PETITION TO LIST THE
Scalloped Hammerhead Shark (*Sphyrna lewini*)
UNDER THE U.S. ENDANGERED SPECIES ACT
Either Worldwide or as one or more Distinct Population Segments

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Petition Submitted to the U.S. Secretary of Commerce, Acting through the National Oceanic and Atmospheric Administration and the National Marine Fisheries Service

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INTRODUCTION

Petitioners WildEarth Guardians and Friends of Animals request the Secretary of Commerce, acting through the National Marine Fisheries Service[1] (NMFS), an agency within the National Oceanic and Atmospheric Administration (NOAA), to list the scalloped hammerhead shark (*Sphyrna lewini*) as "threatened" or "endangered" under the U.S. Endangered Species Act (ESA) (16 U.S.C. §§ 1531-1544). We request that NMFS list the species (1) throughout its entire range or, alternatively (2) as five distinct population segments (DPS's) under the ESA representing each subpopulation of the species. The five subpopulations, any of which might qualify for listing as a DPS, include the Eastern Central and Southeast Pacific, the Eastern Central Atlantic, the Northwest and Western Central Atlantic, the Southwest Atlantic, and the Western Indian Ocean.[2] Finally, we request designation of critical habitat for the species in U.S. waters.

The scalloped hammerhead is a coastal and semi-pelagic fish, living in both coastal and offshore waters in tropical and sub-tropical regions. Populations of the species occur worldwide, but all are in decline. The International Union for Conservation of Nature (IUCN) lists scalloped hammerhead as "endangered" on the IUCN Red List (IUCN Red List 2010a, Exhibit 1 at 1). The IUCN also classifies the five subpopulations of the species: the Eastern Central and Southeast Pacific subpopulation is assessed as "endangered" (IUCN Red List 2010b, Exhibit 2 at 1), the Eastern Central Atlantic subpopulation is classified as "vulnerable" (IUCN Red List 2010c, Exhibit 3 at 1), the Northwest and Western Central Atlantic subpopulation is considered "endangered" (IUCN Red List 2010d, Exhibit 4 at 1), the Southwest Atlantic subpopulation as "vulnerable" (IUCN Red List 2010e, Exhibit 5 at 1), and the Western Indian Ocean

[1] Recently renamed National Oceanic and Atmospheric Administration Fisheries Service.
[2] A sixth DPS of scalloped hammerhead might exist off the coast of Australia, but data on this population is incomplete.

subpopulation is classified as "endangered" (IUCN Red List 2010f, Exhibit 6 at 1). In the alternative to listing the species under the ESA worldwide, we request that NMFS list each, or any, of these discrete and significant subpopulations as DPS's. The locations and other particular factors affecting each of these subpopulations are discussed *infra*.

There are three main threats to the scalloped hammerhead. The first and most serious threat is overutilization for commercial and recreational purposes. The primary cause of the species' decline is exploitation by fishing. Second, the lack of adequate regulatory mechanisms has allowed exploitation of the species to continue unchecked. Finally, other natural or manmade factors such as low reproductive rates make the shark more susceptible to exploitation and human population growth, threatening the continued survival of this species.

PETITIONERS

WildEarth Guardians is a nonprofit environmental advocacy organization that works to protect wildlife, wild places and wild waters in the United States. The organization has more than 12,000 members and supporters and maintains offices in New Mexico, Colorado and Arizona.

Friends of Animals is a nonprofit, international animal advocacy organization. Incorporated in the state of New York since 1957, the group advocates for the interests of animals in living free, on their own terms.

ENDANGERED SPECIES ACT

Congress enacted the ESA in order to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered species and threatened species…" (16 U.S.C. §

1531(b)). Section 3 of the ESA (16 U.S.C. § 1532), defines key terms in the Act. Those relevant to this petition include:

1. § 1532(16) "The term 'species' includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature."

2. § 1532(6) "The term 'endangered species' means any species which is in danger of extinction throughout all or a significant portion of its range ..."

3. § 1532(20) "The term 'threatened species' means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

A species must satisfy at least one of five listing criteria in order to qualify for listing as a "threatened" or "endangered" species under the ESA. Section 4 of the ESA (16 U.S.C. § 1533(a)(1)), sets forth the five listing factors:

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

Considering these factors, the scalloped hammerhead or any of the five DPS's of the species, may qualify as "threatened" or "endangered" due to: (B) overutilization for commercial and recreational purposes, (D) the inadequacy of existing regulatory mechanisms, and (E) other factors, including low reproductive rates causing higher risk of overutilization. The scalloped hammerhead is highly imperiled from these threats and could become extinct worldwide or extirpated in more or more of the DPS's in the foreseeable future.

CRITERIA FOR DISTINCT POPULATION SEGMENTS

Species may qualify for protection under the ESA regionally as DPS's. Analysis of scalloped hammerhead populations indicates that the Eastern Central and Southeast Pacific,

Eastern Central Atlantic, Northwest and Western Central Atlantic, Southwest Atlantic, and the Western Indian Ocean subpopulations qualify for protection as DPS's according to the ESA. NMFS and the U.S. Fish and Wildlife Service have jointly published principles for defining a DPS (61 Fed. Reg. 4722 (Feb. 7, 1996)). A species must be a vertebrate that is discrete from other populations of the species and significant to the species. These terms are defined as follows:

> *Discreteness*: A population segment of a vertebrate species may be considered discrete if it satisfies either one 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. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
> 2. It is delimited by international governmental boundaries within which differences 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 Act.
>
> *Significance*: If a population segment is considered discrete under one or more of the above conditions, its biological and ecological significance will then be considered in light of Congressional guidance…that the authority to list DPS's be used''…sparingly'' while encouraging the conservation of genetic diversity. In carrying out this examination, the Services will consider available scientific evidence of the discrete population segment's importance to the taxon to which it belongs. This consideration may include, but is not limited to, the following:
> 1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon,
> 2. Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon,
> 3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range, or
> 4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.
>
> (Id. at 4725).

Although these guidelines are "non-regulatory" and serve only as policy guidance for the agencies, NMFS is committed to using these criteria for evaluating DPS's described in this petition (Id. at 4723).

SPECIES CLASSIFICATION AND TAXONOMY

Common Name. *Sphyrna lewini* is known by the common names "cornuda," "cornuda común," and "scalloped hammerhead" ("Sphyrna lewini" ITIS online database, Exhibit 7 at 1). In this petition it is referred to as "scalloped hammerhead."

Taxonomy. The petitioned species is *Sphyrna lewini*. The full taxonomic classification is shown in Table 1.

Table 1. Taxonomy of *Sphyrna lewini*

Kingdom	Animalia
Phylum	Chordata
Subphylum	Vertebrata
Class	Chondrichthyes
Subclass	Elasmobranchii
Superorder	Euselachii
Order	Carcharhiniformes
Family	Sphyrnidae
Genus	*Sphyrna*
Species	*lewini*

Source: Integrated Taxonomic Information System (www.itis.gov), Exhibit 7 at 1

SPECIES DESCRIPTION

The scalloped hammerhead is the second largest hammerhead shark, with a maximum total length of about 12 to 13.8 feet (370 to 420 centimeters). Males mature at 4.6 to 5.4 feet (140 to 165 centimeters) and reach at least 9.7 feet (295 centimeters), while females mature at about 7 feet (212 centimeters) and reach at least 10.1 feet (309 centimeters). At birth, pups average 1.38 to 1.8 feet (42 to 55 centimeters) in length (Compagno 1984, Exhibit 8 at 546).

The body of the shark is fusiform, or spindle-shaped, with a large first dorsal fin and low second dorsal and pelvic fins ("Scalloped Hammerhead--*Sphyrna lewini*" NOAA NEFSC,

Exhibit 9 at 1). The rear margin of the pectoral fins is straight, with ventral tips dusky in adults and occasionally black in juveniles (Id.). The front teeth of the scalloped hammerhead are straight, while the rest have oblique cusps (unlike the great hammerhead, which has serrated teeth) (Id.).

Distinctive Features

The scalloped hammerhead can be distinguished from other hammerheads by its unique head. Like all hammerheads, the scalloped hammerhead has an elongated head, with eyes and nostrils on the lateral ends. The scalloped hammerhead has a central indentation of the head, followed by two more, one on each side of the center ("Scalloped Hammerhead" FMNH, Exhibit 10 at 3). This gives the head a "scalloped" appearance (Figure 1).

