COSEWIC
Assessment and Status Report

on the

Shortfin Mako
Isurus oxyrinchus

Atlantic Population

in Canada

ENDANGERED
2019

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous report(s):

COSEWIC. 2017. COSEWIC assessment and status report on the Shortfin Mako *Isurus oxyrinchus*, Atlantic population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 34 pp. (http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1).

COSEWIC 2006. COSEWIC assessment and status report on the shortfin mako *Isurus oxyrinchus* (Atlantic population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 24 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

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COSEWIC
Assessment Summary

Assessment Summary – May 2019

Common name
Shortfin Mako - Atlantic Population

Scientific name
Isurus oxyrinchus

Status
Endangered

Reason for designation
This wildlife species has a single highly migratory population in the North Atlantic, a portion of which is present seasonally in Canadian waters. The primary threat is considered to be bycatch in pelagic longline fisheries in the North Atlantic. The 2017 stock assessment indicates that the population is depleted and overfishing above sustainable levels is continuing. Life-history characteristics such as slow growth, late age of maturity and low reproductive rates mean that this shark species has relatively low productivity when compared to other shark species. Thus, the susceptibility to continued decline is considerable and once the population is depleted, the capacity to recover is limited.

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

Status history
Designated Threatened in April 2006. Status re-examined and designated Special Concern in April 2017. Status re-examined and designated Endangered in May 2019.

COSEWIC
Executive Summary

Shortfin Mako
Isurus oxyrinchus

Atlantic population

Wildlife Species Description and Significance

Shortfin Mako (*Isurus oxyrinchus*) is one of two species in the genus *Isurus* (the other being the Longfin Mako, *I. paucus*) and one of five species in the family Lamnidae or mackerel sharks. Other lamnid sharks found in Canada include the White Shark (*Carcharodon carcharias*), Salmon Shark (*Lamna ditropis*), and the Porbeagle shark (*L. nasus*).

Based on biogeographical separation, genetic differences with other global populations, and no evidence of structuring within the North Atlantic, Shortfin Mako in Canada are considered to be part of the wider North Atlantic population, in a single designatable unit (DU).

Although this species is not directly targeted in Canada, it is caught and landed as bycatch in a limited number of Canadian fisheries. Due to its energetic displays and edibility, it is sought by sport anglers as a game fish in the United States and occasionally in Canada.

Distribution

Shortfin Mako are widespread in temperate and tropical waters of all oceans from about 50°N and are distributed throughout the North Atlantic in waters south of 60˚N to the equator. They are a highly migratory species typically associated with warm Gulf Stream waters and a summer and fall visitor in Canadian waters, the northern extension of the North Atlantic-wide population. They have been recorded from Georges and Browns Bank, along the continental shelf of Nova Scotia, the Grand Banks, and Gulf of St. Lawrence.

Habitat

Temperature appears to be the dominant factor defining Shortfin Mako distribution. Preferred water temperature is between 17-22°C, making it unlikely that Shortfin Mako have extended residency in Canadian waters. A lack of data has prevented identification of habitats necessary for critical life functions (e.g., mating, pupping) of this species in Canadian waters, impeding investigation of whether Shortfin Mako habitat has changed over time in the North Atlantic DU, including in Canadian waters.

Biology

Shortfin Mako are aplacental viviparous with developing embryos known to feed on unfertilized eggs during the 15-18 month gestation period. Females have 11 pups on average every three years. The estimated age at which half the individuals are mature is 8 years for males and 18 years for females. They are a low productivity species compared with other sharks and have a generation time of about 25 years. It appears that females migrate to latitudes of 20°-30°N to give birth. No pregnant females have been observed outside of this range.

This species can withstand natural changes in its environment as adults can move long distances and prey upon a wide variety of species, including Bluefish (*Pomatomus saltatrix*), Butterfish (*Peprilus sp.*), tunas (Scombridae), mackerels, bonitos, and Swordfish (*Xiphias gladius*).

Population Sizes and Trends

A catch rate series from the Canadian pelagic longline fishery from 1996 to 2014 is the only available index of abundance in Canadian waters. The most recent data show a non-significant decline in catch rates compared to earlier in the time series. However, Canadian waters are at the northern fringe of Shortfin Mako range and therefore the Canadian index may reflect distributional shifts rather than changes in abundance.

In 2017, the International Commission for the Conservation of Atlantic Tunas (ICCAT) carried out a comprehensive assessment of Shortfin Mako. Based on three different modelling approaches, the Commission concluded that there was a 90% combined probability from all the models that north Atlantic Shortfin Mako population is overfished and undergoing overfishing. Estimates from an ICCAT stock synthesis model suggest that population biomass and size of the spawning stock fecundity (an index of number of mature individuals) have declined by 60% and 50% respectively from 1950 to 2015, with most of the decline occurring since the early 1980s.

Threats and Limiting Factors

Bycatch in commercial longline fisheries targeting pelagic tunas and Swordfish is the main cause of mortality within Canadian waters and throughout the range of the Shortfin Mako. Total mortality of captured Shortfin Mako in the Canadian longline fishery is 49% which includes those retrieved dead and those that die after release. Post-release survival of injured and healthy individuals was estimated to be 31% using satellite tags (n=33) (Figure 17; Campana *et al.* 2015), resulting in a historical average annual estimate of total Canadian mortality at about 69 t/year." Mature females comprise less than 1% of the observed Shortfin Mako caught in the Canadian DFO Maritimes Region pelagic longline fishery, based on at-sea observer coverage averaging about 5% of the annual fishing effort (about 10% in the most recent three years).

Total fishing mortality for the entire North Atlantic is uncertain due to poor catch reporting, particularly in years prior to 1996. From 1996-2015, average reported annual landings were around 3550 t Atlantic-wide, but this number was considered to be an underestimate by a recent ICCAT study that estimated the average catch during this time period at 4673 t.

Due to their life-history characteristics such as relatively slow growth, late age of maturity and low reproductive rates, Shortfin Mako populations have relatively low productivity compared with other sharks, thus the capacity to recover is limited once the population is depleted.

