PETITION TO LIST THE NORTHEASTERN PACIFIC POPULATION OF WHITE SHARK (*CARCHARODON CARCHARIAS*) AS THREATENED OR ENDANGERED

OCEANA
CENTER FOR BIOLOGICAL DIVERSITY
SHARK STEWARDS

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Notice of Petition

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Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. §1533(b), Section 553(3) of the Administrative Procedure Act, 5 U.S.C. § 553(e), and 50 C.F.R. §424.14(a), the Center for Biological Diversity, Oceana, and SharkStewards ("Petitioners") hereby petition the Secretary of Commerce and the National Oceanographic and Atmospheric Administration ("NOAA"), through the National Marine Fisheries Service ("NMFS" or "NOAA Fisheries"), to list the Northeastern Pacific distinct population segment ("DPS") of the white shark, *Carcharodon carcharias,* as threatened or endangered, and to designate critical habitat to ensure its survival and recovery.

NMFS has jurisdiction over this petition. This petition sets in motion a specific process, placing definite response requirements on NMFS. Specifically, NMFS must issue 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.* Petitioner needs not demonstrate that the petitioned action *is* warranted, rather, Petitioner must only present information demonstrating that such action *may* be warranted. This petition relies on the best available science to demonstrate that listing the Northeastern DPS of white shark *is* warranted, and accordingly the available information indicates that listing this species as either threatened or endangered *may* be warranted. Accordingly, NMFS must promptly make a positive initial finding on the petition and commence a status review as required by 16 U.S.C. § 1533(b)(3)(B).

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The Center for Biological Diversity is a non-profit, public interest environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law.

Oceana is the largest international advocacy group working solely to protect the world's oceans. Oceana wins policy victories for the oceans using science-based campaigns. Since 2001, Oceana has protected over 1.2 million square miles of ocean and innumerable sea turtles, sharks, dolphins and other sea creatures. Global in scope, Oceana has offices in North, South and Central America and Europe.

Shark Stewards is dedicated to protecting sharks from overfishing and shark finning through policy and advocacy. A project of the non-profit Turtle Island Restoration Network, our mission is to mobilize people in local communities around the world to protect marine wildlife and the oceans and inland watersheds that sustain them.

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Executive Summary

White sharks, *Carcharodon carcharias*, of the northeastern Pacific Ocean are in peril. New studies demonstrate that these sharks form a genetically distinct population. Such a population, covering a significant portion of the world's oceans, urgently needs protection under the Endangered Species Act. Other new studies show that this population has only a few hundred adult and sub-adult individual white sharks left – a population level so low that the species is at risk of extinction even without regard to other threats. Yet there are other threats. The primary threat to the northeastern Pacific population of white sharks is commercial fishing. U.S. and Mexican fishing vessels incidentally catch and kill white sharks in unsustainably high numbers. Other threats include contamination, coastal development, pollution, ocean acidification, and climate change. The continued persistence of this unique population of white sharks is further at risk from sharks' low fecundity and late maturity. Action by NOAA Fisheries is needed to ensure that white sharks in the northeastern Pacific do not become extinct. Therefore, this petition seeks to list the distinct population segment of white sharks in the northeastern Pacific as threatened or endangered under the United States Endangered Species Act.

White sharks are a cosmopolitan species found in temperate and subtropical seas. Genetic studies have demonstrated unique populations exist in South Africa, Australia, the northwestern Atlantic, the northeastern Pacific, and the southwestern western Pacific. It has already been documented that some of these populations are declining globally, and due to this decline they are recognized by the International Union for Conservation of Nature (IUCN) as vulnerable. White sharks are also currently listed on Appendix II under the Convention for International Trade in Endangered Species (CITES). In addition, individual countries have recognized the vulnerability of shark species and taken some steps to protect white sharks within their national waters.

The northeastern Pacific unique population of white sharks is extremely low in size and has essential habitat in the California Current ecosystem along the western shores of North America. Photographic identification using classical mark-recapture methods has provided the first estimate of adult and subadult white shark abundance of the northeastern Pacific distinct population segment. The combined estimates from Central and Northern California and Guadalupe Island aggregation sites suggests there are approximately 339 subadult and adult white sharks in the Northeastern Pacific and that there is a low number of reproductively capable females left in the population. The population estimates for this top predator in the northeast Pacific are on par with other large predators that have already been listed under the Endangered Species Act (e.g., orcas, polar bears), and the estimates are lower than the vast majority of fish species currently listed under the Endangered Species Act. A population estimate this low presents significant inherent extinction risk, as it is likely far below its minimum viable population size. The white sharks in this population are susceptible to stochastic and/or catastrophic events, whether natural or anthropogenic.

In the northeastern Pacific, research indicates that white sharks have a coastal residency for much of their juvenile, sub-adult life. As adults, they switch from being piscivores to marine mammal predators and have a more oceanic life history spending up to six months offshore and six months nearshore. When in the coastal zone of North America, they are localized at specific marine mammal rookeries or hot spots along the North American west coast. All major pinniped species (northern elephant seals, California sea lions, and harbor seals) serving as primary prey for adult northeastern Pacific white sharks were hunted to the brink of extinction and have only begun to recover in the last half century. Since prey is a critical component of white shark habitat, northeastern Pacific white sharks have suffered a serious curtailment of their habitat, and hence carrying capacity, at the locations in which their adult populations are most concentrated with high levels of site fidelity. Therefore, although the current northeastern Pacific white shark population is being quantified, the history of human exploitation, both indirectly through killing prey and directly through capture, has likely resulted in a heavily depleted white shark population, which would comport with declining trends in most other large shark species worldwide for which long-term population data exist. The northeastern Pacific population of white sharks is also smaller than other regional white shark populations that utilize a comparable amount of coastal habitat, such as white sharks off Australia and South Africa.

Threats to this population of white sharks continue, including mortality inflicted by fisheries. As young pups, white sharks are endangered by set and drift gillnet fisheries off the coasts of California and Mexico. These fisheries set nets which catch California halibut, white seabass, Pacific swordfish, common thresher sharks, and benthic fish. These nets also entangle juvenile white sharks as bycatch. Long soak times lead to mortality when these predators are caught and drowned. Even though global concern about the decline of white sharks has caused directed fishing of them to be banned in many places, the bycatch of juvenile northeastern Pacific white sharks by North American fleets continues to be a significant problem. Reported white shark captures off Southern California indicates an increasing bycatch trend over the last decade, ranging from 2-25 white sharks annually with a mean of greater than 10 sharks per year since 1981. Reported white shark interactions comprise a fraction of the total captures, so the total is likely much greater. Observer coverage in the set gillnet fishery alone has been low and inadequate to estimate accurately the total white shark bycatch. Although some white shark mortality has been observed, without sufficient observer coverage or increased effort to monitor these fisheries, the true bycatch remains unknown. What is known is that these indiscriminate, entangling fishing gears threaten an already small population of long-lived apex predators that each bear relatively few young over their lifetime. Despite this, there are no limits on white shark bycatch in U.S. or Mexican Pacific Coast fisheries.

In addition to the threat of capture in fishing, other threats face the northeastern Pacific population of white sharks. New data shows that juvenile northeastern Pacific white sharks are among the most heavily contaminated with mercury, PCBs, and DDT of all shark species tested to date. Mercury levels in juvenile white sharks greatly exceed levels in all other species of sharks tested in the region and are six times higher than established thresholds known to cause physiological and reproductive harm in other marine fish. Moreover, the cumulative impacts of multiple stressors, including contamination, bycatch, coastal development, pollution, ocean acidification, and climate change, put northeastern Pacific white sharks at great risk of extinction.

In sum, Northeastern Pacific white sharks are at great risk. These sharks are so rare and their population is so low that their continued survival is threatened. Accordingly, the northeastern

Pacific population of white shark warrants listing as Endangered or Threatened under the Endangered Species Act.

I. Description, Biology, and Ecology of the White Shark

A. Introduction to White Sharks

Carcharodon carcharias, more commonly known as "white sharks", "great white sharks," or "white pointers" (herein referred to as "white sharks") are one of over 450 shark species of the class Chondrichthyes (Harrison 2010). White sharks are apex predators (Compagno *et al.* 1997) with naturally low abundance (Domeier 2012), low productivity (Cailliet *et al.* 1985), and low fecundity (Compagno *et al.* 1997). They are a geographically wide-ranging species, found throughout temperate and tropical oceans in low densities (Compagno *et al.* 1997; Domeier and Nasby-Lucas 2006; Domeier *et al.* 2012). They are pelagic sharks, capable of trans-oceanic migrations but they also have pronounced coastal focal points and have been observed to enter enclosed bays, lagoons, harbors, and estuaries, but do not enter brackish or fresh water (Compagno *et al.* 1997). Although white sharks are globally distributed (see Figure 3) and found as far north as Queen Charlotte Island off the Alaskan coast (Klimley 1985), their primary concentrations are in South Africa, Australia/New Zealand, the North Atlantic, and northeastern Pacific (Boustany *et al.* 2002; Domeier and Nasby-Lucas 2006; Weng *et al.* 2007; Jorgensen 2010). The South Africa, Australia/New Zealand, and northeastern Pacific populations are all genetically distinct from one another (Pardini *et al.* 2000; Pardini *et al.* 2001; Jorgensen 2010; Chapple *et al.* 2011; Blower *et al.* 2012).

White sharks in the Pacific occur throughout the ocean basin from western waters off Australia and New Zealand and Japan to central Pacific waters in the Hawaiian archipelago and into Northeastern Pacific waters. Only in recent years with increased efforts towards electronic tagging (Boustany *et al.* 2002; Bruce *et al.* 2006 ; Weng *et al.* 2007; Domeier and Nasby-Lucas 2008; Jorgensen 2010; Domeier 2012) and genetic analyses (Jorgensen 2010; Blower *et al.* 2012) has the population structure in this cosmopolitan shark been identified. Research now indicates the northeastern Pacific population of white sharks are a genetically distinct, demographically isolated population (Jorgensen 2010) as identified through a combination of satellite tagging (Boustany *et al.* 2002; Weng *et al.* 2007; Domeier and Nasby-Lucas 2008; Jorgensen 2010; Block *et al.* 2011), passive acoustic monitoring (Jorgensen 2010), and mtDNA analysis (Jorgensen 2010). The Northeastern Pacific population of great whites originated from the Australia/New Zealand population, having migrated during the Late Pleistocene 200,000 years ago (Jorgensen 2010; Blower *et al.* 2012). Once white sharks migrated from Australia/New Zealand waters, it appears that site fidelity has prevented mixing of the western and eastern Pacific populations as evidenced by genetic divergence of the significant divergence between the Australian and northeastern Pacific populations (Jorgensen 2010).

Electronic tagging has revealed that the northeastern Pacific white sharks display philopatric behaviors that have resulted in a genetically discernible, separate population (Jorgensen 2010; Chapple *et al.* 2011). This behavior is characterized by an inshore, continental shelf migration phase and an offshore pelagic phase (Boustany *et al.* 2002; Weng *et al.* 2007). When northeastern Pacific white sharks return during their coastal phase into the California Current, they demonstrate strong site fidelity to geographic locations coincident with marine mammal rookeries (Klimley and Anderson 1996; Jorgensen 2010; Anderson *et al.* 2011; Chapple *et al.* 2011; Sosa-Nishizaki *et al.* 2012). These locations include coastal aggregation sites off California (Farallon Islands, Año Nuevo) and Guadalupe Island, located 240 km off the west coast of Baja California, Mexico (Domeier *et al.* 2012). During the offshore phase of their migration, the sharks have been shown with electronic tracking tags to aggregate in the "white shark café" (a.k.a., "Shared Offshore Foraging Area" ("SOFA")) — an open ocean area between Hawaii and California — and, to a lesser extent, the Hawaiian archipelago. (Klimley and Anderson 1996; Boustany *et al.* 2002; Domeier and Nasby-Lucas 2006; Weng *et al.* 2007; Domeier and Nasby-Lucas 2008; Jorgensen 2010; Block *et al.* 2011; Chapple *et al.* 2011).

In addition, a new publication contains a wealth of new scientific information presented at the 2010 International White Shark Symposium regarding all aspects of white shark biology, life history, and conservation (Domeier 2012).

B. Physical Description of White Sharks

Compagno *et al.* (1997) describe the physical characteristics of white sharks, describing them in detail as:

> *"[a] very large stocky spindle-shaped shark reaching at least 6m TL [total length]. Two spineless dorsal fins and an anal fin; a conical head and moderately long bluntly conical snout: relatively small conspicuously dark eyes without nictitating eyelids and lateral on head: minute spiracles; five very long gill slits. no nasoral grooves or barbels on nostrils: mouth long, broad, broadly angular, and extending anterior to eyes; massive jaws: no labial furrows: large flat triangular, serrated bladelike teeth in upper jaw. narrower in lower jaw, tooth row count 23-28/20-26; first dorsal fin origin over pectoral fin rear tips, a large falcate first dorsal fin, falciform pectoral fins, very small pivot-based second dorsal and anal fins with second dorsal base partly anterior to anal base. upper and lower precaudal pits and strong keels on its caudal peduncle. crescentic caudal fin with an undulated dorsal margin and a long ventral lobe, no interdorsal ridge: dorsal and lateral surface light gray to brownish, bluish, or almost blackish, not bright blue but in life sometimes with a coppery sheen, lower flanks and underside abruptly white, usually black spot at axilla and on underside of pectoral fin tips."*

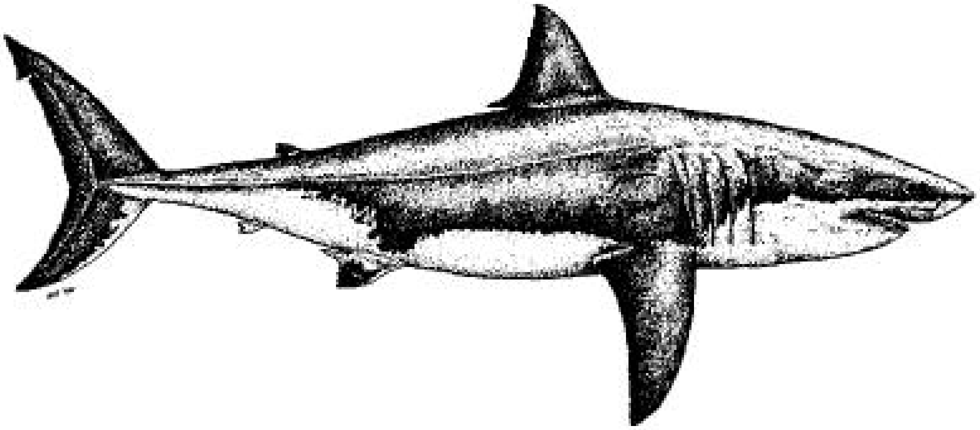


Figure 1: diagram of a white shark, *Carcharodon carcharias* (Compagno *et al.* 1997)

Countershading of white sharks from above helps these sharks blend into rocky or vegetated bottom habitat, allowing them to sneak up and ambush their prey (Klimley and Ainley 1996). White sharks usually search, stalk, and strike their prey from below and their camouflaging helps them remain undetected by their prey, particularly by seals swimming at the water's surface (Martin and Hammerschlag 2012). White sharks are hunting specialists with strong, large, serrated teeth allowing them to slice, cut, and fracture their prey quickly and with high impact (Applegate and Espinosa-Arrubarrena 1996).