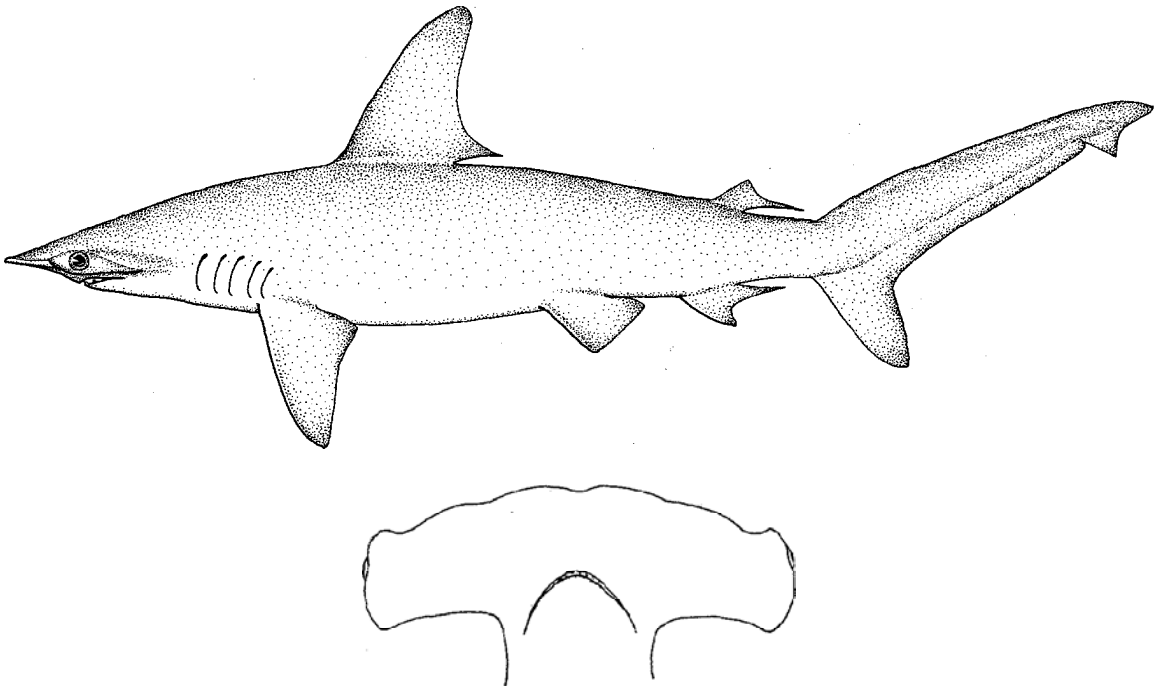


Figure 1. Sketch of Scalloped Hammerhead
Source: Compagno 1984, Exhibit 8 at 545

The coloration of the scalloped hammerhead ranges from a brownish-gray to bronze color on its back, with a white underside ("Scalloped Hammerhead" FMNH, Exhibit 10 at 5 (Figure 2). The ends of the head are slightly swept back, and the mouth is broadly arched (Id. at 3).

Figure 2. The Scalloped Hammerhead
Source: NOAA

GEOGRAPHIC DISTRIBUTION

The scalloped hammerhead is a circumglobal species, living in temperate and tropical seas along coastal zones and in deep water adjacent to them (Compagno 1984, Exhibit 8 at 546). Scalloped hammerheads rarely venture into waters cooler than 22˚ C (72˚ F) ("Scalloped Hammerhead--*Sphyrna lewini*" NOAA NEFSC, Exhibit 9 at 1). Populations occur in portions of the Atlantic, Pacific and Indian oceans (IUCN Red List 2010a, Exhibit 1 at 2-3).

In the Atlantic, the species lives in waters from New Jersey to Uruguay, including the Gulf of Mexico and the Caribbean; and in the eastern Atlantic, it ranges from the Mediterranean and Senegal to the Democratic Republic of the Congo (formerly Zaire) (Compagno 1984, Exhibit 8 at 546; IUCN Red List 2010a, Exhibit 1 at 2). Three DPS's of scalloped hammerhead may be found in the Atlantic Ocean. Populations in the Pacific occur in Thailand, Vietnam,

Indonesia, China, Japan, Philippines, Australia, and New Caledonia (IUCN Red List 2010a, Exhibit 1 at 2). In the eastern Pacific, the scalloped hammerhead ranges from southern California (including the Gulf of California) to Panama, Ecuador, and northern Peru, and includes waters off Hawaii and Tahiti (Id. at 3). Finally, in the Indian Ocean, the species exists from South Africa, Maldives and the Red Sea to Pakistan, India, and Myanmar (Id. at 2) (Figure 3). Scalloped hammerhead in the Pacific and Indian oceans may comprise one DPS each.

Fishing crews have found scalloped hammerheads in the following United Nations Food and Agriculture ("FAO") Fishing Areas: 21, 31, 34, 41, 47, 51, 57, 61, 71, 77, and 87 (CITES CoP15 Prop. 15, Exhibit 11 at 4).

While the scalloped hammerhead occurs throughout the world, recent studies found genetic distinctions between the Northwest Atlantic, Caribbean Sea, Southwest Atlantic, Eastern Central Atlantic and Indo-Pacific populations, effectively dividing the species into more discrete regional groups (Chapman et al. 2009, Exhibit 12 at 222). Genetic distinction among populations is an important factor for considering both a population's discreteness and significance under the DPS policy (61 Fed. Reg. 4722 (Feb. 7, 1996)). Genetic distinction is a measure of discreteness because it indicates if and to what extent populations are interbreeding. Genetic distinction is also an indication of a given population's significance, as measured by the importance of that population to the species as a whole.

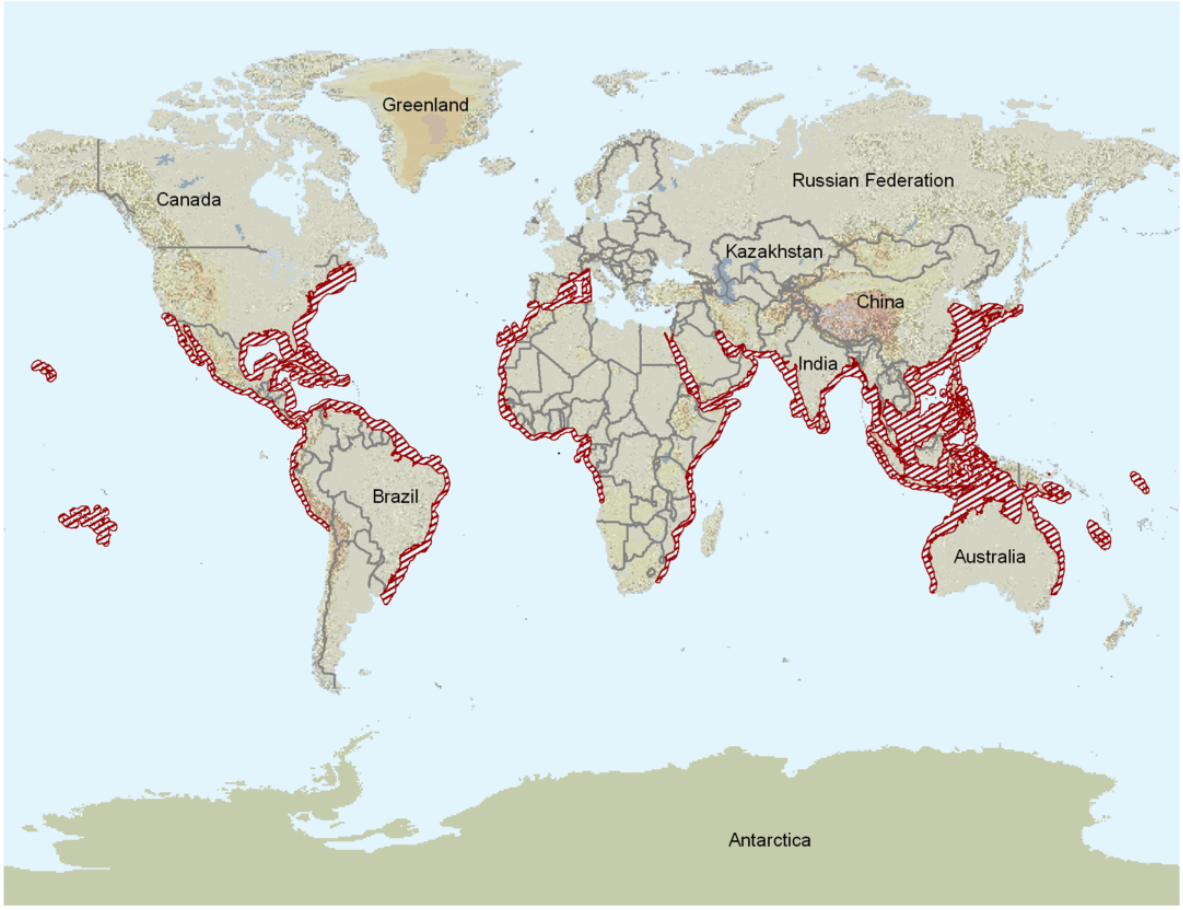


Figure 3. Global distribution of the Scalloped Hammerhead
Source: IUCN Red List 2010a, Exhibit 1 at 3