Protection, Status and Ranks

There is a Canadian ban on shark finning (i.e., removing and retaining fins while discarding the shark's body at sea). There is no targeted fishery for Shortfin Mako sharks in Atlantic Canada but incidentally captured individuals are permitted to be retained in some fisheries. Fishing regulations and protective measures for the DFO Maritimes Region include a non-restrictive annual landings limit for Shortfin Mako of 100 t, and use of corrodible circle hooks to reduce post-release mortality in the pelagic longline fishery. In 2015, voluntary release of live Shortfin Mako in the DFO Maritimes Region was supported by the longline fishing industry. A mandatory release of live Shortfin Mako caught in the pelagic longline fishery has been in place since 2018. Present regulations do not limit total fishing mortality or discarding at sea. Canada also requires that all landed sharks have their fins naturally attached to prevent any shark finning activity.

Shortfin Mako (North Atlantic) was last assessed in 2018 by the International Union for Conservation of Nature (IUCN) as "Endangered". The US National Oceanographic and Atmospheric Administration (NOAA) describes the population status as "overfished and subject to overfishing". COSEWIC assessed the Atlantic population of Shortfin Mako as "Threatened" in 2006 but subsequently it was not listed on Schedule 1 of the *Species at Risk Act*. COSEWIC re-assessed the population as "Special Concern" in 2017 prior to the comprehensive ICCAT assessment discussed in this updated COSEWIC report.

TECHNICAL SUMMARY

Isurus oxyrinchus

Shortfin Mako *(*Atlantic population)

Requin-taupe bleu (population de l'Atlantique)

Range of occurrence in Canada: Québec, New Brunswick, Newfoundland and Labrador, Nova Scotia, Prince Edward Island, Atlantic Ocean

Demographic Information

Generation time based on G = age at maturity/natural mortality	25 yrs
Is there an observed continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Biomass estimated to have declined by 50%, and Spawning Stock Fecundity by 60% (1966 to 2015, 50 years)
Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Biomass estimated to have declined by 50%, and Spawning Stock Fecundity by 60% (1950 to 2015, 66 years)
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Likely reversible b. Yes, fishing mortality c. No
Are there extreme fluctuations in number of mature individuals?	No, low productivity species

Extent and Occupancy Information

Estimated extent of occurrence	1,060,000km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	>> 2000 km²
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No

Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	>10. Large range, caught in several global fisheries throughout North Atlantic.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
	558,000 (North Atlantic population)
Total	

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	No analysis available

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? No What additional limiting factors are relevant?

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Single population of which individuals in Canada are part
Is immigration known or possible?	Possible, genetic evidence has not ruled out male migration across north-south hemisphere boundaries. Global population is declining.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term

Are conditions deteriorating in Canada?[+]	Unknown
Are conditions for the source population deteriorating?	Unknown
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Possible, but unlikely given the overall population is declining.

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: Designated Threatened in April 2006. Status re-examined and designated Special Concern in April 2017. Status re-examined and designated Endangered in May 2019.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2bd
Reasons for designation: This wildlife species has a single highly migratory population in the North Atlantic, a portion of which is present seasonally in Canadian waters. The primary threat is considered to be bycatch in pelagic longline fisheries in the North Atlantic. The 2017 stock assessment indicates that the population is depleted and overfishing above sustainable levels is continuing. Life-history characteristics such as slow growth, late age of maturity and low reproductive rates mean that this shark species has relatively low productivity when compared to other shark species. Thus, the susceptibility to continued decline is considerable and once the population is depleted, the capacity to recover is limited.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2, with an estimated 60% and 50% decline in Biomass and Spawning Stock Fecundity, respectively. Spawning Stock Fecundity is considered to be an index of number of mature individuals. The primary threat (overfishing) is continuing.
Criterion B (Small Distribution Range and Decline or Fluctuation): Exceeds thresholds, criterion not met.
Criterion C (Small and Declining Number of Mature Individuals): Exceeds thresholds, criterion not met.
Criterion D (Very Small or Restricted Population): Exceeds thresholds, criterion not met.
Criterion E (Quantitative Analysis): Not done.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

PREFACE

Shortly after the completion of the 2017 Shortfin Mako COSEWIC status report the International Commission for the Conservation of Atlantic Tunas (ICCAT) carried out a comprehensive assessment of the same population involving updated catch series and utilizing three different assessment models. The population model also included a longer time series than the previous assessment. This updated COSEWIC assessment reflects the most globally accepted understanding of the North Atlantic Shortfin Mako population.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2019)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Shortfin Mako (*Isurus oxyrinchus*) is one of two species in the genus *Isurus* (the other being the Longfin Mako, *I. paucus*) and one of five species in the family Lamnidae or mackerel sharks. Other lamnid sharks found in Canada include the White Shark (*Carcharodon carcharias*), Salmon Shark (*Lamna ditropis*), and Porbeagle (*Lamna nasus*). There are no recognized subpopulations of Shortfin Mako.

Morphological Description

This large shark species reaches a maximum size of about 445 cm total length (TL). Males mature at 166–204 cm TL and females at 265–312 cm TL (Rigby *et al*. 2019).

Shortfin Mako are identified by a pointed snout, relatively small eyes, long smooth-edged dagger-like teeth without side cusps (on both jaws), and a U-shaped mouth. The lower anterior teeth protrude horizontally on jaws even when the mouth is closed. Pectoral fins are slightly curved with tips relatively narrow, anterior margins about 16 to 22% of total length and shorter than head length. Origin of first dorsal fin over or just behind the pectoral free rear tip; first dorsal-fin apex broadly rounded in young but more angular and narrowly rounded in large juveniles and adults; first dorsal-fin height greater than base length in large individuals but equal or smaller in young below 185 cm. The crescent-shaped caudal fin has a horizontal primary keel but no secondary keel. The dorsolateral colouration is brilliant blue or purplish, with white below the underside of snout in young and adults. The head is dark in colour and partially covers the gill septa. The dark colour of the flanks does not extend ventrally onto the abdomen; the pelvic fins are dark on anterior halves, white on posterior halves, with the undersides white.

Misidentifications have occurred in warmer waters where the two mako species ranges commonly overlap. In Canada, where Longfin Mako are extremely rare, misidentification between the two species is not believed to be a problem. In Atlantic Canada, Shortfin Mako has been misidentified as Porbeagle shark and may have contributed to underestimation of Shortfin Mako landings data prior to 1996 (Campana *et al*. 2004a).

Population Spatial Structure and Variability

Current understanding of the population spatial structure of Shortfin Mako globally and in the North Atlantic specifically has been achieved through over 50 years of conventional tagging, recent satellite tagging, and genetic studies over the last two decades (ICCAT 2012, Campana *et al.* 2015).