Newborn white sharks range from of 120-150 cm in length (Francis 1996). Sub-adult and adult white sharks observed from 2006 to 2008 off the coast of California measured 2.6 m to 5.3 m in total length (Chapple *et al.* 2011). These size ranges are comparable to a study of white sharks off Guadalupe Island from 2001-2005, where the total length of white sharks ranged from 2.5 m to 5.5 m (Domeier and Nasby-Lucas 2006). Observations of white shark size off Guadalupe Island demonstrate that females are often larger than males (Nasby-Lucas and Domeier 2012).

C. Taxonomic Clades and Ancestry of the White Shark

White sharks belong to the class Elasmobranchii, order Lamniformes, family Lamnidae, genus *Carcharodon*, and species *carcharias*. *Carcharodon* is part of a primitive clade (Applegate and Espinosa-Arrubarrena 1996) with fossil records of the genus *Carcharodon*, dating to the Paleocene. The exact lineage of *Carcharodon carcharias* is still speculative. Debate surrounds divergent theories on the lineage of white sharks. One theory is that *C. carcharias* evolved from the now extinct *C. megalodon* which existed in the lower-middle Miocene (Applegate and Espinosa-Arrubarrena 1996; Gottfried *et al.* 1996). *C. megalodon* is the largest macropredatory shark known to have existed on Earth and is also aptly known as the megatooth shark or simply megalodon with an estimated total maximum length of 15 m (almost 50 feet) and triangular teeth reaching a height of 168 mm (6.6 inches) (Gottfried *et al.* 1996). Another theory is that white sharks are a descendant of an extinct lineage of mako sharks (Long and Waggoner 1996; Nyberg *et al.* 2006) also present during the late Miocene.

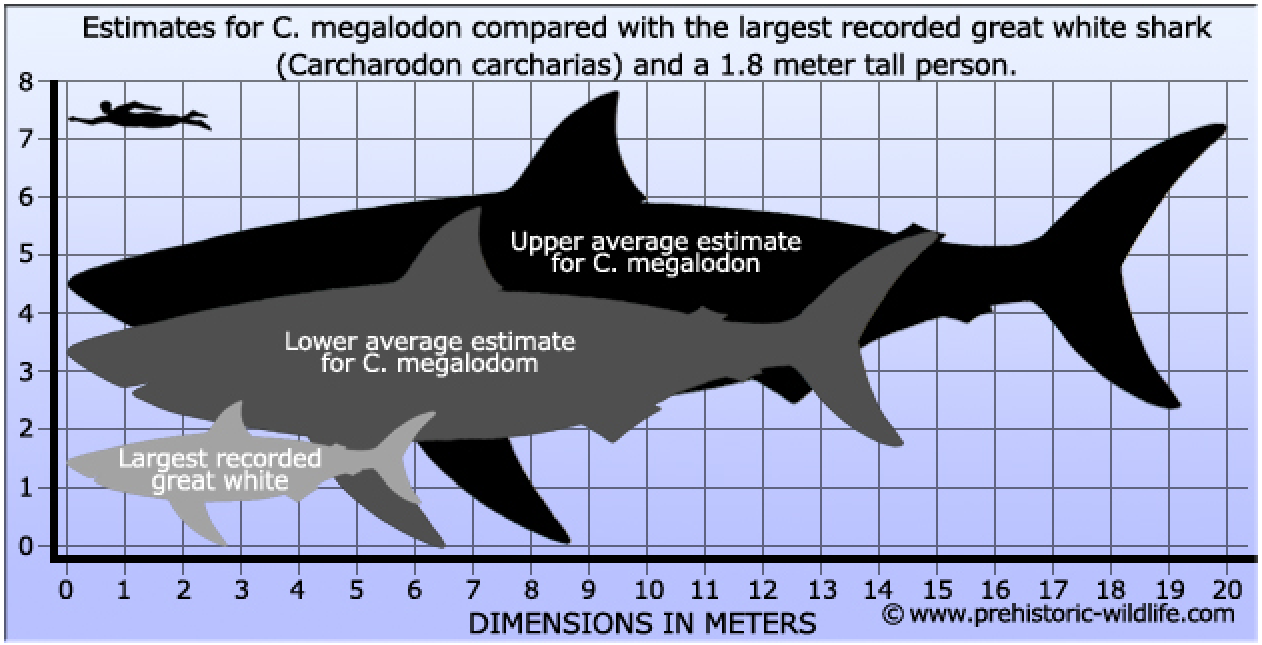


Figure 2: Size comparison of the white shark (*Carcharodon carcharias*) with its possible ancestor, the now extinct megatooth shark (*Carcharodon megalodon*). Image from: http://www.prehistoric-wildlife.com/species/m/megalodon.html

White sharks are members of the family Lamnidae. This family includes the porbeagle (*Lamna nasus*), the salmon shark (*Lamna ditropis*), and the short and long finned makos (*Isurus oxyrinchus* and *Isurus paucus*). These sharks are unique for their robust stiff swimming form (Lamniform swimming), and remarkable endothermic physiology (Carey *et al.* 1982). The capacity for this lineage to warm their muscles, viscera, brain and eye (Carey *et al.* 1982) is unique amongst all living sharks.

D. Life History

White sharks are characterized as apex predators with low productivity, slow growth, and low fecundity (Cailliet *et al.* 1985; Francis 1996; Compagno *et al.* 1997; Domeier 2012). With the recent progress in studying Northeastern Pacific white sharks the sub-adult stage is the least understood life-history stage of this population (Domeier 2012). Young of the year or pups are found in the Southern California Bight and Northern Mexico (Dewar *et al.* 2004; Weng *et al.* 2007). Sub-adult and adult white sharks have an inshore, continental shelf phase and an offshore pelagic phase associated with large oceanic movements (Boustany *et al.* 2002). Adults from tagging studies have displayed long oceanic offshore migratory capacity including trans-oceanic movements (Boustany *et al.* 2002; Bonfil *et al.* 2005). This capacity to have inshore and offshore life history phases appears to be associated with ontogenetic shifts from fish feeding to marine mammal foraging. In the northeastern Pacific, tracking has shown that adult white sharks demonstrate strong site fidelity to three geographic locations consisting of 1) coastal aggregation sites off California and Guadalupe Island, Mexico; 2) the Hawaiian archipelago; and 3) the white shark café, or SOFA, bordered by the North Pacific (Klimley and Anderson 1996; Domeier and Nasby-Lucas 2006; Domeier and Nasby-Lucas 2008; Jorgensen 2010; Block *et al.* 2011; Chapple *et al.* 2011).

The nursery for juvenile young of the year sharks in the northeastern Pacific exists in the California Current and tagging suggests fidelity to these regions exists as young sharks (Dewar *et al.* 2004; Weng *et al.* 2007). Before offshore migrations were recognized for this population, Klimley (1985) proposed the region spanning from Point Conception, California to Vizcaíno Bay, Mexico to be pupping grounds where juveniles spend the first three years of their life. To date, the areas of breeding and pupping remain in question, but young of the year sharks within a few months of birth have been found along coastal California and Mexico waters, suggesting that birthing may occur close by.

White sharks, like most large chondrichthyans, are of low productivity relative to teleost fishes, a consequence of their different life-history strategies. The r/K selection theory refers to the selection of combinations of biological traits in an organism that trade off between quantity and quality of offspring (MacArthur and Wilson 1967). Species that are "r-selected" have traits of high reproduction at low cost per individual offspring, while "K-selected" species expend high cost in reproduction for a low number of more difficult to produce offspring. By nature, white sharks with their "K-selected" life history strategies and high position in trophic food webs are more likely to be affected by intense fishing activity and other sources of mortality than most r-selected teleosts.

E. Reproduction and Growth

Adult whites grow to a maximum size of approximately 6 m (20 ft) in length (Cailliet *et al.* 1985; Wilson and Patyten 2008), weigh up to 3,000 kilograms (approx. 6,600 pounds), and longevity is estimated to be 30 years (Cailliet *et al.* 1985; Anderson *et al.* 2011). Female white sharks mature between 4-5m in length and 12-14 years of age whereas males mature between 3.5-4.1 m in length and 9-10 years of age (Compagno *et al.* 1997). As the largest predatory shark, their productivity is particularly low, as larger fish tend to have lower productivity (Roberts and Hawkins 1999). The productivity (r_{msy}) of the white shark, 0.04 to 0.056 (4 to 5.6% annual population increase), is lower than that of many more abundant large sharks (Australia and Madagascar 2004). Young-of-the-year survival is estimated to be low, despite their large size at birth (Australia and Madagascar 2004)

White sharks bear live young (Compagno *et al.* 1997) and females give birth to between 2 and 10 pups per litter, and perhaps as many as 14 (Francis 1996; Wilson and Patyten 2008). White shark reproduction is characterized by oophagy (Francis 1996; Uchida *et al.* 1996) where embryos are nourished by feeding on immature egg cells produced by the ovary while still inside the mother's uterus. Analysis of a single female white shark with eight pups indicated multiple paternity, lending evidence that white sharks are polyandrous maters (where females mate with more than one male over the course of a single breeding season) (Gubili *et al.* 2012). Females may also be mating during the fall coastal aggregations in October through January in coastal waters. Many factors of mating are still unknown including how long females can store sperm between mating and ovulation (Domeier 2012).

It is believed the gestation period is anywhere from 12 months (Wilson and Patyten 2008) to 22 months (Domeier 2012) which would only allow for breeding to occur every other year. This is supported by observations off Guadalupe Island (Domeier 2012) and at the southeastern Farallon Island (Pyle *et al.* 2003) where males return annually to these aggregation sites whereas mature females may return every other year. It has also been suggested that variations in return of mature females to aggregation sites may be due to unsuccessful mating or that females may skip reproductive cycles (Nasby-Lucas and Domeier 2012). More information is required to assess the maturation, breeding and pupping success of females. Information about where and when white sharks breed and pup, as well as the length of gestation, is the hardest information to actually obtain.

Consequently, little is currently known about white shark breeding behavior or where breeding occurs. No direct, confirmed observations of white shark breeding exist anywhere in the world. To date, it remains unclear whether offshore migrations of northeastern Pacific white sharks are for foraging or breeding (Carlisle *et al.* 2012). Mating can take place where the sharks occur in mixed gender aggregations and this currently appears possible both in the coastal and offshore aggregation sites (Domeier 2012). While in the Café some sorting of genders has been described spatially. When female white sharks travel through the Café, they may avoid the area in which males are foraging (Domeier 2012). During some periods there is spatial overlap of genders in this region. This may represent mating aggregations. Isotopic data indicates feeding occurs in offshore areas but energy is primarily coming from the California Current, so the purpose of the offshore migrations is still unconfirmed (Carlisle *et al.* 2012). At any given coastal aggregation site, both sexes are present. On average, male white sharks returned to the Farallon Islands coastal aggregation sites annually, but females return only every other year (Pyle *et al.* 2003). In Mexico, 55% of females were seen at Guadalupe Island in consecutive years (Domeier and Nasby-Lucas 2006). These two areas appear to have separate aggregations with little evidence thus far of significant overlap, however as increased tagging occurs this may change. At present, the location of mating remains unknown.

Indirect mating records include seminal fluid present in claspers of examined male white sharks and bite marks on the bodies or fins of female white sharks. Six of 11 (55%) of male white sharks from Guadalupe Island and Southeast Farallon Islands examined from 2007 to 2009 had seminal fluid present in the groove of at least one clasper. Males of many species of sharks grasp females with their jaws during copulation and this same behavior is likely true of white sharks. Conspecific bite marks on the flanks, head, or gill region were observed on 17 individual female white sharks off Guadalupe Island (Domeier 2012) suggestive of recent mating. Both mating indicators have also been observed in white sharks off of Australia and New Zealand (Francis 1996). Natal homing behavior of females has also been observed for the Australia and New Zealand populations (Bonfil *et al.* 2005). Of the great whites observed in the white shark café, the females were present over a broader spatial area than males. It is hypothesized that this behavioral difference is due to foraging needs of females and is possibly related to energetic requirements of breeding.

F. Movement and Distribution of Northeastern Pacific White Sharks

Globally, white sharks are a cosmopolitan species (Figure 3). In the northeastern Pacific, white sharks have been observed from Mazatlan, Mexico to the Bering Sea (Kato 1965; COSEWIC 2006). White shark records from Pacific Canada consist almost exclusively of strandings on the leeward shores of Queen Charlotte Islands during late autumn and winter months (COSEWIC 2006). Northeastern Pacific white sharks also travel into the Gulf of California (Sea of Cortez). Thirty-eight records of white sharks from 17 locations in the Gulf of California were recorded from 1964-2010. For the most part, observations of juveniles were restricted to the upper Gulf of Baja California in shallow waters off the fishing town of El Golfo de Santa Clara which may be a secondary nursery ground for juvenile white sharks (Galván-Magaña *et al.* 2010). The presence of juveniles (less than 300cm TL) was highest between January to May (with 10 records of juvenile white sharks caught) (Galván-Magaña *et al.* 2010). Data from pop up satellite tags adhered to white sharks off California's coast between 1999 and 2000 revealed that the migration, dive depths, and temperature ranges are much greater for this species of shark than previously thought (Boustany *et al.* 2002).

