COSEWIC Status Report

on

White Shark
Carcharodon carcharias

prepared for

COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA

by

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EXECUTIVE SUMMARY

Species information

The (great) white shark (*Carcharodon carcharias* (Linnaeus, 1758)) is the only living species of this genus. In French it is called ‘grand requin blanc’. It is recognizable in the field by its conspicuously black iris and a sharp contrast between dorsal and ventral colouration changing from dark (grey or black) to white. Genetic evidence combined with satellite tracking information clearly shows that this species is wide-ranging and as such it highly unlikely that there is genetic structure in Canadian populations. Gene flow between Atlantic and Pacific populations is likely restricted, but overall there is no genetically unique Canadian population.

Distribution

The white shark is widely distributed in sub-polar to tropical seas of both hemispheres, from 60°N to 60°S, but it is most frequently observed and captured in inshore temperate waters over the continental shelves of the western North Atlantic, Mediterranean Sea, southern Africa, southern Australia, New Zealand, and the eastern North Pacific. White shark records from Pacific Canada consist almost exclusively of strandings on the leeward shores of the Queen Charlotte Islands (Haida Gwaii) during late autumn and early winter months. Off Atlantic Canada, the white shark has been recorded from the Northeast Newfoundland Shelf, the Strait of Belle Isle, the St. Pierre Bank, Sable Island Bank, the Forchu Misaine Bank, in St. Margaret’s Bay, off Cape La Have, in Passamaquoddy Bay, in the Bay of Fundy, in the Northumberland Strait, and in the Laurentian Channel as far inland as the Portneuf River Estuary.

Habitat

The white shark occurs in both inshore and offshore waters, from the intertidal to the upper continental slope and mesopelagic zone. Known bathymetric range is from just below the surface to just above the bottom down to a depth of at least 1,280 m. It occurs in the breakers off sandy beaches, off rocky shores, and readily enters enclosed bays, lagoons, harbours, and estuaries, but does not penetrate brackish or fresh waters to any extent.

Biology

Reproductive mode is ovoviviparous. Gestation period is unknown, but may last 14 months. Litter size varies from 2 to 10 and possibly to 17 with an average of 7, with fecundity increasing with size of the female. Length at birth is assumed to be between 109 and 165 cm, with known length of the smallest free-swimming neonates 109 to 129 cm. Possible white shark pupping areas on the west and east coasts of North America include off southern California and the Mid-Atlantic Bight, respectively. Length of reproductive cycle in the white shark is unknown, but may be more than three years as post partum females may take a year or more off between pregnancies to rebuild

energy stores. Maximum lifetime reproductive output of a female white shark has been estimated to be 45 pups with pup survival considered to be low.

Age and size at maturity in white sharks varies regionally. Males reach sexual maturity at an age of 8 to 10 years and a length of 3.5 to 4.1 m while females reach maturity at an age of 12 to 18 years and a length of 4 to 5 m. Longevity in this species is estimated to be 23-60 years. Generation time has been estimated at 23 years and natural mortality at 0.077 $year^{-1}$ and 0.125 $year^{-1}$. Intrinsic rate of population increase is estimated at 0.04-0.056.

White sharks are an apex predator with a wide prey base feeding primarily on teleosts, elasmobranchs, and marine mammals, as well as cephalopods, other molluscs, decapods, marine birds, and reptiles.

Biological information from Canadian waters is limited.

Population sizes and trends

There are no estimates of population size in Canadian waters or elsewhere in the world. Given the low encounter rate in commercial and recreational fisheries in Canada, abundance in Canada has likely always been much lower than in adjacent southern U.S. waters.

A single recent study in North Atlantic waters estimates a decline of 79% based on catch rates in American pelagic longline fleets. There are several locations throughout the world with documented declines in population.

Limiting factors and threats

Humans are the most significant predators of white sharks taking them as sport fish, commercial bycatch, and for international trade of their lucrative body parts. The white shark’s tendency to investigate boats and other floating objects often brings them to the surface, where they can be easily hooked, shot, or harpooned.

Special significance of the species

The white shark is the quintessential shark species due to its large size, predatory nature and reputation for occasionally attacking humans. The celebrated cultural status of the white shark makes its jaws and teeth particularly sought after as curios and its fins for Asian delicacies and traditional medicines. Even in the face of protective legislation, the high prices some individuals are willing to pay for white shark parts is an incentive likely sufficiently powerful to stimulate and maintain a clandestine black market trading in such goods.

Existing protection

In the Fall of 2004, CITES listed white shark in appendix II. The International Union for Conservation of Nature (IUCN 2000) listed white shark globally as ‘vulnerable’. No federal or provincial laws explicitly protect white sharks in Canadian waters. On Canada’s Pacific coast, hook and line fisheries are prohibited from keeping any species of shark except dogfish, and therefore white shark receives some protection by this regulation.

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SPECIES INFORMATION

Name and classification

The (great) white shark (*Carcharodon carcharias* (Linnaeus, 1758)) is the only living species of this genus. Over the years there have been proposals to name separate regional populations, but to date morphometry, meristics, coloration and skeletal anatomy from different ‘centres of abundance’ are not recognizably separable. The accepted French name for white shark is ‘grand requin blanc’.

Morphological description

The following description is taken primarily from Compagno (2001). The snout is bluntly conical (Figure 1a). The interior teeth are enlarged and the anterior, intermediate and lateral teeth are compressed and form a continuous cutting edge. The intermediate teeth are enlarged and are over two-thirds the height of adjacent anteriors. The total tooth count is 44 to 52.

The body usually stout with the dorsal fin origin usually over the pectoral inner margins. The origin of the anal-fin is under or slightly posterior to second dorsal-fin insertion. The total vertebral count is between 170 and 187 with total length of adults between 3.8-6 m and possibly longer. Typically there is a black axillary spot at the insertion point of the pectoral fin; and the pectoral fin tips are usually abruptly black on their ventral surfaces.

Field Marks: Heavy spindle-shaped body with a moderately long conical snout. The teeth are large, flat, and triangular with blade-like serrations. The gill slits are long. The first dorsal fin is large with a dark, free rear tip; the second dorsal is minute; and the caudal fin is large and crescentric.

The dorsal surface is a grey or brownish-grey to blackish above and the ventral surface of body is white. The margin between the dark dorsal and white ventral surfaces is sharply delimited. The iris of the eye is conspicuously black

Genetic description

Genetic evidence combined with satellite tracking information indicates that this species is wide-ranging and as such it is highly unlikely that there is genetic structure within Canada’s Atlantic and Pacific populations (Pardini et al. 2001, Boustany et al. 2002).