HABITAT

The scalloped hammerhead is a coastal and semi-oceanic pelagic shark. The species is found over continental and insular shelves, as well as ranging into adjacent deep water (CITES CoP15 Prop. 15, Exhibit 11 at 4). Scalloped hammerheads range from intertidal inshore areas and estuaries to offshore waters up to depths of 900 feet (275 meters) ("Scalloped Hammerhead" FMNH, Exhibit 10 at 2).

LIFE HISTORY

The scalloped hammerhead is a long-lived species, with the oldest known individuals estimated at 30.5 years, for both males and females (Piercy et al. 2007, Exhibit 13 at 34).

Reproduction and Dispersal

The scalloped hammerhead is viviparous, with eggs hatching inside the body of the female and receiving nourishment from a yolksac placenta (Compagno 1984, Exhibit 8 at 546). Gestation occurs over a 9-12 month period, until the females move inshore to give birth during summer months. Compared to other species of sharks, the scalloped hammerhead has relatively large litters, anywhere between 15 and 31 pups (Compagno 1984, Exhibit 8 at 546; IUCN Red List 2010a, Exhibit 1 at 4). Predation on the pups is high, primarily by other sharks and adult scalloped hammerheads, perhaps explaining the species' larger litter size relative to other sharks (IUCN Red List 2010a, Exhibit 1 at 4). Despite its relatively high reproductive rate, the species struggles to recover from exploitation compared to other shark species (CITES CoP15 Prop. 15, Exhibit 11 at 3).

Reports differ on when the scalloped hammerhead reaches sexual maturity. Studies in the Gulf of Mexico have estimated that males mature at 10 years and females at 15 (Bransletter 1987, Exhibit 14 at 167). However, estimates obtained in the Taiwanese Pacific show males maturing at 3.8 years and females at 4.1 years (Chen et al. 1990, Exhibit 15 at 166). These different estimates may not reflect actual biological differences, however, but might be simply a result of using different methods of determining scalloped hammerhead age (IUCN Red List 2010a, Exhibit 1 at 5).

Juveniles live in inshore areas, migrating out to deeper waters as they grow. Adults are known to aggregate at seamounts and islands (CITES CoP15 Prop. 15, Exhibit 11 at 4). Adults occur alone, in pairs, or in small schools, while juveniles gather in large schools (Figure 4) ("Scalloped Hammerhead" FMNH, Exhibit 10 at 3).

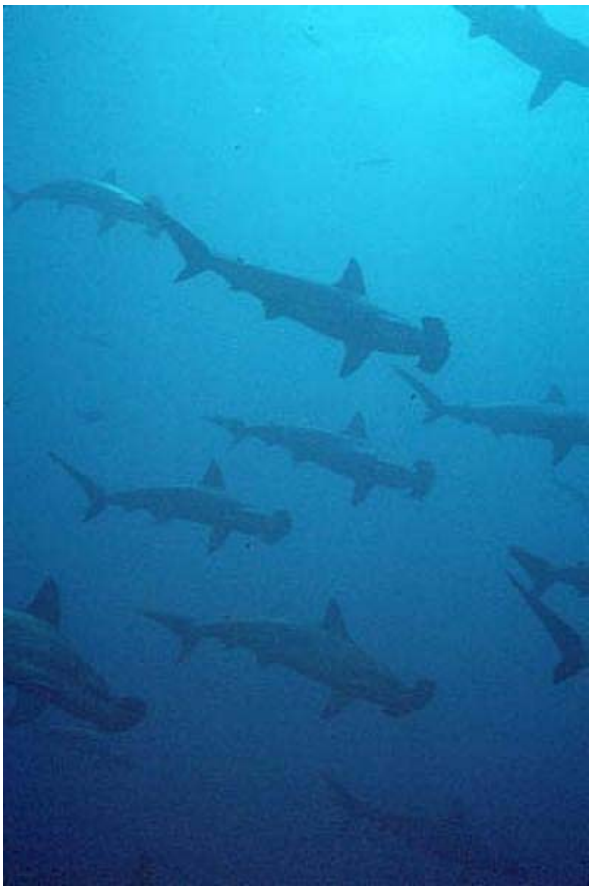


Figure 4. School of Scalloped Hammerheads
Photo: U.S. Geological Survey

Diet

Adult scalloped hammerheads feed on mesopelagic fish and squid, preferring stingrays in some areas (IUCN Red List 2010a, Exhibit 1 at 4-5). Compagno, in the United Nations Food and Agriculture Organization (FAO) species catalogue, provided a detailed account of prey species of the scalloped hammerhead:

> the scalloped hammerhead takes a wide variety of fish prey, but also invertebrates (especially cephalopods). Food items include sardines and herring, anchovies, ten-pounders (Elopidae), conger eels, milkfish, sea catfish, silversides, halfbeaks, mullet, lizardfish, barracuda, bluefish, Spanish mackerel, jacks, porgies, mojarras, cardinal fishes, goatfish, grunts, damselfishes, parrotfishes, wrasses, butterfly fishes, surgeonfish, gobies, flatfish, sharpnose sharks (*Rhizoprionodon*), blacktip reef sharks, angelsharks, stingrays, squid, octopi, cuttlefishes, sea snails, shrimp, mantis shrimp, crabs, lobsters, and isopods.

(Compagno 1984, Exhibit 8 at 546).

ECOLOGICAL ROLE

Most sharks, including the scalloped hammerhead, play an important role in maintaining oceanic ecosystems as apex predators. Ecosystem stability and biodiversity, a main goal of the ESA, could seriously suffer from the removal of a top predator (Camhi et al. 1998, Exhibit 16 at 18).

POPULATION STATUS AND TRENDS

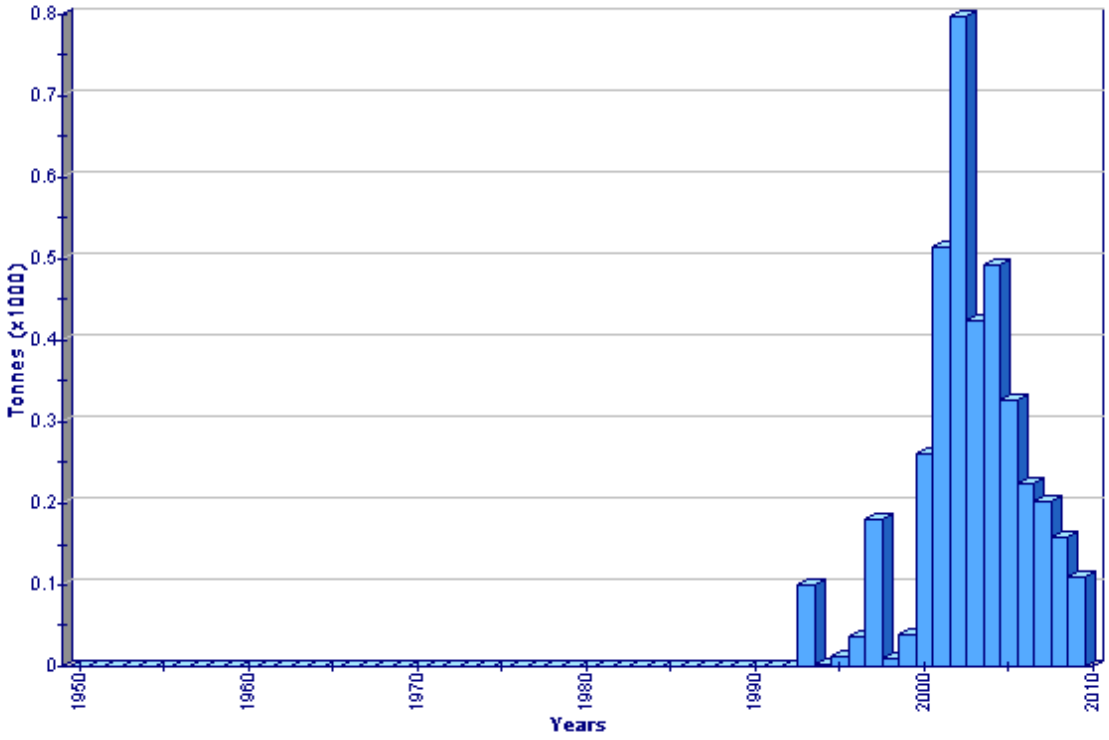
Exact estimates of the global population of scalloped hammerheads do not exist. Nevertheless, the IUCN recognizes imperiled subpopulations of the scalloped hammerhead in the Eastern Central and Southeast Pacific, the Eastern Central Atlantic, the Northwest and Western Central Atlantic, the Southwest Atlantic, and the Western Indian Ocean (IUCN Red List 2010a, Exhibit 1 at 1). Recent studies show that the Northwest Atlantic, Caribbean Sea, and Southwest Atlantic populations are genetically distinct from each other, as well as from the Eastern Central Atlantic, Indian Ocean, and Pacific populations (Chapman et al. 2009, Exhibit 12 at 222).