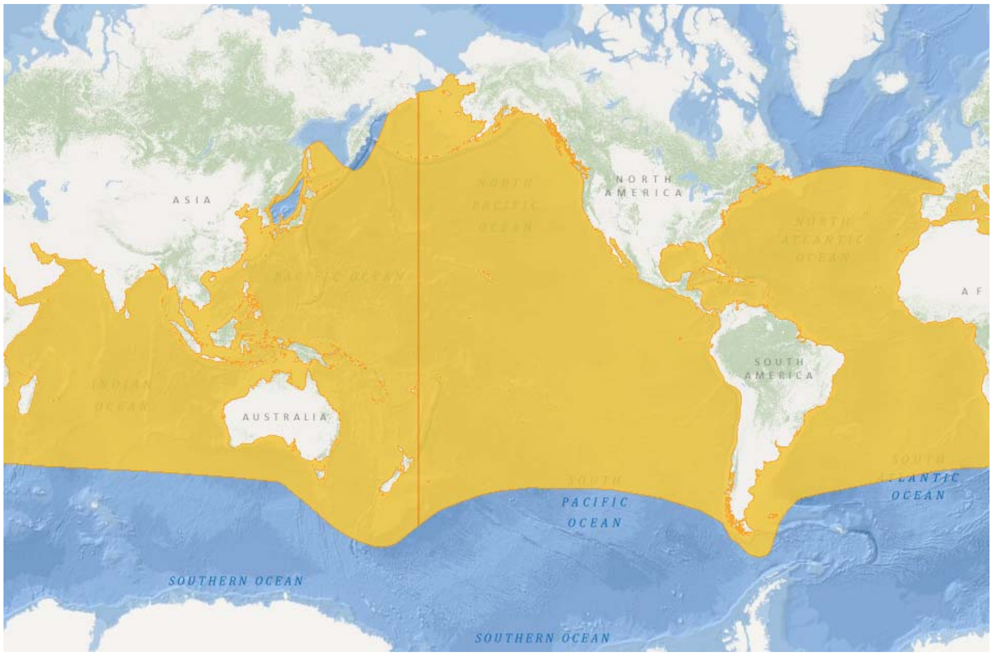


Figure 3: Global distribution map of white sharks. From Fergusson *et al.* (2009)

Male white sharks generally arrive at the same time to coastal aggregation sites at the Farallon Islands and the offshore Island of Guadalupe, Mexico from late July through August and females arrive several weeks thereafter (Domeier 2012). These sharks are observed at coastal aggregation sites through February (Jorgensen 2010; Chapple *et al.* 2011), peaking in abundance between September and November (Pyle *et al.* 2003). At Guadalupe Island, peak abundances of white sharks occurs from July-December (Domeier and Nasby-Lucas 2006; Nasby-Lucas and Domeier 2012). Most male white sharks begin their departure to the offshore areas between January and March. That said, white sharks have been recorded departing as early as December and as late as May (Domeier and Nasby-Lucas 2008). Females were seen between September and December; whereas males were present in varying abundances year round (Domeier and Nasby-Lucas 2006; Nasby-Lucas and Domeier 2012).

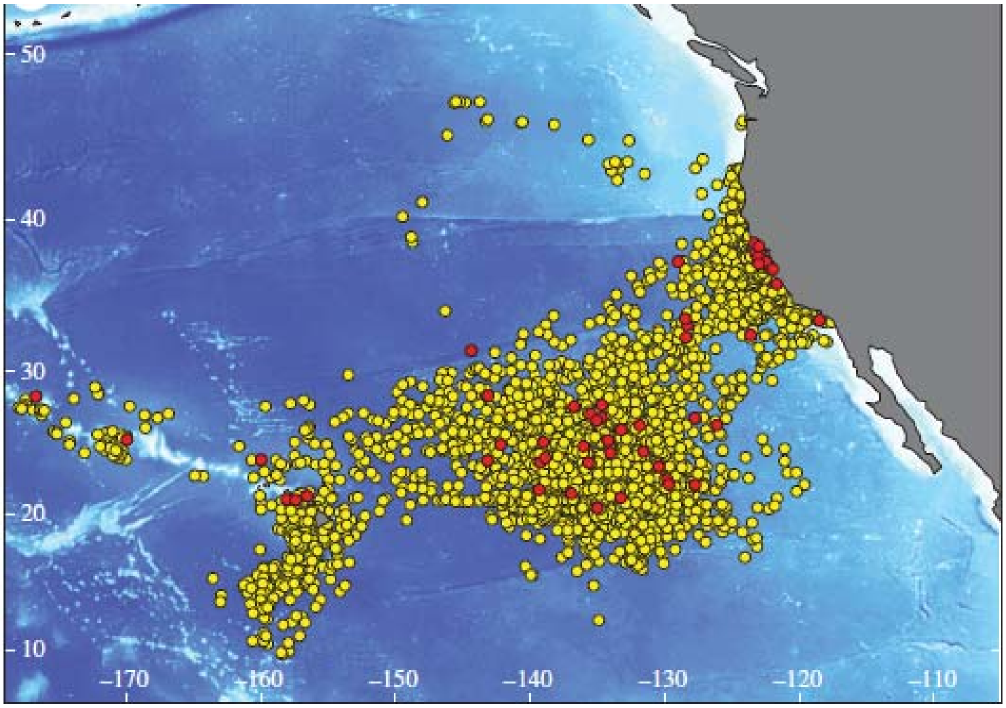


Figure 4: Site fidelity of satellite tagged white sharks to three core areas in the Northeastern Pacific included the North American continental shelf waters, the waters surrounding the Hawaiian Island Archipelago, and the white shark Café. Yellow circles represent position estimates from light- and SST-based geolocations. Red circles indicate satellite tag endpoint positions. From Jorgensen (2010).

Sex ratio can change slightly throughout the course of several weeks as male white sharks tend to arrive to the Central California and Guadalupe Island coastal aggregation sites several weeks prior to female arrival (Domeier 2012). For example, the sex ratio is closest to parity at Guadalupe Island in November (Domeier 2012).

A greater proportion of white sharks from the California coastal aggregation sites travel to the Hawaiian Islands compared to those from off Guadalupe Island (Domeier 2012). One hypothesized explanation for this difference in migratory destinations is that the coastal California population goes to the Hawaiian Islands to target prey that are not available in the White Shark Café (Domeier 2012). Movement patterns of white sharks tagged off the Farallon Islands indicate they use waters off Kauai, Maui, Lanai, Kahoolawe, and Hawaii for foraging (Weng *et al.* 2007).

How or when subadult white sharks learn to migrate to coastal aggregation sites or when they initiate seasonal offshore migrations to the White Shark Café is poorly understood. It is also unknown how white sharks make precise long-distance ocean migrations (Domeier 2012). The northern Gulf of Baja may be an important feeding area for juvenile white sharks as it is habitat for seasonally large schools of medium to large fish upon which juvenile white sharks may prey. Juvenile white sharks may migrate from the cool waters on the outer side of the Baja Peninsula to warmer waters of the northern Gulf of California which may be a secondary nursery ground where they benefit from abundant food sources and protection (Galván-Magaña *et al.* 2010).

Distribution of juvenile white sharks is not as well understood as that of sub-adult and adult white sharks (Santana-Morales *et al.* 2012). Between 1999 and 2010, 111 juvenile white sharks were recorded as being incidentally caught in the artisanal and commercial fisheries along the Pacific coast of Baja California, Mexico (Figure 5). These catch records indicate the continental shelf is an important habitat for young-of-the-year and juvenile white sharks in this area. Vizcaino Bay may even be a nursery area, as 66 of the 111 young of the year and juvenile white sharks were documented in this region (Santana-Morales *et al.* 2012). Five white sharks were captured inside the coastal lagoon of Ojo de Liebre (Baja California) by artisanal seine-net fisheries. Young white sharks may use coastal lagoons such as this one as a refuge and feeding area. The continental shelf of Bahia Sebastian Vizcaino extends as far off shore as 140km and may provide juvenile white sharks with a larger forage base since it is important habitat for many teleost and elasmobranch species upon which juvenile white sharks feed (Santana-Morales *et al.* 2012). It is not conclusively known if juvenile white sharks remain on the shelf of the Pacific coast of Baja California year-round (Santana-Morales *et al.* 2012).

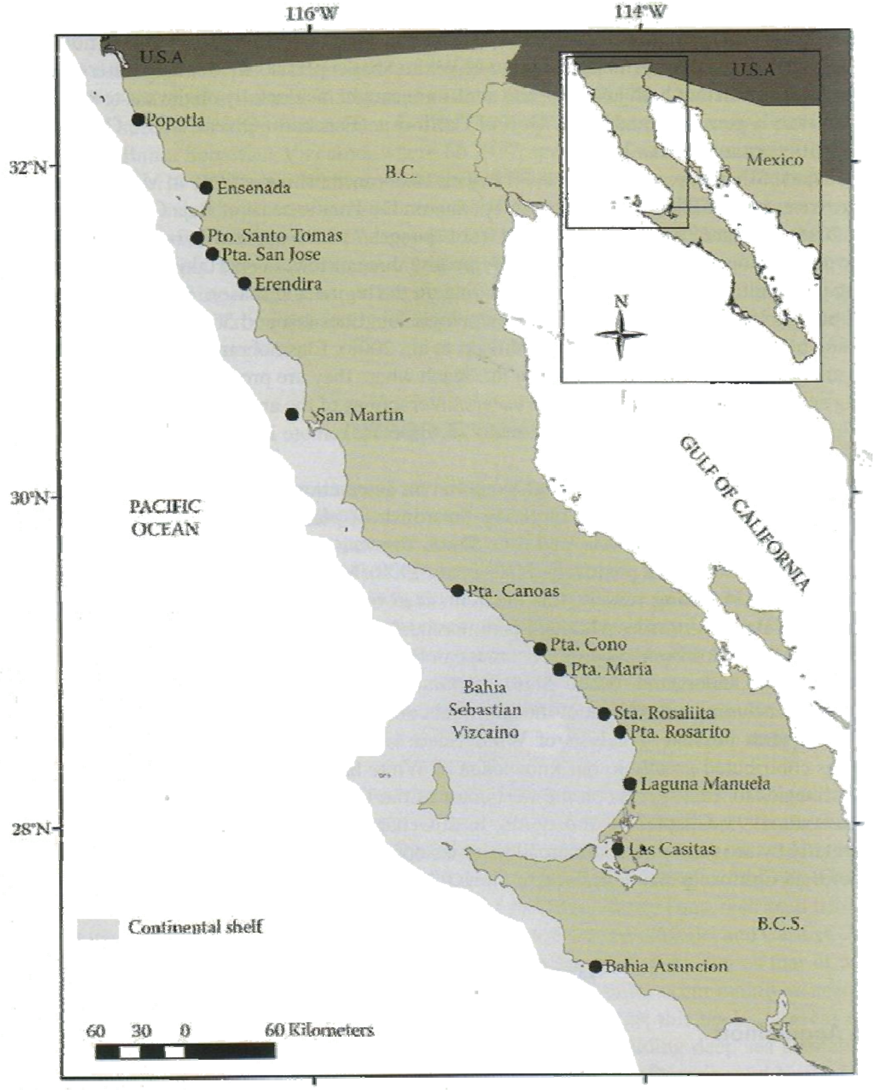


Figure 5: Location of the fishing camps with juvenile white shark records on the Pacific coast of Baja California, Mexico. From (Santana-Morales *et al.* 2012).

G. Diet and Feeding Behavior

While white sharks are opportunistic predators, both juveniles and adults exhibit site fidelity which likely increases their foraging success (Compagno *et al.* 1997; Jorgensen 2010; Hussey *et al.* 2012). White sharks feed in all parts of the water column from the surface to the seafloor. They show size-based preference to prey in the sense that as white shark size increases, so does the size range of its prey (Casey and Pratt 1985; Klimley 1985; Hussey *et al.* 2012). Generally speaking northeastern Pacific juvenile white sharks prey on fish, small sharks, and rays. Identified prey items for 14 stomach samples of juvenile white sharks caught in Mexican fisheries included specimens of the taxa: *Thunnus* spp., *Scomber japonicus*, *Atractoscion nobilis*, *Myliobatis californica*, *Mustelus* spp., unidentified Scombridae spp., cephalopods (order *Teuthoidea*), crustaceans, and other items (egg capsules of *Raja* spp.) (Santana-Morales *et al.* 2012). Adult white sharks feed on the same prey as juveniles but extend their prey base to also include seals, sea lions, dolphins, seabirds, marine turtles, rays, and other sharks (Wilson and Patyten 2008). The presence of seal colonies influences white shark movement (Hussey *et al.* 2012). White sharks are also opportunistic scavengers and have been reported to feed on whale carcasses (Pyle *et al.* 2003).

Figure 6: A white shark off of Guadalupe Island, Mexico. Photo by Jim Agronick (Shutterstock).

This trend in prey size and range is evidenced in a study (Klimley 1985) of white sharks off the coast of California documenting the following dietary items based on stomach contents, summarized in the following table:

Table 1: White shark prey items, by size class

Size (cm in length)	Prey found in stomach contents
<200	bony fish (cabezon, lingcod), cartilaginous fish

	(spiny dogfish), crustaceans, and cephalopods
200 to 400	bony fish (Pacific sardine, king salmon, white seabass, black rockfish, stripped bass), cartilaginous fish (soupfin shark and bat ray), as well as one pinniped and one crustacean.
>400	pinnipeds (northern elephant seals and California sea lions), bony fish, cartilaginous fish, and crustaceans

This is consistent with a study on the South Africa white shark population that examined stomach contents of white sharks incidentally caught in beach protection nets along the coast of KwaZulu-Natal, South Africa between 1978 and 2009. Sharks were divided into four size classes: <185 cm; 185-234.9cm; 235-284.9cm: and >285cm. Stomach contents of the smallest shark size class consisted of elasmobranchs, teleost fish, and cephalopods. For size class >285cm, seal was the most common prey item (Hussey *et al.* 2012).

Limitations are inherent in diet studies. For example, it is possible white sharks could feed heavily on cephalopods and teleost fish while offshore, but if so the stomach contents could be digested and not detected once the shark migrates back to inshore waters where it can be more easily studied (Hussey *et al.* 2012). Prey populations are also likely to be affected by overfishing in many parts of the world (Australia and Madagascar 2004).

White sharks of the Farallon Islands are known to prey on California sea lions, harbor seals, and immature northern elephant seals (Pyle *et al.* 2003). Populations of these pinnipeds were drastically reduced to levels approaching extinction by commercial hunting. This depletion of the prey base likely reduced the carrying capacity of northeastern Pacific white sharks, potentially reducing their populations. Pinniped stocks have increased in recent decades, however, they remain below pre-hunting levels. Off the Farallon Islands, Sydeman and Allen (1999) reported recovery gains of all species of pinnipeds with the exception of the Steller sea lion. However, the slow intrinsic growth rates of white sharks as K-selected species suggest that the population may still be far below what current levels of prey might support. These trends in prey indicate that habitat remains in an impacted state and that current white shark population size is far below natural levels.