In 2012, the International Commission for the Conservation of Atlantic Tunas (ICCAT) collated all available conventional tagging information (i.e., wire tags) in the North Atlantic. Since 1962, a total of 9218 tags have been released and 1203 recaptured (Figure 1). Most of these tags have been deployed off the northeast coast of the United States. While Shortfin Mako were found to travel large distances of up to 3400 km across the Atlantic, most movement was between south and east within the northwest Atlantic with very few captures below 20˚N and none south of 5˚N (Figure 1).

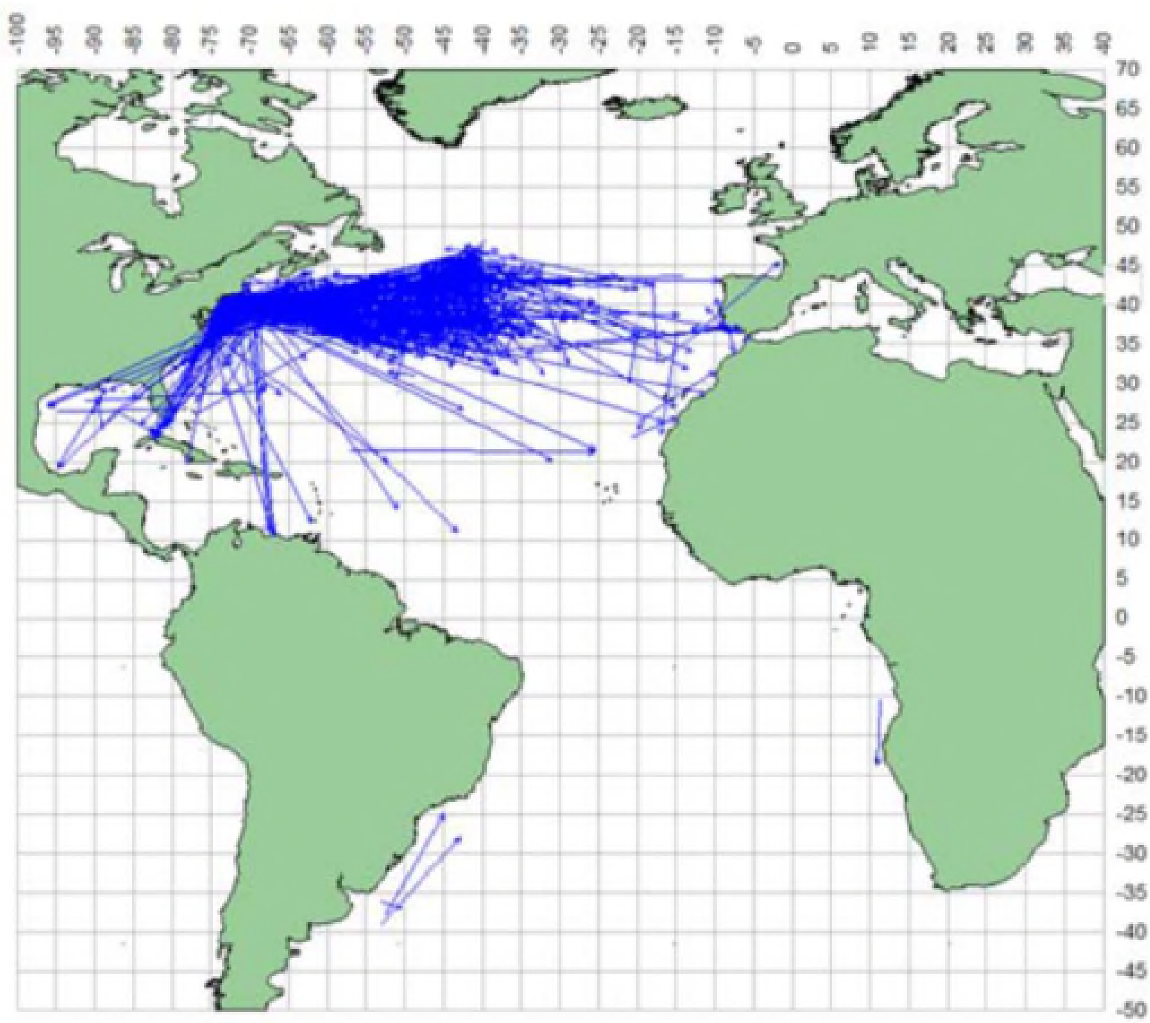


Figure 1. Tag and release distributions for Shortfin Mako in the Atlantic Ocean displayed as straight lines between release and recovery locations (ICCAT 2012).

Shark tagging using conventional tags occurred in Canadian waters between 1961 and 1986 (n=110) and more recently between 2006 and 2015 (n=32) with five and two recaptures respectively (Figure 2; Showell *et al.* 2017). Between 2010 and 2014, the Canadian Shark Laboratory deployed 43 satellite tags on both healthy and injured Shortfin Mako primarily from the Scotian Shelf, of which 34 were recovered or transmitted data (Campana *et al.* 2015; Showell *et al.* 2017; Figure 3). Both conventional and satellite tagging information from individuals tagged in Canada during summer months suggests general movement in a south, east or southeasterly direction and over large distances easterly toward the central Atlantic or south toward the Caribbean.