Designatable units

White sharks in Canada’s Atlantic and Pacific oceans occupy two distinct biogeographic units with no interchange through the Arctic, and likely limited interchange between ocean basins from dispersal around the southern tip of South

America. For the purpose of this report, Canada's Atlantic and Pacific populations are treated as two separate designatable units.

DISTRIBUTION

Global range

The white shark is widely distributed in sub-polar to tropical seas of both hemispheres, from 60°N to 60°S, but it is most frequently observed and captured in inshore temperate waters over the continental shelves of the western North Atlantic, Mediterranean Sea, southern Africa, southern Australia, New Zealand, and the eastern North Pacific (Compagno 2001). In the western North Atlantic, the white shark ranges from Hare Bay, Newfoundland, to northern Brazil (Templeman 1963, Gadig and Rosa 1996). In the eastern North Pacific, it ranges from the central Bering Sea to Mazatlan, Mexico (Kato 1965, Cook pers. comm.1987). This species occurs sporadically in Canadian waters, known from only 47 confirmed or probable records since 1874 (Table 1, Figure 2).

Until relatively recent it was thought that the white shark was primarily an inhabitant of tropical and warm temperate seas (Bigelow and Schroeder 1948; Garrick and Schultz 1963).

The northernmost record of a white shark in the eastern North Pacific, is a single white shark approximately 4 m in total length observed feeding on salmon in the spring of 1985 off Cordova, Alaska (latitude 60°17'N). Species confirmation is supported by the carcass of a Sockeye Salmon (*Oncorynchus nerka*) bearing distinctive bites of a white shark (author, unpublished data). At least 15 other specimens have been reported from Washington, British Columbia, and Alaska (Bonham 1942; LeMier 1951; Pike 1962; Royce 1963; Karinen et al. 1985; Coad 1995; Collier et al. 1996).

The northernmost record for a white shark in the western North Atlantic is a 3.7 m specimen caught in August 1956 on a codtrap leader set at a depth of 25 m off Ireland Bight, Hare Bay, Newfoundland (latitude 51°18'N) (Templeman 1963). Mollomo (1998) gives 44 other records of this species from Maine and Atlantic Canada waters. Collectively, the foregoing suggests that occurrences of the white shark in Canadian waters are not extralimital but represent part of the normal range for this species.

Canadian range

In Canada's Pacific waters, the white shark has been recorded from Esperanza Inlet and Hecate Strait (Pike 1962; author, unpublished data). White shark records from British Columbia consist almost exclusively of strandings on the leeward shores of the Queen Charlotte Islands (Haida Gwaii) during late autumn and early winter months (Figure 2a, Table 1), plus a single attack on commercial fishing gear (Collier et al. 1996). Lack of strandings from seaward shores of the Queen Charlottes may reflect

sparse human settlement rather than distributional or stranding bias of white sharks.

Off Atlantic Canada, the white shark has been recorded from the northeast Newfoundland Shelf, the Strait of Belle Isle, the St. Pierre Bank, Sable Island Bank, the Forchu Misaine Bank, in St. Margaret's Bay, off Cape La Have, in Passamaquoddy Bay, in the Bay of Fundy, in the Northumberland Strait, and in the Laurentian Channel as far inland as the Portneuf River Estuary (Putnam 1874; Piers 1934; Vladykov and McKenzie 1935; Day and Fisher 1954; Leim and Day 1959; Vladykov and McAllister 1961; Templeman 1963; Arnold 1972; Molomo 1998). White shark records from Atlantic Canada (Figure 2b, Table 1) consist primarily of incidental captures plus four cases of attacks on boats (Templeman 1963; Mollomo 1998). Of 30 Atlantic Canada records for which the month is known, 20 occurred during the month of August, the remainder occurred during June, July, or September with one record in both November and December. Clustering of white shark records in Atlantic Canada during late summer months suggests they may be correlated with the seasonal shift of the warm Gulf Stream toward the coast (Hogg 1992).

HABITAT

Habitat requirements

The white shark occurs in both inshore and offshore waters, from the intertidal to the upper continental slope and mesopelagic zone. Known bathymetric range is from just below the surface to just above the bottom down to a depth of at least 1,280 m (Bigelow and Schroeder 1948). It occurs in the breakers off sandy beaches, off rocky shores, and readily enters enclosed bays, lagoons, harbours, and estuaries, but does not penetrate brackish or fresh waters to any extent (Compagno 2001). Known temperatures from which the white shark has been recorded range from 5 to 27°C (Nakaya 1994; Boustany et al. 2002). Off California this species seems more abundant at temperatures of 14-15°C than at 11°C or below (Compagno 2001). The white shark is a wide-ranging, nomadic species capable of crossing ocean basins as it occurs sporadically off oceanic islands such as Hawaii (Taylor 1985) and the Azores (Compagno et al. 1997) and recent mtDNA studies suggest there is no population structure between California and New Zealand and South Africa and Tasmania (Martin pers. comm. 2002). Movement of this species from coastal waters into oceanic waters far offshore is further supported by a recent satellite tracking study (Boustany et al. 2002).

Habitat trends

It is unknown to what degree habitat deterioration has contributed to the apparent global decline of this species. In Canadian waters, both Atlantic and Pacific, there is no reason to suspect that habitat alteration is influencing white shark abundance or distribution. The Australian Madagascar CITES Proposal (2004) makes the case that inshore coastal feeding and breeding habitats of white sharks has deteriorated in the form of increased fishing pressure, pollution resulting in bioaccumulation, and possible

prey depletion (Australia and Madagascar CITES Proposal 2004). For the purpose of this report, increased fishing pressure is a cause of mortality and not a habitat issue.

Habitat protection/ownership

There are some marine protected areas in California which overlap with known important white shark areas. Generally, there has been little effort to protect white shark habitat.

BIOLOGY

Life cycle and reproduction

Knowledge of the reproduction and life history of the white shark is incomplete. Reproductive mode is ovoviviparous (aplacentally viviparous), with yolk sac reserves augmented at late term via oophagy (Gilmore 1983; Francis 1996; Uchida et al. 1996). Gestation period is unknown, but may be similar to that of its close relative, the shortfin mako (*Isurus oxyrinchus*), in which gestation has been estimated to last 14 months (Mollet et al. 2000). Litter size varies from 2 to 10 and possibly to 17 with an average of 7 (Compagno 2001; Cliff et al. 2000), with fecundity increasing with size of the female. Length at birth is assumed to be between 1.09-1.65 m (Compagno 2001). Possible white shark pupping areas on the west and east coasts of North America include off southern California (Klimley 1985) and the Mid-Atlantic Bight (Casey and Pratt 1985), respectively. The length of the reproductive cycle in the white shark is unknown, but may be more than three years as post partum females may require a year or more between pregnancies to rebuild energy stores (Compagno 1991). Maximum lifetime reproductive output of a female white shark has been estimated to be 45 pups (Compagno 1991). Pup survival is considered to be low (Australia and Madagascar CITES Proposal 2004).