Once believed extinct in the early 1800s, the northern elephant seal, *Mirounga angustirostris*, has rebounded in the past few decades, and is one of the favored prey of the northeastern Pacific white shark. Prior to the 1970s, however, the population was extremely depleted. Current populations of northern elephant seals in the United States and Mexico were all originally derived from a few tens or a few hundreds of individuals surviving in Mexico after being nearly hunted to extinction (Stewart *et al.* 1994). The most recent population estimate of the California northern elephant seal stock was approximately 124,000, with a minimum population estimate of 74,913 (Carretta *et al.* 2011). The California population was continuing to grow through 2005, but appeared to be stable or even slowly decreasing in Mexico (Stewart *et al.* 1994). Based on 1,221 days of shark observations at Southeast Farallon Island from 1988 to 2004, Brown *et al.* (2010) found that the number of observed white shark attacks on elephant seals was positively correlated with elephant seal abundance with a mean predation peak on October 30, and suggested that white sharks play a major role in regulating the population of this pinniped species. There is evidence of prey saturation occurring in some years, indicating a threshold prey level above which additional shark predation does not occur (Brown *et al.* 2010).

Similarly impacted from hunting and loss of reproductive habitat, the California sea lion population (*Zalophus californianus*), which occurs from the offshore islands of Mexico north to Vancouver Island, British Columbia, has increased dramatically in this century after a sharp reduction in population size (Carretta *et al.* 2011). Commercial harvest in the 1800s and early 1900s likely reduced the numbers of California sea lions at the turn of the century to only a few thousand animals (Bonnot 1928; Cass 1985). With curtailment of commercial hunting in the early 1940s, the population gradually began to recover. Following passage of the Marine Mammal Protection Act in 1972, the California sea lion population off the West Coast of the United States has increased steadily at an average annual rate of more than 5% since the mid-1970s (Carretta *et al.* 2011). The total population for California Sea Lions was estimated in 2011 at 296,750 with an minimum population estimate of 153,337 (Carretta *et al.* 2011).

Harbor seals (*Phoca vitulina*) off the west coast of North America were greatly reduced by commercial hunting in the 1800s and early 1900s to only a few hundred individuals in isolated areas along the California coast (Bonnot 1928; Bartholomew and Boolootian 1960). The population has increased dramatically in the last half of the 20th century with an estimated annualized growth rate of 3.5% from 1982-1995. The California harbor seal population estimate for 2011 was 30,196 seals, with a minimum population estimate of 26,667 seals (Carretta *et al.* 2011).

Of note is that in 1997, shark activity at Southeast Farallon Island ceased following the predation of an individual white shark by killer whales (*Orcinus orca*), indicating that killer whales may affect both the abundance and feeding behaviors of white sharks (Pyle *et al.* 1999).

The California Central Coast white shark population likely migrates offshore in the winter to feed and/or breed (Jorgensen 2010). The white shark café is characterized by low epipelagic productivity. Because meso-pelagic squid are present, it is hypothesized that white sharks may directly feed on squid or forage on species that target squid like other sharks or swordfish (Domeier 2012). This theory is also consistent with observations of white sharks from Guadalupe Island after arriving at the white shark café where they engage in very frequent deep dives, some recorded in excess of 980 m. This observed behavior may be for feeding on squid, swordfish, and other sharks (Domeier and Nasby-Lucas 2008).

Hawaiian waters are likely important foraging areas for northeastern Pacific white sharks as supported by migrations recorded by satellite tags (Jorgensen 2010). Northeastern Pacific white sharks have been observed extensively using waters around the Hawaiian archipelago in winter and spring. Both white sharks from Central California and Guadalupe Island have been tracked to Hawaiian waters (Domeier and Nasby-Lucas 2008). Northeastern Pacific white sharks that move from the white shark café to Hawaiian water likely do so for food (Domeier and Nasby-Lucas 2008).

Less information is available on white shark diet composition at Guadalupe Island. Domeier (2012) reported an observation of a white shark preying upon an elephant seal at Guadalupe Island. Guadalupe Island northeastern Pacific white sharks have been frequently observed feeding on yellowfin tuna hooked on rod-and-reel (Domeier and Nasby-Lucas 2006). Other observations of feeding on California sea lions, northern elephant seals, and possibly Guadalupe fur seals have been made at Guadalupe Island (Hoyos, pers comm., Sharkdiver videos, 2012).

H. Habitat Requirements

Incidental catch of young-of-the-year ("YOY") white sharks in shallow coastal (15-60 m depth) gillnet fisheries suggest the flat, sandy bottom is important nursery habitat for immature white sharks. However, the relative importance of flat, sandy substrate versus reef and kelp habitats to YOY is unknown (Domeier 2012).

Coastal areas off of Southern California and Baja Mexico are likely important nursery areas for YOY white sharks (Klimley 1985) and also may be parturition sites (Domeier 2012). The geographic area of nursery habitat may be season dependent, expanding from the Southern California Bight in the summer south into Mexican waters in autumn (Weng *et al.* 2007). The white shark is often reported close inshore to the surfline and when they are along the continental shelf, white sharks generally occur near the surface or at the bottom rather than mid water depths (Australia and Madagascar 2004).

Similarity in water temperatures among global nursery areas for white sharks indicates there may be an optimal thermal environment for juvenile white sharks (Weng *et al.* 2007). A study (Weng *et al.* 2007) tracking six juvenile white sharks in the Northeast Pacific documented sea surface temperatures ranging from 15.0°C to 23.4°C. Nursery area water temperatures have been documented as high as 26°C in eastern South Africa and as low as 16°C in northern New Zealand (Weng *et al.* 2007). The benthic zone also appears to be important habitat for juvenile white sharks as supported by demersal fish found in the stomach contents of juvenile white sharks (Weng *et al.* 2007) and by-catch of these white sharks in the bottom set gillnet fishery (Dewar *et al.* 2004). In addition, the Southern California Bight is home to a number of diurnal migrating fish species, and an important spawning ground for species that have been documented in white shark stomach contents (Dewar *et al.* 2004).

The surface mixed layer is likely the primary habitat for Central California juvenile white sharks and is the warmest waters of the California Current (Weng *et al.* 2007). Although juvenile white sharks have been observed using the cooler waters of the thermocline (Dewar *et al.* 2004; Weng *et al.* 2007), it is hypothesized that the surface mixed layer is important foraging habitat for these young white sharks (Weng *et al.* 2007). YOY white sharks have demonstrated they can tolerate much colder temperatures but it appears their tolerance is limited (Dewar *et al.* 2004). A YOY white shark was exposed to water temperatures as low as 9°C in the Southern California Bight, but spent the majority of its time (89% of total time) in warmer temperatures ranging from 16°C-22°C (Dewar *et al.* 2004). It appears that young white sharks are more temperature sensitive than adult sharks, whereby they expand their range from the nursery areas of the Southern California Bight into colder northern California waters as they age (Weng *et al.* 2007). Adult northeastern

Pacific white sharks have been documented in waters ranging in temperature from 4°C in the offshore focal area to 27.2°C in waters south of Hawaii (Weng *et al.* 2007).

As northeastern Pacific white sharks mature, they are likely able to access colder waters, foraging to greater depths and further north. Average dive depths of northeastern Pacific white sharks off Central California are shallower than those off Guadalupe Island white sharks likely due to the difference in bathymetry between the two regions. White sharks off Central California rarely dive below 50m, whereas white sharks off Guadalupe Island have been found to spend 22% of their time at that depth (Domeier *et al.* 2012). Dissolved oxygen, which decreases with depth, likely affects dive behavior of white sharks, but the exact minimum dissolved oxygen concentration for white sharks is unknown. The oxygen minimum layer in the eastern Pacific, however, is shallower than that of the central and western Pacific which may compress vertical habitat (Domeier *et al.* 2012).

Coastal habitat of sub-adult and adult white sharks is important for foraging (Weng *et al.* 2007). The presence of large pinniped colonies is likely an important factor directing presence of white shark aggregation sites during the sharks' adult years as evidenced by spatial overlap (Domeier *et al.* 2012). In fact, timing of the departure of white sharks from the Farallon Islands may coincide with a decline in peak abundance of YOY elephant seals, as these young seals leave the area as adult male elephant seals arrive at the haul out sites to establish their mating territory (Weng *et al.* 2007). Higher density pinniped colonies include Año Nuevo, Farallon Islands, and Guadalupe Island. Guadalupe Island is a haul out and pupping site for Northern elephant seals (*Mirounga angustirostris*), the Guadalupe fur seal (*Arctocephalus townsendi*), and the California sea lion (*Zalophus californianus*) (Domeier and Nasby-Lucas 2006).

I. Global White Shark Population Trends

> *The rarity of white sharks means that catch records are rare and population trend data scarce. All data series available (catch per unit effort and catches), however, demonstrate either significant population declines over time or stability (no recovery), even in areas where the species has long been protected.* (Australia and Madagascar 2004).

Although the historic abundance and trends of the northeastern Pacific population of white sharks are unknown, most other white shark populations have been declining. The white shark meets the Food and Agriculture Organization of the United Nation's ("FAO") guidelines for the listing of commercially exploited aquatic species. It lies well inside FAO's lowest productivity category of highly vulnerable species (those with an intrinsic rate of population increase of <0.14 and a generation time of >10 years). Musick *et al.* (2000) assigned eastern Pacific white sharks to the category of *conservation dependent*, based on the American Fisheries Society criteria, due to low to very low productivity. Notably some white shark population declines have also exceeded the qualifying level for consideration for Appendix I listing (a decline to 20% of historic baseline). There is no reason to believe that other stocks are not similarly or more seriously depleted (Australia and Madagascar 2004).

Trends in population are also difficult to establish as there are no reliable metrics with which to compare changes in population status over time (DEWHA 2009). While declines appear to be the trend, there may be other influences. For example, Bruce (2008) suggests that high levels of inter-annual variability observed in white shark numbers may be a reflection of changes in distribution over years, or changes in historical game-fishing records may reflect changes in fishing behaviors (DEWHA 2009).

A notable decline has occurred in the Northwest Atlantic white shark population. Cliff *et al.* (1996) estimated a greater than 66% decline in fisheries catch of white sharks in the North Atlantic. Although the absolute population is unknown, 380 individuals had been recorded as of 1985 (Casey and Pratt 1985) and a population decline of 79% was observed between 1986 and 2000 (95% Confidence interval: 59-89%) (Baum *et al.* 2003). The depleted population of white sharks may no longer be able to fulfill their former ecological role (McPherson and Myers 2009). Some of the population declines summarized above were the result of the removal of only small numbers of animals (tens to low hundreds annually) (Australia and Madagascar 2004).

Data from beach meshing programs in New South Wales and Queensland, Australia show a gradual and irregular decline in catch per unit effort (CPUE) since the 1960s (J.D. Stevens and B. Bruce pers. comm.) In South Africa, trends in KwaZulu-Natal meshing programmes are variable and less clear, but essentially downward (IUCN). Other indices of catch-rates are available from: California, between 1960-1985 as 0-14 sharks per year (mean 3.2) (Klimley 1985): KwaZulu-Natal, between 1974-1988 as 22-61 sharks per year (Cliff *et al.* 1989); and the Central Mediterranean Sea (Sicilian Channel), between 1950-1994 as 0-8 sharks per year (mean 2.2, Fergusson unpubl.). We presently have no complete data for Japan, New Zealand or Chile. In other areas, catches are much more nominal and very sporadic (e.g., Brazil, Hawaii).

The first population estimate of white sharks of the east coast of Africa from 1996 was 1,279 individuals (Dudley 2012). Regional centers of white shark abundance are from False Bay to KwaZulu-Natal, South Africa (Dudley 2012); the coastline between these two regions of abundance is approximately 1500km. At the time of its nomination for listing as a protected species in 1996, it was proposed that the Australian population of white sharks numbered less than 10,000 mature individuals (EA 1996). A recent study determined genetic population subdivision between eastern and southwestern coastal regions off Australia and that there are approximately 800 breeding individuals off the east coast (Blower *et al.* 2012). Tracking data of juvenile white sharks from this region showed that they transit over 2,000 km of coastline from eastern Tasmania to southern Queensland (Bruce and Bradford 2012). The northeastern population of white sharks utilizes a comparable amount of coastal habitat to that of the Australia and South Africa populations, but the population size of the northeastern Pacific white sharks relative to the length of transited coastline is much smaller (see Table 2).

Table 2: Summary of population information and coastal habitat length for the major populations of white sharks globally.

Geographic white shark population	Approximate length of coastal habitat used as centers of abundance (km)*	Population estimates or indices	Population Trend

Northeastern Pacific (US West Coast	1,200	339 sub-adults and adults (Chapple *et al.* 2011; Sosa-Nishizaki *et al.* 2012)	unknown
Northwestern Atlantic (US East Coast)	3,000	Unknown	79% decline (95% CI:59 to 89%) (Baum *et al.* 2003)
Australia (East Coast)	2,000	800 breeding individuals off AUS east coast (Blower *et al.* 2012)	>70% decline since 1950 off New South Whales (Reid and Krogh 1992)
Africa (Southeast Coast)	1,500	1,279 (Dudley 2012)	Unknown (decline from 1966-1972, but no trends in catch rate in recent decades via protective net capture data) (Dudley 2012)
Adriatic Sea	-	-	>80% decline (Soldo and Jardas 2002)

*Coastal habitat lengths were estimated using Geographic Information Systems utilizing identified ranges from published literature.

J. Northeastern Pacific White Shark Population

No historic population estimate exists for the northeastern Pacific population of white sharks. However, two research teams have published census estimates on the northeastern Pacific population in the last two years and both studies have provided alarmingly low estimates. Both studies utilized techniques involving photographic mark-recapture methods. The combined estimates from California Central Coast and Guadalupe Island aggregation sites suggest a total of 339 subadult and adult white sharks in the northeastern Pacific (Chapple *et al.* 2011; Sosa-Nishizaki *et al.* 2012).

Abundance of the California Central Coast population was estimated via photographically identified mark-recapture data resulting in a population estimate of 219 mature and sub-adult individuals (Chapple *et al.* 2011). The estimate of 219 adults and sub-adults is based on a Bayesian mark-recapture algorithm assuming a closed population. This resulted in a 95% confidence interval from 130 to 275 adults and sub-adults. Although this first estimate is the result of only two seasons of mark-recapture (September-January 2006-2008) it serves as a baseline and suggests the coastal northeastern Pacific population is relatively small, even for apex predators (Chapple *et al.* 2011).

Encounter histories of photographically identified white sharks over nine years (2001-2009) provide the first Guadalupe Island population size estimate of 120 individuals (Sosa-Nishizaki *et al.* 2012). Using a combination of the Cormack Jolly-Seber model and generalization of the Jolly-Seber model, this study resulted in a 95% confidence interval that the population is between 114 and 134 adults and sub-adults based on the assumption this is an open population.

The abundance of juvenile and YOY white sharks in the northeastern Pacific population is unknown (Chapple *et al.* 2011). However, high recapture rates (Weng *et al.* 2007) of these young northeastern Pacific white sharks suggest even the addition of these age classes would still result in a low abundance relative to other apex predators (Chapple *et al.* 2011). As the majority of white sharks within the subadult and adult age classes are likely accounted for in the California Central Coast and Guadalupe Island aggregations, there is concern that the total number of the northeastern Pacific white sharks is alarmingly low (Sosa-Nishizaki *et al.* 2012).

