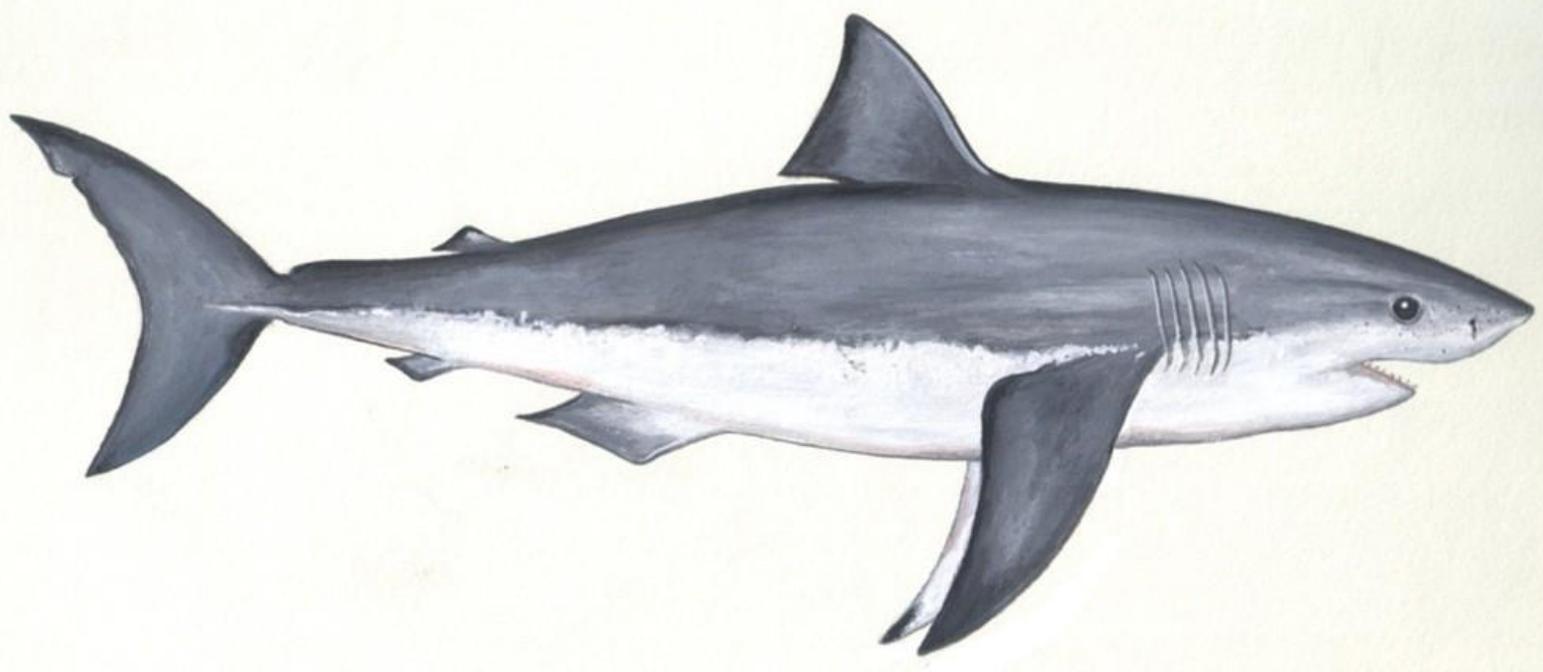


Recovery Strategy for the

White Shark (*Carcharodon carcharias*)

Atlantic population



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Preface

The federal, provincial, and territorial government signatories under the [Accord for the Protection of Species at Risk \(1996\)](#) agreed to establish complementary legislation and programs that provide for the protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of a recovery strategy for species listed as extirpated, endangered, or threatened and are required to report on progress 5 years after the publication of the final document on the [Species at Risk Public Registry](#) and every subsequent 5 years.

The Minister of Fisheries is the competent minister under SARA for the White Shark (Atlantic population) and has prepared this recovery strategy, as per section 37 of SARA. In preparing this recovery strategy, the competent minister has considered, as per section 38 of SARA, the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty. To the extent possible, this recovery strategy has been prepared in cooperation with other federal government departments, provincial governments, Indigenous organizations, and others as per subsection 39(1) of SARA.

As stated in the preamble to SARA, success in the recovery of this species depends on the commitment and cooperation of many different groups that will be involved in implementing the measures set out in this strategy and will not be achieved by Fisheries and Oceans Canada (DFO), or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different groups. Canadians are invited to join in supporting and implementing this strategy for the benefit of the White Shark (Atlantic population) and Canadian society as a whole.

This recovery strategy will be followed by 1 or more action plans that will provide information on recovery measures to be taken by DFO and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

DFO wishes to acknowledge the many individuals who provided valuable input into the development of this recovery strategy.

Executive summary

The Atlantic population of White Shark (*Carcharodon carcharias*) in Canada was listed as endangered under the *Species at Risk Act* (SARA) in 2011. This recovery strategy is part of a series of documents for this species that are linked and should be taken into consideration together; including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports ([COSEWIC 2006](#); [2021](#)), a recovery potential assessment (RPA) ([DFO 2006](#)), an evaluation of scope for harm ([DFO 2017](#)), and an action plan (to come). The feasibility of recovery of the White Shark in Atlantic Canadian waters is unknown. In keeping with the precautionary principle, a recovery strategy has been prepared as would be done when recovery is determined to be feasible.

Globally, White Sharks are rare, though they are known to occur in certain areas with greater frequency, and are widely distributed throughout sub-tropical and temperate seas. White Sharks range along the Atlantic coast of North America, especially from Massachusetts to New Jersey in summer and off the Atlantic coast of Florida in winter. White Shark records in Atlantic Canada¹ are relatively rare, but occur most frequently from June to September (DFO 2020).

Human-induced mortality is the main threat to White Sharks. This species is caught as commercial bycatch, sought as a sport fish, and subject to a lucrative international trade in its body parts, particularly jaws, teeth, and fins. White Shark recovery is limited by the species' naturally low abundance, low reproductive capacity, slow growth, and late maturation, which contribute to overall low productivity (Bowlby and Gibson, 2020).

The size of the White Shark population in the Northwest Atlantic is unknown. Studies suggest a decline of as much as 86% in the 1970s and 1980s (Baum et al. 2003; McPherson and Myers 2009; Curtis et al. 2014). More recent data suggest an increase in abundance following implementation of conservation measures in the 1990s (Curtis et al. 2014). Despite this positive trend, population abundance estimates remain below historic estimates from 1961, and the susceptibility of White Shark populations to anthropogenic threats warrants concern about recovering the species.

A description of the broad strategies to be taken to address threats to the species' survival and recovery, as well as research and management approaches needed to meet the population and distribution objectives, are included in section 7. These will help inform the development of specific recovery measures in 1 or more action plans.

The identification of critical habitat for White Shark is not possible at this time, due to insufficient information. The schedule of studies outlines the research required to identify critical habitat to achieve the species' population and distribution objectives (section 8).

Incidental interactions with White Sharks during the following activities are exempted by the recovery strategy (section 10 of this document):

- fishing under the authority of a commercial licence issued under the *Fisheries Act*

¹ White Shark are distributed in the waters off the 4 Atlantic provinces, and Quebec. Here and throughout the recovery strategy, references to Atlantic Canada in relation to White Shark distribution or to recovery measures also include Quebec.

- fishing under the authority of a communal commercial licence issued under the *Aboriginal Communal Fishing Licences Regulations*
- scientific research activities undertaken by DFO and authorized under the *Fishery (General) Regulations*

In addition, directed interactions with White Sharks during the following activities are exempted by the recovery strategy:

- scientific research activities undertaken by DFO for White Shark conservation purposes and authorized under the *Fishery (General) Regulations*

A proposed action plan will be completed within 5 years of posting the final recovery strategy.

Recovery feasibility summary

It is difficult to assess the feasibility of recovery for the portions of the Northwest Atlantic population of White Shark that utilize Atlantic Canadian waters because it depends on the overall recovery of the population throughout its range as well as how movement patterns are influenced by ocean conditions. While climate change may lead to White Shark habitat degradation on a global scale, it could also increase habitat suitability for White Sharks in Atlantic Canadian waters, increasing their seasonal abundance in Atlantic Canadian waters (Bastien et al. 2020). Conversely, if the population were to experience a decline, as it has in the past (Baum et al. 2003; McPherson and Myers 2009), movement to the northern extent of its range could become less frequent, resulting in decreased occurrences in Atlantic Canadian waters.

Based on the following 4 criteria established in the *Species at Risk Act* Policies (Government of Canada 2009), the feasibility of recovery of the White Shark in Atlantic Canadian waters is unknown. In keeping with the precautionary principle, a recovery strategy has been prepared as per subsection 41(1) of SARA, as would be done when recovery is determined to be feasible. This recovery strategy addresses the unknowns surrounding the feasibility of recovery.

1. Are individuals of the wildlife species that are capable of reproduction available now or in the foreseeable future to sustain the population or improve its abundance?

Answer: Yes.

Individuals capable of reproduction are currently available to contribute to population growth and abundance in United States (U.S.) waters (Casey and Pratt 1985; Curtis et al. 2014). White Sharks inhabiting Canadian waters are not expected to be distinct or separate from the broader Northwest Atlantic population (COSEWIC 2021).

2. Is sufficient suitable habitat available to support the species, or could suitable habitat be made available through habitat management or restoration?

Answer: Yes.

White Sharks occur in temperate and tropical waters with a wide distribution that includes both coastal and pelagic (offshore) waters (Compagno 2001). In the Western Atlantic, White Sharks have been found from Newfoundland and Labrador to the Gulf of Mexico (Casey and Pratt 1985; Skomal et al. 2012; Curtis et al. 2014; Skomal et al. 2017). Electronic monitoring suggests approximately 25% of the population uses Canadian waters (Bowlby et al. 2022). White Sharks are generalist predators that can partially regulate their body temperature (Compagno 2001), characteristics that allow them to succeed in a variety of environmental conditions.

3. Can the primary threats to the species or its habitat (including threats outside Canada) be avoided or mitigated?

Answer: Yes.

In the Northwest Atlantic, the incidental catch of White Sharks in U.S. fisheries appears to be the most significant source of mortality (Santana-Morales et al. 2012; Curtis et al. 2014). White Shark bycatch is documented in both fixed and mobile gear fisheries (for example, trap net,

gillnet, and otter trawl). In Atlantic Canada, incidental fishing mortality is the primary documented source of mortality (see section 5.2.2 for further information). Although incomplete reporting and species misidentification may affect available data, records of incidental White Shark captures causing mortality are very rare in Canadian waters (DFO 2017).

The recovery of a wide-ranging species like the White Shark is challenging when its management is shared by several countries. Canadian efforts can contribute to the recovery and protection of the Northwest Atlantic population of White Shark; however, collaboration with other jurisdictions is paramount to recovery. Collaboration with the U.S., other nations, and international organizations such as the International Commission for the Conservation of Atlantic Tunas, Regional Fisheries Management Organizations, and the International Union for Conservation of Nature can continue to facilitate the development and implementation of mitigation and management measures that contribute to the recovery of this population beyond Canada.

Existing fishing licence conditions requiring the live release of incidentally captured White Sharks when possible, support threat mitigation and among others, are required as part of the exemption described in section 10 of this recovery strategy. Another condition of the exemption is the mandatory reporting of incidental captures in a DFO-approved SARA monitoring document, which will provide information to better understand the threat of bycatch, and to support recovery. In addition, research and monitoring will improve knowledge of White Shark biology, ecology, and seasonal distribution, thereby informing additional mitigation and management measures.

Effects of climate change on White Shark are not well understood but could alter their distribution in Atlantic Canadian waters. The threat of climate change to White Sharks cannot be mitigated at a regional scale; however, this is not identified as a primary threat to the species.

4. Do recovery techniques exist to achieve the population and distribution objectives or can they be expected to be developed within a reasonable timeframe?

Answer: Unknown.

Available data are insufficient to support traditional fisheries assessment models, which can be used to determine quantitative abundance and population and distribution objectives for species at risk (DFO 2006). As an alternative, this recovery strategy incorporates a qualitative recovery goal until sufficient information is available to develop quantitative population and distribution objectives. As further information becomes available regarding threats and threat mitigation, it is assumed that more targeted recovery techniques and management measures can be developed within Canada to reduce human-induced mortality to this species.

Table of contents

Preface	i
Acknowledgments	i
Executive summary	ii
Recovery feasibility summary	iv
Table of contents	vi
1 Introduction	1
2 COSEWIC species assessment information	2
3 Species status information	2
4 Species information	3
4.1 Description	3
4.2 Population abundance and distribution	4
4.3 Needs of the species	9
5 Threats	9
5.1 Threat assessment	9
5.2 Description of threats	12
5.2.1 Directed fishing, finning, and curio trade	12
5.2.2 Commercial bycatch	13
5.2.3 Recreational fishing	14
5.2.4 Shark control programs	15
5.2.5 Persecution	15
5.2.6 Ecotourism	15
5.2.7 Public aquaria	16
5.2.8 Persistent bioaccumulation of toxins	16
5.2.9 Habitat degradation	17
5.2.10 Other threats	17
6 Population and distribution objectives	19
7 Broad strategies and general approaches to meet objectives	20
7.1 Actions already completed or currently underway	20
7.2 Strategic direction for recovery	22
8 Critical habitat	24
8.1 Identification of the species' critical habitat	24
8.2 Schedule of studies to identify critical habitat	24
9 Measuring progress	25
10 Activities permitted by the recovery strategy	25
10.1 Commercial and communal commercial fisheries	27
10.2 DFO-led scientific activities directed at White Shark for conservation purposes	28
10.3 DFO-led research activities likely to interact incidentally with White Shark	29
11 Statement on action plans	30
References	31
Appendix A: record of cooperation and consultation	42
Appendix B: threat categories	43
Appendix C: reporting White Shark sightings	44

1 Introduction

The White Shark (*Carcharodon carcharias*) Atlantic population² was listed as endangered under the *Species at Risk Act* (SARA) in 2011.

This recovery strategy is part of a series of documents regarding White Shark (Atlantic population) that should be taken into consideration together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports ([COSEWIC 2006](#); [2021](#)), the recovery potential assessment (RPA) ([DFO 2006](#)), the evaluation of scope for harm ([DFO 2017](#)), and the subsequent action plan(s) (to come). A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets objectives and identifies the main areas of activities to be undertaken. Detailed planning for species recovery is done at the subsequent action plan stage.

The RPA is a process undertaken by Fisheries and Oceans Canada (DFO) to provide the information and scientific advice required to implement SARA, relying on the best available scientific information, data analyses, and modelling, and expert opinions. The outcome of this process informs many sections of the recovery strategy. For more detailed information beyond what is presented in this recovery strategy, refer to the COSEWIC status reports (COSEWIC 2006; 2021) and the RPA (DFO 2006).