The IUCN classifies the scalloped hammerhead as an "endangered" species globally. According to the IUCN, an endangered species faces a "very high risk of extinction in the wild" (Red List Categories 2001, Exhibit 17 at 14). The IUCN recognizes a species as "endangered" when it has sufficient evidence that it meets at least one of the criteria showing severe population decline (Id. at 18-20).

Commercial fishing applies tremendous pressure on scalloped hammerhead numbers and is largely responsible for the species' global decline. Commercial fishing operations both target the species and unintentionally capture it as bycatch (IUCN Red List 2010a, Exhibit 1 at 1). The fishing methods most often used are trawls, purse seines, gillnets, fixed bottom longlines, pelagic longlines, and inshore artisanal fisheries. The schooling habits exhibited by scalloped

hammerheads render them vulnerable to capture in high numbers by these methods, especially pups and juveniles (Id.). Concentrated fishing pressure can rapidly deplete regional populations of the species (Id.). Scientists expect scalloped hammerheads to have a low resilience to exploitation based on analysis of the species' life history (Maguire et al. 2006, Exhibit 18 at 25). The FAO recently presented data showing a peak in reported catch in 2002 (Figure 5). These data confirm a drastic decline in reported scalloped hammerhead take since the 2002 peak, which is indicative of falling population numbers (FAO Species Fact Sheets, Exhibit 19 at 2-3) with the same or even greater fishing effort (see *infra* at pages 15, 18).

Figure 5. Catches of Scalloped Hammerhead
Source: FAO Species Fact Sheets, Exhibit 19 at 3-4



The FAO report is not the only source showing tremendous decline in scalloped hammerhead caught since 2002. Maguire notes the same peak in reported numbers of multiple

species of hammerhead sharks caught around 2002 (Maguire et al. 2006, Exhibit 18 at 25) (Figure 6). While not as current, these data also show a similarly sharp decline in sharks taken in the years following the 2002 peak (with no reported change in fishing effort).

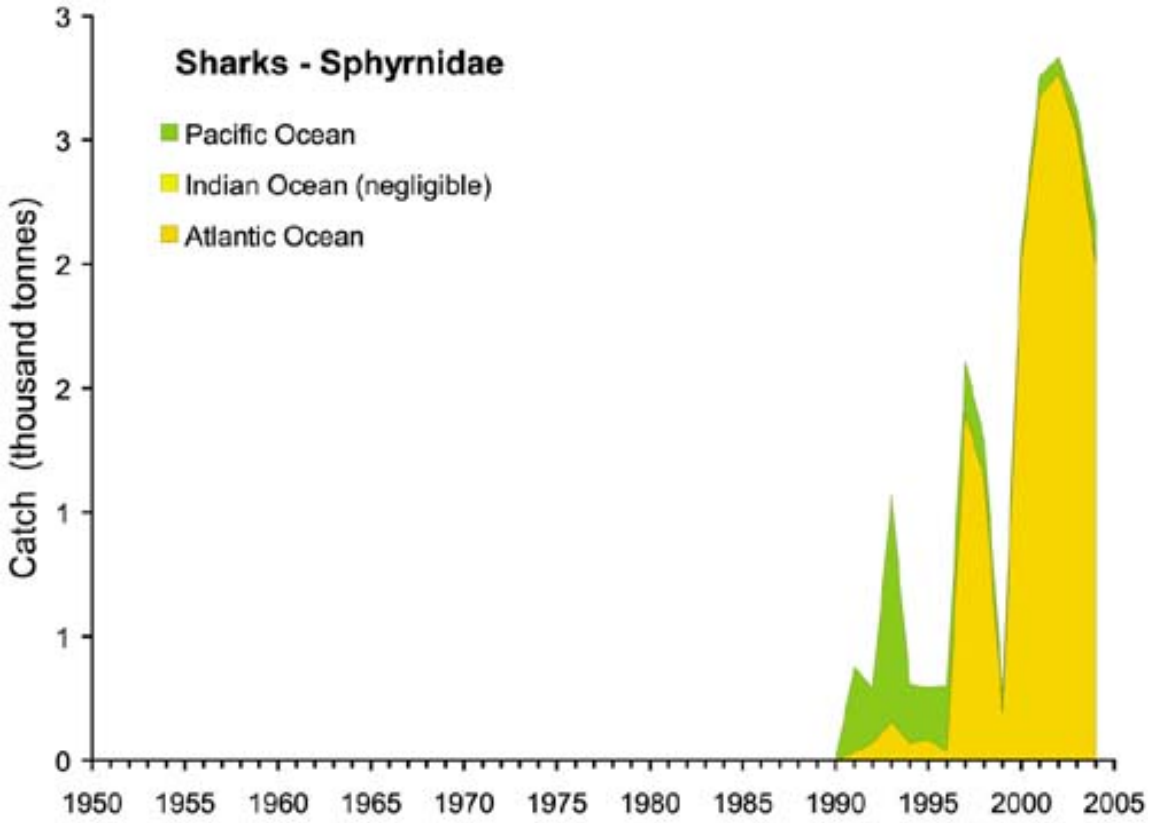


Figure 6. Catches of hammerhead, bonnethead and scoophead sharks (family Sphyrnidae)
Source: Maguire et al. 2006, Exhibit 18 at 25

In addition to classifying the global population of the scalloped hammerhead as an endangered species, IUCN also recognizes five subpopulations, each with its own individual classification.

Eastern Central and Southeast Pacific Subpopulation

IUCN classifies the scalloped hammerhead as endangered in the Eastern Central and Southeast Pacific portion of its range (IUCN Red List 2010b, Exhibit 2 at 1). Fisheries target juveniles and pups throughout this range, leading to heavy exploitation. The species is easily

targeted by commercial fishers due to the aggregating tendencies of adults and the use of historic nurseries (Id.).

Specific information for scalloped hammerhead in this particular region is unavailable, but informal observations and overall shark estimates are available. Reports from divers and tourists in the Galapagos Islands indicate a severe decrease in the number of sharks observed, as well as a decrease in the sightings of hammerhead schools (Id.). Reports from Costa Rica's exclusive economic zone (EEZ) for catch rates of pelagic sharks, including scalloped hammerhead, from 1991-2000 show a decrease of 60 percent (CITES CoP15 Prop. 15, Exhibit 11 at 7). In Ecuador, concern has grown over illegal fishing around the Galapagos. Because the fins of the scalloped hammerhead are highly valuable in worldwide markets, experts expect that a large portion of this illegal fishing targets scalloped hammerheads (IUCN Red List 2010b, Exhibit 2 at 1).

These decreases are not due to a reduced fishing effort, but rather population decline. In 1991, 27 percent of the total catch in Costa Rica included pelagic sharks. In 2003, pelagic sharks constituted less than 5 percent of the total catch, with less than 0.1 percent consisting of scalloped hammerheads. Between 2004 and 2006, the number of scalloped hammerheads landed by artisanal longline and drift net fleets (which account for 80 percent of shark landings) dropped by nearly half (CITES CoP15 Prop. 15, Exhibit 11 at 7).