Age and size at maturity in white sharks varies regionally (Wintner and Cliff 1999). Males reach sexual maturity at an age of 8 to 10 years and a length of 3.5 to 4.1 m (Pratt 1996; Compagno 2001) while females reach maturity at an age of 12 to 18 years and a length of 4 to 5 m (Francis 1996; Compagno 2001; Australia and Madagascar CITES Proposal 2004).

Longevity in this species is estimated to be 23-60 years (Cailliet et al. 1985; Mollet and Cailliet 2002; Australia and Madagascar CITES Proposal 2004). Generation time has been estimated at 23 years and natural mortality abetween 0.077 $year^{-1}$ and 0.125 $year^{-1}$ (Smith et al. 1998; Mollet and Cailliet 2002). Intrinsic rate of population growth (i.e., annual population increase) is estimated at 4-5.6% (Smith et al. 1998).

The maximum size of the white shark is unknown, with length and especially mass of large individuals notoriously difficult to validate (see Mollet et al. 1996). The largest captured specimens measured between 5-5.80 m in total length. Reports of white sharks reaching total lengths greater than 7 m have been reliably reported but have not

been verified (Compagno 2001).

Life History Information from Canadian Waters

There have been no scientific studies or surveys of white sharks in Canadian waters. Opportunistic data from strandings or bycatch have shown that reproductively mature white sharks of both sexes have been recorded from Pacific and Atlantic Coasts of Canada (Figure 2, Table 1).

The largest verified white sharks from Canadian waters are a 5.2 m individual found stranded at Long Inlet, Graham Island, Queen Charlotte Islands, British Columbia, on 16 December 1986 (Coad 1995), and another of the same length and 907 kg in mass captured between Bliss and Whitehorse islands, southern New Brunswick, in August 1971 (Arnold 1972).

Behaviour

Behaviour of the white shark is incompletely known. In cool temperate waters, this species is often observed scavenging on floating cetacean carcasses, either with aggregates of conspecifics (Pratt et al. 1982; Fallows pers. comm. 2000) or with other large sharks (Dudley et al. 2000). Natural predation by white sharks on pinnipeds is observed seasonally at the Farallon Islands, California (Klimley 1994; Klimley et al. 1992, 1996), off the Western and Eastern Cape, South Africa (Stewardson and Brett 2000, Fallows and le Sueur 2001). A single case of possible white shark courtship and mating has been reported (Francis 1996). Recent studies reveal that the white shark exhibits a variety of social behaviours and may travel in small but stable groups (Compagno 2001; Collier pers. comm. 1986; Fallows pers. comm. 2000).

The white shark is a highly visual creature with a duplex retina featuring a low rod-to-cone ratio (about 4:1) that is well adapted to acute, and possibly full-colour vision (Gruber and Cohen 1995). This species will visually investigate virtually any object at the surface, from boats and surfboards to floating kelp and rubbish (Strong 1996; Collier pers. comm. 1986; Fallows pers. comm. 2000). The white shark’s curiosity about novel objects and activities at the surface often brings it into contact with humans (Miller and Collier 1981; Burgess and Callahan 1996; R. Collier pers. comm. 1986; C. Fallows pers. comm. 2000).

Herbivory/predation

White sharks are born at a total length of 1.09-1.65 m. Their large size at birth precludes predation from most marine animals. Humans have been identified as the single largest cause of mortality to adult sharks (Compagno 2001). Newborns are likely

taken by other shark species and possibly marine mammals but there is no evidence of this. There is one reported attack of an orca whale (*Orcinus orca*) on a white shark off California.

Physiology

White sharks can tolerate a wide range of temperatures and therefore have been observed from sub-polar to tropical waters (5-27°C). There is some evidence that white sharks have a temperature preference around 14-15°C but are regularly found in warmer temperatures.

The ability for white sharks to perform as agile predators in colder water is in part attributable to countercurrent vascular heat exchangers which allow them to maintain a body temperature higher than the ambient water (Compagno 2001).

Dispersal/migration

White sharks are able to swim long distances over extended periods with an average cruising speed of 3.2 kph (Compagno 2001). Seasonal and size-class distribution of 109 white sharks captured along the West Coast of North America suggests pregnant individuals may migrate south to southern California waters to give birth (Klimley 1985), but this remains to be demonstrated. Sonic telemetry studies conducted at the Farallon Islands, California, suggest that larger white sharks concentrate predatory effort in relatively small areas, while smaller individuals cruise larger areas (Goldman and Anderson 1999). Size-based differences in white shark activity space at the Farallones may reflect learning in larger sharks to concentrate predatory effort in areas that have proved successful in previous years and/or displacement of smaller sharks by larger conspecifics. A satellite telemetry study revealed that four of six white sharks tagged off the Farallon Islands traveled at depths of 300 to 500 m far into the open Pacific – in once case, a 4.7-m male, traveled from the Farallones to off Kahoolawe, Hawaii, a distance of 3,800 km; the other two sharks remained close to the Farallones (Boustany et al. 2002).

Of 36 white sharks tagged in the western North Atlantic through the National Marine Fisheries Service (NMFS) Cooperative Shark Tagging Program, only 2 were recaptured, both female (Kohler et al. 1998). Of these, one traveled north from off Assateague Island National Seashore, Virginia, to off Gloucester, Massachusetts, the other south from off Moriches, Long Island, New York, to Charleston, South Carolina.

A study of mtDNA of 95 white sharks from South Africa, Australia, and New Zealand suggests sex-biased dispersal of this species: males migrate long distances (up to and including crossing entire ocean basins) while females occupy relatively small ranges (Pardini et al. 2001). This differential dispersal may reflect sex differences in

parental investment between males and females, allowing the latter to conserve energy stores toward nourishment of pups. In a recent oral presentation, unpublished data was presented that showed satellite tracking of a female white shark (3.8 m total length) that traveled from Gansbaai, South Africa, to Exmouth, Western Australia – a distance of approximately 10,000 km – in 3 months; possibly disproving Pardini et al.'s (2001) hypothesis of female philopatry in this species (Bonfil pers. comm. 2004).