Although both studies used photographic mark-recapture methods to arrive at the first index of abundance for these two white sharks aggregations, the assumptions used in the models varied between closed and open populations. Sosa-Nishizaki *et al.* (2012) argue that the assumption of equal probability of recapture used in both the California Central Coast and Guadalupe Island aggregation estimates was violated and actually underestimates the actual population, urging that more monitoring and research is needed to conclusively determine the absolute population of northeastern Pacific white sharks (Sosa-Nishizaki *et al.* 2012). However, even if the actual population at Guadalupe Island is triple the current estimates, the population is still dangerously low and far less than the vast majority of other ESA-listed marine fish. In fact, despite the potential underestimation, Sosa-Nishizaki *et al.* (2012) ultimately conclude that these first indices of abundance suggest the northeastern Pacific adult white shark population is small and that continued monitoring and precautionary management is needed.

Evaluating sex ratios documented from various studies of the California Central Coast and Guadalupe Island aggregations can provide additional insight into the status of the overall Northeastern Pacific population. In particular, the population of reproductively capable females is a critical parameter in the context of extinction risk. As presented below, sex ratios documented to date favor males, suggesting that there may be less than 100 reproductively capable females in the population.

Results from a nine year photographic mark-recapture study of Guadalupe Island white sharks (population estimate of 120 sub-adult and adults) showed 51 females and 69 males, with a sex ratio significantly different from 1:1 (Sosa-Nishizaki *et al.* 2012). A separate publication on Guadalupe Island white sharks utilizing photographic and video records from 2001-2005 identified 73 individuals, 33 females and 40 males (Domeier and Nasby-Lucas 2006). Photographic mark-recapture data from white sharks near the Farallon Islands and Tomales Bay, California between 1987 and 2008 revealed that confirmed males were sighted twice as often as confirmed females (1.8:1) (Anderson *et al.* 2011). However, the ratio of unknown to known sex was 4.26:1 (Anderson *et al.* 2011). The sex ratio documented from two seasons of photographic mark-recapture of white sharks off Tomales Point and the Farallon Island, California (2006-2008) was 19 females, 69 males, and 42 unknown (Chapple *et al.* 2011). The large number of unknowns is because it is much easier to identify the presence of claspers than the absence of them.

Sex ratios from these four studies are consistent with previous findings that few mature females and even smaller number of pregnant female white sharks exist at any given time (Compagno *et al.* 1997). Sex ratios heavy on the male side are of concern for a species of low population size, especially given that females take 12-14 years to reach sexual maturity (Compagno *et al.* 1997) and likely breed only every other year (Domeier 2012). Of particular importance to the longevity of a species are reproductively mature females. Generally speaking if a population is composed of 50% males and 50% female, and only half of the females are reproductively mature, then only 25% of the total population of females capable of reproducing. Large, mature females make up only a very small proportion of the total population, but they are the most important breeding segment of the population (Australia and Madagascar 2004). The fact that female white sharks do not reproduce every year and their gestation period is likely longer than 12 months makes them that much more vulnerable to exploitation (Australia and Madagascar 2004). Applying the 25% multiplier to the central estimate of Northeastern Pacific white sharks suggests this population consisting of 339 adults and sub-adults contains less than 100 females capable of reproducing.

While there remain uncertainties regarding the precision of the central estimate, population sizes at levels at this order of magnitude creates an inherent risk of population level effects from stochastic impacts, whether natural or anthropogenic. In such situations, catastrophic and/or stochastic events can cause extirpation and extinction (Mangel and Tier 1994). Currently available estimates suggest substantial risk of extinction as the population is far below the minimum viable population ("MVP") for most species, even apex predators. MVP is typically estimated as the population size necessary to ensure 90-95 survival between 100-1000 years into the future, given stochastic events (Soule 1987). An MVP of 500 to 1,000 has often been given as an average for terrestrial vertebrates when inbreeding or genetic variability is ignored (Lehmkuhl 1984; Thomas 1990). K-strategists like white sharks have higher MVPs than r-selected species, as they are easily affected by inbreeding depression and typically have low population densities while occurring over a wide range. When inbreeding effects are included, estimates of MVP for many species are in the 1,000s. Based on a meta-analysis of reported values in the literature for many species, Traill *et al.* (2007) reported a median MVP of 4,169 individuals.

Site fidelity may also cause periods of local vulnerability and increase localized depletion rates (Hueter *et al.* 2004; Domeier and Nasby-Lucas 2006). The geographic concentrations of juveniles and adults during key periods of white shark life history put the entire population at risk from environmental change, oil spills, geological events, or other catastrophes. The only way to buffer against that risk and increase the probability of long-term population persistence is to increase the population size and its genetic diversity across a range of habitats. Recovery of northeastern Pacific white sharks and persistence of the population must be robust enough to endure catastrophic events. Ultimately, as even the most optimistic population estimates for the northeastern Pacific white shark are dangerously low and there is no evidence for recovery, immediate listing under the Endangered Species Act is warranted.

II. The Northeastern Pacific Population of White Sharks Warrants Protection Under the Endangered Species Act

The northeastern Pacific population of great white shark is a distinct population segment ("DPS"), and it must be classified as threatened or endangered under the Endangered Species Act. First, the northeastern Pacific population of great white sharks meets the criteria as a DPS because it is distinct and significant. Second, this DPS has an extremely small population, making it highly vulnerable, and threats to the northeastern Pacific DPS of white shark meet the listing criteria under the Endangered Species Act. Finally, NMFS must designate critical habitat for the northeastern Pacific white shark.

This petition is filed pursuant to Section 4(b) of the Endangered Species Act, 16 U.S.C. §1533(b), Section 553(3) of the Administrative Procedure Act, 5 U.S.C. § 553(e), and 50 C.F.R. § 424.14(a). Petitioners request that the Government list the northeastern Pacific white shark as an endangered distinct population segment and designate critical habitat. This petition sets in motion a specific process, placing definite response requirements on NMFS. NMFS must issue an initial finding concerning 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. Petitioners need not demonstrate that the petitioned action *is* warranted. Rather, Petitioners need only present information demonstrating that such action *may* be warranted. The northeastern Pacific population of white sharks satisfies the requirements for listing under the ESA. Accordingly, NMFS must promptly make a positive initial finding on the petition and commence a status review as required by 16 U.S.C. § 1533(b)(3)(B).

The term "species" is defined broadly under the Endangered Species Act to include "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." 16 U.S.C. § 1532 (16). A distinct population segment of a vertebrate species can be protected as a "species" under the Endangered Species Act even though it has not formally been described as a "species" in the scientific literature. A species may be composed of several distinct population segments, some or all of which warrant listing under the Endangered Species Act. NMFS and the U.S. Fish and Wildlife Service have promulgated a policy setting forth the criteria for determining a distinct population segment. *Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act*, 61 Fed. Reg. 4722 (Feb. 7, 1996).

The northeastern Pacific white shark population is both "discrete" and "significant," thereby meeting the qualifications for separate listing as a distinct population segment under the Services' policies. Petitioners also request that critical habitat be designated for the northeastern Pacific distinct population segment of the white shark concurrently with its listing as endangered, pursuant to 16 U.S.C. § 1533(a)(3)(A) and 50 C.F.R.§ 424.12.

A. The Northeastern Pacific Population of White Sharks Is a Distinct Population Segment

The northeastern Pacific population of white sharks satisfies the criteria of a "distinct population segment" set forth in the Services' policy statement. Under this policy, once a population segment is found to be both discrete and significant, it is a distinct population segment that may be considered for listing under the Act. NMFS & FWS, *Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act*, 61 Fed. Reg. 4722 (Feb. 7, 1996) at 4725. A population segment may be classified as discrete in relation to the rest of the species with which it is associated. *Id*. A discrete population may be classified as biologically or ecologically significant to the larger species. *Id.*; *see also Southwest Ctr. for*

Biological Diversity v. Babbitt, 980 F. Supp. 1080, 1085 (D. Ariz. 1997). Because the northeastern Pacific white shark meets these factors, it should be classified as a distinct population segment.

1. The Northeastern Pacific White Shark Is a Discrete Population Segment

The northeastern Pacific white shark is "discrete." The joint Services' joint policy states that a population segment of a vertebrate species is 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. 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.

NMFS & FWS, *Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act*, 61 Fed. Reg. 4722 (February 7, 1996). The northeastern Pacific population of white sharks clearly satisfies the first criterion and, as to the second criterion, the population also crosses international boundaries from US waters to high seas and Mexican waters, and to a lesser extent Canada, where differences in management and exploitation exist.

As to the first criterion, the northeastern Pacific population of white sharks differs markedly from other oceanic populations of the species because of physical (genetic) and behavioral (site fidelity) factors.

Physical (Genetic) Factors:

The northeastern Pacific population of white shark is reproductively isolated, and genetic analysis demonstrates that this population is genetically distinct. While having some genetic similarities with the Australian/New Zealand population of white shark, sampling shows that these populations have been separated for hundreds of thousands of years resulting in a clear genetic divergence between the populations (Jorgensen 2010). The northeastern Pacific population is thought to have initially been established approximately 200,000 years ago by individuals that migrated from Australia/New Zealand waters (Jorgensen 2010).

Globally, at least three white shark matrilineal populations have been identified via analysis of DNA sequences from the mitochondrial control region locus. These three populations are South Africa/northwest Atlantic; Northeastern Pacific; and Southwest Pacific (Gubili *et al.* 2012). A study of mitochondrial DNA analysis identified two main lineages. The north Pacific samples cluster with several from the southwest Pacific (Australia), but within the cluster they are genetically distinct; this demonstrates that the northeastern Pacific white sharks are distinct from, but a clear descendant of, the southwestern Pacific group (Gubili *et al.* 2012). Northeastern Pacific estimates of gene flow suggest these two populations are reproductively isolated (Gubili *et al.* 2012).

These genetic differences are collaborated by another study by Jorgensen et al. (2010), that identified, through a combination of satellite tagging, passive acoustic monitoring, and mtDNA analysis, that the northeastern Pacific population of white sharks are a genetically distinct, demographically isolated population. A shallow genetic history is consistent with numerous species in the eastern Pacific. This study identified that northeastern Pacific white sharks are a clear descendant of AUS/NZ white sharks, but demonstrate highly significant population divergences (pairwise F_{ST}= 0.68, < 0.0001) (Jorgensen 2010). Mitochondrial control region sequences of northeastern Pacific white sharks were compared to published sequences of white sharks from South Africa and AUS/NZ. Northeastern Pacific white sharks formed a unique monophyletic clade (bootstrap = 58%, Bayesian posterior probability = 60%) of relatively recently derived lineages (Jorgensen 2010).

In sum, DNA analysis shows that the Northeastern Pacific population of white sharks is genetically distinct, and that little geneflow has occurred among Pacific populations since they diverged approximately 200,000 years ago.

Behavioral (Site Fidelity) Factors:

Behavioral factors also distinguish this population. The northeastern Pacific population of white sharks is made up of one group that transits the California Central Coast and one that transits Guadalupe Island, Mexico and this population is distinct because their behavioral patterns separate them geographically from other white sharks. The northeastern Pacific population of white shark is characterized by site fidelity and distinct migratory patterns.

Although white sharks are capable of long-distance dispersal, their behavior keeps the populations isolated from one another. Northeastern Pacific white sharks display philopatric behaviors resulting in a genetically discernible, separate population (Chapple *et al.* 2011). Since the northeastern Pacific white shark population established and diverged from the Australia/New Zealand population, site fidelity has prevented continued mixing of the two populations, as evidenced their genetic divergence (Jorgensen 2010). Electronic tracking data of California Central Coast white sharks and those from Guadalupe Island, Mexico confirm these individuals remain within a fixed geographical range and there is no evidence of straying or spatial overlap with the Australia/New Zealand population (Jorgensen 2010).

As part of their site fidelity, the northeastern Pacific population of white sharks maintains migratory patterns that are also distinct from other populations. This philopatric, or homing, behavior is characterized by an inshore, continental shelf migration phase and an offshore pelagic phase associated with transoceanic migration (Boustany *et al.* 2002). Northeastern Pacific white sharks demonstrate strong site fidelity to three specific geographic locations (Jorgensen 2010; Anderson *et al.* 2011; Chapple *et al.* 2011; Sosa-Nishizaki *et al.* 2012). These locations are 1) their respective coastal aggregation sites off California and Guadalupe Island, Mexico; 2) the Hawaiian archipelago; and 3) the Shared Offshore Foraging Area ("SOFA") bordered by the North Pacific Gyre (Klimley and Anderson 1996; Domeier and Nasby-Lucas 2006; Domeier and Nasby-Lucas 2008; Jorgensen 2010; Chapple *et al.* 2011). Thus, behavioral characteristics and genetic differences demonstrate that the northeastern Pacific population of great white shark is distinct.

The northeastern Pacific population of white sharks are should also be considered discrete under the second criterion on as well. The northeastern Pacific population of white shark inhabits the waters of the United States' Exclusive Economic Zone and also transits the high seas and occurs in Mexican waters, with potentially infrequent migrations to the Exclusive Economic Zone of Canada. Thus, these white sharks are subject to exploitation outside US waters, by non-US actors and they may be impacted by differences in management. The white shark café region, for example, is a zone with international longline fisheries specializing in big-eye and yellowfin tuna.

Furthermore, treating the northeastern Pacific population as a distinct population segment is prudent because this is the population of white sharks needing management in the United States as many of this population's focal areas are subject to U.S. management jurisdiction. The United States will play a crucial role in the management of this population because the northeastern Pacific population of white sharks is encountered by United States fisheries. Researchers note that management of this population as a discrete unit is feasible and desirable:

> Concordance between contemporary movement and genetic divergence based on mitochondrial DNA demonstrates a demographically independent management unit not previously recognized. This population's fidelity to discrete and predictable locations offers clear population assessment, monitoring and management options. (Jorgensen 2010).

Moreover, management by the United States is necessary because site fidelity may cause periods of local vulnerability and increase localized depletion rates (Hueter *et al.* 2004; Domeier and Nasby-Lucas 2006). Researchers note that the existence of matrilineal clades that do not mix means that local populations could be endangered (Gubili *et al.* 2012). For shark species that demonstrate strong philopatry to nursery areas, once the population has declined or the habitat is lost, re-establishment of reproduction by straying animals may take a very long time (Hueter *et al.* 2004).

Thus, the northeastern Pacific population should be considered discrete because (1) it is primarily in US waters, (2) it ranges internationally into waters with differing management regimes, and (3) US management is critical for this particular population.