Eastern Central Atlantic Subpopulation

The Eastern Central Atlantic subpopulation is one of two that the IUCN has separately classified as "vulnerable" rather than "endangered." According to the IUCN, a vulnerable species faces a "high risk of extinction in the wild" (Red List Categories 2001, Exhibit 17 at 14). The IUCN recognizes a species as "vulnerable" when it has sufficient evidence that it meets at least

one of the criteria showing significant population decline (Id. at 21-23). Data for this particular subpopulation are unavailable (IUCN Red List 2010c, Exhibit 3 at 1). However, estimates of population trends in this region are likely similar to populations in the Northwest Atlantic, as fishing pressures are similar and commercial fleets tend to shift between the two (Zeeberg et al. 2006, Exhibit 21 at 192; Buencuerpo et al. 1998, Exhibit 22 at 684). Notably, IUCN has assessed the larger hammerhead species *Sphyrna mokarran*, which has virtually disappeared, as "critically endangered" in the same area. (IUCN Red List 2010c, Exhibit 3 at 1). This could lead to even more fishing pressure on the scalloped hammerhead, which is already in decline.

Northwest and Western Central Atlantic Subpopulation

The IUCN classifies the Northwest and Western Central Atlantic subpopulation of scalloped hammerhead as "endangered." This population ranges from the coasts of New Jersey to the Caribbean (IUCN Red List 2010d, Exhibit 4 at 1).

In the U.S., recreational and commercial fisheries both target the species and capture it as bycatch. Between 1986 and 2000, records of logbook data from the U.S. fishing fleet indicate a population decline of 89 percent (Baum et al. 2003, Exhibit 23 at 390). The same study showed a similar trend for most sharks in the region, including overall hammerhead populations (Id.) (Figure 7).

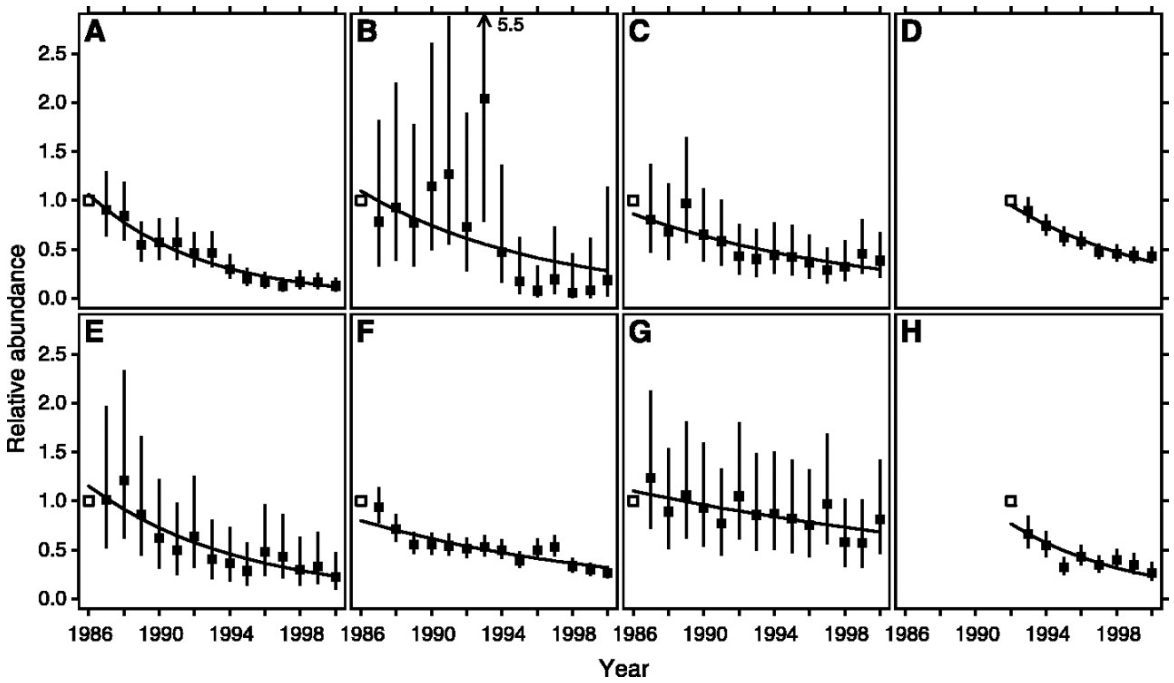


Figure 7. Declines in Estimated Relative Abundance for Coastal Shark Species
[(A) hammerhead, (B) white, (C) tiger, and (D) coastal shark species identified from 1992 onward]
and Oceanic Shark Species [(E) thresher, (F) blue, (G) mako, and (H) oceanic whitetip]
Source: Baum et al. 2003

Other studies confirm declining populations of scalloped hammerhead in the region. In North Carolina, research showed an incredible 98 percent decline between 1972 and 2003 (Myers et al. 2007, Exhibit 20 at 1847). In South Carolina, fisheries reported a 66 percent decrease between 1983 and 1995 (IUCN Red List 2010a, Exhibit 1 at 5). Further, NMFS recently published a notice that the Atlantic population of scalloped hammerhead is "overfished," although exploitation of the species continues (76 Fed. Reg. 23794 (Apr. 28, 2011)). The agency also noted that this population of scalloped hammerhead has been reduced by an estimated 83 percent from its original size (Id.). Based on all of these estimates, it is clear that this subpopulation of scalloped hammerhead is in decline.

Estimates of the age of maturity for females in this subpopulation is 15 years, making the species vulnerable to and slow to recover from exploitation (IUCN Red List 2010a, Exhibit 1 at 5).

Southwest Atlantic Subpopulation

The IUCN ranks the Southwest Atlantic subpopulation of scalloped hammerhead as "vulnerable." It ranges from the Caribbean and the Gulf of Mexico to Uruguay (IUCN Red List 2010e, Exhibit 5 at 1). Commercial fisheries in this region operate similarly to those in the Northwest Atlantic, although heightened demand for shark fins has increased fishing pressure, especially in Brazil. Brazilian fisheries tally all hammerheads caught together, so species-specific data is unavailable (Id.). Furthermore, many hammerheads caught are simply finned (fins removed on the boat and the rest of the carcass dumped overboard) and are not included in reported numbers (Id.). Fisheries target juveniles in inshore areas, using gillnets and trawl nets, and oceanic adults, using gillnets and longlines (Id.).

Western Indian Ocean Subpopulation

The IUCN classifies scalloped hammerhead as "endangered" in the Western Indian Ocean. Shark population levels are unknown throughout most of this area, especially for specific species. Scientists studied sharks off South Africa and reported a significant decrease in scalloped hammerheads caught despite increasing fishing pressure between 1978 and 2003 (Dudley and Simpfendorfer 2006, Exhibit 24 at 231). Fishing efforts rose consistently over the period surveyed. Of the species studied, the scalloped hammerhead showed the greatest reduction in take per unit effort (Id. at 230). The IUCN presumed declining populations of scalloped hammerhead throughout the region are due to many of the world's most active shark fisheries, such as Indonesia, Japan, and Oman (IUCN Red List 2010f, Exhibit 6 at 1). Hong

Kong, the world's largest market for shark fins, is equally influential in the decline of the species (Abercrombie et al. 2005, Exhibit 25 at 775).

IDENTIFIED THREATS TO THE PETITIONED SPECIES: CRITERIA FOR LISTING

The scalloped hammerhead meets at least three of the criteria for listing identified in ESA Section 4 (16 U.S.C. §1533(a)(1)) (in bold):

> A. The present or threatened destruction, modification, or curtailment of its habitat or range;
> **B. Overutilization for commercial, recreational, scientific, or educational purposes;**
> C. Disease or predation;
> **D. The inadequacy of existing regulatory mechanisms; or**
> **E. Other natural or manmade factors affecting its continued existence.**

Commercial fishing, historic and current, has exploited the scalloped hammerhead, and represents a major threat to the species (Criterion B). Existing regulatory mechanisms, such as national protection programs or international protection by the Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES), are inadequate or nonexistent (Criterion D). Finally, biological factors, such as late age of maturity, make the scalloped hammerhead slow to recover from exploitation (Criterion E). Each of these threats applies to the species as a whole and to each DPS.