No tagging or telemetry studies have been published on white sharks in Canadian waters and available data are inadequate to draw any meaningful conclusions.

Interspecific interactions

The white shark is an apex predator exploiting a very broad prey spectrum. Teleosts, elasmobranchs, and marine mammals are the main prey categories, but it also takes cephalopods, other molluscs, decapods, marine birds, and reptiles (Cortéz 1999). The white shark also scavenges marine mammal carcasses, fisheries offal, and fishes caught on lines (Compagno 2001). Its dentition broadens with growth and it has been suggested that, at a length of about 300 cm, this species undergoes an ontogenetic dietary shift from bottom-dwelling fishes to marine mammals (Tricas and McCosker 1984). Smaller white sharks (<2.5 m total length) tend to consume relatively small demersal prey, including teleosts, small elasmobranchs, and invertebrates, while larger individuals tend to take larger nektonic prey, including pinnipeds, odontocetes, and large elasmobranchs (Klimley 1985; Cliff et al. 1989; Bruce 1992). However, at every growth stage, the white shark is highly opportunistic and apparently can capture and kill a wide variety of prey. For example, LeMier (1951) reported that the stomach of a 4.4 m white shark captured in Willapa Harbor, Washington, September 1950 contained: four partly digested salmon (*Oncorynchus* sp.), vertebral columns of Pacific hake (*Merlucius productus*) and rockfish (*Sebastes* sp.), the hides of two harbour seals (*Phoca vitulina*), and 150 crabs, primarily dungeness crabs (*Cancer magister*) with the remainder rock crabs (*C. productus*). Feeding periodicity in an adult white shark (~ 4.5 m total length), based on calculated metabolic rate and calorie content of blubber-rich food, has been estimated to be between 45 and 90 days (Carey et al. 1982; Klimley et al. 2001).

In Canada, diet and feeding behaviour of the white shark in Canadian waters have only been reported from the Atlantic coast. In August 1953, between Passamaquoddy Bay and Grand Manan Island, a pale grey shark more than 4.3 m long – believed to be a white shark – was observed to bite a full-grown harbour porpoise (*Phocoena phocoena*) in half and consume the posterior part while the anterior part was retrieved by a fisherman with a gaff (Day and Fisher 1954). In August 1953, an adult male harbour seal was shot near Docet Island, in the St. Croix River between Maine and New Brunswick; its right rear flipper and tail were severed and bore fresh tooth slashes of a size that strongly suggested they were made by a white shark (Day and Fisher 1954). In July 1962, a 3 m white shark caught near Wallace, Nova Scotia, had a "small porpoise" (probably *P. phocoena*) in its stomach. In September 1969, near the mouth of Passamaquoddy Bay, New Bruinswick, two specimen collectors lost a harbour porpoise

to a shark at least 4 m long (Arnold 1972). In August 1971, a 5.2 m white shark was caught between Bliss and Whitehorse islands, New Brunswick; its stomach contained three harbour porpoises, estimated to have been between 1.2 to 1.5 m long, in variable stages of digestion and with their tail stalks severed (Arnold 1972). The white shark has also been implicated in attacks on grey seals (*Halichoerus grypus*) off eastern Canada (Brodie and Beck 1983). In Atlantic Canada, the white shark probably also feeds on a wide variety of fish and invertebrate prey, but this remains to be documented.

Based on reports from Washington State (Bonham 1942; LeMier 1951) and southeastern Alaska (author, unpublished data), diet of white sharks in Canada's Pacific waters probably includes green sturgeon (*Acipenser medirostris*), sockeye salmon (*Oncorhynchus nerka*) and other Pacific salmonids, rockfishes, hakes, Pacific halibut (*Hippoglossus stenolepis*), harbour seal, and Steller sea lion (*Eumetopias jubatus*).

Adaptability

The life history of the white shark suggests that it is unable to withstand high anthropogenic mortality. The widespread distribution combined with an opportunistic feeding strategy may allow for the species to adapt by dispersing from localized catastrophic events and changing prey sources.

POPULATION SIZES AND TRENDS

Search effort

There are no surveys for white sharks in Canadian waters. Most records in Canadian waters come from opportunistic stranding reports, published historical observations, investigative work by the authors, and the occasional reported incidental catch. Observer databases from both coasts were examined for records as were all available fisheries surveys. Effort was made to examine surveys in adjacent jurisdictions.

Abundance

Information on the global population size of white sharks is sparse, but most sources agree the species is relatively rare compared with sympatric shark species. As an apical predator occupying a mean trophic level of 4.5, population size in a given region is necessarily low (Cortez 1999). Based on a low encounter rate, it is suspected that abundance of white sharks in Canadian waters is less than neighbouring southern regions.

Pacific

Off Pacific Canada between 1961 and 2004, 13 white sharks records have been collected (Table 1). Most of these records are from stranded animals. Given the low

frequency of sightings in Canada's Pacific waters, it is not possible to estimate a population but it is assumed to be very low. For the eastern North Pacific, from northern Washington to central Mexico, between 1936 and 1984, 116 white sharks were documented (Klimley 1985). In Monterey Bay, California, white sharks were sighted during spotter aircraft surveys between 1948 and 1950; 104 white sharks were seen in 445 flights (average 0.23 per flight); a maximum of 27 white sharks were recorded in any one month (Squire 1967). There are no indicators of abundance anywhere in the North Pacific at present time.

Atlantic

Off Atlantic Canada between 1874 and 2004, 34 white shark observations have been recorded, with only one record over the last decade (Table 1). There are only two records from the Scotia Fundy Observer Program which indicates that white sharks are not regularly caught in Atlantic Canadian waters. In U.S. Atlantic waters, longlining has resulted in significant catches. Baum et al. (2003) reported 6087 records of white shark in the U.S. pelagic longline database from 1986-2000 extracted from over 200 000 sets. Most of these records (80%) were from areas south of Florida (Areas 2-4) (Figure 3). Since the early 1990s no sharks have been reported from Areas 6 and 7. There are no estimates of white shark abundance in Canadian waters but given the low encounter rate in commercial and recreational fisheries, the population is likely much lower than in adjacent southern U.S. waters.

