386/0.

Dulvy, N.K., Baum, J.K., Clarke, S., Compagno, L.J.V., Cortes, E., Domingo, A., Fordham, S., Fowler, S., Francis, M.P., Gibson, C., Martinez, J., Music, J.A., Soldo, A., Stevens, J.D. and S. Valenti. 2008. You can swim but you can't hide: the global status and conservation of oceanic pelagic sharks and rays. Aquatic Conservation: Marine and Freshwater Ecosystems 18: 459-482. Online at: http://www.dulvy.com/publications/2008/Dulvy_etal_2008_AC_pub.pdf

Ebert, D.A., and M.F.W. Stehmann. 2013. Sharks, batoids, and chimaeras of the North Atlantic. FAO Species Catalogue for Fishery Purposes. No. 7. Rome, FAO. 523 pp. Available at: http://www.fao.org/docrep/017/i3178e/i3178e.pdf

Federal Register (76 FR 53652). 2011. Atlantic Highly Migratory Species; Atlantic Shark Management Measures. FR Vol. 76, No. 228 (29 August 2011), p. 53652-53658. Available at: http://www.gpo.gov/fdsys/pkg/FR-2011-08-29/pdf/2011-21732.pdf

Federal Register (76 FR 72891). 2011. Endangered and Threatened Wildlife; 90-Day Finding on a Petition to List the Scalloped Hammerhead Shark as Threatened or Endangered Under the Endangered Species Act. FR Vol. 76, No. 228 (28 November 2011), p. 72891-72896. Available at: http://www.nmfs.noaa.gov/pr/pdfs/fr/fr76-72891.pdf

Federal Register (77 FR 73220). 2012. Endangered and Threatened Wildlife and Plants: Proposed Listing Determinations for 82 Reef-Building Coral Species; Proposed Reclassification of Acropora palmata and Acropora cervicornis From Threatened to Endangered; Proposed Rule. FR Vol. 77, No. 236 (7 December 2012), p. 73220-73262. Available at: http://www.gpo.gov/fdsys/pkg/FR-2012-12-07/pdf/FR-2012-12-07.pdf

Florida Fish and Wildlife Conservation Commission (FFWCC). 2012. Great Hammerhead Shark. Available at: http://myfwc.com/research/saltwater/sharks-rays/shark-species/great-hammerhead/.

Grace, M., and T. Henwood. 1997. Assessment of the distribution and abundance of coastal sharks in the U.S. Gulf of Mexico and eastern seaboard, 1995 and 1996. Marine Fisheries Review 59: 23-32. Available at: http://aquaticcommons.org/9813/1/mfr5944.pdf

Greene, C.H., Pershing, A.J., Cronin, T.M., and N. Ceci. 2008. Arctic climate change and its impacts on the ecology of the North Atlantic. Ecology 89: S24-S38.

Hammerschlag, N., Gallagher, A.J., Lazarre, D.M., and C. Slonim. 2011. Range extension of the Endangered great hammerhead shark *Sphyrna mokarran* in the Northwest Atlantic: preliminary data and significance for conservation. Endangered Species Research 13: 111-116. Available at: http://www.rjd.miami.edu/scientific-publications/pdf/Hammerschlag%20et%20al.%202011.%20ESR.pdf.

Hayes, C.G. 2007. Investigating single and multiple species fisheries management: stock status evaluation of hammerhead (*Sphyrna* spp.) sharks in the western North Atlantic Ocean and Gulf of Mexico. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Master's thesis. 114 p. Available at: http://scholar.lib.vt.edu/theses/available/etd-01182008-105214/unrestricted/Hayes_Thesis_FINAL.pdf

Hayes, C.G., Jiao, Y., and E. Cortés. 2009. Stock Assessment of Scalloped Hammerheads in the Western North Atlantic Ocean and Gulf of Mexico. North American Journal of Fisheries Management 29: 1406-1417.

Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K., Knowlton, N., Eakin, C.M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R.H., Dubi, A., and M.E. Hatziolos. 2007. Coral reefs under rapid climate change and ocean acidification. Science 318: 1737–1742. Available at: http://www.eeb.cornell.edu/harvell/Site/2007_files/HoeghGulberg07.pdf.

Howarth, R.W., Swaney, D.P., Boyer, E.W., Marino, R., Jaworski, R. and C. Goodale. 2006. The influence of climate on average nitrogen export from large watersheds in the Northeastern United States. Biogeochemistry 79: 163-186.

Hueter, R., G. Cailliet, J. Musick, G. Burgess, J. Tyminski, D. Ebert, D. Grubbs and C. Conrath. 2007. Highly migratory shark fisheries research by the National Shark Research Consortium, 2002-2007. Mote Marine Laboratory Technical Report No. 1241. 122 p. Available at: http://www.flmnh.ufl.edu/fish/sharks/nsrc/nsrc_fiveyearreport.pdf

Hughes, T.P. 1994. Catastrophes, phase-shifts, and large scale degradation of a Caribbean coral reef. Science 265: 1547–1551. Available at: http://bio.classes.ucsc.edu/bio160/Bio160readings/Catastrophes,%20Phase%20Shifts.pdf.

Humane Society International (HSI). 2013. Shark Conservation: A Timeline. Available at: http://www.hsi.org/issues/shark_finning/timelines/shark_conservation_timeline.html.