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

Fishing, both historic and current, is the main cause of depleted scalloped hammerhead populations. The shark has very high commercial value, especially its fins, which, when combined with its slow rate of reproduction, makes the species highly vulnerable to exploitation (Dulvy et al. 2008, Exhibit 26 at 461). While scalloped hammerheads are mainly valued for their fins, the species is also economically valuable for other reasons. The shark's flesh is sold in various forms as food, the hides are valued, and the remainder is used for vitamins and fishmeal ("Scalloped Hammerhead" FMNH, Exhibit 10 at 8).

Scalloped hammerheads are both targeted and caught as bycatch in fishing operations (e.g., shrimp trawlers). As shown above, populations are declining worldwide and in every portion of the species' range, almost exclusively due to exploitation (see Population Status and Trends *supra* at 12). Populations have decreased substantially in the Eastern Central and Southeast Pacific, especially off the shores of Ecuador where fishing pressure is high (IUCN Red List 2010b, Exhibit 2 at 1). In U.S. Atlantic waters, fishing pressure has remained high, but the catch has decreased significantly, around 89 percent (Baum et al. 2003, Exhibit 23 at 390).

"Finning" is of particular concern for the scalloped hammerhead and other sharks. Fishers land the sharks and remove only their fins, disposing of the remainder of the carcasses overboard. Through this method fishers are able to catch and kill many more sharks than their boats could otherwise hold (CITES CoP15 Prop. 15, Exhibit 11 at 8). Market analysis indicates demand for shark fins is anticipated to increase, but even current levels of shark fishing are unsustainable if shark populations, including the scalloped hammerhead, are to survive (Id.).

The U.S. has already recognized the need to protect the scalloped hammerhead against overutilization. Recently, the U.S. and Palau submitted a proposal to list three species of hammerhead shark, including the scalloped hammerhead, under CITES (Id.). However, the proposal was not ratified when it failed to receive a required two-thirds majority vote from CITES signatories. Nevertheless, the proposal indicates the U.S. has recognized that overutilization is a threat to the scalloped hammerhead and that existing regulatory mechanisms are inadequate to conserve the species (see (Factor D) The Inadequacy of Existing Regulatory Mechanisms *infra* at 21).

The constant and growing threat of overutilization requires the scalloped hammerhead receive protection under the ESA, either worldwide or in a series of DSP's. The local character

of fishing and finning operations naturally results in a wide and inconsistent range of take of scalloped hammerhead. The variety of methods used to capture the species, employed by the many nations that pursue the scalloped hammerhead, result in significant differences in exploitation and conservation (61 Fed. Reg. 4725), and highlight the importance of the discrete subpopulations of the shark. Reported genetic variations among the subpopulations and the gaps that will likely result in the species' range with continued overutilization underscore the significance of the subpopulations. We therefore request that NMFS address the discreet and significant subpopulations of the scalloped hammerhead as DPS's for protection under the ESA.

(Factor D) The Inadequacy of Existing Regulatory Mechanisms

The scalloped hammerhead is not adequately protected from endangerment or extinction by existing regulatory measures, whether federal, state, or international. While some plans have been proposed to manage trade, few have been adopted, and most are ineffective. In order to better regulate fishing for scalloped hammerhead, relevant countries and the international community need to develop "[m]anagement plans, fishing regulation, and monitoring programs" throughout the range of the species (IUCN Red List 2010a, Exhibit 1 at 9). Analysis of the Hong Kong shark fin market indicates that hammerhead fins, expected to be made up largely of scalloped hammerhead fins, are the second-most traded fins due to their high value (Dulvy et al. 2008, Exhibit 26 at 461). Given this demand, and the shark's vulnerability to commercial fishing, national and international regulations are urgently needed to protect the scalloped hammerhead from the pressures of the human market.

Finning bans are the most common form of regulation intended to manage shark species. Finning bans have been adopted in 19 countries, including the U.S. Shark Finning Prohibition

Act (16 U.S.C. §1857(1)(P) (2011)),[3] and nine Regional Fishery Management Organizations (Dulvy et al. 2008, Exhibit 26 at 474). These bans are usually enforced through a monitored fin to carcass weight ratio, but many ratios are too high to be effective and contain loopholes to allow the continued removal of fins from sharks at sea (Id.). While such bans address the issues of cruelty and waste, they accomplish little to reduce the number of sharks caught and killed. Without enforced catch limits, finning bans alone are insufficient to effectively lower species mortality. Furthermore, regulatory agencies rarely enforce these bans due to the high costs involved (Id.).

International Regulation

Little international regulation of fishing or trading in scalloped hammerhead exists. The *Sphyrnidae* family is listed in Annex I, Highly Migratory Species, of the United Nations' Convention on the Law of the Sea (IUCN Red List 2010a, Exhibit 1 at 8). This encourages member states of the United Nations to cooperate in management of the listed species, but no management has yet been implemented (Id.).

The U.S. and Palau intended the CITES proposal to not only stem depredation of the species, but also to standardize international regulation for the species. The U.S. would not have made the proposal if current regulatory mechanisms were adequate. It is evident that the U.S. views additional regulation as a necessary addition existing laws. The present state of global regulatory mechanisms protecting the scalloped hammerhead is, therefore, inadequate by U.S. standards.

[3] Some U.S. states may have enacted finning bans, but they would be no more effective at regulating shark mortality than national and international bans described here.

Eastern Central and Southeast Pacific Region

There are no measures in place specific to scalloped hammerheads in the Eastern Central and Southeast Pacific, although some countries have recognized the need for regulation. Ecuador enacted laws restricting fishing around the Galapagos Islands, but poaching is commonly reported (IUCN Red List 2010b, Exhibit 2 at 4).[4] Ecuador also banned the export of fins from the country, but the only effect of this law has been to establish illegal trade routes via Peru and Colombia (CITES CoP15 Prop. 15, Exhibit 11 at 12). Mexico has named some areas protected from fishing in efforts to decrease exploitation, but poaching is commonplace there as well (IUCN Red List 2010b, Exhibit 2 at 4).

Eastern Central Atlantic Region

Little regulation exists in the Eastern Central Atlantic region, especially off the North African coast. However, Spain enacted a law that banned any catch or transport of scalloped hammerhead by Spanish fishing vessels, effective January 1, 2010 (CITES CoP15 Prop. 15, Exhibit 11 at 12). While the Spanish regulation is laudable, it is only one of many countries fishing for this subpopulation.

Northwest and Western Central Atlantic Region

In the U.S., scalloped hammerheads are included in the Large Coastal Shark complex management unit and in the NMFS Federal Fisheries Management Plan for Atlantic Tuna, Swordfish, and Sharks (IUCN Red List 2010d, Exhibit 4 at 3). These management plans regulate fishing in the Atlantic generally, but there are no regulations specific to the scalloped hammerhead. These plans have failed to prevent the large population declines of many shark

[4] See also Associated Press, "Ecuador: Illegal boat caught with 357 dead sharks", *Washington Post* (July 21, 2011) (reporting 357 sharks caught illegally in Galapagos Islands National Park).

species in the area, such as the scalloped hammerhead, white sharks, and thresher sharks (Baum et al. 2003, Exhibit 23 at 389).

Southwest Atlantic Region

There are no regulations specific to the scalloped hammerhead in the Southwest Atlantic region, but Brazil has made efforts to reduce general overfishing. Brazilian laws restrict the length of gillnets and ban trawling within 3 nautical miles of shore (IUCN Red List 2010e, Exhibit 5 at 3). Brazil also passed a law banning shark finning. However, enforcement of these laws rarely occurs (Id.)

The existing regulatory mechanisms applicable to scalloped hammerhead are inadequate for protecting the species from becoming threatened or endangered. Protection under the ESA would be a meaningful and effective method to correct this inadequacy. Protection under the ESA would most directly protect the population in the Northwest and Western Central Atlantic region and in territorial waters in the Pacific, where the scalloped hammerhead would be under the jurisdiction of the U.S. (16 U.S.C. § 1538(a)(1)), including prohibiting the import or export of the species from or to the U.S. (16 U.S.C. § 1538(a)(1)(A)). Listing would encourage international efforts to protect the scalloped hammerhead through financial and technical assistance or law enforcement (16 U.S.C. § 1537). It would also support the proposal to list the scalloped hammerhead under CITES brought by the U.S. and Palau, which would assist in standardizing regulations pertaining to the scalloped hammerhead worldwide.