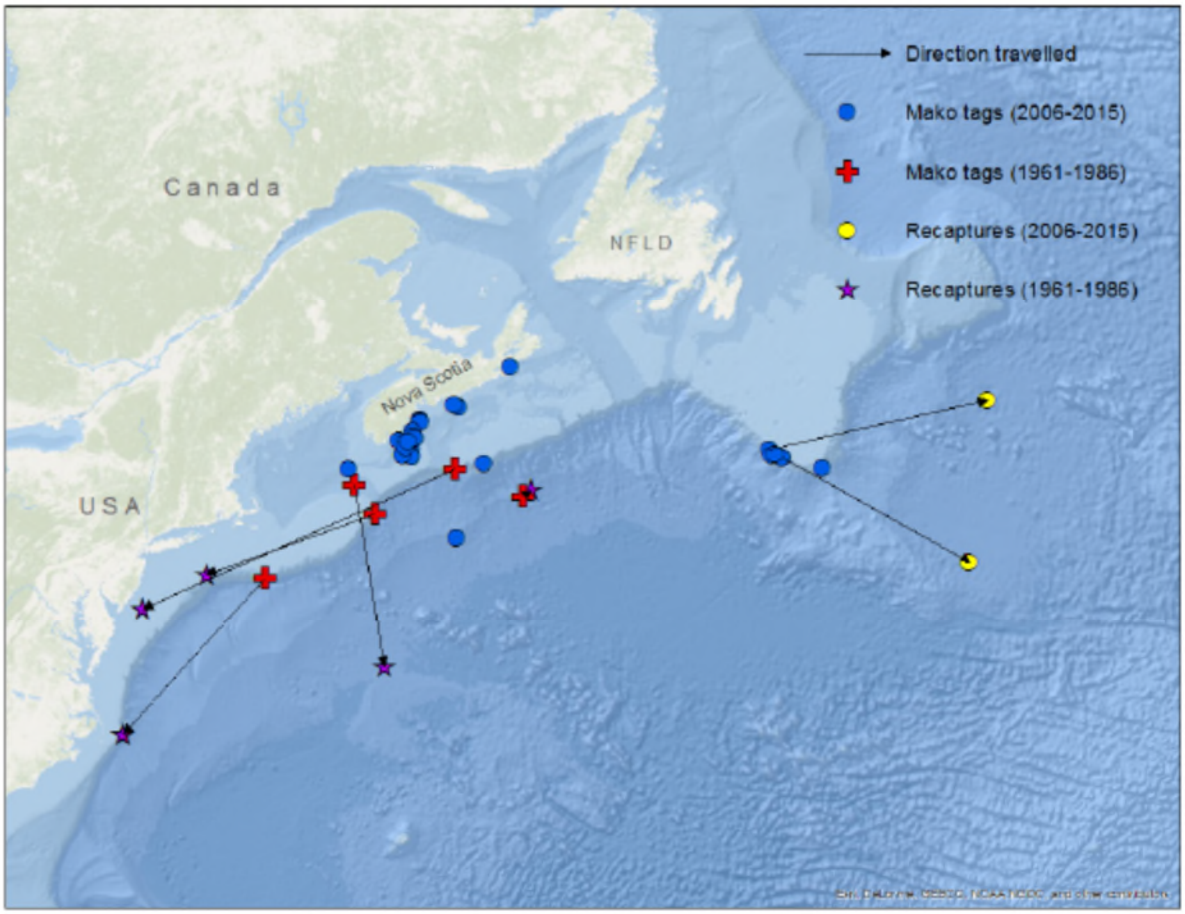


Figure 2. Canadian Shortfin Mako conventional tagging releases (n=32) and recovery (n=6) over two time periods. Source: Showell *et al.* 2017.

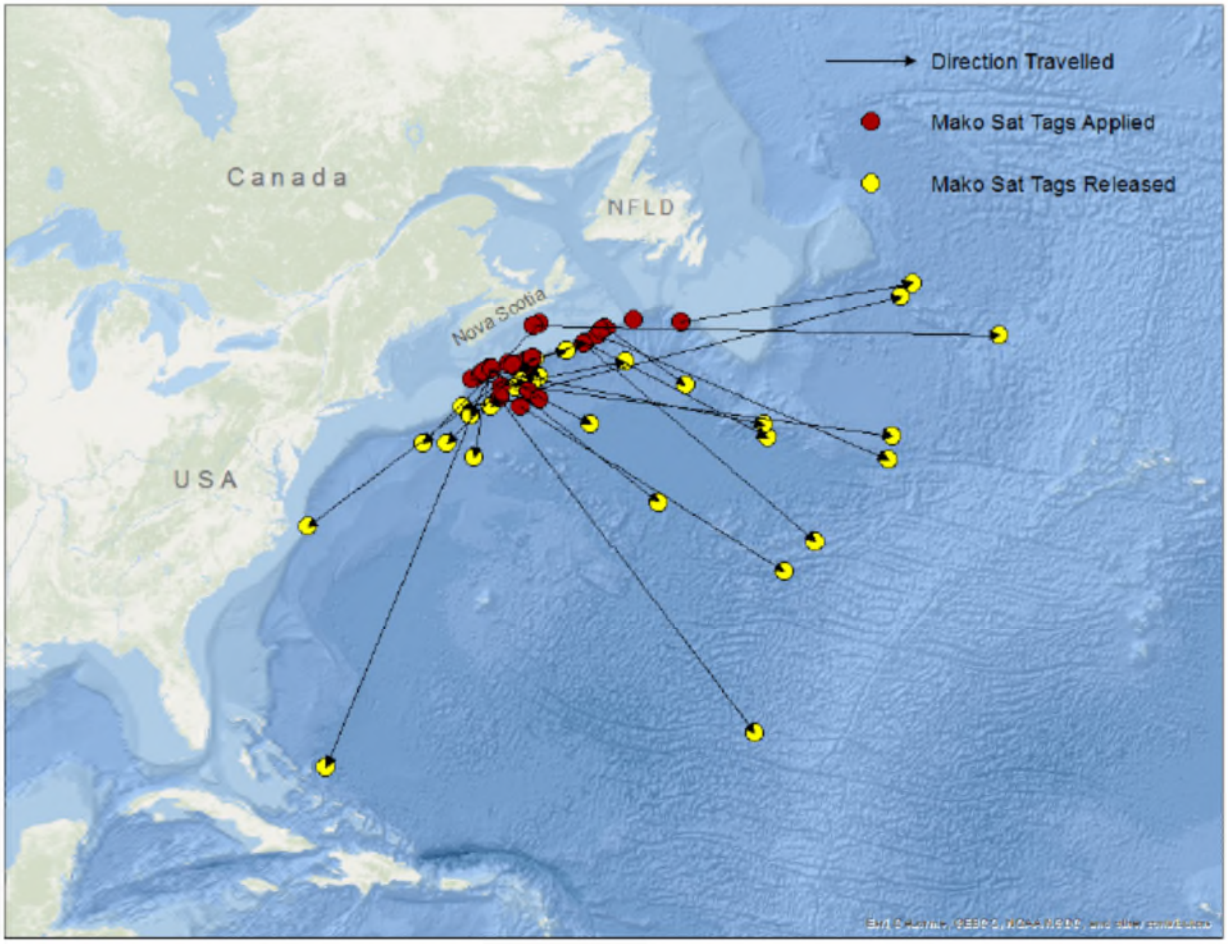


Figure 3. Canadian Shortfin Mako PSAT pop-up satellite tagging application sites (n=43) and data release positions (n=34). Source: Showell *et al.* 2017.