² Globally, White Sharks form 2 genetically distinct population lineages. The South African and Northwest Atlantic populations are separate from the Indo-Pacific and Mediterranean populations. The genetic differences between the South African population and the Northwest Atlantic population suggest they are reproductively isolated from one another (Gubili et al. 2012; O’Leary et al. 2015). COSEWIC (2021) refers to an “Atlantic population” to distinguish it from White Sharks in the Canadian Pacific region. White Sharks that occur in Atlantic Canada are neither biologically nor ecologically distinct from the larger Northwest Atlantic population (COSEWIC 2021). This recovery strategy refers to the subset of the Northwest Atlantic White Shark population in the waters of Atlantic Canada while they are in Atlantic Canadian waters. Recovery efforts in Atlantic Canada are expected to positively affect the Northwest Atlantic White Shark population.

2 COSEWIC species assessment information

Date of assessment: April 2021

Common name (population): White Shark (Atlantic population)

Scientific name: *Carcharodon carcharias*

Status: Endangered

Reason for designation: This highly mobile species is a seasonal migrant in Atlantic Canada and considered to be part of a widespread Northwest Atlantic population. The status of the Canadian population is considered to be the same as that of the broader Northwest Atlantic population. That broader population is estimated to have declined by >70% over the past 1.5 generations (since the 1960s) because of incidental mortality from fishing. However, the population appears to have remained stable since the 1990s and is projected to remain stable or increase slightly. Although measures to improve fishing practices have been introduced, the primary threat continues to be mortality from incidental capture in fisheries. The species is still vulnerable to this threat because of its long generation time (42 years) and low reproductive rate.

Occurrence: Atlantic Ocean, New Brunswick, Newfoundland and Labrador, Prince Edward Island, Nova Scotia, Québec

Status history: Designated Endangered in April 2006. Status re-examined and confirmed in May 2021.

3 Species status information

The White Shark has been internationally recognized as an at-risk species for several decades. Table 1 provides a summary of the various status designations assigned to this species. This list is not exhaustive, and these designations are not all associated with legally binding prohibitions to protect the species. More information on national-level protections afforded to White Sharks can be found in Bruce (2008) and Santa-Morales et al. (2012).

Table 1. Summary of existing protection or other status designations assigned to White Shark. These represent the most recent assessment years and may not capture historical designations.

Jurisdiction	Authority/organization	Year	Status/description	Designation level
Canada	<i>Species at Risk Act</i> S.C. 2002, c. 29	2011	Listed as endangered on schedule 1	Population
Canada	Committee on the Status of Endangered Wildlife in Canada	2006, 2021	Assessed as endangered	Population

Jurisdiction	Authority/organization	Year	Status/description	Designation level
United States	Magnuson-Stevens Fishery Conservation Act - Atlantic Highly Migratory Species Fishery Management Plan	1997	Prohibited species	Population
Mediterranean	Bern Convention on the Conservation of European Wildlife and Natural Habitats	1982	Listed in appendix III	Population
International	United Nations Convention on the Law of the Sea (1982)	1982	Listed in annex I	Species
International	The Convention on the Conservation of Migratory Species of Wild Animals	2007	Listed in appendix I and appendix II	Species
International	Convention on International Trade in Endangered Species of Flora and Fauna	2005	Listed in appendix II	Species
International	International Union for Conservation of Nature Red List	2018	Assessed as vulnerable	Species

Upon listing as an endangered species (2011), the White Shark (Atlantic population) became protected wherever it is found by section 32 of SARA:

“No person shall kill, harm, harass, capture, or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species.” [subsection 32(1)]

“No person shall possess, collect, buy, sell, or trade an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species, or any part or derivative of such an individual.” [subsection 32(2)]

Under section 73 of SARA, the competent minister may enter into an agreement or issue a permit, if the pre-conditions are met, authorizing a person to engage in an activity affecting a listed wildlife species, any part of its critical habitat or its residences.

4 Species information

4.1 Description

White Sharks are large endothermic (warm-blooded) predators that occupy the apex of most food webs where they occur (Compagno 2001). The largest individuals can reach over 6 m in length. Length at birth is between 109 cm and 165 cm. White Sharks can be distinguished by their stout body with a conical snout, and large, flat, triangular serrated teeth. They have long gill slits and conspicuously large black irises. Similar to most sharks, they have 2 dorsal fins; the first is large with a dark rear tip that is not attached to the back, and the second is much smaller. The caudal fin is large and crescent-shaped. As shown in figure 1, the dorsal surface is darker,

ranging from grey or brownish-grey to blackish, while the ventral surface of the body is a sharply contrasting white (COSEWIC 2021).

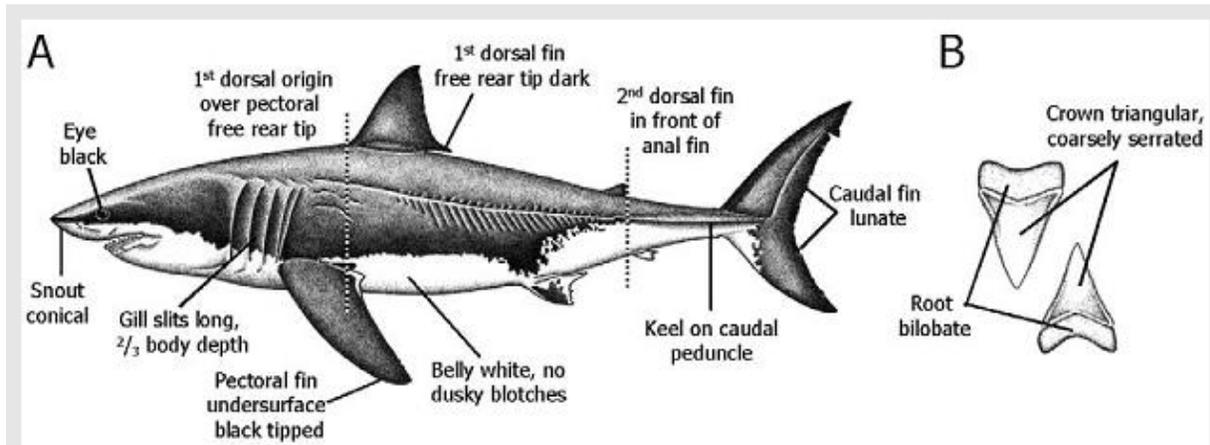


Figure 1. Characteristics useful for identifying the White Shark. A. Lateral view, B. detail of upper and lower anterior teeth. Diagrams by R. Aidan Martin. Source: COSEWIC 2021.

Little is known about White Shark biology and ecology (Bruce 2008). White Sharks are slow-growing and long-lived, surviving up to 73 years (Hamady et al. 2014; Natanson and Skomal 2015). They are late-maturing, at 26 years for males and 33 years for females (Natanson and Skomal 2015). Length at sexual maturity has been estimated as 4 to 5 m for females and 3.1 to 4.1 m for males, based on dissection of reproductive organs of both sexes, and/or the extent of clasper calcification in males (Francis 1996; Pratt 1996; Tanaka et al. 2011). More recent research has estimated total length at sexual maturity as 4.1 m for females and 3.3 m for males of the Northwest Atlantic population (Márquez-Farías et al. 2024).

White Sharks have a long gestation period (10 to 20 months), small litter size (2 to 17 pups) (Bruce 2008; COSEWIC 2021) and low reproductive capacity (Smith et al. 1998). Generation time is uncertain due to varying estimates of life history parameters, but is estimated at 23 to 62 years, likely closer to 62 years (Bruce 2008; Hamady et al. 2014; DFO 2017). The species is known to be highly opportunistic and preys on a wide spectrum of organisms such as fish (including skates and other sharks), seals, whales, marine turtles, marine birds, and some invertebrates (squids and crustaceans) (Bruce 2008). Individuals larger than 3 to 4 m feed predominantly on marine mammals (Klimley 1985; Estrada et al. 2006). White Sharks have also been observed to scavenge on dead marine mammals, such as whales (Skomal et al. 2012). White Sharks are known to aggregate near concentrations of schooling fish typically in upwelling areas and near seal colonies (Compagno 2001). Diet varies by region according to the availability, abundance, and vulnerability of prey (Compagno 2001).

White Sharks are obligate ram breathers, meaning they must swim to breathe. If they are restricted from swimming, they will drown.

4.2 Population abundance and distribution

White Sharks are distributed globally throughout temperate and subtropical regions (see figure 2). DNA evidence and tagging studies suggest a single, wide-ranging population in the

Northwest Atlantic, with limited gene flow among other populations (Boustany et al. 2002; Gubili et al. 2011; O’Leary et al. 2015). This means that the Northwest Atlantic population is largely genetically isolated from populations elsewhere in the Atlantic, Mediterranean, and Pacific oceans.

In the Western Atlantic, White Sharks are known to range from Bonavista Bay, Newfoundland and Labrador, to Northern Brazil (Compagno 2001; Fergusson et al. 2005).

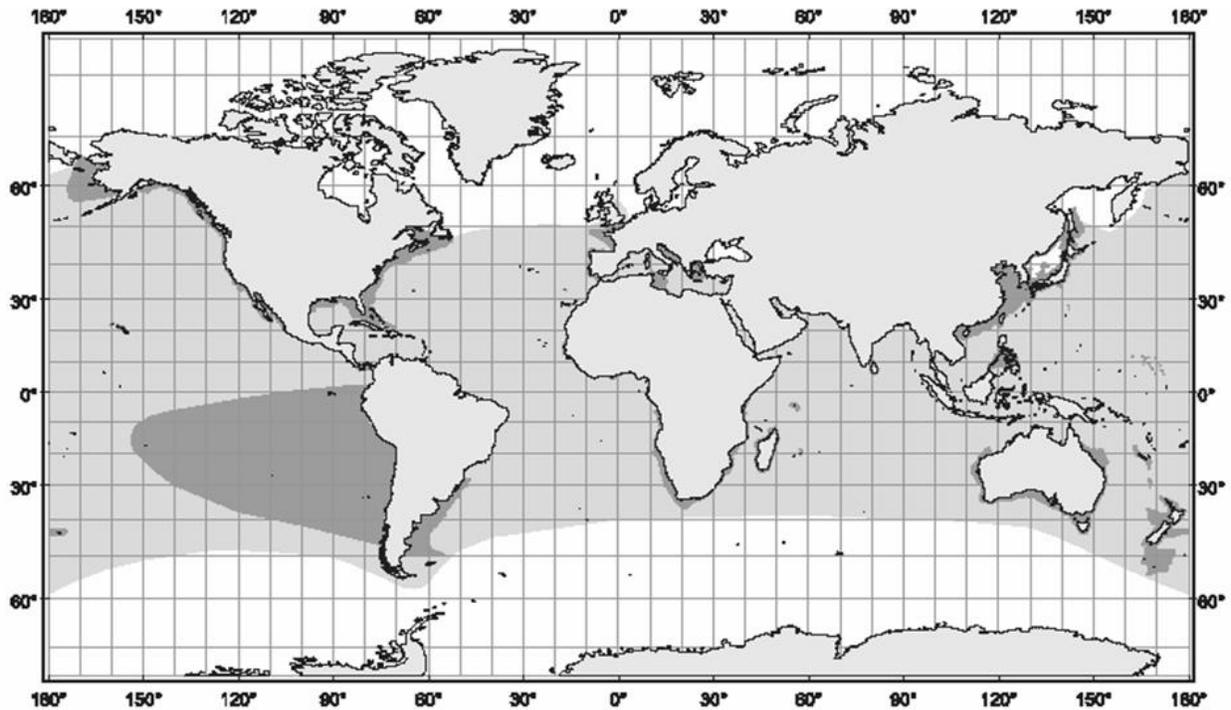


Figure 2. Global distribution of White Sharks. Dark grey represents the confirmed range; light grey represents the suspected or unconfirmed range (Compagno 2001).

Atlantic Canadian waters represent the northern extent of the population’s distribution (Curtis et al. 2014; COSEWIC 2021). The earliest reported sighting of White Shark in Canadian waters occurred in 1873. Confirmed sightings have been reported throughout Atlantic Canadian waters, the majority of which occur between June to September with the most recorded sightings occurring in August (figure 3) (COSEWIC 2021; DFO 2024). In recent years, increased research and identification efforts have revealed Atlantic Canadian waters to be more frequently used than previously thought (Skomal et al. 2017; Bastien et al. 2020).

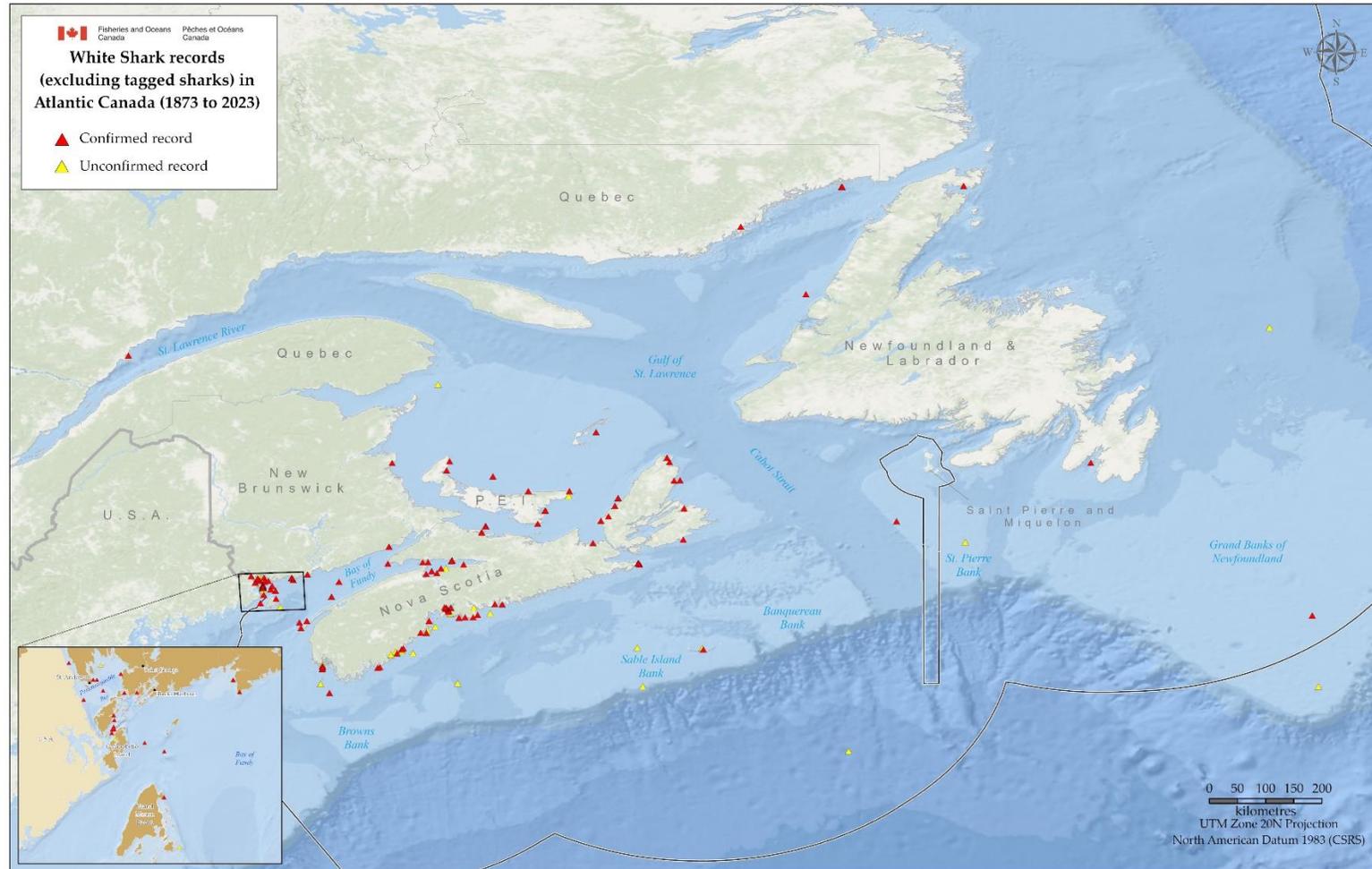


Figure 3. White Shark records (1873 to 2023) in Atlantic Canada (DFO 2024). Locations are indicated using coordinates when available. If no coordinates were provided, the location is indicated approximately using the description provided with the record. Note that effort is not accounted for in this figure, nor is effort equally distributed throughout the area captured. Data derived from satellite or acoustic tagging are not included in this map. Fisheries and Oceans Canada reviews records and classifies them as either confirmed or unconfirmed, based on the available information (for example, pictures, videos, and descriptions).