(Factor E) Other Natural or Manmade Factors Affecting Continued Existence

Biological Vulnerability

The scalloped hammerhead has numerous biological characteristics that make it especially vulnerable to human activities, particularly fishing. As discussed *supra*, the

reproductive rate of the scalloped hammerhead make it biologically susceptible to threats of endangerment. Gestation takes 9-12 months, resulting in a slow recovery from population loss. The long period of time (reportedly 5-15 years depending on region) for juveniles to reach maturity and high predation on pups further hampers the species' ability to recover from exploitation and other effects (IUCN Red List 2010a, Exhibit 1 at 4).

The scalloped hammerhead's schooling behavior is also problematic for the species. Juveniles are especially vulnerable because they form large schools in shallow coastal areas where fishing pressure is high (Compagno 1984, Exhibit 8 at 546). Commercial fishers may take large numbers of scalloped hammerhead at a time with relative ease by focusing on areas where large schools are present.

The physical size of the scalloped hammerhead may also be a detriment. Dulvy notes a correlation between a species' body size and its extinction risk among marine species (Dulvy et al. 2003, Exhibit 27 at 28-35). This is likely due to the fact that fishers tend to target larger species due to the higher value of each individual. The large size of the scalloped hammerhead is a potential threat to its continued existence.

These biological factors render the scalloped hammerhead vulnerable to extensive fishing, which has a tremendous effect on the survival of the species. Protection under the ESA would regulate take and provide the species an opportunity to recover from the steep declines in has suffered in past decades.

Human Population Growth

Human population growth may pose a serious risk to the scalloped hammerhead. The U.S. Census Bureau estimates that the U.S. population, currently at 308.75 million people, will increase to 392 million people by 2050 (Day 2011, Exhibit 28 at 1). The United Nations

Population Fund (UNFPA) predicts an increase of about 2.3 billion people worldwide by 2050, raising the total human population over 9 billion people (UN Population Division 2009, Exhibit 29 at 4). As the most serious threat to the scalloped hammerhead is exploitation by humans, growing populations will intensify that threat. Further, fishing pressures on prey species of the scalloped hammerhead will also increase, reducing available food for the shark.

Human population growth and increasing wealth may have another impact on scalloped hammerhead populations. Human development is highly concentrated in coastal areas. Impacts on scalloped hammerhead habitat from pollution and development will likely increase as more and more people populate coastal areas.

QUALIFICATION AS DISTINCT POPULATION SEGMENTS

In addition to meeting the requirements for ESA listing, a DPS must also satisfy criteria for discreteness and significance as defined in 61 Fed. Reg. 4722 and set forth above (Criteria for Distinct Population Segments *supra* at 3).

Discreteness

Subpopulations of scalloped hammerhead listed above are distinct from each other. Physical barriers isolate populations in the Eastern Pacific, Eastern Atlantic, Western Atlantic, and Indian Ocean: land masses they obviously cannot traverse or open oceans across which they do not travel. The Northwest and Western Central Atlantic and Southwest Atlantic population, while not separated by a physical barrier, are distinct based on physiological factors. The Chapman study indicates a genetic discontinuity that evinces a marked separation between these populations of the species (Chapman et al. 2009, Exhibit 12 at 222).

Furthermore, despite the species' declining numbers, the scalloped hammerhead has a global range that extends across many international governmental boundaries (Figure 3). The

result is a broad and varied spectrum of harvest control, habitat management, conservation statuses, and regulatory mechanisms. Countries such as Brazil and Ecuador have adopted regulations limiting fishing of scalloped hammerhead. Conversely, no government has implemented any rules concerning capture of the species in the Eastern Atlantic region. This is significant in light of the ESA, since two primary problems facing the scalloped hammerhead are overutilization and inadequate regulations—problems that are typically local in nature.

Due to the physical and physiological factors separating populations of scalloped hammerheads and the broad differences in regulation of their management and capture, the subpopulations of scalloped hammerhead should be considered sufficiently discrete for protection as DPS's under the ESA.

Significance

Each of the subpopulations of scalloped hammerhead is biologically or ecologically significant. Loss of the species from the Eastern Pacific, Eastern Atlantic, Western Atlantic, or Indian Ocean would "result in a significant gap in the range of the taxon" (61 FR 4722 at 4725). Moreover, loss of the Northwest and Western Central Atlantic population, Southwest Atlantic population, or the Eastern Central and Southeast Pacific or Western Indian Ocean populations would mean a loss of unique genetic characteristics not found in any other population (see Chapman et al. 2009, Exhibit 12).

The final qualification for protecting a population as a DPS, if it is found to be both discrete and significant, is whether the DPS merits such protection. As shown above, population estimates for the scalloped hammerheads in each of the DPS's have declined rapidly in recent years. Additionally, each DPS meets multiple ESA listing criteria. Consequently, each of the five DPSs warrants listing as "threatened" or "endangered" under the ESA.

REQUESTED DESIGNATION

This petition hereby requests the Secretary of Commerce and the National Marine Fisheries Service to list the scalloped hammerhead shark (*Sphyrna lewini*) worldwide as "threatened" or "endangered" under the Endangered Species Act. Alternatively, we request the Secretary to list the species' five subpopulations in the Eastern Central and Southeast Pacific, Eastern Central Atlantic, Northwest and Western Central Atlantic, Southwest Atlantic, and the Western Indian Ocean as distinct population segments. The species meets at least three of the criteria for listing under Section 4 of the ESA: overutilization, inadequacy of existing regulatory mechanisms, and other natural or manmade factors. Listing the species will provide the scalloped hammerhead with much needed regulatory protection, and will serve as an important measure to lessen the threat of extinction.

CRITICAL HABITAT

This petition requests designation of critical habitat in U.S. waters for this species along with final ESA listing. Critical habitat should protect the areas most important to the scalloped hammerhead's survival, such as breeding grounds or coastal areas. Areas should include waters around the Hawaiian Islands, Southern California, and the coastal region between South Carolina and central Florida, which is believed to be an important nursery area in the Western Atlantic (IUCN Red List 2010a, Exhibit 1).

CONCLUSION

The U.S. has already acknowledged that the scalloped hammerhead is threatened by exploitation and that additional regulation is needed to conserve the species, as these were core contentions supporting its proposal to list the species under CITES. The U.S. must continue to seek protection for the species—particularly since its CITES proposal was rejected—by listing

the scalloped hammerhead under its own Endangered Species Act, either worldwide or in a series of five DPSs. The substantive protections provided by the ESA can help reverse population declines in scalloped hammerhead and support recovery of the species.

REFERENCES

Baum, J., Clarke, S., Domingo, A., Ducrocq, M., Lamónaca, A.F., Gaibor, N., Graham, R., Jorgensen, S., Kotas, J.E., Medina, E., Martinez-Ortiz, J., Monzini Taccone di Sitizano, J., Morales, M.R., Navarro, S.S., Pérez, J.C., Ruiz, C., Smith, W., Valenti, S.V. & Vooren, C.M. 2007. *Sphyrna lewini*. In: IUCN 2010a. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded on **6 May 2011**.
Online at: http://www.iucnredlist.org/apps/redlist/details/39385/0 [Exhibit 1]

Baum, J., Clarke, S., Domingo, A., Ducrocq, M., Lamónaca, A.F., Gaibor, N., Graham, R., Jorgensen, S., Kotas, J.E., Medina, E., Martinez-Ortiz, J., Monzini Taccone di Sitizano, J., Morales, M.R., Navarro, S.S., Pérez, J.C., Ruiz, C., Smith, W., Valenti, S.V. & Vooren, C.M. 2007b. *Sphyrna lewini (Eastern Central and Southeast Pacific subpopulation)*. In: IUCN 2010b. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>.
Downloaded on **6 May 2011**. Online at: http://www.iucnredlist.org/apps/redlist/details/165291/0 [Exhibit 2]

Baum, J., Clarke, S., Domingo, A., Ducrocq, M., Lamónaca, A.F., Gaibor, N., Graham, R., Jorgensen, S., Kotas, J.E., Medina, E., Martinez-Ortiz, J., Monzini Taccone di Sitizano, J., Morales, M.R., Navarro, S.S., Pérez, J.C., Ruiz, C., Smith, W., Valenti, S.V. & Vooren, C.M. 2007c. *Sphyrna lewini (Eastern Central Atlantic subpopulation)*. In: IUCN 2010c. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>.
Downloaded on **6 May 2011**.
Online at: http://www.iucnredlist.org/apps/redlist/details/165297/0 [Exhibit 3]