Collectively, tagging studies from both Canada and the US indicate that tagged individuals are highly migratory primarily using waters west of 40˚ longitude and north of 30˚ latitude.

Genetic evidence, primarily from analyses using mitochondrial DNA, supports a distinct North Atlantic population and wide spatial separation from other populations. Heist *et al.* (1996) used mitochondrial DNA (mtDNA) to analyze population structure in Shortfin Mako. They found that the North Atlantic population differed substantially from populations in the South Atlantic and North and South Pacific (overall $F_{ST} = 0.15$) The authors concluded that the North Atlantic population experienced very restricted gene flow from other areas and therefore may warrant separate management consideration. Schrey and Heist (2003) investigated microsatellite (nuclear) DNA at four loci using 433 samples from the North Atlantic, South Atlantic, North Pacific, South Pacific, and the Atlantic and Indian Ocean coasts of South Africa. This latter study found very low levels of differentiation even among the major ocean basins (global $F_{ST} < 0.003$) and only a weak basis for rejecting the hypothesis that Shortfin Mako comprise a single global population.

Under one mutation model the P value was slightly less than 0.05, whereas under another mutation model the P value was slightly above 0.05. Power analysis indicated very high power to detect population structure at the level indicated by the mtDNA study. Schrey and Heist (2003) suggested that one way to explain both datasets is that females are strongly philopatric (hence the strong differences at the maternally inherited mtDNA) but males are good dispersers (hence at best weak differentiation at nuclear DNA markers). Using similar mtDNA techniques (n=106), genetic separation of North Atlantic and Pacific Shortfin Mako populations was reconfirmed by Taguchi *et al.* (2011).

Designatable Units

Canadian waters are near the periphery of the species' range in the North Atlantic (see Distribution section below). Based on biogeographical separation, genetic differences with other global populations, and no evidence of structuring within the North Atlantic, Shortfin Mako in the North Atlantic are considered to be a population and the single DU in Canada is part of a wider North Atlantic population. Shortfin Mako that come into Canadian waters are part of the North Atlantic population.

Shortfin Mako in Canadian waters likely represent a small portion of the North Atlantic population although no information on what proportion resides in Canada is available.

Special Significance

Although this species is not directly targeted in Canada, it is incidentally caught and sold because of its high quality meat. Due to its energetic displays during capture and its edibility, it is highly prized by sport anglers, with most of the recreational fishing for this species occurring in the United States. Throughout its range, including Canadian waters, the meat is utilized fresh, frozen, smoked, and salted for human consumption; the oil is extracted for vitamins; the fins used for shark-fin soup; the hides processed into leather; and the jaws and teeth used for ornaments.

The Shortfin Mako is an opportunistic apex predator with a wide prey base and as such is likely important in structuring pelagic marine ecosystems.

DISTRIBUTION

Global Range

Shortfin Mako are found worldwide in temperate and tropical seas. The North Atlantic population range of Shortfin Mako is considered to be all waters south of 60˚N to the equator (Figure 4a).

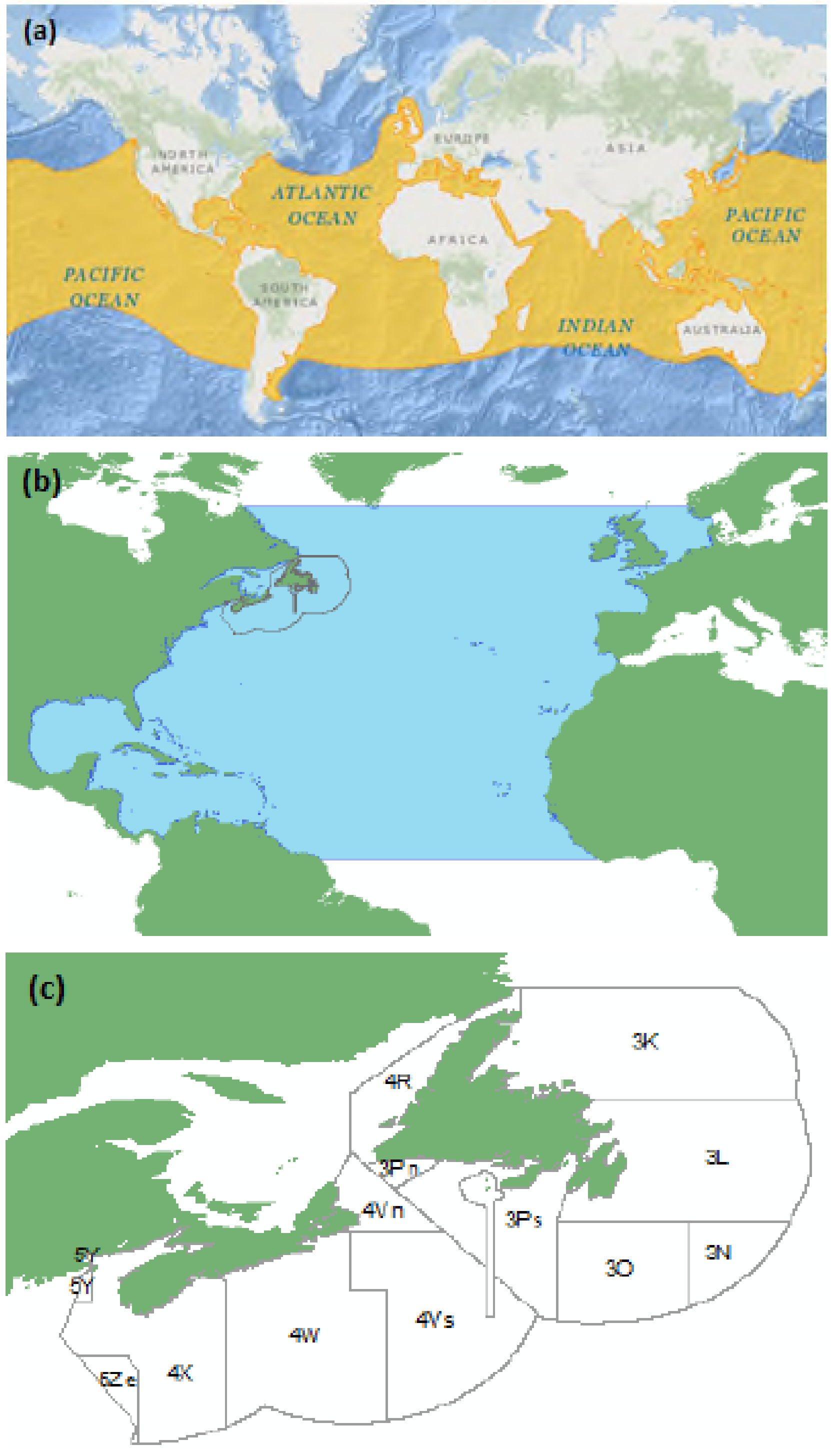


Figure 4. Approximate (a) Global distribution; (b) North Atlantic distribution of designatable unit and (c) Canadian area of occupancy for the North Atlantic designatable unit of Shortfin Mako. Sources: Caillet *et al.* 2009; Showell *et al.* 2017.