White Sharks use inshore, continental shelf, pelagic, and mesopelagic waters, regularly undertake long offshore migrations, and appear to follow common routes when moving between coastal areas (Boustany et al. 2002; Bruce et al. 2006; COSEWIC 2021; Franks et al. 2021). Telemetry and photographic studies of White Sharks have improved understanding of local movements, residency patterns, and long-distance migrations (Klimley and Ainley 1996; Bonfil 2004; Bruce et al. 2006; Bruce 2008; Duffy et al. 2012; Skomal et al. 2017; Winton et al. 2023).

Only a portion of the broader Northwest Atlantic population enters Canadian waters seasonally, with evidence that individuals repeatedly return to similar areas over numerous years (Franks et al. 2021; Bowlby et al. 2022). Sub-adult and mature White Sharks of both sexes occur in Atlantic Canadian waters and range widely throughout the region (Skomal et al. 2017; Bastien et al. 2020; Franks et al. 2021; Bowlby et al. 2022). Juveniles and sub-adults are more likely to make use of Canadian waters (Bowlby et al. 2022).

With respect to the Northwest Atlantic population, areas of high White Shark concentration vary seasonally, with higher density in the mid-Atlantic Bight, New England, and Canadian waters during summer, and off the southeastern U.S. and in the Gulf of Mexico during winter (Curtis et al. 2014). In Canada, the waters surrounding Nova Scotia (including the Bay of Fundy and into the Gulf of St. Lawrence) and the shelf break around the Grand Banks are high-use areas (Franks et al. 2021). While coastal sharks include juvenile, sub-adult, and adult sharks, pelagic habitat is more common amongst sub-adult and adult individuals (Curtis et al. 2014, Skomal et al. 2017). Foraging behaviour could result in movement to pelagic habitat; however, Skomal et al. (2017) indicated that offshore movements by females could coincide with gestation, as suggested by tagging studies in the Pacific (Domeier and Nasby-Lucas 2013; Domeier 2012). One coastal nursery location has been identified off Long Island, New York (Shaw et al. 2021), but neonates or young-of-the-year have not yet been documented in Canada (Bowlby et al. 2022). There seems to be a seasonal pattern in inshore and offshore habitat use, with individuals tending to remain in continental shelf waters (< 200 m) during the summer and autumn throughout the Northwest Atlantic, only making use of deeper habitats at other times of the year (Skomal et al. 2017; Bowlby et al. 2022). White Sharks have been documented in a wide range of water temperatures (-0.9 to 30.5°C) (Bigelow and Schroeder 1948; Franks et al. 2021).

Research off California showed that females exhibit a 2-year migratory pattern, using inshore or offshore waters depending on their life cycle stage, while males exhibit a 1-year migratory pattern (Domeier and Nasby-Lucas 2013). Genetic studies have shown that the dispersal of White Sharks may be sex-biased, with higher site fidelity exhibited by females (Pardini et al. 2001; Gubili et al. 2012).

White Sharks are globally rare and population data are limited (COSEWIC 2021). Global abundance, including for the Northwest Atlantic population, is unknown. Even in known hotspots such as off central California and South Africa, population estimates indicate that the species exists in relatively low numbers (Chapple et al. 2011; Andreotti et al. 2016). Within the Northwest Atlantic population, Curtis et al. (2014) collected 649 verified records (excluding tagged detections) over a 210-year period (1800 to 2010), 94% of which occurred after 1950. Winton et al. (2023) estimated that 800 White Sharks visited the Cape Cod aggregation site from 2015 to 2018.

Research suggests historic population declines in the Northwest Atlantic, off the coasts of South Africa and eastern Australia, and in the Adriatic Sea (Pepperell 1992; Reid and Krough 1992; Cliff et al. 1996; Soldo and Jardas 2002; Baum et al. 2003; Curtis et al. 2014). More recent studies show relative stability in South Africa (Bowlby et al. 2023; 2024) and apparent increases

in abundance in the Northwest Atlantic, New Zealand, and California (Dudley and Simpfendorfer 2006; Reid et al. 2011; Lowe et al. 2012; Curtis et al. 2014). Prior to 2014, the only published study examining trends in White Shark abundance in the Northwest Atlantic Ocean used catch-per-unit-effort data from an American pelagic longline fishery to estimate a 79% decline between 1986 and 2000 (Baum et al. 2003). However, the magnitude of this decline has been disputed (Burgess et al. 2005). Research by McPherson and Myers (2009) suggested an 86% decline of White Sharks in eastern Canadian waters over 3 generations (1926 to 1988) based on sightings data. Curtis et al. (2014) reviewed data from 1800 to 2010 to collate the most comprehensive dataset of sightings and catch-per-unit effort information on White Sharks in the Northwest Atlantic. Their analysis suggests that White Sharks in the Northwest Atlantic increased in abundance following the implementation of conservation measures in the U.S. during the 1990s, a common trend for White Shark populations globally. However, the magnitude of population increase is uncertain, largely because productivity is now thought to be lower than historically assumed (Bowlby and Gibson 2020).

Despite apparent positive population trends, mortality from anthropogenic threats remains a concern for the long-term viability of the Northwest Atlantic population (Curtis et al. 2014; COSEWIC 2021). A recent population viability analysis suggested that total annual removals for the Northwest Atlantic population should remain below 10 animals to ensure population growth rates remain positive and result in long-term persistence of the population (Bowlby and Gibson 2020).

The Mi'kmaq people of Atlantic Canada state that the White Shark has been known to their people for thousands of years; a White Shark tooth, dated 1,000 to 2,000 years before present day, was found in an oyster midden on Pig Island, Nova Scotia, located in the Northumberland Strait (Gilhen 1998; COSEWIC 2021). Indigenous knowledge is a source of information about White Shark distribution and habitat use. Local knowledge possessed by ocean users is also a source of information on White Shark distribution and habitat use.

4.3 Needs of the species

The habitat needs of White Shark within Atlantic Canadian waters are unknown. As described in 4.2, they occur regularly in Atlantic Canadian coastal and pelagic waters, mainly during summer and fall months, though there have also been documented occurrences in winter months.

Warmer waters during the summer and the presence of seal rookeries may help explain their distribution as it is probable that White Sharks scavenge on and hunt marine mammals in Atlantic Canada (Brodie and Beck 1983; Lucas and Natanson 2010; COSEWIC 2021).

White Shark survival and recovery are subject to inherent limiting factors including their naturally low abundance, slow growth, late maturation, and low fecundity, which lead to overall low productivity (COSEWIC 2021). These factors may be magnified by site fidelity displayed by female White Sharks, which may increase their vulnerability to exploitation (Pardini et al. 2001). White Sharks may also be particularly susceptible to environmental toxicity and pollution, due to their life history and ovoviviparous reproduction (COSEWIC 2021). The disproportionately high representation of juveniles and sub-adults in Canadian waters (Bowlby et al. 2022) may render the population increasingly vulnerable to the impacts of threats affecting those life stages in Canadian waters.

5 Threats

5.1 Threat assessment

A threat is defined as any human activity or process that has caused, is causing, or may cause harm, death, or behavioural changes to a wildlife species at risk, or the destruction, degradation and/or impairment of its habitat, to the extent that population-level effects occur (DFO 2014b). A human activity may exacerbate a natural process, such as the prevalence of disease (DFO 2014b). COSEWIC (2006; 2021) assessed White Shark in Atlantic Canada as endangered largely due to threats occurring outside of Canadian waters that likely influence the ability of the species to recover within Canadian waters. Its status was re-examined and confirmed as endangered in May 2021 (COSEWIC 2021). Threats to White Shark are summarized in table 2, and described in more detail in section 5.2 and COSEWIC (2006; 2021). Threat assessment categories are defined in appendix B.

The threat assessment presented in table 2 was completed based on information in the COSEWIC status report (COSEWIC 2006), the RPA (DFO 2006), the evaluation of scope for harm (DFO 2017), other published information, and expert opinion. The threat assessment was not subject to scientific peer review and preceded the publication of the most recent program guidance on assessing threats to species at risk (DFO 2014b). The results of the assessment are subject to change as new information becomes available. In the absence of a population estimate, and without knowledge of how threats may have affected the population to date, population-level effects cannot be determined with any certainty. Instead, probable population-level effects are inferred from what is currently known about the rate of mortality and injury to individuals, where available.

Table 2. Summary of threats to White Sharks globally and within Atlantic Canada. Refer to Appendix B for definitions of terms used herein.

Threat	Scale	Level of concern	Extent	Occurrence	Frequency	Severity	Causal certainty
Directed fishing, finning, and curio trade	Global	High	Widespread	Current	Continuous	High	High
	Atlantic Canada	Low	Unknown	Unknown	Unknown	Unknown	Unknown
Commercial bycatch	Global	High	Widespread	Current	Continuous	High	High
	Atlantic Canada	Low	Unknown	Current	Recurrent	Unknown	Unknown
Recreational fishing	Global	Medium	Widespread	Current	Continuous	Moderate-low	Medium
	Atlantic Canada	Low	Unknown	Current	Unknown	Low	Low
Shark control programs	Global	Low	Localized	Current	Continuous	Moderate-low	Low
	Atlantic Canada	N/A	N/A	N/A	N/A	N/A	N/A
Persecution	Global	Low-medium	Unknown	Current/historical	One-time / continuous	Unknown	Medium
	Atlantic Canada	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

Threat	Scale	Level of concern	Extent	Occurrence	Frequency	Severity	Causal certainty
Ecotourism	Global	Low	Localized	Current	Recurrent	Unknown	Low
	Atlantic Canada	Low	Localized	Current	Recurrent	Unknown	Low
Public aquaria (historic)	Global	Low	Unknown	Historical	One(1)-time	Unknown	Low
	Atlantic Canada	N/A	N/A	N/A	N/A	N/A	N/A
Persistent bioaccumulation of toxins	Global	Low	Unknown	Unknown	Unknown	Unknown	Low
	Atlantic Canada	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Habitat degradation	Global	Low	Widespread	Unknown	Unknown	Unknown	Low
	Atlantic Canada	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

5.2 Description of threats

Global threats are relevant to all White Shark populations, but little is known about how threats affect the portion of the Northwest Atlantic population occurring in Atlantic Canadian waters. Threats are described below in a global context and, where possible, information regarding the White Shark in Atlantic Canadian waters is provided. The COSEWIC (2021) assessment identifies human activities, primarily commercial and recreational fishing, the curio trade in jaws and teeth, trade in fins for food and trophies, and the bioaccumulation of toxins, as the main threats to White Sharks. Other potential threats (section 5.2.10) may result in direct mortality or injury to individual sharks, may affect their behaviour and habitat use, and may contribute to reduced population fitness and viability.

5.2.1 Directed fishing, finning, and curio trade

Global

White Sharks are predominantly caught as commercial bycatch, although small-scale and artisanal fisheries in some areas also target the species (Compagno 2001). White Sharks are mostly targeted for their highly valued teeth, jaws, and fins (Compagno 2001; CITES 2004). Teeth and jaws are used in the curio trade for jewelry, souvenirs, decorations, and collectibles. Large sharks are more in demand for the higher value of their jaws and individual teeth (Compagno 2001; Bonfil et al. 2004; Duffy 2004; Fowler et al. 2005). The highly valued fins of White Sharks make them more vulnerable to finning. This refers to the removal and retention of shark fins and the discard of the remainder of the body at sea, a practice which contributes significantly to the overexploitation of sharks worldwide (IUCN 2003). Fins are then sold both as food and as trophies. The meat, skin, cartilage, and liver oil of the species are used for human consumption, although the high mercury content of the meat limits its demand (Compagno 2001).

The high value and notoriety of White Shark products encourage poaching and illegal trade. Evidence suggests that where legislative protections for the species exist, White Sharks were still poached and traded as of the early 2000s, including in Australia, South Africa, and the U.S. (CITES 2004; Shivji et al. 2005). Considering the high value, ease of transport, and ready market for White Shark teeth, this threat may be more significant than current Convention on International Trade in Endangered Species (CITES) records indicate (Cooper 2009).

Because of the unknown extent of fishing throughout its range, including illegal, unreported, and unregulated fishing and trade, combined with the high value of White Shark products, this threat is considered to be an important source of mortality for White Sharks globally.

Atlantic Canada

Finning in Canadian waters, and by Canadian licence holders operating outside the Canadian Exclusive Economic Zone (EEZ), has been banned since 1994 (DFO 2007). Canada has adopted protective shark finning policies (Pikitch et al. 2008) that are described in section 7.1. Illegal trade of White Shark products in Atlantic Canada is thought to be minimal or non-existent, though further information is required to properly assess its contribution to the level of concern for this threat. Directed fishing and retention of bycaught White Sharks is not permitted within Atlantic Canadian waters.