2. The Northeastern Pacific Population of White Sharks is Significant

The northeastern Pacific white shark population is significant to the taxon. The joint NMFS and FWS listing policy requires that once a population is established as discrete, then the biological and ecological significance is next considered. Each population segment's significance must be analyzed on a case-by-case basis. NMFS & FWS, *Policy Regarding the Recognition of Distinct*

Vertebrate Population Segments Under the Endangered Species Act, 61 Fed. Reg. 4722 (February 7, 1996). 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 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 segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range.
> 4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

The Northeastern Pacific population of white sharks satisfies three of these "significance" criteria: (1) this population is in a unique ecological setting for which it plays a fundamental role; (2) the loss of this discrete population would result in a significant gap in the range of the taxon; and (3) this population has genetic characteristics that differ markedly from other populations.

a. The northeastern Pacific population of great white shark is in a unique ecological setting for this species

Persistence of the northeastern Pacific population of white sharks in the California Current ecosystem is unique to this species because they are the only population in this unique ecosystem. This population of white sharks lives in a coastal upwelling system that is biologically rich. The upwelling phenomenon results in a dynamic ocean environment that results in varying abundances of prey and predators. It is also highly sensitive to the impacts of El Niño Southern Oscillation. The presence of this population in the area of the Pacific known as the white shark café between Hawaii and California is unique to this taxon and their behavior of foraging and mating in this area is significant to the species.

Additionally, the role of great white sharks in the northeastern Pacific ecosystem is essential for the health of the ecosystem. The California Current Large Marine Ecosystem is an important habitat for an array of marine species including the white sharks (Block *et al.* 2011). Top predators may play an important top-down role in structuring the California Current Large Marine Ecosystem given that there is an extensive density of top predators in the region (Block *et al.* 2011).

White sharks play a key role in regulating prey populations (Brown *et al.* 2010). Impacts of shark depletion can radiate through the food web in complex and unpredictable ways (Stevens *et al.* 2000). Effects of shark depletion may be ecologically and economically significant and may persist over long time periods (Stevens *et al.* 2000). Early studies have demonstrated that removing predators from a marine ecosystem can have a dramatic impact on the structure of prey species (Paine 1969). Ecologists have long predicted that the demise of top predators like sharks can trigger destructive consequences in marine ecosystems.

The role of apex predators such as white sharks in marine ecosystems is important and complex. A recent study published in *Science* (Estes *et al.* 2011) stated:

> *Until recently, large apex consumers were ubiquitous across the globe and had been for millions of years. The loss of these animals may be humankind's most pervasive influence on nature. Although such losses are widely viewed as an ethical and aesthetic problem, recent research reveals extensive cascading effects of their disappearance in marine, terrestrial, and freshwater ecosystems worldwide.*

Studies confirm that the loss of sharks from an ecosystem, such as a coral reef, can trigger a chain of effects moving down through lower levels of the food web in what has been termed a "trophic cascade" (Sandin *et al.* 2008). Some large shark species can exert strong top-down forces with the potential to shape marine communities over large spatial and temporal scales (Ferretti *et al.* 2010). Here, the role of white sharks as apex predators consuming other large predators such as elephant seals and sea lions has been reported routinely at the Farallones (Pyle *et al.* 1996; Pyle *et al.* 2003; Brown *et al.* 2010). In the absence of human predation, populations of northern elephant seals, California sea lions and other pinnipeds are unregulated by any other major predator but white sharks, with the possible exception of seasonal visitations by orcas. Thus, it is reasonable to speculate that the absence or depletion of white sharks will have a direct impact on the pinniped population size and demography, and indirectly on the food that the pinnipeds consume including commercially valuable species like rock fish, salmon, halibut and seabass. The economic benefits of protecting white sharks may benefit California fishing industries by allowing the northeastern Pacific white shark population to grow and regulate these populations of mid-trophic level predators.

Therefore, not only does the northeastern Pacific white shark occupy a unique ecological setting making it significant to the taxon, but it also plays a unique and fundamental role as an apex predator in the California Current ecosystem.

b. Loss of the northeastern Pacific population of great white shark would result in a significant gap in the range of the taxon.

The loss of the northeastern Pacific population of white sharks would result in a significant gap in the range of the species as recent data indicates that the northeastern Pacific population does not mix with any other regional populations of white sharks and would likely not be replaced by immigrating individuals from an outside population (Hueter *et al.* 2004; Jorgensen 2010). The northeastern Pacific white shark persists only in its unique range. As described above, the northeastern Pacific white sharks do not interbreed with other breeding populations.

As discussed, the range of the northeastern Pacific population is focused on three core areas: (1) the North America shelf waters off the West Coast of the United States, (2) the slope and offshore waters of the Hawaiian archipelago, and (3) the offshore white shark café between Hawaii and California (Jorgensen 2010). These areas are specific to this population. While white sharks can migrate large distances, their homing behavior keeps the breeding populations separate (Jorgensen 2010). The presence of genetically distinct populations of white shark in various locations shows that they do not mix (Gubili *et al.* 2012).

For shark species that demonstrate strong philopatry to nursery areas, once the population has declined or the habitat is lost, re-establishment of reproduction by straying animals is unlikely on a human time scale (Hueter *et al.* 2004). The physical and behavioral characteristics of white sharks prevent them from recolonizing areas of local extirpation. Because individual sharks are not migrating throughout the world, this means that extirpation of the northeastern Pacific white sharks would create a significant gap in the range of the taxon. Individuals from other populations are not able to replace the northeastern Pacific population because they exhibit their own site fidelity. Accordingly, if this population were lost then this portion of the global range of white shark would be extirpated and likely unable to recolonize on any realistic timescales.

c. The northeastern Pacific discrete population segment of white sharks differs markedly from other populations of the species in its genetic characteristics

The Northeastern Pacific white shark is markedly different from other populations, and this has been demonstrated by genetic analysis. As described in the above section on discreteness, studies demonstrate that this population may have descended from the Australia/New Zealand population over 200,000 years ago (Jorgensen 2010). Since then, however, the population has been isolated and only interbreeded; thus resulting in a genetic distinction from all other white shark populations (Jorgensen 2010; Gubili *et al.* 2012). Accordingly, the northeastern Pacific population of white shark is genetically significant to the entire taxon and meets this criteria of significance.

Due to the above listed factors, the northeastern Pacific white shark is a discrete, significant, and distinct population segment. Throughout their life cycle they remain in three areas primarily off California, Hawaii, Guadalupe Island and migrate between these areas. They reproduce and breed only within this population and they do not interbreed with other populations. The extinction of this population would create a significant gap in the range of the species and would be a great loss to the taxon as a whole. Management of this population as a distinct population segment is necessary for their conservation and supported by the best available science.

B. The Northeastern Pacific Population of White Sharks Merits Listing as Threatened or Endangered Under the ESA

The northeastern Pacific population of white sharks meets the criteria for listing as threatened or endangered. Under the ESA, 16 U.S.C. § 1533(a)(1), NMFS is required to list a species for protection if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range. In making such a determination, NMFS must analyze the species' status in light of five statutory listing factors. 16 U.S.C. § 1533(a)(1)(A)-(E); 50 C.F.R. § 424.11(c)(1) - (5). These factors are:

> (A) the present or threatened destruction, modification, or curtailment of its habitat or range;
> (B) over-utilization 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 survival.

Many of these factors have played a role in bringing the Northeastern Pacific white shark to its current, perilous condition.

A species is “endangered” if it is “in danger of extinction throughout all or a significant portion of its range” due to one or more of the five listing factors. 16 U.S.C. § 1531(6). A species is “threatened” if it is “likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” 16 U.S.C. § 1531(20). Under the ESA, a “species” includes any species, subspecies or “distinct population segment” of a vertebrate fish or wildlife. 16 U.S.C. § 1532(16). Here, Petitioners show that the northeastern Pacific white shark is a Distinct Population Segment and meets the listing criteria for protection as threatened or endangered under the ESA.

In further support of such listing, NMFS should note that white sharks are classified as “vulnerable” by the International Union for the Conservation of Nature (“IUCN”), the world’s foremost authority on the status of threatened species (Fergusson *et al.* 2009). IUCN 2001; Akçakaya *et al.* 2006). While the IUCN listing affords no actual regulatory protection to any species, such a listing is an unequivocal statement from scientists that the species is imperiled and warrants protection. This classification for white shark is evidence that the petitioned species may warrant protection under the ESA.

Threats to northeastern Pacific white sharks include 1) their low population level; 2) incidental bycatch in fisheries; 3) high contaminant levels; 4) habitat alteration due to ocean acidification, ocean warming, and other stressors; and 5) paucity of scientific data on key population factors.

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

The habitat of the northeastern Pacific white shark is changing, and these changes pose a threat to the long-term survival of the shark. Increasing human activity, especially that concentrated in coastal areas, may lead to degradation of important inshore feeding and reproduction habitat for white sharks. An array of pollutants have also been documented discharging into the Southern California Bight for quite some time (Mull *et al.* 2012), which can degrade critical habitat for northeastern Pacific white sharks, particularly juveniles based on the fact that this area serves as nursery habitat as described previously.

The present state of white shark habitat has been highly modified by human activity. As described in the prey section, all primary pinniped species which are prey, and hence part of the habitat for adult life stage white sharks were massive depleted by human exploitation. While population trends for these pinnipeds are increasing, they remain below historic levels and were in a depleted state for a prolonged period. In addition, there have been and continue to be major commercial fisheries for most of the prey items for other life stages of white sharks as defined by

(Klimley 1985; Ellis and McCosker 1995), including Pacific sardine, salmon, white seabass, black rockfish, striped bass, spiny dogfish, crustaceans, cephalopods, cabezon, lingcod, and Pacific mackerel (CDFG 2010).

Ocean acidification is rapidly progressing and will grow more severe in the range of the northeastern Pacific white shark. A recent study found that ocean acidification is progressing rapidly in the California Current marine ecosystem and projected that much of the nearshore region will experience summer-long undersaturation in the top 60 meters within the next 30 years (Gruber *et al.* 2012). While severity of the effects on specific species or the overall ecosystem are uncertain, the California Current marine ecosystem is moving rapidly toward conditions that are well outside the natural range; this could adversely impact the marine food web, including white sharks. Studies demonstrate that ocean acidification has negative impacts on fish, with effects on their metabolism and other biological functions (Portner 2008). In fish, high concentrations of carbon dioxide in seawater can lead to cardiac failure (Ishimatsu et al. 2004). In conditions simulating future seawater with elevated carbon dioxide, larval clownfish lost their detection and homing abilities to find suitable habitat (Munday et al. 2009). Ocean acidification also decreases the sound absorption of seawater causing sounds to travel further with potential impacts on marine mammals and other marine life that may be sensitive to noise of vessel traffic, seismic surveys, military sonar, and other noise pollution (Hester et al. 2008). Already sound travels 10-15 percent further with a change of 0.1 pH, and it is predicted to increase about 40 percent by mid century with corresponding ocean acidification (Hester et al. 2008). In combination with ocean warming, these effects could be cumulative and synergistic (Portner 2008).

2. Over-utilization for commercial, recreational, scientific, or educational purposes

Right now, the key direct threat to the northeastern Pacific population of white sharks is that they are being captured and killed in fishing gear. Accordingly, they are being over-utilized for commercial purposes. In addition to the incidental catch of sharks, they are also caught for the sale of their fins for soup and in the curio trade.

The inquisitive nature of white sharks coupled with their habit of aggregating at coastal locations makes them behaviorally and biologically vulnerable to targeted commercial and recreational fisheries and as bycatch in fisheries targeting other species (Australia and Madagascar 2004). This species is unquestionably vulnerable to directed exploitation by the curio trade and the shark-fin trade (Shivji *et al.* 2005). The overall, long-term impact of these causes of mortality upon regional populations, coupled with those caused through intended and unintended commercial fishery captures is detrimental. The removal of even a few individuals has been documented to have a quantifiable, tangible reduction in overall white shark activity and abundance at discrete localities based upon observations at the Farallon Islands following the cull of four local sharks in 1984 (Pyle *et al.* 2003).

While life history determines the level of mortality sharks can sustain, their vulnerability depends on the combination of life history, sensitivity to habitat loss (Heupel *et al.* 2007) and susceptibility to fisheries. The latter relates to many factors including geographic range (Reynolds *et al.* 2002; Shepherd and Myers 2005), habitat use (Garcia *et al.* 2008), behavior (Ward and Myers 2005; Gilman *et al.* 2008), and body size (Dulvy *et al.* 2003; Field *et al.* 2009).

It is well documented that sharks are vulnerable to over-exploitation (Baum *et al.* 2003) given their slow growth rate, low fecundity, older age of maturity, and naturally high mortality rates of juveniles within the first year (Stevens *et al.* 2000; Wilson and Patyten 2008). Catch per unit effort data from the northwest Atlantic indicate that even bycatch of this species unsustainable (Australia and Madagascar 2004).

Tagging data of juvenile white sharks in the Southern California Bight show they prefer the surface mixed layer indicating that these young sharks may be most susceptible to fishing gear at these depths (Weng *et al.* 2007). In addition, diel patterns show juveniles are more likely to be captured in bottom set-gillnets during daylight (Weng *et al.* 2007). Substantial commercial fishing activity overlaps with known white shark habitat in the California Current. Very little, if any, fishing effort is documented by observers in most of these fisheries (<5% in recent years), so the magnitude of shark interactions in these fisheries cannot be determined. However, based on reported interactions, the most significant documented threat posed by human activity facing the northeastern Pacific population of white sharks is incidental catch in entangling set and drift gillnet fisheries off California and Mexico (Figure 7). Of white shark caught in these gears in Southern California, the vast majority are young-of-the-year and juveniles.

The following three U.S. west coast fisheries accounted for 81% of all reported white shark captures off Southern California (Lowe *et al.* 2012):

1) set gillnet fishery for California halibut, white seabass, and angel shark;
2) drift gillnet fishery (small mesh) for yellowtail, barracuda, and white seabass; and
3) drift gillnet fishery (large mesh) for thresher sharks and swordfish.

These three fishing gears are considered “entangling nets”, Recreational hook and line fishing accounted for 8% of all reported white shark captures, while the remaining 11% were caught with set lines, harpoon, trawl, purse seine, lobster trap, gaff, or unspecified fishing gears (Lowe *et al.* 2012).