Canadian Range

The Canadian range is an estimate based on the distribution of all known observations collected from commercial fisheries (ZIFF (Zonal Interchange File Format)) and MARFIS (Maritimes Fisheries Information System) databases, Canadian at-sea fisheries observer data (DFO Maritimes Region Observer Program, Newfoundland and Labrador Region Observer Program), research surveys, and tagging data overlapping with a NAFO fishing area (Figure 5; Showell *et al.* 2017). In Canadian waters the Shortfin Mako is typically associated with warmest available waters such as in and around the Gulf Stream. It has been recorded from Georges and Browns Bank, along the continental shelf of Nova Scotia, the Grand Banks and even into the Gulf of St. Lawrence (Showell *et al.* 2017). Canadian at-sea fisheries observer data from Canadian, Faroese, and Japanese fishing vessels indicate that Shortfin Mako are caught both in inshore waters and offshore waters from the southern extent of Canada's Exclusive Economic Zone (EEZ) to 50ºN. This species is a highly migratory seasonal visitor (summer and fall) to Canada's Atlantic coast. Shortfin Mako in Canadian waters represents the northwestern extension of the North Atlantic-wide population and is likely a small portion of the North Atlantic population during their residency. There are no data to indicate either an expansion or reduction in Shortfin Mako range within Atlantic Canadian waters.

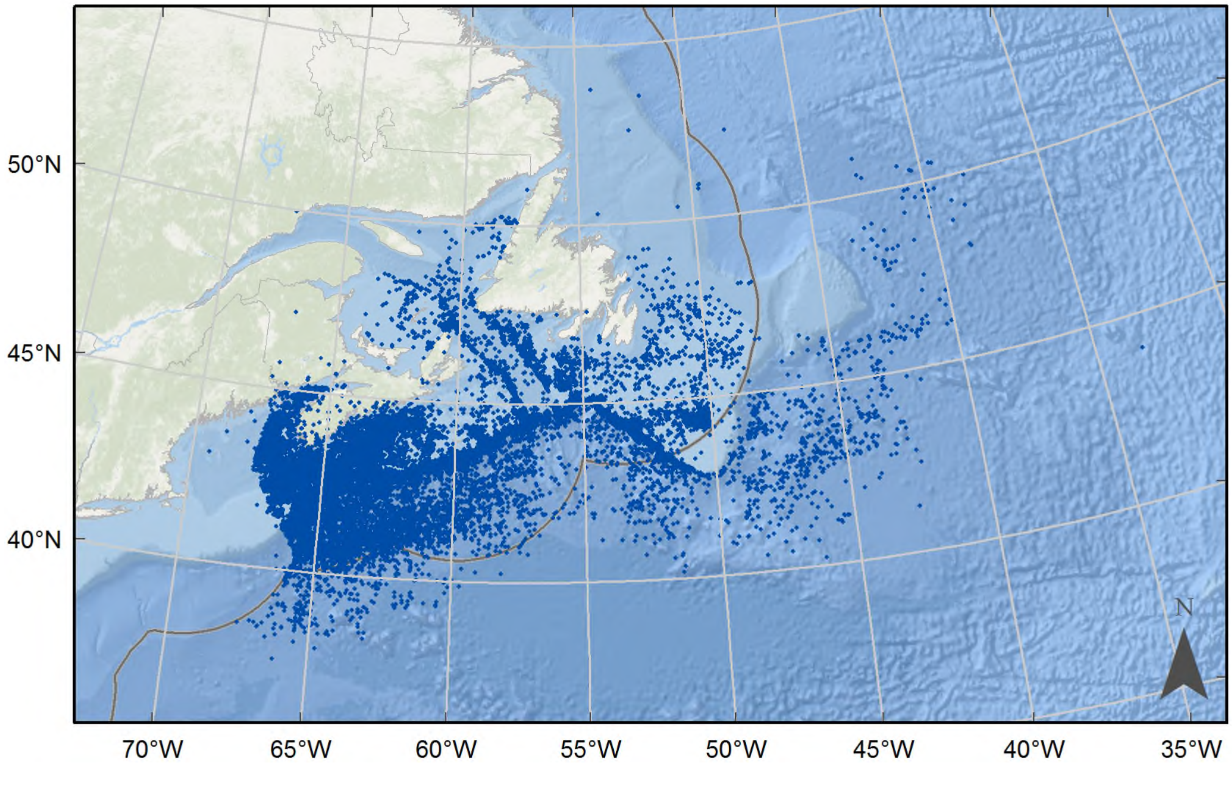


Figure 5. Combined observations of Shortfin Mako in Canadian waters from ZIFF and MARFIS observer databases (1998-2014). Showell *et al.* 2017.

Extent of Occurrence and Area of Occupancy

The extent of occurrence within the Canadian portion of this DU was calculated to be the sum of the portion of Northwest Atlantic Fishery Organization (NAFO) areas 3KL+3NOP+4R+4VWX+5Y+5Ze within Canada's EEZ (1.06 million km^2) (Figure 4b,c; Showell *et al.* 2017). The current biological area of occupancy, represented by frequent sightings or captures is approximately 800,000 km^2 (Campana *et al.* 2004a).