5.2.2 Commercial bycatch

Global

Bycatch refers to interaction of non-target species with fishing gear. Because White Sharks are obligate ram breathers, they are particularly susceptible to mortality as a result of bycatch in fishing gear that restricts or prohibits movement, limiting the flow of water over their gills. Globally, White Sharks are captured in both fixed gear and mobile gear fisheries (Curtis et al. 2014). Compagno (2001) lists longlines, hook-and-line, fixed bottom gillnets, pelagic gillnets, fish traps, herring weirs, trammel nets, bottom and pelagic trawls, and purse seines as fisheries with the highest rates of White Shark bycatch. Globally, it is unclear which of those fisheries capture the most White Sharks as bycatch (Diaz and Serafy 2005; Moyes et al. 2006; Campana et al. 2009). COSEWIC (2021) indicated that the American pelagic longline fishery is the primary cause of bycatch mortality in the Northwest Atlantic, based largely on Baum et al. (2003), with most bycatch occurring south of Florida. Historic and current studies from southern California indicate that net fisheries, such as trammel nets, drift and set gillnets, catch more White Sharks than other fisheries studied (Lowe et al. 2012; Santana-Morales et al. 2012).

Commercial bycatch in the southern U.S. appears to be the most important source of mortality for the species in the Northwest Atlantic (Curtis et al. 2014).

Atlantic Canada

Information on bycatch of White Sharks in Atlantic Canada is sparse. Commercial bycatch resulting in mortality³ is thought to be rare, based on 31 records between 1873 and 2023, though it is probable that this underestimates the true rate of interactions resulting in mortality (DFO 2017; 2024).

Approximately 60% of authenticated bycatch occurrences between 1920 and 2023 were in cod or hake gillnets and herring weirs (DFO 2017; 2024). Two White Shark mortalities were recorded in weirs in the Bay of Fundy in 2010 and 2011 (DFO 2017). Throughout Atlantic Canada, there are only 4 records of White Shark bycatch in at-sea observer databases (DFO 2024). For all 4 records, species identification was unconfirmed due to small recorded sizes of the individuals caught and a lack of photo or video confirmation. Other bycatch records were obtained from COSEWIC (2006), through a literature review, and recent records were obtained from fish harvesters.

No studies have investigated shark catch or mortality rates from herring weirs; however, mortality could be low if the entrapped shark remained submerged and was free to move and breathe prior to escape or live-release in a timely manner. Live-release of White Sharks from brush weirs, however, would be improbable as most brush weirs go dry as the tide goes out. Although White Shark mortality rates in gillnets in Atlantic Canada have not been determined, they are expected to be high because the gillnet gear restricts movement and limits the flow of

³ As a precautionary approach, in the 2017 “Evaluation of Scope for Harm for White Shark (*Carcharodon carcharias*) in Atlantic Canada” (DFO 2017), an assumption was made that White Shark bycatch records resulted in mortality, if mortality or live release was not indicated. It is possible that mortality did not occur in some cases (for example, there are 6 incidental captures in herring weirs in the outer Bay of Fundy that could have resulted in live release). An additional precautionary measure was to include unconfirmed records in the analysis.

water over the gills, impairing breathing. The only known study to examine shark bycatch mortality in Atlantic Canadian gillnet fisheries took place in Newfoundland waters from 2001 to 2003 (Benjamins et al. 2010). This study was unable to determine mortality rates for any species including White Sharks.

There are 2 records of White Shark interactions in DFO-approved SARA monitoring documents. However, Hurtubise et al. (2020) found that, for endangered Leatherback Sea Turtles, these records underestimate true turtle-fishery interaction rates in Atlantic Canada. These findings are likely also true for other SARA species for which the submission of SARA monitoring documents is required, including White Shark.

Commercial gear types that have caught White Sharks incidentally in other jurisdictions but have no recorded interactions with White Sharks in Atlantic Canada have the potential for future interactions in Atlantic Canada. These include but are not limited to mid-water trawls and bottom longlines (Compagno 2001).

Commercial bycatch is considered to be of low concern within Atlantic Canadian waters based on available records; however variability in at-sea observer coverage in Canadian fisheries that may interact with White Sharks makes quantitative assessments of the frequency and magnitude of bycatch challenging.

COSEWIC (2021) specifies that long-term warming may shift the centre of distribution for this species to the north, potentially changing the frequency of incidental captures in fisheries in Atlantic Canada relative to other parts of the population's range.

5.2.3 Recreational fishing

Global

Recreational shark fisheries are often poorly documented by government agencies and are not typically considered a priority for management. White Sharks are subject to targeted sport fisheries for game-fishing records and trophy jaws due to their size, notoriety, and powerful resistance to capture (Compagno 2001; CITES 2004). However, an increasing number of anglers worldwide are voluntarily using catch and release practices for sharks. This trend often coincides with voluntary tagging programs (Babcock 2008). White Sharks have been a prohibited species (that is, no commercial or recreational harvest) throughout the U.S. since 1997 (Curtis et al. 2014).

Atlantic Canada

Records indicate that in Atlantic Canada, White Sharks have only been caught during recreational fishing activities 4 times since 1873. This low number is attributed in part to their scarcity, size, and ability to bite through regular tackle (DFO 2006). In Canada, recreational shark fishing, including shark charters and fishing tour operations, is restricted to hook and release (that is, no retention permitted) and White Sharks can not be targeted. A small number of shark fishing derbies have historically been held by some communities in the Maritime provinces. Retention of some shark species is permitted in these derbies, but White Sharks cannot be targeted or retained.

5.2.4 Shark control programs

Global

White Sharks are intentionally targeted by beach meshing and drumline programs to protect swimmers in South Africa, Australia, and New Zealand (CITES 2004; Curtis et al. 2012; Gibbs et al. 2019). The numbers of such captures are low, and thus the threat to the population is likely low, though the mortality rate of those captured in the meshing and on traditional drumlines is high. The use of Shark-Management-Alert-in-Real-Time (SMART) drumlines in Australia represents a less harmful alternative to traditional shark control programs (Tate et al. 2021; Butcher et al. 2023).

Atlantic Canada

Shark control programs do not occur in Atlantic Canadian waters.

5.2.5 Persecution

Global

Due to their sometimes-lethal interactions with humans, White Sharks have acquired a negative reputation that is perpetuated by popular media. As a consequence, campaigns to kill White Sharks sometimes take place after shark attacks or in anticipation of such attacks (for example, shark culls) (CITES 2004; Fergusson et al. 2005; Curtis et al. 2012). In addition, White Sharks are sometimes killed because they are considered a nuisance to fisheries. The issue is exacerbated by their tendency to investigate boats and other floating objects, bringing them to the surface and potentially increasing their chance of being intentionally injured or killed (Compagno 2001).

Atlantic Canada

Given that persecution of White Shark has occurred elsewhere where the species' habitat use overlaps with humans this may also occur in Atlantic Canadian waters. However, there are no confirmed records of this threat occurring within Atlantic Canada.

5.2.6 Ecotourism

Global

Poorly managed ecotourism operations are a potential threat to White Sharks. In several parts of the world (for example, the U.S., Mexico, South Africa, Australia, and New Zealand) cage diving and other types of tourism operations have been developed to observe White Sharks in their natural environment. The long-term effects of these activities on White Shark populations are unknown (CITES 2004), although effects on White Shark behaviour may be of concern (Laroche et al. 2007; Huveneers et al. 2018). A main concern is the provisioning of food in the form of bait, which has been linked to negative impacts on White Shark surface behavior and habitat use, leading to conditioning that may result in increased rate of interactions between sharks and humans (Becerril-García et al. 2020a). There have been several studies investigating the impacts of tourism on White Shark behavior, residency, and activity, particularly in South Africa and Australia where known White Shark aggregation sites overlap with tourism activities (Huveneers et al. 2018). Harmful interactions between White Sharks and

cages have also been recorded during ecotourism operations (Becerril-García et al. 2019; 2020a). Globally, White Shark cage diving is often subject to management and regulations to mitigate impacts to White Shark health and behaviour (Bruce 2015).

Atlantic Canada

Currently, there is limited ecotourism directed at White Sharks within Atlantic Canada. However, as public awareness of and interest in White Sharks in Atlantic Canadian waters increases, the potential for ecotourism operations directed at the species also increases.

Within Atlantic Canadian waters, there are several known pinniped aggregation sites, most notably for grey seals. There is limited research available documenting seasonal White Shark aggregations around these pinniped colonies or elsewhere in Atlantic Canada, and the impact that baiting activities from ecotourism operations might have on altering White Shark behavior or distribution is unknown.

5.2.7 Public aquaria

Global

Public aquaria captured live White Sharks for exhibits during the 1970s and 1980s; these sharks usually perished after a few days in captivity (Compagno 2001). The Monterey Bay Aquarium in California has had 5 live White Shark exhibitions since 2004. All sharks survived and were successfully returned to the wild after 6 months or less spent at the Aquarium. The threat is considered historical since White Sharks are infrequently taken for this purpose.

Atlantic Canada

Live capture of White Sharks is not considered a threat within Atlantic Canadian waters, as it is not known to occur, nor is it permitted.

5.2.8 Persistent bioaccumulation of toxins

Global

Due to their diet and longevity, White Sharks are likely to bioaccumulate pollutants in their bodies, as has been observed in other shark, ray, and skate (elasmobranch) species (Cagnazzi et al. 2019).

White Shark specimens from South African waters were found with high levels of organochlorine pesticides, metals (for example, mercury), and polychlorinated biphenyls (PCBs) (Schlenk et al. 2005). Juveniles in the Southern California Bight had mercury levels 6 times greater than the established wildlife screening value of concern, significant levels of organic contaminants in their livers, and dichlorodiphenyltrichloroethane (DDT) concentrations exceeding those reported for any other elasmobranch (Mull et al. 2012). The potential for female White Sharks to transfer contaminants to offspring is elevated due to the species' high trophic position (Lyons et al. 2013).

Accumulations of these toxins result in severe health issues (for example, reproductive impairment, skeletal abnormalities, endocrine disruption, and immunotoxicity) in a number of marine mammals, and may be of concern for White Sharks. However, research suggests that

White Sharks may have physiological protective mechanisms to mitigate the effects of such toxins, as White Sharks in South Africa had blood concentrations of heavy metals that would normally be toxic in vertebrates but showed no evidence of adverse health effects (Merly et al. 2019).

Atlantic Canada

Numerous studies have assessed the potential prevalence and impacts of bioaccumulation on White Shark in the Northwest Atlantic. Marciano et al. (2024) found accumulation of Per/Polyfluoroalkyl Substances (PFASs) within White Shark plasma and liver tissues, with sharks sampled off Nova Scotia having higher plasma PFAS concentrations than those sampled elsewhere within the population's range, potentially attributable to differences in diet. Bielmyer-Fraser et al. (2023) found that concentrations of certain metals varied based on collection site, that concentrations of nickel varied based on sex, and that efficient detoxification strategies may exist within the population. Crawford et al. (2023) found bioaccumulate of mercury in White Shark plasma and tissue, with muscle tissue mercury levels comparable to other White Shark populations, but plasma mercury levels exceeding those documented in other populations by almost 4 times. This bioaccumulation was not, however, associated with poor health markers, suggesting that the species possesses effective mechanisms for responding to such physiological stress.

5.2.9 Habitat degradation

Global

Increasing coastal development, dumping of organic waste, overfishing of prey species, and climate change may lead to degradation of important feeding, mating, and pupping areas for White Sharks. However, White Sharks may adapt their behaviour and habitat use in response to habitat degradation. COSEWIC (2021) specifies that increasing water temperatures and ocean acidification may negatively affect White Shark pups and nursery grounds, because pups cannot move long distances to find waters conducive to their survival and growth. Documentation of how habitat degradation may have altered the health, distribution, and productivity of sharks remains scarce.

Atlantic Canada

White Shark habitat use in coastal and offshore Atlantic Canadian waters encompasses a large geographic area for a significant period of the year (see section 4.2 Population abundance and distribution). While not documented in published literature, various forms of habitat degradation could potentially pose a threat to the species.

5.2.10 Other threats

Some additional anthropogenic activities are thought to present potential threats to White Sharks globally and in Atlantic Canada, although they are poorly understood. These are not included in table 2, as little to no information is available to assess the level of concern and causal certainty.

Anthropogenic electromagnetic fields

Elasmobranch species, such as White Shark, possess an electrical sense that can detect localized electromagnetic fields (EMFs) that they may use for larger-scale navigation (reviewed in Hueter et al. 2004). Studies of other elasmobranchs indicate that the detection of EMFs helps them to detect prey, avoid predators, and orient themselves at local scales. They may use EMFs in their environment both actively and passively for navigation (Hueter et al. 2004).

Anthropogenic sources of EMFs have been introduced into the marine environment from a wide variety of sources in many parts of the world (Normandeau et al. 2011). Little is known about their impact on marine species and ecosystems. Although there is a lack of information on EMF effects to White Shark and other marine species, EMFs present a potential threat.

In Atlantic Canada, potential anthropogenic sources of EMFs include submarine power and telecommunication cables and offshore renewable energy development structures (for example, wind or tidal power) (Isaacman and Daborn 2011; Normandeau et al. 2011; DFO 2013a; COSEWIC 2021). Such EMFs may interfere with a shark's ability to use its electromagnetic sense which could have effects on shark behaviour and the carrying out of life functions. The range of EMF emissions from sources such as submarine cables may be minimal and localized. Given current knowledge gaps in shark biology, the level of concern that this threat may pose to White Sharks globally and within Atlantic Canada is not well understood (Isaacman and Daborn 2011; Normandeau et al. 2011; DFO 2013a).

Acoustic disturbance

Ocean noise is increasing globally. Sources of anthropogenic noise include commercial shipping, natural resource exploration and extraction, and industrial development (for example, pile driving).

Based on their auditory system, White Sharks are thought to be sensitive to even the smallest vibration or sound (Martin 2003). Field and laboratory experiments on other shark species indicate that sharks can hear sounds with frequencies ranging from about 10 Hz (hertz, cycles per second) to about 800 Hz, and are most responsive to sounds lower than 375 Hz. Studies also show that sharks are most attracted to irregular pulse sounds at relatively low frequencies, such as those commonly associated with a struggling fish (Martin 2003). The results of these studies may be applicable to White Sharks; however, the overall impact of anthropogenic noise on White Sharks is poorly understood. It may displace White Sharks from preferred foraging areas, or obscure their ability to detect prey, which may have energetic costs for individuals and at the population level.

Coastal and offshore development

Coastal and ocean development includes coastal construction on land, in-water development such as wharf construction and dredging, oil and gas exploration and development, and renewable energy development such as wind and tidal power, among other activities. These activities could cause habitat degradation (for example, by introducing contaminants and excess sediments), acoustic disturbance, and/or other impacts to White Sharks and their prey.

Tidal power development within the Bay of Fundy has the potential to overlap with areas of known White Shark occurrence. Tidal power generation involves placing a power-generating structure, such as a turbine, in the marine environment. Potential effects on species in the area

may arise from physical interactions, acoustic disturbance, or the creation of EMFs from subsea power cables (AECOM 2009). Collisions with tidal turbines could occur and potentially result in injury or mortality of White Sharks and their prey. The potential for mortality or injury likely depends on the tidal system design (for example, turbine diameter, number of turbines, blade speed, position in water column). Cables associated with tidal power generation emit low level EMFs and are not likely to cause avoidance behaviour (AECOM 2009). Some tidal energy designs may present risks to White Shark prey and the cumulative effects of multiple tidal turbines, especially at commercial scales, could increase the likelihood or severity of threats to White Sharks. Because the effects of tidal power development on White Sharks are unknown, environmental effects monitoring plans that will fully monitor the potential effects of tidal power projects on the species should be developed.