Baum, J., Clarke, S., Domingo, A., Ducrocq, M., Lamónaca, A.F., Gaibor, N., Graham, R., Jorgensen, S., Kotas, J.E., Medina, E., Martinez-Ortiz, J., Monzini Taccone di Sitizano, J., Morales, M.R., Navarro, S.S., Pérez, J.C., Ruiz, C., Smith, W., Valenti, S.V. & Vooren, C.M. 2007d. *Sphyrna lewini (Northwest and Western Central Atlantic subpopulation)*. In: IUCN 2010d. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>.
Downloaded on **6 May 2011**. Online at: http://www.iucnredlist.org/apps/redlist/details/165293/0 [Exhibit 4]

Baum, J., Clarke, S., Domingo, A., Ducrocq, M., Lamónaca, A.F., Gaibor, N., Graham, R., Jorgensen, S., Kotas, J.E., Medina, E., Martinez-Ortiz, J., Monzini Taccone di Sitizano, J., Morales, M.R., Navarro, S.S., Pérez, J.C., Ruiz, C., Smith, W., Valenti, S.V. & Vooren, C.M. 2007e. *Sphyrna lewini (Southwest Atlantic subpopulation)*. In: IUCN 2010e. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded on **6 May 2011**.
Online at:http://www.iucnredlist.org/apps/redlist/details/165296/0 [Exhibit 5]

Baum, J., Clarke, S., Domingo, A., Ducrocq, M., Lamónaca, A.F., Gaibor, N., Graham, R., Jorgensen, S., Kotas, J.E., Medina, E., Martinez-Ortiz, J., Monzini Taccone di Sitizano, J., Morales, M.R., Navarro, S.S., Pérez, J.C., Ruiz, C., Smith, W., Valenti, S.V. & Vooren, C.M. 2007f. *Sphyrna lewini (Western Indian Ocean subpopulation)*. In: IUCN 2010f. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded on **6 May 2011**.
Online at:http://www.iucnredlist.org/apps/redlist/details/165294/0 [Exhibit 6]

"Sphyrna lewini." ITIS online database. *Integrated Taxonomic Information System*. http://itis.gov [Accessed March 2011] [Exhibit 7]

Compagno, L.J.V., FAO species catalogue. Vol. 4. 1984 Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2. Carcharhiniformes. FAO Fish.Synop., (125)Vol.4, Pt. 2: 545-546. Online at: ftp://ftp.fao.org/docrep/fao/009/ad123e/ad123e34.pdf [Accessed May 2011] [Exhibit 8]

"Scalloped Hammerhead--*Sphyrna lewini*." NOAA Northeast Fisheries Science Center index of shark species. http://na.nefsc.noaa.gov/sharks/species/schh.html [Accessed May 2011] [Exhibit 9]

"Scalloped Hammerhead." Florida Museum of Natural History Ichthyology Education Biological Profiles. http://www.flmnh.ufl.edu/fish/gallery/descript/schammer/scallopedhammerhead.html [Accessed May 2011] [Exhibit 10]

CITES CoP15 Prop. 15. Proposal to include Hammerhead, Sandbar, and Dusky Sharks in Appendix II. Fifteenth meeting of the Conference of Parties, 13-25 March 2010. Online at: http://www.cites.org/eng/cop/15/prop/E-15-Prop-15.pdf [Accessed May 2011] [Exhibit 11]

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. [Exhibit 12]

Piercy, A.N., Carlson, J.K., Sulikowski, J.A. and Burgess, G. 2007. Age and growth of the scalloped hammerhead shark, *Sphyrna lewini*, in the north-west Atlantic Ocean and Gulf of Mexico. *Marine and Freshwater Research* 58: 34-40. [Exhibit 13]

Branstetter, S. 1987. Age, growth and reproductive biology of the Silky Shark,*Carcharhinus falciformis*, and the Scalloped Hammerhead, *Sphyrna lewini*, from the northwestern Gulf of Mexico. *Environmental Biology of Fishes* 19: 161-173. Online at: http://www.springerlink.com/content/w1t674407m5006n1/fulltext.pdf [Accessed May 2011] [Exhibit 14]

Chen, G.C.T., Leu, T.C., Joung, S.J. and N.C.H. Lo. 1990. Age and growth of the Scalloped Hammerhead, *Sphyrna lewini*, in northeastern Taiwan waters. *Pacific Science* 44(2): 156-170. [Exhibit 15]

Camhi, M., Fowler, S.L., Musick, J.A., Bräutigam, A. and Fordham, S.V. 1998. Sharks and their Relatives – Ecology and Conservation. IUCN/SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. iv + 39 pp. Online at: http://data.iucn.org/dbtw-wpd/edocs/SSC-OP-020.pdf [Accessed May 2011] [Exhibit 16]

IUCN. (2001). *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. Ii + 30 pp. http://www.iucnredlist.org/documents/redlist_cats_crit_en.pdf [Accessed June 2011] [Exhibit 17]

Maguire, J.J., Sissenwine, M., Csirke, J., Grainger, R. and Garcia, S. 2006. The state of world highly migratory, straddling and other high seas fishery resources and associated species. FAO Fisheries Technical Paper. FAO, Rome, Italy. Online at: http://www.fao.org/docrep/009/a0653e/a0653e05.htm#bm05.2.6 [Accessed May 2011] [Exhibit 18]

"Sphyrna lewini." *Species Fact Sheets*. Fisheries and Aquaculture Department, United Nations Food and Agriculture Organization. 2011. http://www.fao.org/fishery/species/2028/en. [Accessed May 2011] [Exhibit 19]

Myers, R.A., Baum, J.K., Shepherd, T.D., Powers, S.P. and Peterson, C.H. 2007. Cascading Effects of the Loss of Apex Predatory Sharks from a Coastal Ocean. *Science* 315: 1846-1850. Online at: http://www.nceas.ucsb.edu/~baum/Julias_NCEAS_Website/publications_files/Myers_Baum_etal_2007_Science.pdf [Accessed May 2011] [Exhibit 20]

Zeeberg, J., Corten, A. and Graaf, E.D. 2006. Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa. *Fisheries Research* 78: 186–195. Online at: http://www.xs4all.nl/~jzeebe1/Mauritanie_Zeeberg.pdf [Accessed May 2011] [Exhibit 21]

Buencuerpo, V., Rios, S. and Moron, J. 1998. Pelagic sharks associated with the swordfish, *Xiphias gladius*, fishery in the eastern North Atlantic Ocean and the Strait of Gibraltar. *Fishery Bulletin* 96: 667–685. Online at: http://fishbull.noaa.gov/964/buencuerpo.pdf [Accessed May 2011] [Exhibit 22]

Baum, J., Myers, R.A., Kehler, D.G., Worm, B., Harley, S.J. and Doherty, P.A. 2003. Collapse and conservation of shark populations in the Northwest Atlantic. *Science* 299: 389-392. Online at: http://www.sciencemag.org/content/299/5605/389.full [Accessed May 2011] [Exhibit 23]

Dudley, S. and Simpfendorfer, C. 2006. Population status of 14 shark species caught in the protective gillnets off KwaZulu-Natal beaches, South Africa, 1978-2003. *Marine and Freshwater Research* 57: 225-240. [Exhibit 24]

Abercrombie, D. L., S. C. Clarke, 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. [Exhibit 25]

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 [Accessed May 2011] [Exhibit 26]

Dulvy, N., Sadovy, Y., and J. Reynolds. 2003. Extinction vulnerability in marine populations. *Fish and Fisheries* 4: 25-64. Online at: http://www.botany.hawaii.edu/faculty/cunningham/cunninghamcourse/Dulvy_et_al_FF_03.pdf [Accessed May 2011] [Exhibit 27]

Day, J.C. 2011. "National Population Projections." *Population Profile of the United States*. U.S. Census Bureau. http://www.census.gov/population/www/pop-profile/natproj.html. [Accessed May 2011] [Exhibit 28]

UN Population Division. "WORLD POPULATION TO EXCEED 9 BILLION BY 2050: Developing Countries to Add 2.3 Billion Inhabitants with 1.1 Billion Aged Over 60 and 1.2 Billion of Working Age." UNFPA, 11 Mar. 2009. http://www.un.org/esa/population/publications/wpp2008/pressrelease.pdf. [Accessed May 2011] [Exhibit 29]