HABITAT

Habitat Requirements

<u>North Atlantic Designatable Unit</u>

Although there have been several satellite tags deployed on Shortfin Mako in Canadian waters since the 2006 COSEWIC report, this new information has not changed the general understanding of habitat requirements in the North Atlantic (Campana *et al.* 2015). Temperature appears to be the dominant factor defining Shortfin Mako distribution. Preferred water temperature is between 17-22°C and consequently, in the Atlantic, they are often associated with Gulf Stream waters (Compagno 2001) which occur largely outside of Canadian waters. Temperature and depth recorders on satellite transmitters indicate that Shortfin Mako occur between 10.4-28.6˚C and from surface to 556 m (Loefer *et al.* 2005).

Canadian Waters

Typically, Shortfin Mako occur offshore on the continental shelf break, on the continental shelf, and occasionally near-shore. In the western North Atlantic they move onto the continental shelf when surface temperatures exceed 17°C, typically June through to December.

A lack of data has prevented any identification of habitats necessary for critical life functions (e.g., mating, pupping) of this species in Canadian waters. Godin *et al.* (2015 unpublished data) identified areas of higher catch (landings+discards) rates (Figure 6) suggesting where Shortfin Mako may concentrate in Canadian waters but no habitat features have been ascribed to these areas.

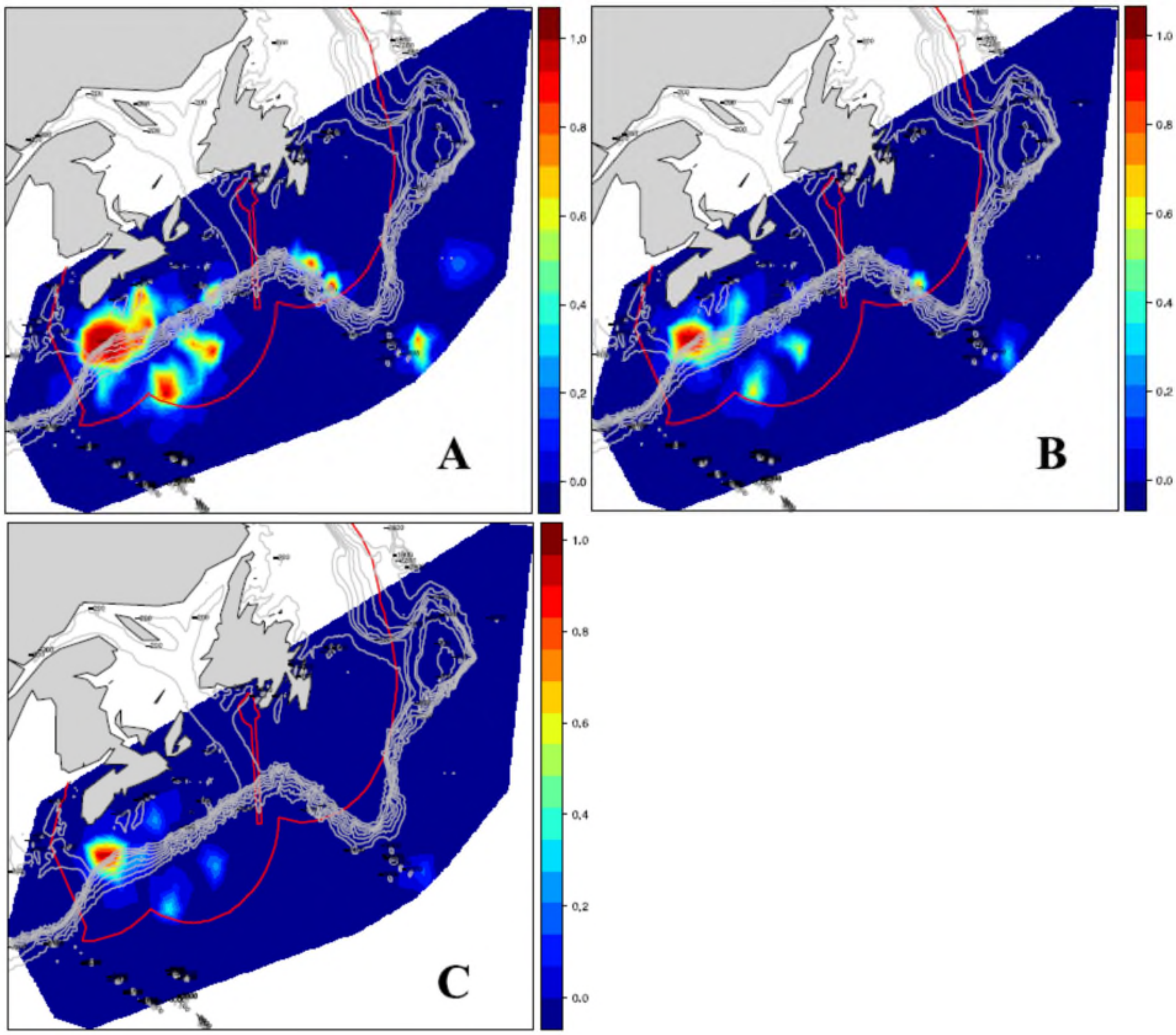


Figure 6. Core hotspots showing the probabilities of Shortfin Mako catch (landings+discards) in the Canadian pelagic longline fishery, 2003-2013: (a) catches two times (4 sharks/set); (b) five times (10 sharks/set) and (c) ten times (20 sharks/set) the average number of sharks per set. Red line indicates the 200 mile Canadian Exclusive Economic Zone. Source: Godin *et al.* 2015.

Habitat Trends

Insufficient data have impeded investigation of whether Shortfin Mako habitat has changed over time in the North Atlantic DU or Canadian waters. Although the North Atlantic has experienced positive temperature anomalies in recent decades that might affect their distribution, there has been no research into the timing of offshore and inshore migrations and distribution patterns of Shortfin Mako.