COSEWIC (2021) also identified aquaculture as a potential threat to the species in Atlantic Canada, as White Shark interactions with salmon aquaculture sites have been documented. Although net modifications can reduce the possibility of such interactions, they constitute an entanglement risk for White Sharks. Moreover, while interactions are likely rare, increasing aquaculture activity may result in more interactions and entanglements.

Other potential threats include physical disturbance from offshore wind farm developments, vessel strikes in shipping lanes, and displacement caused by oil and gas platform developments. At the time of assessment, COSEWIC (2021) indicated these threats are unlikely to impact the species due to one or more of the following factors: White Shark behaviour and/or the current extent and intensity of the potential threat.

6 Population and distribution objectives

Population and distribution objectives establish, to the extent possible, the number of individuals and/or populations, and their geographic distribution, that are necessary for the recovery of the species. The population and distribution objectives for White Shark in Atlantic Canada are:

Population objective: maintain or increase the population of White Sharks that frequents Atlantic Canadian waters.

Distribution objective: maintain the distribution of White Sharks in Atlantic Canadian waters.

There is insufficient information available on White Shark abundance and distribution in Atlantic Canadian waters to set quantitative objectives. Planned and ongoing research and management measures in Canada are expected to contribute to recovery of the population and provide information that will help refine these objectives in the future.

The population and distribution objectives recognize that White Sharks occurring in Atlantic Canadian waters represent an unknown proportion of the greater Northwest Atlantic population, and that changes in the Northwest Atlantic population as a whole will likely be reflected in the portion of White Sharks occurring in Canadian waters. This recovery strategy therefore focuses on reducing human-induced mortality in Canadian waters, while also collaborating internationally, to influence total abundance of White Shark in the Northwest Atlantic. If in the future the Northwest Atlantic population is deemed stable, recovery efforts will focus on maintaining this stability. No efforts will be made to alter White Shark distribution patterns in isolation of changes in overall population abundance and distribution.

White Shark recovery in Atlantic Canada will depend on conservation strategies implemented throughout the population's range. For this reason, recovery efforts in Atlantic Canada alone may not result in the species being assessed at a lower at-risk status (for example, threatened, special concern, or not at risk).

Population and distribution objectives will be reassessed within a biologically meaningful timeframe where recovery can be measured effectively, or as new information becomes available. A 5-year or similar reporting timeframe would not provide an accurate assessment of recovery, given the longevity and late age at maturity of this species. Generation times remain uncertain with estimates in support of a shorter (for example, 26 years) or longer (for example, 62 years) generation time (DFO 2017). In any case, the species' longevity and life history characteristics mean that it may take decades for population changes to become evident and for recovery to be achieved. Interim measures of progress will be necessary to track recovery in the shorter term (section 9).

7 Broad strategies and general approaches to meet objectives

Research and management approaches required to meet the population and distribution objectives, including actions already completed or underway, are described in this section and grouped under the following broad strategies:

Broad strategy 1: research and monitoring

Broad strategy 2: management and protection

Broad strategy 3: international collaboration

Broad strategy 4: engagement, stewardship, and public outreach

7.1 Actions already completed or currently underway

Broad strategy 1: research and monitoring

Several long-term research programs have been established by government, academia, and ENGOs to study and monitor White Shark within Atlantic Canada. Research to date has focused on telemetry studies of White Shark habitat use in Canadian waters, as well as the assessment of population abundance and trends. Research on other threats faced by the population and by the species more broadly (for example, bioaccumulation and ecotourism) is also ongoing. Necropsies have also been conducted on White Sharks that have been found dead within Atlantic Canada, to improve understanding of their health as well as threats to the species.

Broad strategy 2: management and protection

Since listing in 2011, White Shark has been subject to SARA section 32, which means that it is prohibited to kill, harm, harass, capture, take, possess, collect, buy, sell or trade any part or derivative of an individual of the species. When applicable, fishing licences also acting as SARA permits issued under the authority provided by section 74, are issued following a review of the proposed activity against the SARA section 73 permitting requirements. These licences permit incidental interactions with White Sharks and are subject to conditions, such as releasing any White Shark to the water in the manner that causes the least harm and reporting any interactions with White Sharks in a DFO-approved SARA monitoring document.

The at-sea observer program contributes to monitoring White Shark interactions with fishing gear. The percentage of at-sea observer coverage varies substantially among fisheries, with some fisheries having no at-sea observer coverage. Dockside monitoring is required for 100% of all commercial large pelagic landings, including any authorized bycatch shark landings, although no fishery is permitted to land White Shark (DFO 2007; Hanke et al. 2012).

Canada's "[National Plan of Action for the Conservation and Management of Sharks](#)" (DFO 2007) created a national framework for the management of commercial shark species and is expected to indirectly benefit White Shark through increased management efforts directed at shark species. Canada has banned shark finning since 1994. This ban is applied through DFO's fisheries licence condition restrictions in commercial large pelagic and groundfish fisheries in Atlantic Canada. In 2016, Canada committed to a Northwest Atlantic Fisheries Organization (NAFO) decision to adopt a "fins naturally attached" policy, requiring all bycaught sharks landed in Canada to have their fins left naturally attached (that is, fins not removed from a shark's carcass) (DFO 2016). This policy is also implemented through licence conditions (DFO 2019).

In 2019, the Government of Canada amended the *Fisheries Act* to define and prohibit the practice of shark finning and to ban the import and export of shark fins that are not attached to a shark carcass, except in accordance with a permit issued by the Minister of Fisheries for scientific research relating to shark conservation and only if such research is likely to benefit the survival of any shark species (DFO 2019). Policies and other legislation that apply to all shark species, as discussed above, provide additional layers of protection to that already provided under SARA for White Shark.

Broad strategy 3: international collaboration

In 2005, NAFO banned shark finning and the trans-shipment and landing of shark fins that are not attached to a shark carcass in the NAFO Regulatory Area (NAFO 2005). In 2016, NAFO adopted measures that prohibit the removal of shark fins on vessels (NAFO 2016). As a contracting party to NAFO, both of these measures apply to Canadian vessels when operating in the NAFO Regulatory Area. The International Commission for the Conservation of Atlantic Tunas (ICCAT) has not adopted a "fins naturally attached" policy (Shark League 2017). However, since 2004, ICCAT has implemented a policy that the total weight of the shark fins on board must not exceed 5% of the total body weight of the sharks on board (ICCAT 2005; DFO 2014a). There have been numerous international measures that offer some level of protection for White Sharks (see table 1).

Canada is a signatory to the United Nations "International Plan of Action for the Conservation and Management of Sharks", which aims to ensure the long-term conservation and management of sharks through data collection and research, threat mitigation, and collaborative action (FAO 1999).

Numerous collaborative international research partnerships exist, as described under Broad strategy 1: research and monitoring.

Broad strategy 4: engagement, stewardship, and public outreach

A range of products and activities provide the public with a general education on White Shark and more targeted educational materials are available to ocean users who may encounter the species. These include resources on identification of and best practices for handling White Shark to aid in their release from both commercial and recreational fishing gear.

Numerous White Shark sightings reporting initiatives exist or have existed, including the Grand Manan Whale and Seabird Research station and WWF-Canada’s Shark Identification Network, DFO’s White Shark sightings Database, the Canadian Shark Attack Registry, and the Marine Mammal Response Society’s incident reporting hotline for all marine animals in the Maritime Provinces, including White Sharks.

Massachusetts Division of Marine Fisheries also collaborates with the Atlantic White Shark Conservancy and others on a web map and application, “Sharktivity”, that shows White Shark sightings and detections geographically (Atlantic White Shark Conservancy 2024). OCEARCH also maintains a publicly available shark tracker which displays the location of White Sharks tagged by the organization (OCEARCH, 2024).

7.2 Strategic direction for recovery

The research and management approaches needed to meet population and distribution objectives are presented in table 3. These will help inform the development of specific recovery measures in 1 or more action plans.

A higher proportion of the Northwest Atlantic White Shark population is expected to occur in U.S. waters compared to Atlantic Canadian waters (Casey and Pratt 1985; Curtis et al. 2014); thus, the success of recovery actions in Atlantic Canadian waters relies upon action also being taken elsewhere in the Northwest Atlantic. DFO encourages other agencies and organizations to participate in the recovery of the Atlantic population of White Shark through the implementation of this recovery strategy.

Table 3. Recovery planning table for the White Shark (Atlantic population).

General description of research and management approaches	Priority ⁴	Broad strategy	Threat or limitation
1. Undertake scientific research and monitoring to better understand White Shark distribution, habitat use, and diet in Atlantic Canada and White Shark population structure and dynamics in the broader Northwest Atlantic population	High	1, 3	Limited knowledge of habitat use in Canadian waters and population structure, dynamics, and distribution
2. Undertake opportunistic research (for example, biological sample collection, stomach content analysis, identify cause of death) on incidentally captured or dead animals.	Medium	1, 3	Limited knowledge of population, distribution, and habitat use in Canadian waters; limited knowledge of threats

⁴ “Priority” reflects the degree to which the approach contributes directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species:

- “high” priority approaches are considered likely to have an immediate and/or direct influence on the recovery of the species
- “medium” priority approaches are important but considered to have an indirect or less immediate influence on the recovery of the species
- “low” priority approaches are considered important contributions to the knowledge base about the species and mitigation of threats

General description of research and management approaches	Priority ⁴	Broad strategy	Threat or limitation
3. Gather Indigenous and local knowledge to improve understanding of White Shark distribution and habitat use.	Low	1	Limited knowledge of population, distribution, and habitat use in Canadian waters
4. Collect and maintain White Shark sightings information.	Low	1	Limited knowledge of population, distribution, and habitat use in Canadian waters
5. Undertake scientific research to better understand the nature and frequency of documented and emerging threats to White Sharks.	High	1	Limited knowledge of threats
6. Explore and implement improvements to at-sea observer recording methods, requirements, and coverage, as required.	Medium	1, 2	Commercial bycatch
7. Collaborate on regional, national, and international efforts to research and monitor White Sharks, and manage human activities in support of recovery.	High	1, 3	All threats
8. Continue and improve reporting of fisheries interactions in Atlantic Canada, and explore measures for improving compliance as necessary.	Medium	2	Commercial bycatch; recreational fishing
9. Explore and implement measures to mitigate fisheries interactions, as required.	High	2	Commercial bycatch
10. Ensure the protection and recovery of White Sharks is considered in the management of all relevant ocean activities.	High	2	All threats
11. Ensure the continued application of relevant legislation and policies to monitor and control the import and export of White Shark products in Canada, to the extent possible.	Medium	2	Fishing, finning, and curio trade
12. Explore and implement, where appropriate, specific measures to monitor and control the illegal import and export of White Shark products in Canada.	Medium	2	Fishing, finning, and curio trade
13. Promote and support management and trade policies at international fora that encourage the long-term protection and recovery of White Sharks globally.	Medium	3	Fishing, finning, and curio Trade; commercial bycatch
14. Educate stakeholders and the general public about White Shark ecology, conservation and its threats.	Medium	4	Persecution and control; commercial bycatch; recreational fishing; fishing, finning, and curio trade

8 Critical habitat

8.1 Identification of the species' critical habitat

Critical habitat is defined in SARA as "...the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species." [subsection 2(1)]

Also, SARA defines habitat for aquatic species as "... spawning grounds and nursery, rearing, food supply, migration, and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." [subsection 2(1)]

For the White Shark (Atlantic population), the identification of critical habitat is not possible at this time, given currently available information on population distribution and habitat use. The schedule of studies outlines the research required to identify critical habitat to achieve the species' population and distribution objectives.

8.2 Schedule of studies to identify critical habitat

Further research is required to identify critical habitat necessary to support the species' population and distribution objectives and protect the critical habitat from destruction. This additional work includes the studies in table 4.

Table 4. Schedule of studies to identify critical habitat for the White Shark (Atlantic population).

Description of study	Rationale	Timeline ⁵
Undertake ecological studies that provide information on White Shark habitat use and behaviour in Atlantic Canadian waters.	Knowledge of the species and its habitat use in Atlantic Canadian waters is limited. Studies that examine factors such as White Shark distribution and habitat use as defined by oceanographic characteristics, and habitat use by life stage may help to identify critical habitat for this species, as well as the biophysical characteristics of that habitat.	5 years
Conduct studies that aid in understanding seasonal distribution, movement, migration, and abundance of White Shark in Atlantic Canadian waters (for example, through continued tagging and monitoring of White Sharks).	Increase knowledge of White Shark distribution and habitat use in Atlantic Canadian waters to support future identification of critical habitat.	5 years

⁵ Timeline reflects the amount of time required for the study to be completed from the time the recovery strategy is published as final on the Species at Risk Public Registry.

9 Measuring progress

The performance indicators below provide a way to define and measure progress toward achieving the population and distribution objectives. Progress towards meeting these objectives will be reported on in the report on the progress of recovery strategy implementation. A successful recovery program will achieve the overall aim of maintaining or increasing the population of White Sharks that frequents Atlantic Canadian waters and maintaining the distribution of White Sharks in Atlantic Canadian water.

Overarching progress measures

Overarching progress measure #1: The portion of the Northwest Atlantic population of White Sharks that frequents Atlantic Canadian waters is maintained or increased.

Overarching progress measure #2: The distribution of White Sharks in Atlantic Canadian waters is maintained.

Interim progress measures

Until a baseline is established to evaluate the success of the overarching progress measures, the following interim progress measures will be used:

Interim progress measure A: a standardized evaluation of trends in relative White Shark abundance and distribution in Canada has been conducted.

Interim progress measure B: an analysis of available data on White Shark bycatch in Atlantic Canadian fisheries has been conducted.

Interim progress measure C: effective threat mitigation measures have been applied and adapted as new information becomes available, such that total allowable harm is not exceeded⁶.

Interim progress measure D: critical habitat is identified for White Shark in Atlantic Canadian waters.

Interim progress measure E: Canadian participation in international initiatives for the recovery and conservation of White Sharks is maintained and enhanced where appropriate.

10 Activities permitted by the recovery strategy

SARA states that “Subsections 32(1) and (2), section 33 and subsections 36(1), 58(1), 60(1) and 61(1) do not apply to a person who is engaging in activities that are permitted by a recovery strategy, an action plan or a management plan and who is also authorized under an Act of Parliament to engage in that activity, including a regulation made under section 53, 59 or 71.” [subsection 83(4)]

⁶ Based on the Evaluation of Scope for Harm for White Shark (*Carcharodon carcharias*) in Atlantic Canada (DFO 2017)

The initial RPA for White Shark (DFO 2006) concluded that any level of harm would jeopardize the species' survival or recovery. Given that subsequent findings by Curtis et al. (2014) suggested that the population appears to be increasing, DFO re-examined the scope for allowable harm for White Shark in 2016 (DFO 2017). There were 4 criteria considered for this assessment, as outlined in the Revised Framework for the Evaluation of Scope for Harm under section 73 of SARA (DFO 2004):

- 1) is the population so small or spatially concentrated that it is vulnerable to elimination by catastrophic events?
- 2) is the recent trajectory of the population stable or likely to be increasing?
- 3) are known sources of human-induced mortality unlikely to increase?
- 4) is there a high likelihood of achieving recovery goals in reasonable timeframes with allowable harm present?