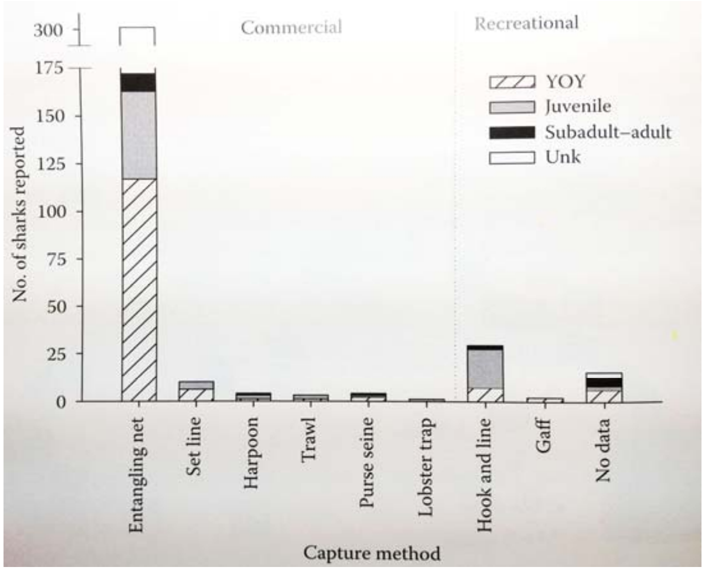


Figure 7: Numbers of reported white shark captures occurring in Southern California by capture method, 1935-2009. From Lowe *et al.* (2012).

The main set gillnet fishery off California primarily targets California halibut, white seabass, and to a lesser extent angel shark using a net mesh size greater than 3.5 inches, typically around 100 m in length. Fishing effort occurs year round, but generally increases during summer months and declines during last three months of the year (NOAA 2011). Currently two drift gillnet fisheries operate off California. "Small mesh" drift gillnets have net mesh sizes between 3.5 in and14 inches, targeting California yellowtail, barracuda, and white seabass. The fishery operates year-round, primarily south of Point Conception with some effort around San Clemente Island and San Nicolas Island. A second drift gillnet fishery ("large mesh") uses a mesh size ≥14 inches and targets thresher sharks and swordfish.

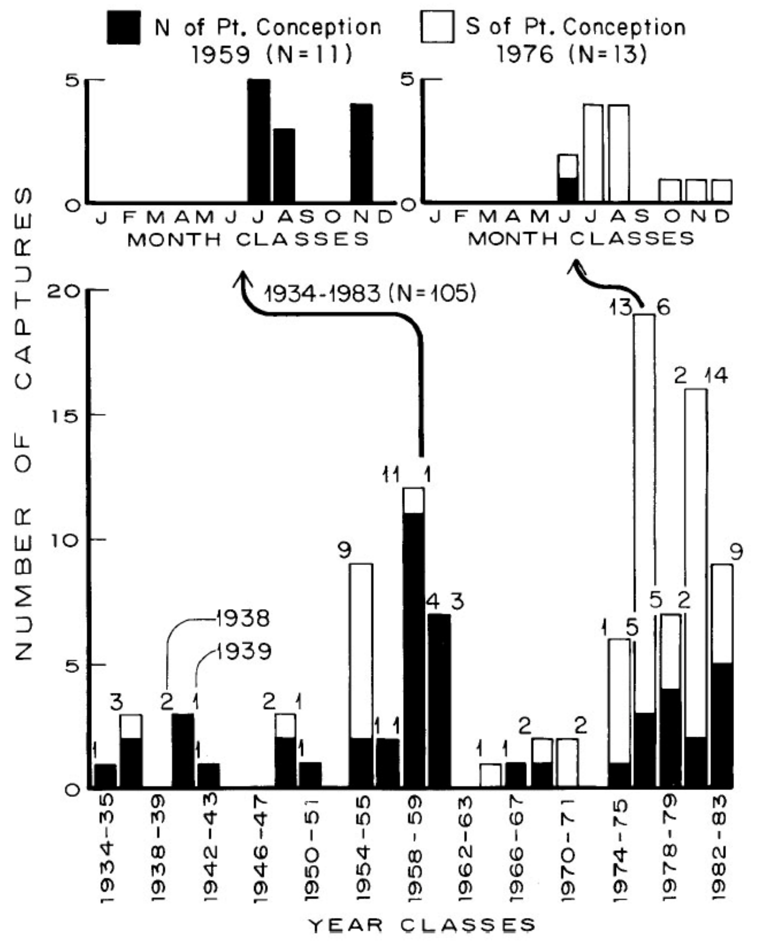


Figure 8: Number of white sharks captured biennially from 1934 to 1983 (below) and monthly (above) during 1959 (lefthand) and 1976 (righthand) along the Western coast of North America. Solid part of the histogram bar indicates the number captures north of Point Conception, the clear part south of Point Conception. Number at top of bar to left gives captures during first year; number to right captures during the second year of biennial class. The largest percentage of white sharks were caught with bottom gillnets (46.9% south of Point Conception and 53.3% north of Point Conception.) (Klimley 1985).

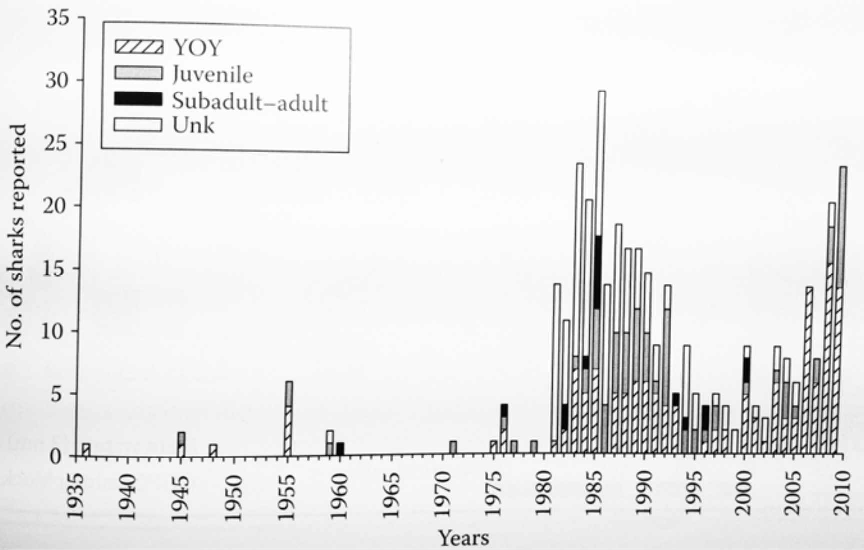


Figure 9: Temporal trends in reported Southern California white shark captures by age class, 1935-2009. From Lowe *et al.* (2012)

The vast majority of white sharks incidentally caught in set and drift gillnets fisheries are young of the year and juveniles. Reported white shark captures off Southern California indicates an increasing bycatch trend over the last decade, ranging from 2-25 white sharks annually with a mean of greater than 10 sharks per year since 1981 (Lowe *et al.* 2012). A total of 369 records of white shark captures were identified between 1936 and 2009, which were mined from news reports, state and federal management agencies, fisheries logbooks, and research institutions. Of these records, 300 were from set and drift gillnets of which 62% of captures occurred in the set-gillnet fishery; 32% occurred in the drift gillnet fishery (targeting pelagic sharks and swordfish); and 6% of the reported captures have no data on the type of gear used (Lowe *et al.* 2012). Of these 39% were young of the year, 21% were juveniles, 5% were subadult/adults, and 35% were of unreported size. Reported landings of white shark bycatch in the Southern California Bight under-represent actual fishing mortality as there is no direct market for white sharks and no incentive to report their bycatch (Dewar *et al.* 2004). Inconsistent logbook compliance is a widely recognized problem in fisheries management (Dewar *et al.* 2004).

Due to their homing behavior, conservation and management of philopatric sharks should take into account the spatial distribution of catch (Hueter *et al.* 2004). The locations of young of the year white shark interactions have been concentrated at discrete locations (Figure 10), which may indicate concentrations of white shark pups along submarine canyons and canyon heads (P. Klimley, *pers. comm.*, 2012). Such concentrations may be conducive to time/area closures as an effective management measures.

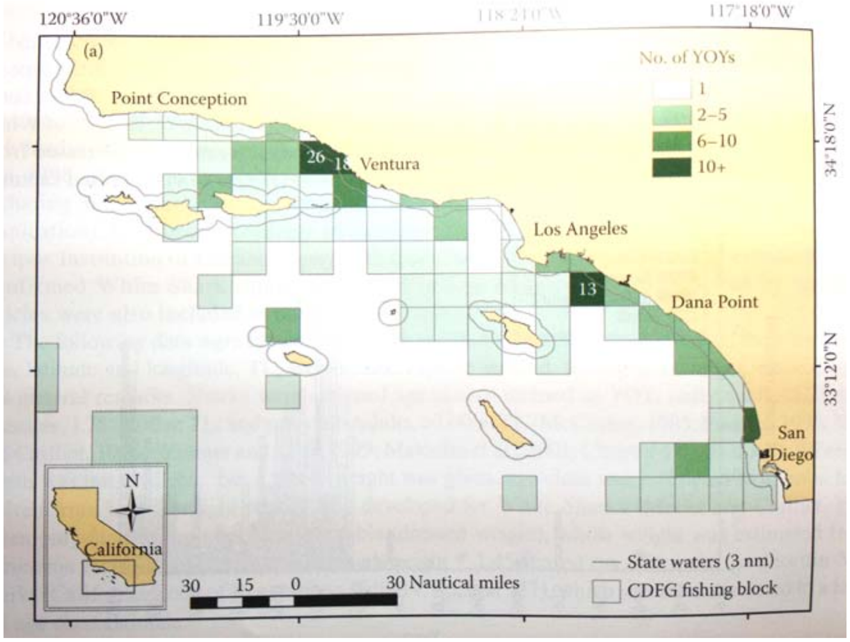
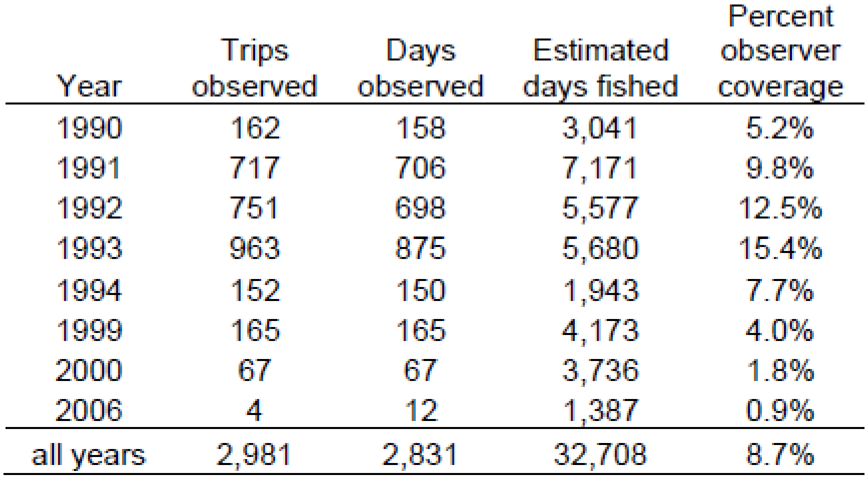


Figure 10: Spatial distribution of reported Young-of-the-Year (YOY) white shark captures occurring in Southern California, 1935-2009. From Lowe *et al.* (2012).

From 1990-2006, one white shark was observed discarded dead in the California set gillnet fishery (Larese 2009). Oceana made a request to L. Enriquez and J. Carretta of NOAA via electronic mail on June 6, 2012 for all bycatch data in both the small mesh drift gillnet fishery and the set gillnet fishery and we have not received this data at the time of this submission. The Monterey Bay Aquarium received entangled white sharks from this fishery in 2004 and 2007, indicating white sharks continue to be caught in this fishery with some regularity. Observer coverage in the set gillnet fishery has been relatively low particularly in recent years (see Table 3), preventing accurate estimates of white shark bycatch in this fishery. Larese (2009) concluded:

> Increased observer coverage to better detect these rare events involving species of management concern is necessary to obtain informative estimates of bycatch levels…. To determine the take of rarely discarded species (i.e. species caught a few times a year) would require 100% observer coverage.

Table 3: Yearly summation of the California set gillnet fishery effort, number of trips observed, and coverage from 1990-2006. From Larese (2009).



Year	Trips observed	Days observed	Estimated days fished	Percent observer coverage
1990	162	158	3,041	5.2%
1991	717	706	7,171	9.8%
1992	751	698	5,577	12.5%
1993	963	875	5,680	15.4%
1994	152	150	1,943	7.7%
1999	165	165	4,173	4.0%
2000	67	67	3,736	1.8%
2006	4	12	1,387	0.9%
all years	2,981	2,831	32,708	8.7%

Since 1990 set gill nets have been prohibited in state waters out to 3 miles from the coastline in Southern California, south of Point Arguello to the Mexico border and within 70 fathoms or one mile, whichever is less, around the Channel Islands (California Code of Regulations, Title 14 §8610.1-8610.3). Since 2002, the California Department of Fish and Game has prohibited gillnetting in ocean waters off central California that are 60 fathoms or less (from Point Reyes to Point Arguello). Although this is not an outright ban in all state waters, the effect is the same as the depth preclusions take off the table any feasible gillnetting sites (i.e. areas that are deeper than 60 fathoms are not feasible to successfully set gillnets). This depth closure has in effect closed the central California coast to set gillnetting.

Following the nearshore set gillnet ban, the remaining offshore set gillnet effort has remained stable and effort has become concentrated near Ventura, Los Angeles/Long Beach, San Onofre, and San Diego. Increased fishing effort in these areas coincides with increased catches of young of the year sharks (especially off Ventura and Los Angeles) (Lowe *et al.* 2012). Despite the regulations curtailing nearshore set gillnet effort, this fishery continues to contribute the greatest number of white shark interactions of any US west coast fishery.

Figure 11: Images from the Sea of Cortez near Guaymas, Mexico of gillnet fishermen landing a white shark measuring nearly 20 feed and weighing 2,000 pounds. http://www.grindtv.com/outdoor/blog/33361/enormous+great+white+shark+hauled+up+by+sea+of+cortez+fishermen/. April 17, 2012.

Over the course of 11 years (1999-2010) incidental catch of 111 juvenile white sharks was documented (Santana-Morales *et al.* 2012) along the coast of Baja California, Mexico. Of those 79.8% were young of the year and the remaining 20.2% were juveniles. Evidence indicates two of the white sharks caught were newborns. Most of the sharks were incidentally caught in the summer months. Bottom gillnets (positioned at depths from 9-32m deep and 2-8km offshore) were responsible for 74.7% of incidental take with drift gillnets comprising 18% of white shark entanglements. Artisanal seine nets accounted for 4.5% of white shark capture. Artisanal fisheries make up at least 80% of elasmobranch fishing in Mexican waters. Artisanal seine-nets are used to catch primarily elasmobranchs and bony fishes, but also commercially important clams and octopus. Historic landings of white sharks via artisanal gear have not been quantified because many of the inshore fishing locations occur in remote locations so these numbers could be higher (Santana-Morales *et al.* 2012). White sharks are still harvested for food and caught in gill nets in the Sea of Cortez (Galván-Magaña *et al.* 2010). Musick *et al.* (2000) reported that white sharks are fished by small-scale long-liners in the Gulf of California.