Fluctuations and trends

Recent North American Trends

There is a general lack of white shark population trend information worldwide reflecting their rarity. Baum et al. (2003) calculated trend information based on catch per unit of effort (CPUE) data from the U.S. pelagic longline swordfish and tuna fleets in the Northwest Atlantic from 1986 to 2000 (Figure 4). They estimated a decline of 79% in CPUE during this period (95% CI: 59 to 89%) which was based on 6087 records primarily from the southeastern seaboard of the United States and Caribbean (Areas 1-4; see Figure 3). Baum et al. (2003) is the only published study examining white shark trend information in North America.

Global Trends

White sharks populations in several regions show marked reduction from historical abundance. Catches of white sharks in the protective beach meshing program off New South Wales, Australia, show an almost unbroken decline since the commencement of meshing in 1937; CPUE over all meshed regions dropping over 80% between 1950 and 1990 (Reid and Krogh 1992). Pepperell (1992) expressed concern at the disappearance of white sharks from game fishing catches off southeastern Australia in the 1980s and Bruce (1992) noted a decline in white shark numbers in some areas off South Australia. A tagging-resighting study of white shark population in South Australia during 5

expeditions over 2.5 years revealed a low estimated probability of survival between samples of 0.20 (Strong et al. 1996). Catches in the beach meshing programme off Natal, South Africa, are among the highest in the world and CPUE data show a long-range, irregular decline between 1974 and 1988 (Cliff et al. 1989). Finally, the killing of four white sharks off Southeast Farallon Island, California in 1982 resulted in a drastic reduction in shark sightings by researchers stationed at the Island during 1983, 1984, and 1985 (Ainley et al. 1985; Pyle et al. 1996). These results suggest that there may be small localized populations which are less migratory and consequently removal of only a few individuals may have a noticeable effect on local populations.

Rescue effect

The relationship between white sharks found in Canadian waters with those found in adjacent jurisdictions is unknown. It is suspected that Canadian waters comprise part of the range of North Pacific and North Atlantic populations and as such, an increase in the total population will likely result in increased abundance of white sharks in Canadian waters.

LIMITING FACTORS AND THREATS

Humans are the most significant predators of white sharks, taking largely unmonitored numbers as sport fish and commercial bycatch as well as targeting them for their lucrative jaws, teeth, and fins (Compagno et al. 1997). Markings found on stranded white sharks in the Queen Charlotte Islands, British Columbia (Figure 2a), suggests that mortality may have resulted from fisheries bycatch (author, unpublished data).

Sixteen of 32 (50%) of white shark records from Atlantic Canada are accidental captures as bycatch (present study). The white sharks' tendency to investigate boats and other floating objects often brings them to the surface, where they can be easily hooked, shot, or harpooned.

As long-lived, apex predators, one would expect white sharks to bioaccumulate pollutants in their tissues. Zitko et al. (1972) found that muscle and liver tissue from white sharks taken in the Bay of Fundy-Gulf of Maine area had higher levels of PCB's and chlorinated hydrocarbon pesticides than other fish. Note, the health impacts of these toxins have not been investigated in elasmobranchs, however – given the fragility of spermatozoa and the well-documented feminizing influence of organochlorides – it seems likely to negatively impact reproductive fitness of males, possibly via compromised gametogenesis or impaired sperm motility.

SPECIAL SIGNIFICANCE OF THE SPECIES

The white shark is the largest predatory fish and the only shark that regularly preys upon marine mammals (Compagno 2001). The species has apparently been known to

the Mikmaq people of Atlantic Canada for thousands of years: a tooth has been found an oyster midden dated 1,000 to 2,000 years B.P. at Pig Island, Northumberland Strait, Nova Scotia (Gilhen 1988).

The white shark is notorious for its attacks on humans and boats (Miller and Collier 1981; Burgess and Callahan 1996). Five attacks by white sharks on boats or fishing gear are known from Canadian waters (Figure 2): 1) in 1873 or 1874 a 4 m white shark attacked a dory off the St. Pierre Bank, Newfoundland; it was identified by tooth fragments embedded in the hull (Putnam 1874); 2) in June 1920, a 4.6 m white shark attacked a boat off Hubbard Cove, St. Margaret's Bay, Nova Scotia; it was identified from scars on the boat and description of a tooth embedded in it (Piers 1934); 3) in July 1932, a 4.6-m white shark attacked a boat 16 km NW of Digby Gut, Nova Scotia; it was identified from a tooth embedded in the hull (Piers 1934); 4) on 9 July 1953, a 3.7 m white shark attacked and sank a dory off Forchu, Cape Breton Island, Nova Scotia, neither of the fishermen was attacked but one of them drowned; the attacker was identified from teeth embedded in the hull (Day and Fisher 1954); and 5) in August 1961, a 4-6 m white shark attacked the canvas float bag of a salmon trawler; it was identified from a tooth and several fragments removed from the bag (Collier et al. 1996).

Due to its large size, photogeneity, predatory prowess, and dangerousness, the white shark has assumed an almost hagiographic status in popular culture (Ellis 1994). The celebrated cultural status of the white shark makes its jaws and teeth particularly sought after as curios and its fins as a food additive, the latter especially in markets catering to Asian delicacies and traditional medicines. Even in the face of protective legislation, the high prices some individuals are willing to pay for white shark parts is an incentive likely sufficiently powerful to stimulate and maintain a clandestine black market trading in such goods.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

In the Fall of 2004, the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) listed white shark in appendix II. The International Union for Conservation of Nature (IUCN 2000) listed white shark globally as 'vulnerable'. In California, the white shark has been protected since 1997, making it illegal to attract or harass a white shark in any way as well as to possess or sell a specimen in whole or in part; any vessel containing white shark material is refused landing in State ports. The species has also been protected along U.S. Atlantic and Gulf Coasts under the federal Fisheries Management Plan since 1997, but recreational catch and release is permitted with a marine sport angling license. The white shark is also listed in Appendices I and II of the Convention on Migratory Species (http://www.wcmc.org.uk/cms/), a United Nations Treaty Organization.