Relative to criteria 1 to 3, this new allowable harm assessment examined past and recent research on White Shark and the Northwest Atlantic population in particular. Criterion 4 was assessed using a simulation model developed for White Shark that accounted for uncertainty in life history parameters (for example, conflicting estimates of longevity and age at maturity) while modeling the probability of population decline under different mortality scenarios (representing different levels of allowable harm). DFO (2017) concluded that there is scope for human-induced mortality in Canadian waters without jeopardizing survival or recovery of the species relative to the 4 criteria based on the following:

- 1) The spatial distribution and movement patterns of White Sharks make the entire population in the Northwest Atlantic relatively invulnerable to localized catastrophic events. Specific components of the population may be vulnerable during specific times of the year, such as when White Sharks frequent spatially-discrete coastal areas such as the Bay of Fundy.
- 2) Although there is substantial uncertainty about the recent population trajectory for White Shark in the Northwest Atlantic, the best available and most current trend estimate suggests that the population has been increasing since the 1990s (Curtis et al. 2014), although the magnitude of increase is uncertain. Indirectly, the development of a fishery-independent monitoring program for White Shark off Cape Cod (since 2009) supports the idea that White Sharks are becoming more abundant in waters adjacent to Canada and possibly in Atlantic Canadian waters.
- 3) The main cause of human-induced mortality in Atlantic Canadian waters was identified as incidental captures by commercial fisheries. Weirs and gillnets appear to have the highest potential for interaction. Reported incidental mortality from 1950 to 2016 remained at 3 individuals per decade across all Atlantic Canadian fisheries; however, the extent of commercial fisheries did not remain static during that period. There is no indication in more recent data that incidental mortality from fisheries is becoming more frequent (DFO 2024), and fewer weirs exist now than historically due to more restrictive management for small pelagic species like mackerel. If incidental mortality in Canadian waters represents a chance event, it is unlikely to increase markedly in relation to future changes in commercial fishing activities.
- 4) There is a high likelihood that the population and distribution objectives can be achieved under various scenarios of allowable harm for White Shark in Canada, even if annual bycatch mortality increases from historical estimates. If the Northwest Atlantic population

of White Shark is characterized by very low intrinsic rates of population increase, few of the simulated population trajectories were predicted to be declining under current mortality levels (3 animals per decade). However, the proportion of population trajectories in decline changes relatively quickly as mortality increases, doubling if 1 mortality occurs each year, increasing by > 5.5 times with 3 mortalities per year, >14 times with 10 mortalities per year and > 19 times with 20 mortalities per year. At this highest level of mortality, 72% of population trajectories were predicted to be in decline.

Given the historical rarity of incidental captures of White Sharks, even at times when they were thought to be more abundant (for example, during the 1950s and 1960s) the highest levels of mortality modelled are not expected to occur in Atlantic Canada (DFO 2017).

Considering the outcomes of the DFO (2017) analysis, population and distribution objectives can likely be achieved if anthropogenic mortality levels remain at current levels, or increase slightly. A maximum mortality rate of 1 White Shark per year, averaged over any 10 year period (that is, maximum of 10 mortalities over 10 years), is therefore deemed acceptable. Scope for harm will be re-evaluated if important new information becomes available (for example, a population abundance estimate is available or has been updated, population trend information suggests a change, or if it is determined that females undergo reproductive senescence).

In accordance with subsection 83(4) of SARA, this recovery strategy permits the activities described in sections 10.1 to 10.3, below.

Persons wishing to engage in activities other than those described in sections 10.1 to 10.3 of this recovery strategy that are likely to kill, harm, harass, capture or take individuals, or destroy any part of its critical habitat (once identified) should apply to the Minister of Fisheries for a permit under section 73 of SARA. If a permit is issued it will, among other things, include terms and conditions governing the activity that the Minister considers necessary for protecting the species, minimizing the impact of the authorized activity on the species or providing for its recovery. Whether or not a permit will be issued is at the Minister's discretion. A permit cannot be issued unless the Minister is of the opinion that:

- (a) all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted,
- (b) all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat (once identified), and
- (c) the activity will not jeopardize the survival or recovery of the species

SARA permit applications can be downloaded from the [DFO Species at Risk website](#).

10.1 Commercial and communal commercial fisheries

In accordance with subsection 83(4) of SARA, this recovery strategy permits harvesters who:

- (a) hold a licence under the *Fisheries Act* to engage in commercial fishing activities, or
- (b) are fishing under the authority of a commercial communal licence issued under the *Aboriginal Communal Fishing Licences Regulations* (SOR/93-332),

to incidentally interact with White Shark such that it results in the unintentional killing, harming, harassing, or capturing of individual White Sharks. This exemption is subject to the following conditions:

- live or dead individual White Sharks or their parts shall not be retained
- a White Shark incidentally captured during fishing activities must be returned forthwith to the place from which it was taken, and where it is alive, in a manner that causes it the least harm
- all interactions with individual White Sharks, dead or alive, shall be recorded in a DFO-approved monitoring document (for example, a SARA log, a fishery monitoring document) and submitted as specified in the licence conditions for individual fisheries (including nil reports, where required)
- the licence holder must also comply with any other conditions related to White Shark included in DFO's fishing licence conditions where mitigation measures are fishery-specific

Licence conditions are reviewed regularly and will be modified, if necessary, as new information becomes available. Other fishery-specific management or mitigation measures may be implemented through conservation harvesting plans and/or integrated fisheries management plans. Management or mitigation measures will be reviewed and modified if necessary as new information becomes available. DFO will work with industry for commercial licences and First Nations for communal commercial licences to refine these measures to support White Shark recovery.

10.2 DFO-led scientific activities directed at White Shark for conservation purposes

In accordance with subsection 83(4) of SARA, this recovery strategy permits scientific research activities that are led by DFO, and authorized under section 52 of the *Fishery (General) Regulations* (SOR/93-53) directed at White Shark, such that they result in the harassing, capturing, harming, or unintentional killing of individual White Sharks. This exemption is subject to the following conditions:

- By December 31 of each year, irrespective of whether permitted activities took place, a report shall be submitted to the regional Species at Risk Program outlining activities carried out in that calendar year. Report requirements include but are not limited to:
 - a description of each activity requiring use of the exemption and the licence number for the associated authorization under section 52 of the *Fishery (General) Regulations*
 - a record of interactions with White Shark that occurred while conducting the exempted activities, including nil reports
 - an assessment of the impact of the exempted activities on individual White Sharks (for example, injuries, behavioural changes)
- The licence holder complies with all conditions of licence related to White Shark

This recovery strategy also permits biological sampling in the course of research activities, which may result in the collection and possession of White Shark parts (for example, blood or tissue).

In the event of a mortality of an individual White Shark, resulting from DFO-led research activities or a mortality that otherwise becomes known to DFO, this recovery strategy permits the DFO researchers to collect and possess individual White Sharks or their parts for research purposes. Possession is subject to the following conditions:

- the regional Species at Risk Program shall be notified immediately if there is a White Shark mortality in the course of DFO-led research activities
- the licence holder is authorized in the licence to collect and possess White Shark parts or a carcass (should unintentional mortality occur)
- the licence holder complies with all conditions of licence related to White Shark

10.3 DFO-led research activities likely to interact incidentally with White Shark

In accordance with subsection 83(4) of SARA, this recovery strategy permits scientific research activities that are led by DFO, and authorized under section 52 of the *Fishery (General) Regulations* (SOR/93-53) such that they result in the incidental killing, harming, harassing, and capturing of individual White Sharks. This exemption is subject to the following conditions:

- every reasonable effort shall be made to release live captured White Sharks as soon as possible, nearest to the place where taken, and in a manner that causes the least harm
- By December 31 of each year, irrespective of whether permitted activities took place, a report shall be submitted to the regional Species at Risk Program outlining activities carried out in that calendar year. Report requirements include but are not limited to:
 - A description of each activity requiring use of the exemption and the licence number for the associated authorization under section 52 of the *Fishery (General) Regulations*;
 - A record of all interactions with White Shark that occurred while conducting the exempted activities, including nil reports; and
 - An assessment of the impact of the exempted activities on individual White Sharks (for example, injuries, behavioural changes).
- the licence holder complies with all conditions of licence related to White Shark

In the event of a mortality of an individual White Shark resulting from research activities, or a mortality that otherwise becomes known to DFO, this recovery strategy permits the researchers to collect and possess individual White Sharks or their parts (for example, blood or tissue). Collection and possession is subject to the following conditions:

- the regional Species at Risk Program shall be notified immediately if there is a White Shark mortality in the course of DFO-led research activities,
- the licence holder is authorized in the licence to possess a White Shark carcass for as long as is necessary to transfer it to an authorized individual conducting directed research
- the licence holder complies with all conditions of licence related to White Shark

Research that is not led by DFO, either directed at White Sharks or with the potential to interact with White Sharks, is not included in this exemption. Persons wishing to engage in such activities must apply for and obtain a permit under section 73 of SARA issued by DFO.

11 Statement on action plans

The federal government's approach to recovery planning is a 2-part approach, the first part being the recovery strategy and the second part being the action plan. An action plan contains specific recovery measures or activities required to meet the objectives outlined in the recovery strategy.

A proposed action plan for the White Shark (Atlantic population) will be completed within 5 years of posting the final recovery strategy.

References

- AECOM (AECOM Canada Ltd.) 2009. Environmental assessment registration document – Fundy tidal energy demonstration project Volume I: environmental assessment. Prepared for FORCE (Fundy Ocean Research Centre for Energy). Project number 107405.
- Atlantic White Shark Conservancy. 2024. [Meet Sharktivity - Atlantic White Shark Sighting And Resource App](#). Web site. [accessed October 11, 2024].
- Andreotti, S., M. Rutzen, S. van der Walt, S. von der Heyden, R. Henriques, M. Meÿer, H. Oosthuizen, and C.A. Matthee. 2016. An integrated mark-recapture and genetic approach to estimate the population size of White Sharks in South Africa. *Marine Ecology Progress Series* 552:241–253.
- Anon. (Anonymous). 2010. Kobe II Bycatch Workshop Background Paper: Sharks. Joint Tuna RFMOs, International Workshop on Tuna RFMO Management Issues Relating to By-catch and to Call on RFMOs to Avoid Duplication of Work on this Issue. 23–25 June, Brisbane, Australia.
- Babcock E. 2008. Recreational fishing for pelagic sharks worldwide. pp.193–202. in M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds.). *Sharks of the open ocean: biology, fisheries and conservation*. Blackwell Publishing. Oxford, UK.
- Bastien, G., A. Barkley, J. Chappus, V. Heath., S. Popov, R. Smith, T. Tran, S. Currier, D.C. Fernandez, P. Okpara, and V. Owen. 2020. Inconspicuous, recovering, or northward shift: status and management of the white shark (*Carcharodon carcharias*) in Atlantic Canada. *Canadian Journal of Fisheries and Aquatic Sciences*, 77(10):1666-1677.
- Baum, J.K., R.A. Myers, D.G. Kehler, B. Worm, S.J. Harley, and P.A. Doherty. 2003. Collapse and conservation of shark populations in the Northwest Atlantic. *Science*, 299:389-392.
- Becerril-García, E.E., E. Sperone, E.M. Hoyos-Padilla, and F. Galvan-Magana. 2019. The surface behaviour of white sharks during ecotourism: A baseline for monitoring this threatened species around Guadalupe Island, Mexico. *Aquatic Conservation Marine and Freshwater Ecosystems*, 29(5):773-782
- Becerril-García, E.E., E.M. Hoyos-Padilla, P. Micarelli, F. Galvan-Magana, and E. Sperone. 2020a. Behavioural responses of white sharks to specific baits during cage diving ecotourism. *Scientific Reports*, 10(11152).
- Becerril-García, E.E., R.O. Martínez-Rincón, F. Galván-Magaña, O. Santana-Morales, and E.M. Hoyos-Padilla. 2020b. Statistical modelling reveals spatial, temporal, and environmental preferences for white sharks at an oceanic aggregation site. *Marine Ecology Progress Series*, 655:171-183.
- Benjamins, S., D. Kulka., and J. Lawson. 2010. Recent incidental catch of sharks in gillnet fisheries of Newfoundland and Labrador, Canada. *Endangered Species Research*, 11:133-146.

- Bielmyr-Fraser, G.K., B. Franks, R. Somerville, R. Hueter, A.L. Newton, and C. Fischer. 2023. Tissue metal concentrations and antioxidant enzyme activity in western north Atlantic white sharks (*Carcharodon carcharias*). *Aquatic Toxicology* 261(106641).
- Bonfil, R., A. Boustany, D.D. Chapman, M.L. Domeier, C. Duffy, S. Fowler, S. Frodham, R. Johnson, A. Kock, K. Laroche, L. Lauck, C. Mciff, S. O'Brien, H. Oosthuizen, E. Pikitch, M. Scholl, M. Shivji, J. Stevens, W. Tsontos, and H. Walter. 2004. White Shark *Carcharodon carcharias*: status and management challenges. Pp 4. Conclusions of the Workshop on Great White Shark Conservation Research. Wildlife Conservation Society, New York, New York.
- Boustany, A.M., S.F. Davis, P. Pyle, S.D. Anderson, B.J.L. Boeuf, and B.A. Block. 2002. Expanded niche for White sharks. *Nature*, 415(6867):35.
- Bowlby, H.D., and A.J.F. Gibson. 2020. Implications of life history uncertainty when evaluating status in the Northwest Atlantic population of white shark (*Carcharodon carcharias*). *Ecology and evolution*, 10(11):4990-5000.
- Bowlby, H., W.N. Joyce, M.V. Winton, P.J. Coates, and G.B. Skomal. 2022. Conservation implications of white shark (*Carcharodon carcharias*) behaviour at the northern extent of their range in the Northwest Atlantic. *Canadian Journal of Fisheries and Aquatic Sciences* 79(11):1843-1859.
- Bowlby, H.D., M.L. Dicken, A.V. Towner, S. Waries, T. Rogers, and A. Kock. 2023. Decline or shifting distribution? A first regional trend assessment for white sharks (*Carcharodon carcharias*) in South Africa. *Ecological Indicators*, 154(110720).
- Bowlby, H.D., M.L. Dicken, A.V. Towner, T. Rogers, S. Waries, and A. Kock. 2024. Ecological conclusions remain unchanged for white sharks in South Africa: A reply to Gennari et al. 2024. *Ecological Indicators*, 165(112160).
- Brodie, P. and B. Beck. 1983. Predation by sharks of the gray seal (*Halichoerus grypus*) in eastern Canada. *Canadian Journal of Fisheries and Aquatic Sciences*, 40:267–271.
- Bruce, B.D., J.D. Stevens, and H. Malcolm. 2006. Movements and swimming behaviour of White sharks (*Carcharodon carcharias*) in Australian waters. *Marine Biology*, 150(2):161-172.
- Bruce, B.D. 2008. The biology and ecology of the white shark, *Carcharodon carcharias*. Pp. 69–81. in M. D. Camhi, E. K. Pikitch, and E. A. Babcock (eds.), *Sharks of the Open Ocean: Biology, Fisheries and Conservation* Blackwell Publishing, Oxford, UK.
- Bruce, B.D. 2015. A review of cage diving impacts on white shark behaviour and recommendations for research and the industry's management in New Zealand. CSIRO Marine & Atmospheric Research.
- Burgess, G.H., L.R. Beerkircher, G.M. Cailliet, J.K. Carlson, E. Cortes, K.J. Goldman, R.D. Grubbs, J.A. Musick, M.K. Musyl, and C.A. Simpfendorfer. 2005. Is the collapse of shark populations in the Northwest Atlantic Ocean and Gulf of Mexico real? *Fisheries*, 30(10):19–26.