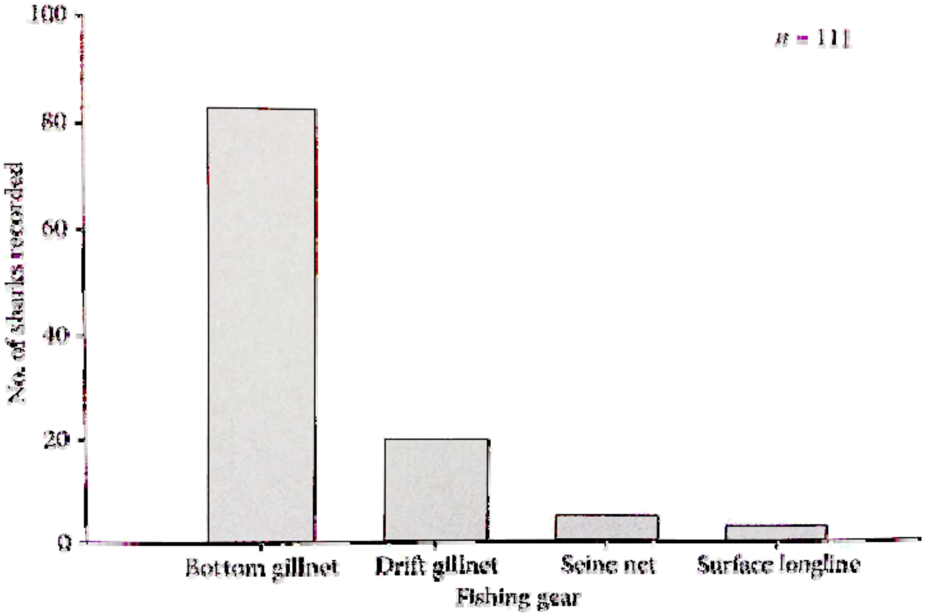


Figure 12: Fishing gear involved in juvenile White Shark captures on the Pacific coast of Baja California, Mexico. n = 111, including all White Shark data. Figure from Santana-Morales *et al.* (2012).

Mature females are likely travel to areas along the coast of southern California and Baja California, Mexico to give birth. Therefore, female white sharks have an increased chance of fatal entanglements in fishing gear along this route (Nasby-Lucas and Domeier 2012). The Southern California Bight is a nursery area for young white sharks and the timing of parturition coincides with the peak of set gillnet fishery season, thus it is not surprising that young white sharks are being caught in the set gillnet fishery around this time. While some of these white sharks are released alive, white sharks are vulnerable to capture trauma and have limited survivorship after capture (Fergusson *et al.* 2009). The vulnerability of the California Central Coast population of white sharks is highlighted by observations following the removal of four great white sharks by a fisherman off the South Farallon Islands in 1982. A study of observations of white shark attacks on pinnipeds suggests that the removal of these four white sharks negatively affected the frequency of shark attack sightings on prey between 1983-1984 (Pyle *et al.* 2003). The significance of this is explained by Chapple (2011), who noted, "[w]ith white sharks, removing even one individual could have very serious consequences for the population and ecosystem."

There remains a strong monetary incentive to capture and process white sharks. Although white shark meat does not command a high ex-vessel price, the price for 1 kg dried white shark fin is approximately US$100 and the jaws can command up to US$500 (Santana-Morales *et al.* 2012). Jaws, teeth and fins are of high value, low volume products that are in considerable international demand in several parts of the world as trophies or curios (the jaws and teeth are readily available through internet sites like eBay for up to US$425/tooth and US$12,500/jaw set) or for the shark fin market. It is suggested that as white shark populations continue to decline, the economic value of trophies such as jaws and teeth will increase, possibly leading to increased targeting, and over-exploitation, as well as growth of an underground sales network or black market for highly lucrative Great White Shark products (Compagno *et al.* 1997). Fins from white sharks have been identified in the Hong Kong shark fin market, and themselves are valued as curios (Clarke 2004). The global shark fin trade has been estimated to take 26-73 million sharks per year (Clarke *et al.* 2006). In addition to trophies, smaller fins from juvenile white sharks are present in the shark fin trade, indicating a multiple use market for white shark fins, including for use as food (Shivji *et al.* 2005).

3. Other Natural or Anthropogenic Factors

High levels of PCB, DDT, and mercury suggest white sharks could be facing physiological impairments and reduced fitness from contaminants. Sharks are particularly vulnerable to accumulation of contaminants due to their high trophic level on the food web, long life spans, and large lipid-rich livers (Mull *et al.* 2012). Juvenile white sharks of the Southern California Bight are more likely to be exposed to contaminants due to their proximity to urban areas along the coastline of their nursery habitats creating the possibility of physical impairment from exposure. The Southern California Bight region has a history of toxic runoff from land to sea (Mull *et al.* 2012).

Young of the year and juvenile white sharks of the Southern California Bight have contaminant levels orders of magnitude greater than those of much larger and older sharks of other species (Mull *et al.* 2012). These young white sharks exhibited PCB liver concentrations 4, 7, and 10 times higher than adult smooth hammerhead sharks from the Ionian Sea and gulper sharks and longnose spurdog sharks from the South Adriatic Sea respectively. The average liver concentration of DDT in young white sharks from the Southern California Bight were 72.37 µg/g lw, 50 times higher than that reported from juvenile white sharks on South Africa's east coast (Mull *et al.* 2012). They also had DDT liver concentrations 12-25 times higher than gulper sharks and longnose spurdogs from the South Adriatic Sea respectively. This lends concern to the impact that mercury, PCBs, and DDT will have on the northeastern Pacific population of white sharks. PCB and DDT levels in liver tissue of white sharks in the Southern California Bight were the highest observed in any elasmobranch reported to date globally.

Of greater concern is the concentration of mercury accumulated by young white sharks. Southern California Bight white sharks had the second highest level of mercury concentrations in muscle tissue for any elasmobranch reported to date (3.01 µg/g w.w) (Mull *et al.* 2012), six times higher than the established wildlife screening value of concern (0.5 µg/g). The muscle Hg concentrations exceed the published threshold for sublethal effects seen in adult teleosts, which include behavioral alterations, emaciation, cerebral lesions, and impaired gonadal development (Wiener *et al.* 2003). These levels greatly exceed other large northeastern Pacific sharks with spatial and dietary overlap (Maz-Courrau *et al.* 2012). Concentrations of selenium in the liver of YOY and juvenile white sharks in the Southern California Bight were higher than examinations of other shark species with the exception of smooth hammerhead sharks from the Ionian Sea (Mull *et al.* 2012), with Hg:Se ratios surpassing the established threshold indicating mercury toxicity (Kaneko and Ralston 2007).

The high levels of PCB and DDT contaminants observed suggest white sharks could be facing physiological impairments especially from elevated levels of mercury in muscle tissue. Other fish species with muscle mercury concentrations that are as high as those observed in the white sharks in the Southern California Bight suffered sublethal effects including changes in behavior, emaciation, and impaired gonadal development (Mull *et al.* 2012). It is plausible that these physiological responses to contaminant loads in white sharks will result in lower survival rates or future reproductive impairment (Mull *et al.* 2012). In this study only concentrations of arsenic and cadmium in liver tissue of white sharks were positively correlated with total length (Mull *et al.* 2012).

Organic and organo-metal contaminants affecting human health also affect health in other vertebrate taxa. Although of increasing importance to human health, the impacts of anthropogenic toxins on the health of most marine species are generally not considered, although enzyme pathways, neurological development and other physiological systems are impacted in a similar fashion.

4. Inadequacy of Existing Regulatory Mechanisms

Despite some protections, white shark populations are still declining globally. There are some prohibitions on the landing, targeting, and trading of northeastern Pacific white sharks (as discussed above); however, existing regulatory mechanisms are inadequate to address the continued incidental catch of white sharks by a suite of fisheries. National protections for white sharks are insufficient when it comes to monitoring, control and surveillance of this species largely because it is bycatch in multiple fisheries not subject to limits on incidental take or adequate observer coverage (Australia and Madagascar 2004). Protective laws are strict, but loopholes and inadequate enforcement causes problems including promoting the black-market for high-value Great White Shark products including jaws, teeth and fins" (Fowler *et al.* 2005).

Many of these regulations are inadequate to provide the necessary protections for sharks. At the international level for example, "the lack of trans-boundary management programmes (essential for a highly migratory species) hampers national conservation and management actions for white sharks" (Australia and Madagascar 2004). No regional fisheries management organizations have implemented any kind of management measures for white sharks. In addition, no international laws are in place to protect living white sharks (Domeier 2012). Efforts to protect sharks through national conventions have sincere intent to but are inefficient due to lack of participation. For example, Malta is still the only Mediterranean State to have ratified the listing of white sharks on Appendix II of the Barcelona Convention in 1995 (Australia and Madagascar 2004). Also, implementation of the voluntary UN FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks, adopted in 1999) has been very disappointing as very few shark fishing states have prepared Shark Plans, despite the repeated requests from FAO and CITES that they should do so (Australia and Madagascar 2004).

In 2002 white sharks were listed in the Convention on International Trade in Endangered Species ("CITES") Appendix III and were uplisted to Appendix II in 2004 as species that may become threatened with extinction unless trade is subject to regulation. However, the CITES listing has been inadequate to effectively prevent continued international trade in white shark fins (Shivji *et al.* 2005). White sharks were also added to the list on both Appendices of the Convention on the Conservation of Migratory Species ("CMS") in 2002 to improve the conservation of the species. Although commercial catches of white sharks are prohibited throughout the U.S. Atlantic, U.S.

Pacific, and Gulf coast federal waters (Australia and Madagascar 2004), concerns over significant levels of bycatch have not been adequately addressed.

For federal management, the Pacific Fishery Management Council's Highly Migratory Species Fishery Management Plan ("HMS FMP") prohibits commercially targeting or landing of white sharks for all U.S. vessels that fish for highly migratory species ("HM"S) within the EEZ and to U.S. west coast vessels that pursue HMS on the high seas (seaward of the EEZ) and land in a U.S. port. The HMS FMP final rule does not apply to U.S. vessels that fish for HMS on high seas and land into a non-U.S. port. There are currently no restrictions on the incidental catch and discarding of white sharks at sea. In addition, observer coverage of the set and drift gillnet fishery is inadequately low. NOAA's Fisheries Southwest Region Drift and Set Gillnet Observer Program has provided approximately 21% observer coverage from 1990 to present. With such low observer coverage, more white sharks likely have been incidentally caught with no associated record, thus underestimating the bycatch of white sharks these fisheries actually have.

Historical fishing, both commercially and recreationally, combined with high numbers of bycatch in the Southern California drift gillnet fishery raised concerns that the northeastern Pacific population of white sharks was in peril. This led to the State of California in 1994 prohibiting catch of this species without special permit. It has been illegal to target white sharks commercially or recreationally in California state waters since January 1, 1994 (Fish and Game Code Section 8599-8599.4) per Assembly Bill (AB) 522 introduced by Democratic member Dan Hauser in 1993. The bill initially had a sunset clause of 5 years, but the law was made permanent in 1996. During scoping meetings prior to the bill's first hearing, the California Gillnetters Association submitted a letter requesting that their bycatch of white sharks be exempt from the bill. This exception was granted by the legislature and therefore there are no limits on incidental catch of white sharks in California waters (Heneman and Glazer 1996).

In summary, existing regulatory mechanisms and voluntary agreements do not provide sufficient protection to white sharks from incidental and lethal fishery takes, particularly in U.S. and Mexican Pacific waters where shark pups are routinely caught as bycatch. Given that the population of northeastern Pacific white sharks is alarmingly low (Sosa-Nishizaki *et al.* 2012), and observations have shown that removing only a small number of individuals can have a noticeable effect on the overall population (Pyle *et al.* 1996), northeastern Pacific white sharks need and deserve protection under the Endangered Species Act.

C. Critical Habitat for the Northeastern Pacific Population of White Sharks Should be Designated

The ESA mandates that, when NMFS lists a species as endangered or threatened, the agency must also concurrently designate critical habitat for that species. Section 4(a)(3)(A)(i) of the ESA states that, "to the maximum extent prudent and determinable," NMFS:

> shall, concurrently with making a determination . . . that a species is an endangered species or threatened species, designate any habitat of such species which is then considered to be critical habitat . . . .

16 U.S.C. § 1533(a)(3)(A)(i); see also id. at § 1533(b)(6)(C). The ESA defines the term "critical habitat" to mean:

> i. the specific areas within the geographical area occupied by the species, at the time it is listed . . . , 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 . . . , upon a determination by the Secretary that such areas are essential for the conservation of the species.

Id. at § 1532(5)(A).

Petitioners expect that NMFS will comply with this unambiguous mandate and designate critical habitat concurrent with the listing of the northeastern Pacific population of white sharks. All state and federal waters utilized by the species for foraging off Hawaii and the U.S. West Coast as indicated by data provided in this petition and elsewhere meet the criteria for designation as critical habitat and must therefore be designated as such.

D. Recommended Management and Recovery Actions

Globally, shark management and conservation has been hindered by lack of knowledge on population status and direction of population trends (Baum *et al.* 2003). The northeastern Pacific population of white sharks requires special protection as a threatened or endangered DPS under the ESA. This population is clearly distinct, significant, and likely contains a low number of individual animals. The population faces a clear and present risk of extinction.

Recovering the northeastern Pacific population of white sharks will require the following management and research efforts:

- Hard limits on the incidental capture of white sharks in U.S. fisheries (particularly the set gillnet and drift gillnet fisheries occurring in the Southern California Bight), including sufficient observer coverage to accurately estimate and enforce such limits;
- Management changes to existing fisheries to reduce the likelihood of interaction (gear modifications, limited soak time for fixed gears, time/area closures, enforcement, etc.);
- The uplisting of this population of white sharks from CITES Appendix II to Appendix I, the highest level of protection under the Convention for the International Trade of Endangered Species;
- Increased coordination and international management between U.S. and Mexico to address fishing impacts in both countries;
- Improved monitoring of abundance and population trends;
- Increased understanding of genetics;
- Increased research on the population size, movements, population dynamics, etc.

The data presented in this petition and supporting documents about the northeastern Pacific population of white sharks demonstrates that a positive 90-day finding is warranted and NMFS should promptly conduct a status review for designation as a distinct population segment and uplisting to threatened or endangered.

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