No federal or provincial laws explicitly protect white sharks in Canadian waters. On Canada's Pacific coast, hook and line fisheries are prohibited from keeping any shark except dogfish and therefore white shark receives some protection by this regulation. In Atlantic Canada, shark fishing regulations prohibit the retention of any recreationally-

caught sharks other than dogfish. [Page Break]

TECHNICAL SUMMARY

Carcharodon carcharias

White Shark Requin Blanc

Range of Occurrence in Canada: Atlantic and Pacific oceans

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **In sufficient data for a calculation**	Likely occasionally found throughout the continental shelves.
• *Specify trend in EO*	Unknown
• *Are there extreme fluctuations in EO?*	Unknown (not likely)
• *Area of occupancy (AO) (km²)* **[explain source of information and calculation]**	unknown
• *Specify trend in AO*	Unknown
• *Are there extreme fluctuations in AO?*	Unknown, possibly seasonal
• *Number of known or inferred current locations*	Throughout Canadian seas
• *Specify trend in #*	Unknown
• *Are there extreme fluctuations in number of locations?*	Not likely
• *Specify trend in area, extent or quality of habitat*	Habitat degradation, including overfishing, pollution

Population Information	
• *Generation time (average age of parents in the population)*	23 yrs (est.)
• *Number of mature individuals*	Unknown
• *Total population trend:*	Unknown
• *% decline over the last/next 10 years or 3 generations.*	Unknown, possibly 79%
• *Are there extreme fluctuations in number of mature individuals?*	Probably not
• *Is the total population severely fragmented?*	No
• *Specify trend in number of populations*	Unknown
• *Are there extreme fluctuations in number of populations?*	Probably not
• List populations with number of mature individuals in each: No data available	

Threats (actual or imminent threats to populations or habitats)
Commercial fishery bycatch; targeted for jaws, teeth, and fins; sport angling; overfishing; coastal habitat modification, pollution.

Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA: Depleted**	
• *Is immigration known or possible?*	Possible
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Yes

• ***Is rescue from outside populations likely?***	**Yes**

Quantitative Analysis	Not done

Current Status COSEWIC: None; CITES Appendix II (October 2004), IUCN- Vulnerable

Author of Technical Summary: Richard Aidan Martin and Scott Wallace

Additional Sources of Information: NA

Recommended Status and Reasons for Designation

[This table is to be completed in the Interim Report by the SSC;
COSEWIC will approve or modify the text in this section for the Final Report]

Recommended Status:	**Alpha-numeric code:**
Reasons for Designation: [Note especially if it is a Canadian endemic with 100% of its distribution in Canada]	
<u>Applicability of Criteria</u> **Criterion A** (Declining Total Population): **Criterion B** (Small Distribution, and Decline or Fluctuation): **Criterion C** (Small Total Population Size and Decline): **Criterion D** (Very Small Population or Restricted Distribution): **Criterion E** (Quantitative Analysis):	

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R. Aidan Martin is the Director of the ReefQuest Centre for Shark Research, a Research Associate of the Zoology Department of the University of British Columbia, and an Adjunct Professor of the Oceanographic Center of Nova Southeastern University. Aidan is internationally recognized as an expert in shark biology and behaviour. He has studied elasmobranch fishes for over 30 years in some 40 countries or island states. His main areas of research are the evolution, phyletic relationships, functional morphology, life history, behavioral ecology, distribution, and conservation of elasmobranchs.

Scott Wallace's research focuses on the sustainability of marine fisheries, conservation of marine biological diversity, and ecosystem-based approaches to fisheries management. He is active in the conservation community where he is currently the Science Advisor to the Sierra Club of Canada, BC Chapter. In this capacity he reviews current fisheries practices, writes status reports, and sits on numerous subcommittees under the umbrella organization of the Pacific Marine Conservation Caucus. Subcommittees include marine mammals, lingcod and rockfish, and species at risk. Current research is focused on the sustainability and current management practices within the Pacific groundfish fishery. He holds a Ph.D. from the University of British Columbia's Fisheries Centre.

Table 1. Chronological list of white shark records from Canada. * = not authenticated; UNK=unknown.

Locality	Date	Length (m)	Sex	Remarks	Reference
Atlantic Ocean					
Pig Island, Northumberland Straight, NS	1000-2000 years bp	UNK	UNK	Tooth in oyster stratum	Gilhen (1998)
St. Pierre Bank, NS	1873 or 1874	3.9	UNK	Teeth in attacked dory	Putnam (1874)
Off Hubbard Cove, St. Margaret's Bay, NS	June 27, 1920	4.6	UNK	Tooth scarpes on attacked dory	Piers (1934)
White Head Island, near Grand Manan, NB	June (mid), 1930	11.3*	UNK	Trapped in herring weir	Vladykov & McKenzie (1935)
16 km NW of Digby Gut, NS	July 2, 1932	4.6	UNK	Tooth in attacked motorboat	Piers (1933)
Harbour de Loutre, Campobello Island, NB	November 22, 1932	7.9*	UNK	Trapped in herring weir	Piers (1933)
Wedgeport, NS	August, 1938	2.6	M	Caught on rod & line by Ms. Micchael Lerner; mass 196 kg	Anon (1940) in Templemann (1963)
Whale Head, N shore, St. Lawrence River	August, 1938	UNK	UNK		Vladykov & McAllister (1961)
Isle Caribou, N shore, St. Lawrence River	August, 1942	2.7	UNK		Vladykov & McAllister (1961)
Isle Caribou, N shore, St. Lawrence River	August, 1943	3	UNK		Vladykov & McAllister (1961)
Deer Island, NB	August 24, 1949	3.87	F	Trapped in herring weir; immature, mass 590 kg	Scattergood et al. (1951)
Portneuf River estuary, N shore, St. Lawrence River	August 27, 1949	4.6	UNK	Shot by W.B. Scott	Templemannn (1963)
Between Passamaquoddy Bay & Grand Manan, NB	August 20, 1952	4.3	UNK	Observed attack on porpoise	Day & Fisher (1954)
Off Fourchu, Cape Breton Island, NS	July 9, 1953	3.7	UNK	Teeth in attacked dory	Day & Fisher (1954)
Wedgeport, NS	July 9-10, 1953	2.4	M	Caught on rod & line (tuna fisherman)	Day & Fisher (1954)
La Have Islands, NS	August 12, 1953	4.7	UNK	Caught in herring trap	Day & Fisher (1954)
St. Croix River, near Dochet Island between ME & NB	August 25, 1953	UNK	UNK	Observed attack on seal	Day & Fisher (1954)
Mace's Bay, Bay of Fundy, NB	August 3, 1954	2.6	UNK	Trapped in herring weir	Leim & Day (1959)
Maces Bay, NB	September 10, 1954	4.87	F	Caught in herring weir	Hogans & Dadswell (1985)
Ireland Bight, Hare Bay; depth 26 m	August 10, 1956	3.7	UNK	Teeth in codtrap leader	Templemannn (1963)
SE Grand Bank (44o30'N, 50o12'W)	August, 1956	3.7-4.6	UNK	Spanish otter trawl Santa Ines	Templemannn (1963)
Northumberland Strait, 13 km off Wallace, NS	July 30, 1962	3	UNK	Caught in hake gillnet; tooth examined by L.R. Day	Templemannn (1963)
Northumberland Strait, 13 km off Wallace, NS	August (1st week), 1962	2.7	UNK	Caught in hake gillnet; ID by W.G. Smith, fishery officer	Templemannn (1963)
Wallace, NS	August, 1962	6*	UNK	Observed in hake gillnets, escaped	Templemannn (1963)
Wallace, NS	September, 1962	6*	UNK	Observed in hake gillnets, escaped	Templemannn (1963)
Passamaquoddy Bay, between ME & NB	1969	UNK	UNK	Observed attack on porpoise	Arnold (1972)
Passamaquoddy Bay off Leonardville, Deer Island, NB	August 13-14, 1971	4.3	F	Caught in otter trawl	Scott & Scott (1988)
Letite Passage, NB	August 8, 1977	5.05	F	Caught in herring weir	Hogans & Dadswell (1985)
Passamaquoddy Bay, off Mascarene Shore, NB	August 8-9, 1977	5.2	UNK	Tarpped in herring weir	Scott & Scott (1988)