- Butcher, P.A., K.A. Lee, C.P. Brand, C.R. Gallen, M. Green, A.F. Smoothey, and V.M. Peddemors. 2023. Capture Response and Long-Term Fate of White Sharks (*Carcharodon carcharias*) after Release from SMART Drumlines. *Biology*, 12(1329).
- Cagnazzi, D., G. Consales, M.K. Broadhurst, and L. Marsili. 2019. Bioaccumulation of organochlorine compounds in large, threatened elasmobranchs off northern New South Wales, Australia. *Marine Pollution Bulletin*, 139: 263–269.
- Campana, S.E., W. Joyce, and M.J. Manning. 2009. Bycatch and discard mortality in commercially caught blue sharks *Prionace glauca* assessed using archival satellite pop-up tags. *Marine Ecology Progress Series*, 387: 241-253.
- Casey, J.G. H.L. Pratt Jr., and C. Stillwell. 1985. Distribution of the white shark, *Carcharodon carcharias*, in the Western North Atlantic. *Memoirs Southern California Academy of Sciences*, 9:2-14.
- Chapple, T.K., S.J. Jorgensen, S.D. Anderson, P.E. Kanive, A.P. Klimley, L.W. Botsford, B.A. and B.A. Block. 2011. A first estimate of white shark, *Carcharodon carcharias*, abundance off Central California. *Biology Letters*, 7(4):581-583.
- Chisholm, J., pers. comm. 2016. Email correspondence to A. Gromack. June 2, 2016. Shark Research Scientist, Shark Research Program, Massachusetts Division of Marine Fisheries, New Bedford, Massachusetts.
- CITES (Convention on International Trade of Endangered Species). 2004. [Proposal for the inclusion of *Carcharodon carcharias* in Appendix II](#). CoP13 Prop. 32 Rev. 1. Pp. 39. Bangkok, Thailand. Website.
- Cliff, G., S.F.J. Dudley, and M.R. Jury. 1996. Catches of white sharks in KwaZulu-Natal, South Africa and environmental influences. pp 351–361 in A. P. Klimley and D. G. Ainley (eds.), *Great White Sharks: the Biology of *Carcharodon carcharias**. Academic Press, London: U.K.
- CMS (Convention on the Conservation of Migratory Species of Wild Animals). 2007. [Meeting to Identify and Elaborate an Option for International Cooperation on Migratory Sharks under the Convention on Migratory Species](#). Mahé, Seychelles, 11–13 December 2007. Website. [accessed July 5, 2021].
- Compagno, L.J.V. 2001. *Sharks of the World. An annotated and illustrated catalogue of the shark species known to date. Volume 2. Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes)*. FAO, Rome, Italy.
- Cooper, E. 2009. WWF-TRAFFIC Canada review review of the UNEP-WCMC CITES Trade Database of shark products [unpublished data]. Email correspondence to L. Outhouse. April 2013. National Director, WWF-TRAFFIC and Wildlife Trade, Vancouver, British Columbia.
- COSEWIC. 2006. COSEWIC assessment and status report on the White Shark *Carcharodon carcharias* (Atlantic and Pacific populations) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 31 pp.

- COSEWIC. 2021. COSEWIC assessment and status report on the White Shark *Carcharodon carcharias* (Atlantic and Pacific populations) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 55 pp.
- Crawford, L.M., J. Gelsleichter, A.L. Newton, L.A. Hoopes, C. Lee, N.S. Fisher,, D.H. Adams, M. Giraud, and A.E. McElroy. 2023. Associations between total mercury, trace minerals, and blood health markers in Northwest Atlantic white sharks (*Carcharodon carcharias*). *Marine Pollution Bulletin*, 195(115533).
- Curtis, T. pers. comm. 2011. Email correspondence to A. Cosandey-Godin (*contractor*). 2011. Sustainable Fisheries Division, Northeast Regional Office, NOAA, Gloucester, Massachusetts, NOAA.
- Curtis, T., B. Bruce, G. Cliff, S. Dudley, S.F.J. Klimley, A. Kock, R.N. Lea, C.G. Lowe, J.E. McCosker, G. Skomal, J.E. Werry, and J. West. 2012. Responding to the risk of white shark attack: updated statistics, prevention, control methods, and recommendations. Pp. 477-509 in Domeier (ed) *Global perspectives on the biology and life history of the white shark*. CRC Press Boca Raton.
- Curtis T.H., C.T. McCandless, J.K. Carlson, G.B. Skomal, N.E. Kohler, L.J. Natanson, G.H. Burgess, J.J. Hoey, and H.L. Pratt Jr. 2014. Seasonal Distribution and Historic Trends in Abundance of White Sharks, *Carcharodon carcharias*, in the Western North Atlantic Ocean. *PLoS ONE* 9(6): e99240.
- Curtis, T.H., G. Metzger, C. Fischer, B. McBride, M. McCallister, L.J. Winn, J. Quinlan, and M. J. Ajemian. 2018. First insights into the movements of young-of-the-year white sharks (*Carcharodon carcharias*) in the western North Atlantic Ocean. *Scientific reports*, 8(1):1-8.
- DFO. 2004. Revised framework for evaluation of scope for harm under section 73 of the *Species at Risk Act*. DFO Can. Sci. Advis. Sec. Stock Status Report 2004/048.
- DFO. 2006. Recovery potential assessment report on white sharks in Atlantic Canada. Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/052.
- DFO. 2007. [Canada's national plan of action for the conservation and management of sharks](#). Website. [accessed August 7, 2013].
- DFO. 2013a. Science review of the Labrador-Island Transmission Link Project environmental impact statement (EIS). DFO Can. Sci. Advis. Sec. Sci. Resp. 2012/021.
- DFO. 2013b. [Policy for Managing Bycatch](#). Website. [accessed February 19, 2018].
- DFO. 2014a. Atlantic Canadian Shark Conservation Action Plan for selected pelagic shark species. Unpublished report.
- DFO. 2014b. Guidance on assessing threats, ecological risk and ecological impacts for species at risk. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/013. 21 pp. (Erratum: June 2016)

- DFO. 2016. [New management measures to strengthen shark finning prevention](#). Website. [accessed December 21, 2016].
- DFO. 2017. Evaluation of Scope for Harm for White Shark (*Carcharodon Carcharias*) in Atlantic Canada. DFO Can. Sci. Advis. Sec. Sci. Resp. 2017/025.
- DFO. 2019. [Government of Canada bans shark finning](#). Website. [accessed July 29, 2021]
- DFO. 2024. White Shark sightings and strandings database. Dartmouth, NS.
- DFO. [White Shark \(*Carcharodon carcharias*\) sightings in Atlantic Canada \(1873 to 2022\)](#). Website. [accessed October 10, 2024]
- Diaz, G.A. and J.E. Serafy. 2005. Longline-caught blue shark (*Prionace glauca*): factors affecting the numbers available for live release. Fisheries Bulletin, 103:720–724.
- Domeier, M.L. and N. Nasby-Lucas. 2013. Two year migration of adult female white sharks (*Carcharodon carcharias*) reveals widely separated nursery areas and conservation concerns. Animal Biotelemetry, 1(2).
- Dudley, S.F.J. 2003. Shark Catch Trends and Effort Reduction in the Beach Protection Program, KwaZulu-Natal, South Africa. Proceedings of Scientific Symposium, 2002. North Atlantic Fisheries Organization SCR Doc. 02/124.
- Dudley, S.F.J. and C.A. Simpfendorfer. 2006. Population status of 14 shark species caught in the protective gillnets off KwaZulu-Natal beaches, South Africa, 1978–2003. Marine and Freshwater Research, 57:225–240.
- Duffy, C. 2004. International trade in white shark (*Carcharodon carcharias*) goods from New Zealand. Shark News 16:1-2.
- Duffy, C., M.P. Francis, M.P. Manning, and R. Bonfil. 2012. Regional population connectivity, oceanic habitat, and return migration revealed by satellite tagging of White Sharks, *Carcharodon carcharias*, at New Zealand aggregation sites. Pp. 301-318. in M.L. Domeier (ed). Global perspectives on the biology and life history of the White Shark, CRC Press, Boca Raton, Florida.
- Estrada, J.A, A.N. Rice, L.J. Natanson, and G.B. Skomal. 2006. Use of isotopic analysis of vertebrae in reconstructing ontogenetic feeding ecology in white sharks. Ecology, 87(4): 829-834.
- Franks, B.R., J.P. Tyminski, N.E. Hussey, C.D., Braun, A.L. Newton, S.R. Thorrold, G.C. Fischer, B. McBride, and R.E. Hueter. 2021. Spatio-Temporal Variability in White Shark (*Carcharodon carcharias*) Movement Ecology During Residency and Migration Phases in the Western North Atlantic. Frontiers in Marine Science, 8(744202).
- FAO. 1999. [International plan of action for the conservation and management of sharks](#). Website [accessed August 7, 2013].

- Fergusson, I., L.J.V. Compagno, and M. Marks. 2005. *Carcharodon carcharias*. IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. Website. [accessed February 6, 2011].
- Findlay, R., Gennari, E., Cantor, M., and D.P. Tittensor. 2016. How solitary are white sharks: social interactions or just spatial proximity? *Behavioral Ecology and Sociobiology*, 7:1735-1744.
- Fowler, S.L., R.D. Cavanagh, M. Camhi, G.H. Burgess, G.M. Cailliet, S.V. Fordham, C.A. Simpfendorfer, and J.A. Musick (comp. and eds.). 2005. Sharks, rays and chimaeras: The status of the chondrichthyan fishes. Status Survey. IUCN/ SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.
- Francis, M.P. 1996. Observations on a pregnant white shark with a review of reproductive biology. Pp. 157-172. in A.P. Klimley and D.G. Ainley (eds.). *Great White Sharks: the Biology of *Carcharodon carcharias**. Academic Press, San Diego.
- Gibbs, L., L. Fetterplace, M. Rees, and Q. Hanich. 2019. Effects and effectiveness of lethal shark hazard management: The Shark Meshing (Bather Protection) Program, NSW, Australia. *People and Nature*, 2:189-203.
- Gilhen, J. 1998. Fishes of Nova Scotia: species reported in the accession books of Henry Piers, Curator of the Provincial Museum, Halifax, from 1899-1940. Curatorial Report, Nova Scotia Museum of Natural History, Halifax.
- GMWSRS (Grand Manan Whale and Seabird Research Station). 2014. Guidelines for Releasing Large Animals from Herring Weirs. Grand Manan Whale and Seabird Research Station Bulletin No. 6.
- Government of Canada. 2009. Species at Risk Act Policies [Draft]. Species at Risk Act, Policies and Guidelines Series. Ottawa, Ontario. Environment Canada. 48 pp.
- Gubili, C., C.A.J. Duffy, G. Cliff, S. Wintner, M. Shivji, D. Chapman, B. Bruce, A. Martin, D. Sims, C.S. Jones, and L. Noble. 2012. Applications of molecular genetics for conservation of the white shark, *Carcharodon carcharias*, L. 1758. Pp. 357-380. in M.L. Domeier (ed) *Global perspectives on the biology and life history of the white shark*, CRC Press, Boca Raton, Florida.
- Hammill, M.O., C.E. den Heyer, and W.D. Bowen. 2014. Grey Seal Population Trends in Canadian Waters, 1960-2014. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/037.
- Hamady, L.L., L.J. Natanson, G.B. Skomal, and S.R. Thorrold. 2014. Vertebral bomb radiocarbon suggests extreme longevity in White Sharks. *PLoS One* 9(1): e84006. doi:10.1371/journal.pone.0084006.
- Hanke, A.R., I. Andrushchenko, and G. Croft. 2012. Observer coverage of the Atlantic Canadian swordfish and other tuna longline fishery: An assessment of current practices and alternative methods. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/049.iii + 84 p.