International Panel on Climate Change (IPCC). 2007. Fourth Assessment Report: Climate Change 2007. Available at: http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html

Jiao, Y., Hayes, C., and E. Cortés. 2009. Hierarchical Bayesian approach for population dynamics modelling of fish complexes without species-specific data. ICES Journal of Marine Science 66: 367-377. Available at: http://icesjms.oxfordjournals.org/content/66/2/367.full.pdf

Kerr, L.A., Connelly, W.J., Martino, E.J., Peer, A.C., Woodland, R.J. and D.H. Secor. 2009. Climate Change in the U.S. Atlantic Affecting Recreational Fisheries. Reviews in Fisheries Science 17: 267-289.

Kohler, N.E., Casey, J.G., and P.A. Turner. 1998. NMFS Cooperative Shark Tagging Program, 1962-93: An Atlas of Shark Tag and Recapture Data. Marine Fisheries Review 60: 1-87.

Lack, M. and G. Sant. 2008. Illegal, unreported and unregulated shark catch: A review of current knowledge and action. Department of the Environment, Water, Heritage and the Arts and TRAFFIC. Canberra, Australia. 62 p.

Levitus, S., Antonov, J.I., Boyer, T.P., and C. Stephens. 2000. Warming of the world ocean. Science 287: 2225-2229.

Los Angeles Times. 2010. Protection for hammerhead and oceanic whitetip sharks rejected at CITES meeting, March 24, 2010. L.A. Unleashed, L.A. Times blogs. Available at: http://latimesblogs.latimes.com/unleashed/2010/03/protection-for-hammerhead-and-oceanic-whitetip-sharks-rejected-at-cites-meeting.html

Morgan, A., and G.H. Burgess 2007. At-vessel fishing mortality for six species of sharks caught in the northwest Atlantic and Gulf of Mexico. Gulf and Caribbean Research **19** (2): 123-129.

Myers, R.A., Baum, J.K., Shepherd, T.D., Powers, S.P. and C.H. Peterson. 2007. Cascading Effects of the Loss of Apex Predatory Sharks from a Coastal Ocean. Science 315: 1846-1850. Available at: http://www.nceas.ucsb.edu/~baum/Julias_NCEAS_Website/publications_files/Myers_Baum_etal_2007_Science.pdf

National Marine Fisheries Service (NMFS). 1993. Fishery Management Plan for Sharks of the Atlantic Ocean. Available at: http://www.nmfs.noaa.gov/sfa/hms/FMP/SHK_FMP/SHK_FMP_1993.pdf.

NMFS. 1999. Final Fisheries Management Plan for Atlantic Tunas, Swordfish, and Sharks. Available at: http://www.nmfs.noaa.gov/sfa/hms/FMP/TunSwoShk_FMP.htm.

NMFS. 2004. 2004 Report to Congress Pursuant to the Shark Finning Prohibition Act of 2000 (Public Law 106-557). Available at: http://www.nmfs.noaa.gov/sfa/domes_fish/ReportsToCongress/SharkFin04.pdf.

NMFS. 2006. Final Consolidated Atlantic Highly Migratory Species Fishery Management Plan. Available at: http://www.nmfs.noaa.gov/sfa/hms/FMP/Consolidated_FMP.htm.

NMFS. 2009. Determination of Endangered Status for Gulf of Maine Distinct Population Segment of Atlantic Salmon, 74 Fed. Reg. 29344 (Jun. 19, 2009) (to be codified at 50 C.F.R. Parts 17 and 224).

NMFS. 2011. U.S. National Bycatch Report. *Edited by* W. A. Karp, L. L. Desfosse, and S. G. Brooke. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-F/SPO-117C, 508 p. Available at: http://www.nmfs.noaa.gov/by_catch/bycatch_nationalreport.htm

NMFS. 2012a. Predraft Amendment 5 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan. Available at: http://www.nmfs.noaa.gov/sfa/hms/FMP/AM5.htm.

NMFS. 2012b. Draft Amendment 5 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan. Available at: http://www.nmfs.noaa.gov/sfa/hms/FMP/am5_draft/amendment_5_deis_111512.pdf.

NMFS. 2012c. Predraft Presentation of Amendment 5 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan. March 2012. Available at: http://www.nmfs.noaa.gov/sfa/hms/Advisory%20Panels/AP2012/Spring/a5_predraft_presentation.pdf.

Nye, J.A., Link, J.S., Hare, J.A. and W.J. Overholtz. 2009. Changing Spatial Distribution of Fish Stocks in Relation to Climate and Population Size on the Northeast United States Continental Shelf. Marine Ecology Progress Series 393: 111-129.

Piercy, A.N., Carlson, J.K., and M.S. Passerotti. 2010. Age and growth of the great hammerhead shark, *Sphyrna mokarran*, in the north-western Atlantic Ocean and Gulf of Mexico. Marine and Freshwater Research 61: 992–998.

Shark Savers. UD. Laws Protecting Sharks. Available at: http://www.sharksavers.org/en/our-programs/shark-sanctuaries/learn-more/laws-protecting-sharks.

Sherman, K. and G. Hempel. (Editors). 2008. The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya. Available at: http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=178:unep-lme-report&catid=39:reports&Itemid=62.

Wake, C. and A. Markham. 2005. Indicators of Climate Change in the Northeast. Clean Air - Cool Planet Report. Available at: http://www.cleanair-coolplanet.org/information/pdf/indicators.pdf.