Gulf of St. Lawrence, off Alberton, PEI	August 4, 1983	5.2	M	Caught in cod gillnet	Scott & Scott (1988)

Table 1 continued.

Locality	**Date**	**Length (m)**	**Sex**	**Remarks**	**Reference**
Off Tiverton, PEI	July, 1988	4.5	UNK	Caught in gillnet	Connors Bros. Ltd. In Mollomo (1998)
Southern Scotian Shelf	November, 1989	UNK	UNK	Japanese longliner (200 kg)	Scotia-Fundy Observer database
Sable Island	Late 1980s	UNK	UNK	Tooth recovered from seal carcass	Campana, pers. comm. (2004)
Bay of Fundy	Early 1990s	4.2	UNK	Caught in gillnet	Campana, pers. comm. (2004)
Scotian Shelf	December, 1999	UNK	UNK	Japanese longliner (65 kg)	Scotia-Fundy Observer database
Pacific Ocean					
Esperanza Inlet, Vancouver Island	August 17, 1961	4-6	UNK	Teeth in float bag of salmon trawler	Collier et al. (1996)
Creek Mouth, Island Bay, QCI	October 24, 1961	3.4	UNK	Stranded on beach	Pike (1962)
Lawn Point, Graham Island, QCI	September (late), 1977	3-4	UNK	Stranded on beach, in advanced state of decomposition	RAM data
Un-named beach, Moresby Island, QCI	October, 1977	4.5	UNK	Stranded on beach	RAM data
Cape Ball, Graham Island, QCI	October 20, 1977	5.5	F	Stranded on beach	RAM data
Un-named beach, Lyell Island, QCI	Novermber 25, 1977	4.5	UNK	Stranded on beach	RAM data
Cape Ball, Graham Island, QCI	Autumn (early), 1983	4	UNK	Stranded on beach	RAM data
Long Inlet, Graham Island, QCI	December 16, 1986	5	UNK	Stranded on beach	RAM data
near Queen Charlotte City, Graham Island, QCI	Autumn (early), 1987	5	UNK	Stranded on beach	RAM data
Long Inlet, Graham Island, QCI	December 16, 1987	5.2	UNK	Stranded on beach	RAM data
East Beach, near Cape Ball, Graham Island, QCI	Autumn, 1988	5	UNK	Stranded on beach	RAM data
Skidegate Inlet, Graham Island, QCI	Autumn, 1988	4-5	UNK	Stranded on beach	RAM data
North side of Goose Island, Queen Charlotte Sound, BC	September, 2004	2.5	UNK	Vertebrae found on beach	Found by Jane Watson ID by RAM
Cape Ball, Graham Island, QCI, BC	25 Oct 2004	4.6	UNK	25 vertebrae, bits of cartilage (including left Meckel's cartilage), chondrocranium, teeth and patches of skin	RAM data

RAM=Richard Aidan Martin

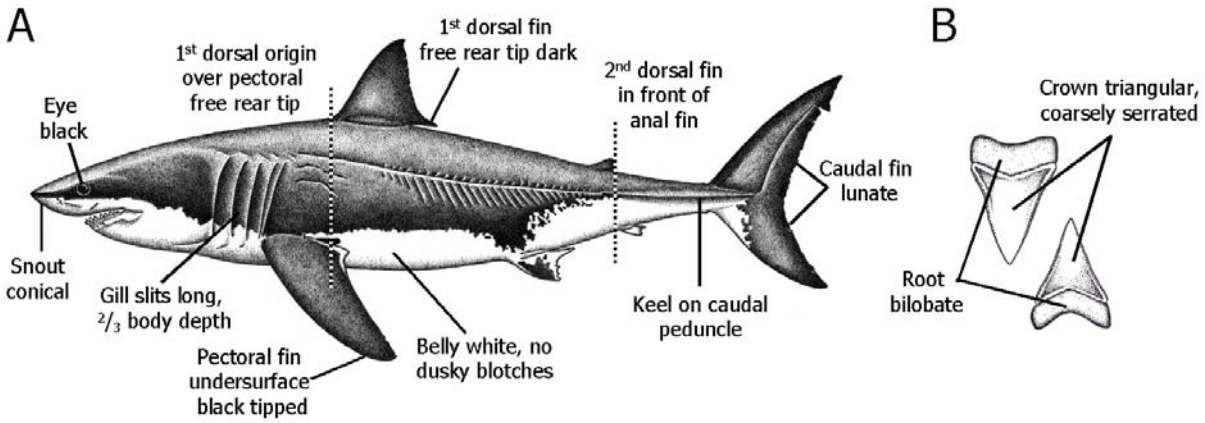

Figure 1. Field characters useful for identifying the white shark (*Carcharodon carcharias*), A. Lateral view, B. detail of upper and lower anterior teeth. Diagrams by Aidan Martin.