- Hueter R.E., D.A. Mann, K.P. Maruska, J.A. Sisneros, and L.S. Demski. 2004. Sensory Biology of Elasmobranchs. Pp 325-368. in J.C. Carrier, J.A. Musick, M.R. Heithaus (eds) *Biology of Sharks and their Relatives*, CRC Press Boca Raton, Florida.
- Hurtubise, J.A., Bond, E.P., Hall, K.E., and M.C. James. 2020. Evaluating mandatory reporting of marine turtle bycatch in Atlantic Canadian fisheries. *Marine Policy*, 121(104084).
- Huvenners, C., K. Apps, , E.E. Becerril-Garcia, , B. Bruce, P.A. Butcher, A.B. Carlisle, T.K. Chapple, H.M. Christansen, G. Cliff, T.H. Curtis, T.S. Daly-Engel, H. Dewar, M.L. Dicken., M.L. Domeier, C.A. Duffy, , R. Ford, M.P. Francis, G.C.A. French, F. Galván-Magaña, E. García-Rodríguez, E. Gennari, B. Graham, B. Hayden, E.M. Hoyos-Padilla, , N.E. Hussey, O.J.D. Jewell, S.J. Jorgensen, A.A. Kock, C.G. Lowe, K. Lyons, L. Meyer, G. Oelofse, E.C. Oñate-González, , H. Oosthuizen, J.B. O’Sullivan, K. Ramm, G. Skomal, S. Sloan, M.J. Smale, O. Sosa-Nishizaki, E. Sperone, E. Tamburin, A.V. Towner, , M.A. Wcisel, K.C. Weng, and J.M. Werry. 2018. Future Research Directions on the “Elusive” White Shark. *Frontiers in Marine Science*, 5(455).
- Huveneers, C., Y.Y. Watanabe, N.L. Payne, and J.M. Semmens. 2018. Interacting with wildlife tourism increases activity of white sharks. *Conservation Physiology*, 6(1), coy019.
- ICCAT (International Commission for the Conservation of Atlantic Tunas). 2005. Report of the 2004 inter-sessional meeting of the ICCAT subcommittee on by-catches: shark stock assessment Tokyo, Japan, 14-18 June 2004. Collected Volume of Scientific Papers ICCAT 58: 799-890.
- IUCN (International Union for Conservation of Nature). 2003. [Shark Finning](#). Information Paper. Website. [accessed February 6, 2011].
- Isaacman, L. and G. Daborn. 2011. Pathway of effects of offshore renewable energy in Canada. Publication No. 102 of the Acadia Centre for Estuarine Research (ACER). Acadia University, Wolfville, NS, Canada.
- Klimley, A.P. 1985. The areal distribution and autoecology of the white shark, *Carcharodon carcharias*, off the west coast of North America. *Memoirs of the Southern California Academy of Sciences*, 9:15–40.
- Klimley, A.P. and D.G. Ainley (Eds). 1996. *Great White Sharks: The Biology of Carcharodon carcharias*. Academic Press, San Diego, 528 pp.
- Laroche, R.K., Kock, A.A., Dill, L.M., and W.H. Oosthuizen. 2007. Effects of provisioning ecotourism activity on the behaviour of white sharks *Carcharodon carcharias*. *Marine Ecology Progress Series*, 338:199-209.
- Lowe, C.G., M.E. Blasius, E.T. Jarvis, T.J. Mason, G.D. Goodmanlowe, and J. O’Sullivan. 2012. Historic fishery interactions with white sharks in the Southern California Bight. Pp. 169-186 in Michael L. Domeier (ed) *Global perspectives on the biology and life history of the white shark*. CRC Press, Boca Raton, Florida.

- Lucas, Z.N. and L.J. Natanson. 2010. Two shark species involved in predation on seals at Sable Island, Nova Scotia, Canada. *Proceedings of the Nova Scotian Institute of Science*, 45: 64-88.
- Lyons, K.A. Carlisle, A. Preti, C. Mull, M. Blasius, J. O'Sullivan, C. Winkler, and C.G. Lowe. 2013. Effects of trophic ecology and habitat use on maternal transfer of contaminants in four species of young of the year lamniform sharks. *Marine Environmental Research*, 90: 27-38.
- Marciano, J., L. Crawford, L. Mukhopadhyay, W. Scott, A. McElroy, and C. McDonough. 2024. Per/Polyfluoroalkyl Substances (PFASs) in a Marine Apex Predator (White Shark, *Carcharodon carcharias*) in the Northwest Atlantic Ocean. *ACS Environmental Au*, 4:152-161.
- Martin, R.A. 2003. Sensory biology: hearing and vibration detection. [Biology of Sharks and Rays](#). ReefQuest Centre for Shark Research. Website. [accessed December 18, 2013].
- McInturf, A.G., J. Bowmna, J.M. Schulte, K.C. Newton, B. Vigil, M. Honig, S. Pelletier, N. Cox, O. Lester, M. Cantor, and T.K., Chapple. 2023. A unified paradigm for defining elasmobranch aggregations. *ICES Journal of Marine Science*, 80(6):1551-1566.
- McPherson, J.M. and R.A. Myers. 2009. How to infer population trends in sparse data: examples with opportunistic sighting records for great white sharks. *Diversity and Distributions*, 15(5):880-890.
- Merly, L.L. Lange, M. Meÿer, A.M. Hewitt, P. Koen, C. Fischer, J. Muller, V. Schilack, M. Wentzel, and N. Hammerschlag. 2019. Blood plasma levels of heavy metals and trace elements in white sharks (*Carcharodon carcharias*) and potential health consequences. *Marine Pollution Bulletin*, 142:85-92.
- Moyes, C.D., N. Fragoso, M.K. Musyl, and R.W. Brill. 2006. Predicting postrelease survival in large pelagic fish. *Transactions of the American Fisheries Society*, 135(5):1389-1397.
- Mull, C.G., M.E. Blasius, J.B. O'Sullivan, and C.G. Lowe. 2012. Heavy metals, trace elements, and organochlorine contaminants in muscle and liver tissue of juvenile White Sharks, *Carcharodon carcharias*, from the Southern California Bight. Pp. 59-75. in M.L. Domeier (ed). *Global perspectives on the biology and life history of the White Shark*, CRC Press, Boca Raton, Florida.
- NAFO (Northwest Atlantic Fisheries Organization). 2005. [NAFO Annual Report 2005](#). Website. [accessed May 26, 2021].
- NAFO (Northwest Atlantic Fisheries Organization). 2016. [NAFO Annual Report 2016](#). Website. [accessed May 26, 2021].
- Natanson, L. and G. Skomal. 2015. Age and growth of the white shark, *Carcharodon carcharias*, in the western North Atlantic Ocean. *Marine and Freshwater Research*, 66(5):387-398.

- Normandeau, Exponent, T. Tricas, and A. Gill. 2011. Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. US Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.
- Ocean Tracking Network. 2013. [Desperately seeking sharks - and all sorts of ocean data: Ocean Tracking Network's newest Wave Glider charts its course](#). Dalhousie University media release. Website. [accessed August 7, 2013].
- OCEARCH. 2024. [OCEARCH Shark Tracker](#). Website. [accessed October 11, 2024].
- O'Leary, S.J., K.A. Feldheim, A.T. Fields, L.J. Natanson, S. Wintner, N. Hussey, M.S. Shivji and Chapman, D.D. 2015. Genetic diversity of White Sharks, *Carcharodon carcharias*, in the Northwest Atlantic and Southern Africa. *Journal of Heredity* 106(3):258-265.
- Pardini, AT., C.S. Jones, L.R. Noble, B. Kreiser, H. Malcolm, B.D. Bruce, J.D. Stevens, G. Cliff, M.C. Scholl, M. Francis, C.A.J. Duffy, and A.P. Martin. 2001. Sex-biased dispersal of great white sharks. *Nature*, 412(6843):139-40.
- Pepperell, J. 1992. Trends in the distribution, species composition and size of sharks caught by Gamefish Anglers off South-eastern Australia, 1961-90. *Marine and Freshwater Research*, 43(1):213.
- Pikitch, E.K., M.D. Camhi, and E.A. Babcock. 2008. Introduction to sharks of the open ocean. Pp 1-13. in M.D. Camhi, E.K. Pikitch and E.A. Babcock (eds). *Sharks of the open ocean: biology, fisheries and conservation*, Blackwell Publishing, Oxford, UK.
- Pratt, H.L., Jr. 1996. Reproduction in the male white shark. Pp. 131-138. in A.P. Klimley and D.G. Ainley (eds.). *Great White Sharks: the Biology of *Carcharodon carcharias**, Academic Press, San Diego.
- Province of Nova Scotia. 2012. [Nova Scotia Marine Renewable Energy Strategy](#). Website. [accessed January 16, 2017].
- Reid, D. and M. Krogh. 1992. Assessment of catches from protective shark meshing off NSW beaches between 1950 and 1990. *Marine and Freshwater Research*, 43(1):283.
- Reid D.D., W.D Robbins, and V.M. Peddemors. 2011. Decadal trends in shark catches and effort from the New South Wales, Australia, Shark Meshing Program 1950–2010. *Marine and Freshwater Research* 62:676–693.
- Santana-Morales, O., O. Sosa-Nishizaki, M. Escobedo-Olvera, E. Onate-Gonzalez, J. O'Sullivan, and D. Cartamil. 2012. Incidental catch and ecological observations of juvenile white sharks, *Carcharodon carcharias*, in western Baja California, Mexico: conservation implications. Pp. 187-198. in Michael L. Domeier (ed) *Global perspectives on the biology and life history of the white shark*, CRC Press, Boca Raton, Florida.

- Schlenk, D., Y. Sapozhnikova, and G. Cliff. 2005. Incidence of organochlorine pesticides in muscle and liver tissues of South African great white sharks *Carcharodon carcharias*. *Marine Pollution Bulletin*, 50(2): 208-211.
- Schilds, A., J. Mourier, C. Huveneers, L. Nazimi, A. Fox, and S.T. Leu. 2019. Evidence for non-random co-occurrences in a white shark aggregation. *Behavioral Ecology and Sociobiology*, 73(139).
- Shark Identification Network. 2013. [White shark sightings. Shark fishing decisions at Atlantic tuna meeting fall short](#). Website. [accessed March Shark League. 2017. [Shark fishing decisions at Atlantic tuna meeting fall short](#). Website. [accessed March 8, 2018].
- Shaw, R.L., T.H. Curtis, G. Metzger, M.P. McCallister, A. Newton, G.C. Fischer, and M.J. Ajemian. 2021. Three-Dimensional Movements and Habitat Selection of Young White Sharks (*Carcharodon carcharias*) Across a Temperate Continental Shelf Ecosystem. *Frontiers in Marine Science*, 8:151.
- Shivji, M.S., D.D. Chapman, E.K. Pikitch, and P.W. Raymond. 2005. Genetic profiling reveals illegal international trade in fins of the great white shark, *Carcharodon carcharias*. *Conservation Genetics*, 6(6):1035-1039.
- Skomal, G.B. 2007. Shark Nursery Areas in the Coastal Waters. *American Fisheries Society Symposium*, 50:17-33.
- Skomal, G.B., J. Chisholm, and S.J. Correia. 2012. Implications of increasing pinniped populations on the diet and abundance of white sharks off the coast of Massachusetts. Pp. 405-418. in M. Domeier (ed.). *Global perspectives on the biology and life history of the Great White Shark*. CRC Press, Boca Raton, Florida, US.
- Skomal, G.B., C.D. Braun, J.H. Chisholm, and S.R. Thorrold. 2017. Movements of the white shark *Carcharodon carcharias* in the North Atlantic Ocean. *Marine Ecology Progress Series*, 580:1-16.
- Smith, S.E., D.W. Au, and C. Show. 1998. Intrinsic rebound potentials of 26 species of Pacific sharks. *Marine and Freshwater Research*, 49:663-678.
- Soldo, A. and I. Jardas. 2002. Occurrence of great white shark, *Carcharodon carcharias* (Linnaeus, 1758) and basking shark, *Cetorhinus maximus* (Gunnerus, 1765) in the Eastern Adriatic and their protection. *Periodicum Biologorum*, 104:195-201.
- Tanaka, S., T. Kitamura, T. Mochizuki, and K. Kofuji. 2011. Age, growth and genetic status of the white shark (*Carcharodon carcharias*) from Kashima-nada, Japan. *Marine and Freshwater Research*, 62(6):548-556.
- Thomsen, F., A. Gill, M. Kosecka, M. Andersson, M. Andre, S. Degraer, T. Folegot, J. Gabriel, A. Judd, T. Neumann, A. Norro, D. Risch, P. Sigray, D. Wood, and B. Wilson. 2015. MaRVEN – Environmental impacts of noise, vibrations and electromagnetic emissions from marine renewable energy. Final Study Report. Prepared for the European Commission, Directorate General for Research and Innovation. 81 pp.

Winton, M.V., G. Fay, and G.B. Skomal. 2023. An open spatial capture-recapture framework for estimating the abundance and seasonal dynamics of white sharks at aggregation sites. *Marine Ecology Progress Series* 751:1-25.

WWF (World Wide Fund for Nature). 2011. [Top priorities for conservation and management of sharks in Atlantic Canada](#). Results from the Atlantic Shark Forum held in Halifax, Nova Scotia on March 31 and April 1st, 2011. Website. [accessed July 5, 2021].

WWF (World Wide Fund for Nature). n.d. [Shark fishing: best catch, handle and release practices](#). Brochure.

Zitko, V., O. Huntzinger, and P.M.K. Choi. 1972. Contamination of the Bay of Fundy-Gulf of Maine area with polychlorinated biphenyls, polychlorinated terphenyls, chlorinated dibenzodioxins, and dibenzofurans. *Environmental Health Perspectives*, 4:47-50.

Appendix A: record of cooperation and consultation

The draft recovery strategy was circulated to First Nations and Indigenous organizations in Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Labrador, and Quebec.

The draft recovery strategy was shared with commercial fishing industry interests, seafood producers, recreational charter boat tour operators and shark tournament organizers, and relevant stakeholders in non-governmental organizations and academia.

The draft recovery strategy was also circulated to relevant provincial government departments, including but not limited to, the Nova Scotia Department of Fisheries and Aquaculture and the New Brunswick Department of Agriculture, Aquaculture and Fisheries.

All comments received during these reviews were considered and addressed to the extent possible.

Appendix B: threat categories

Level of concern: Indicates that managing the threat is of high, medium, or low concern for the conservation of the species. Level of concern rankings are relative to each other, and reflect management priority based on the currently limited knowledge of the White Shark and its threats.

Extent: Refers to whether the threat is localized, meaning it relates to a specific site or a narrow portion of the species' range, or widespread, meaning it relates to the species' whole distribution or a large portion of its range.

Occurrence: Indicates whether the threat is historic, that is, it contributed to a decline but no longer affects the species; current, that is, it is affecting the species now; imminent, that is, it is expected to affect the species very soon; anticipated, that is, it may affect the species in the future; or unknown, that is, it may or may not be occurring currently, but it is a viable threat.

Frequency: Describes the temporal extent of the threat. The threat may be a one(1)-time occurrence, that is, it occurred, or will occur, just once; seasonal, that is, it occurs at certain times of the year only, or else the species has a seasonal presence; recurrent, that is, it occurs on an irregular basis; continuous, that is, it occurs on an ongoing basis.

Severity: Describes the degree of impact (that is, high, moderate, low, or unknown) the threat may have, or is having on the population.

Causal certainty: Reflects the degree of evidence that is known for the threat and how it affects the population. High causal certainty indicates that there is substantial scientific evidence of a causal link between the threat and stresses on the population. Medium causal certainty indicates that there is scientific evidence linking the threat to stresses on the population. Low causal certainty indicates that there is a plausible link with limited evidence that the threat has stressed the population.

Appendix C: reporting White Shark sightings

Everyone who encounters a shark is encouraged to document and report the sighting to Fisheries and Oceans Canada (DFO).

If you see a shark, remain a safe distance away and record as many details of the encounter as possible, such as:

- a photo or video, if possible
- date and time of day
- location (as specific as possible, for example, GPS data)
- other information:
 - length estimate (if possible to determine)
 - sex (if possible to identify; males have visible claspers on the abdomen and females do not)

This information can be reported to DFO through the following mechanisms:

- by email:
 - Shark.MAR@dfo-mpo.gc.ca (Maritimes)
 - dfo.nl.sharksightings-observationsderequins.nl.mpo@dfo-mpo.gc.ca (Newfoundland and Labrador); or
- online: <https://www.dfo-mpo.gc.ca/species-especies/sharks/report-mar-eng.html>

Information on identifying shark species in Atlantic Canada can be found [here](#).