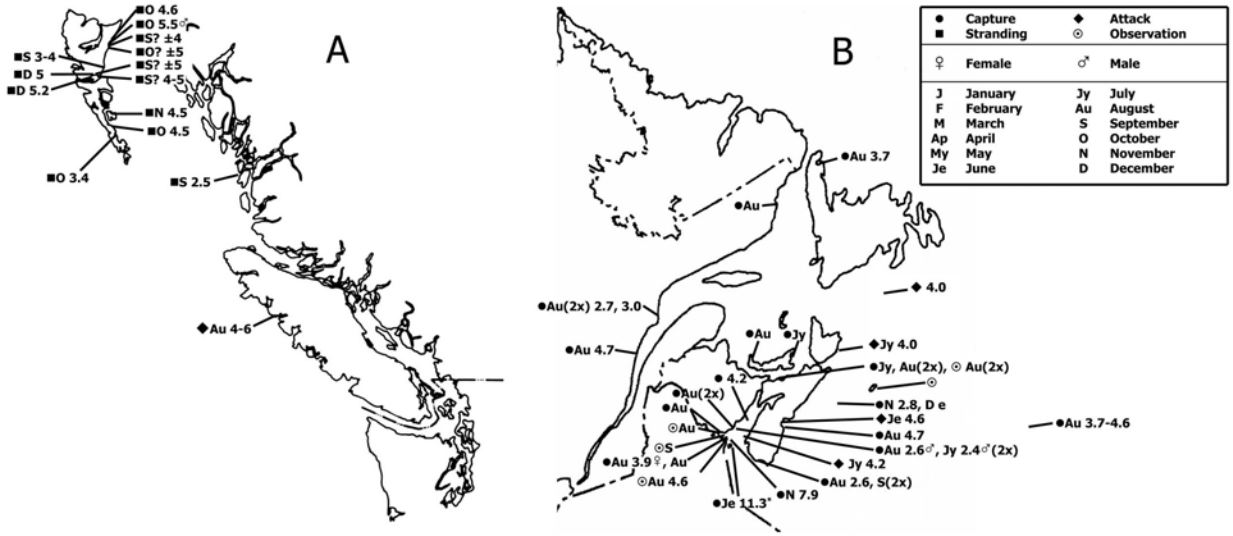

Figure 2. Locality, month, and total length of white shark (*Carcharodon carcharias*) captures, strandings, attacks, and reports from Canadian waters. A. British Columbia. B. Atlantic Canada.

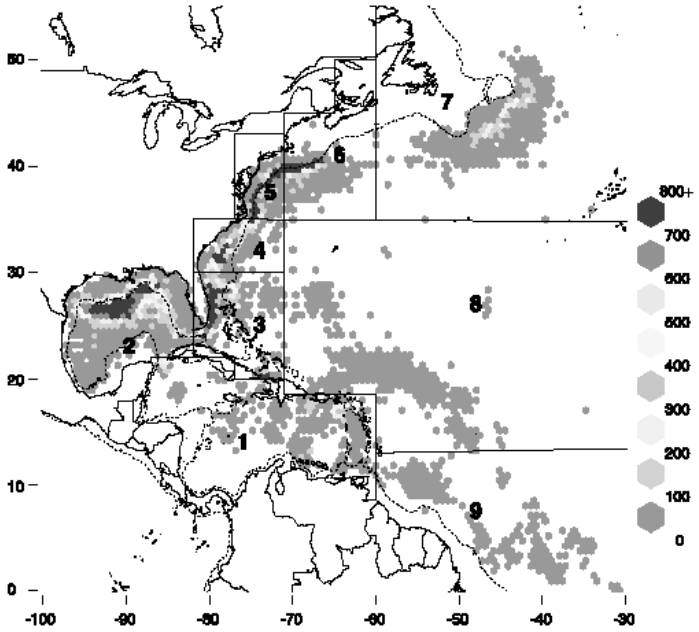

Figure 3. Map of the Northwest Atlantic showing the distribution of effort in the U.S. pelagic longline fishery between 1986 and 2000, categorized by number of sets (0 to 800+), within the nine areas assessed: 1, Caribbean; 2, Gulf of Mexico; 3, Florida East Coast; 4, South Atlantic Bight; 5, Mid Atlantic Bight; 6, Northeast Coastal; 7, Northeast Distant; 8, Sargasso/North Central Atlantic; 9, Tuna North/Tuna South.Areas were modified from the U.S.National Marine Fisheries Service classification for longline fisheries. The 1000-m coastal isobath (dotted line) is given for reference. From Baum et al. 2003.

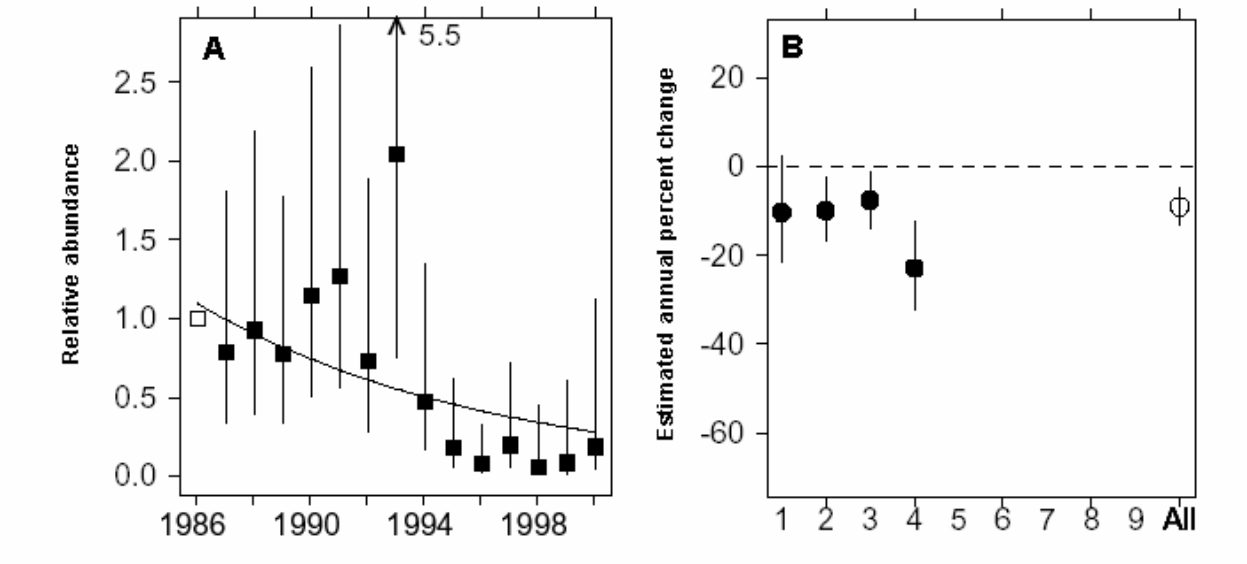

Figure 4. (A) Relative abundance of white shark in the entire west Atlantic indicated by an analysis of U.S. commercial longline fishery logbook (decline of 79%); (B) estimated annual rate of change for nine assessment areas and total. From Baum et al. 2003.