BIOLOGY

Life Cycle and Reproduction

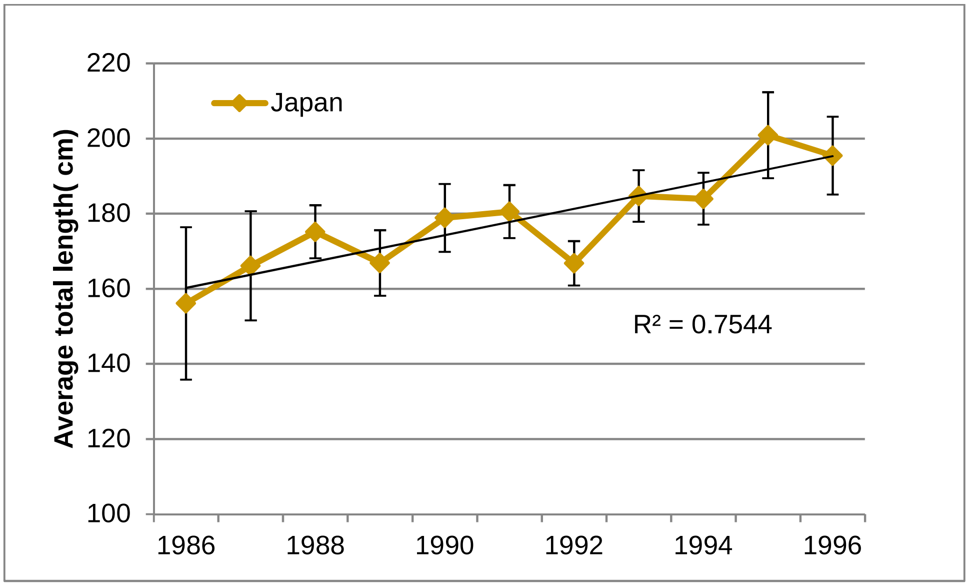
Shortfin Mako are aplacental viviparous with developing embryos known to feed on unfertilized eggs during the gestation period. The estimated gestation period varies globally. In the North Atlantic the gestation period is estimated to be 15-18 months with litter sizes of 11 on average every three years (Campana *et al*. 2004a). After parturition it is thought that females may rest for 18 months and therefore the breeding cycle may be three years (Mollet *et al*. 2000; ICCAT 2012). Birth can occur from late winter to mid-summer with young born at about 70 cm in length (Mollet *et al.* 2000).

Age and growth validation of Shortfin Mako has varied results depending on technique and ocean basin. For the North Atlantic, based on bomb radiocarbon validation, estimated age of 50% maturity is 8 years for males (185 cm fork length) and 18 years for females (275 cm fork length) (Natanson *et al.* 2006). Similar maturity estimates were found by Campana *et al.* (2004a) who reported females to be immature up to 18 years old and 272 cm fork length (Campana *et al.* 2004a).

Fish length data from the Canadian pelagic longline fishery suggest that mature individuals are either rare in Atlantic Canadian waters, do not encounter commercial fishing gear, or if encountered are more likely to break off the line due to their size (DFO 2016). The percentage of mature males (TL>185 cm) and females (TL>275 cm) reported by fishery observers between 2006 and 2015 is estimated at 7% (n=1114) and <1% (n=1025) respectively. The average size of fish captured in the Japanese pelagic longline fishery operating in Canadian waters from 1986 to 1996 increased over that period, while the size composition in the Canadian pelagic longline fishery from 1999 to 2014 has varied without trend (Figure 7).

Natural mortality (M) for North Atlantic Shortfin Mako has been reported in the range of 0.10 to 0.15 by Bishop *et al.* (2006). Smith *et al.* (1998) calculated natural mortality to be 0.16.

Generation time was calculated using the following equation: 1/adult mortality + age of 50% female reproduction: (18+(1/0.15)) = 25 years.



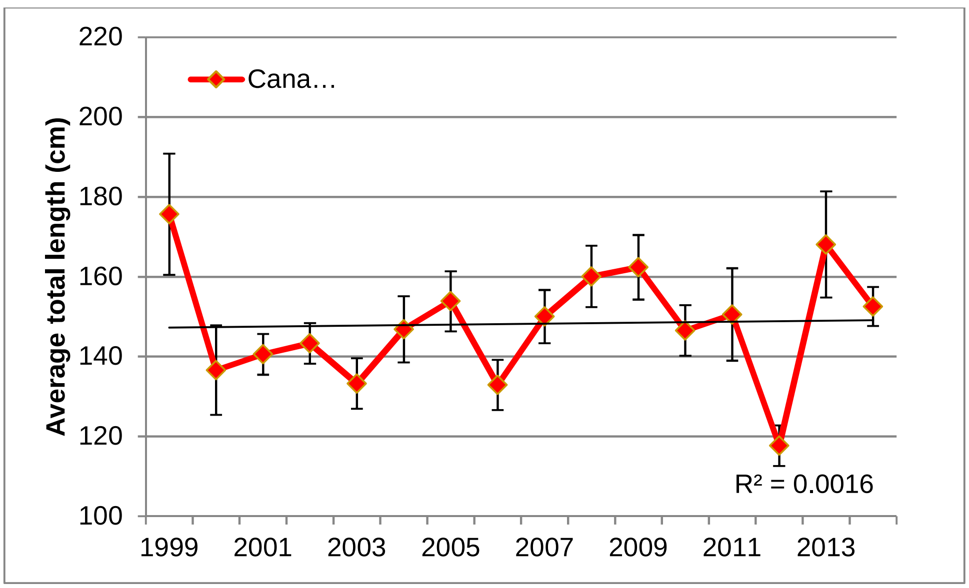


Figure 7. Length-frequency distribution of Shortfin Mako captured in Japanese longline fisheries operating in Canadian waters 1986 to 1996, and Canadian longline fisheries from 1999 to 2014, recorded through Canadian at-sea observer programs. Source: M. Showell, 2017, Department of Fisheries and Oceans, pers. comm.

Physiology and Adaptability

Shortfin Mako adults are likely adapted to withstand the current extent of climate change, changes in prey type, and increasing water temperatures, as they can readily move long distances and prey upon a wide variety of species. Furthermore, adults are distributed over a large area, thereby reducing their susceptibility to localized stochastic events. Their endothermic physiology allows the animal to remain highly active in cooler waters (Carey *et al.* 1981).

Dispersal and Migration

Shortfin Mako are highly migratory with observed movement of up to 3,400 km (Casey and Kohler 1992). Conventional tagging studies show that most recoveries are less than 500 km from tagging location (Kohler *et al*. 1998; ICCAT 2012). Based on both thermal preference and highly mobile behaviour, it is unlikely that Shortfin Mako have extended residency beyond summer and early fall months in Canadian waters. Shortfin Mako (N_{tagged}=9218, $N_{returned}$=1203) tagged and recaptured between 1962-2012 in the northwestern Atlantic demonstrated a range of movement but primarily south, southeast, and eastward from the tagging location (Figure 1).

A study tracking the movement of Shortfin Mako sharks satellite-tagged off the Yucatan Peninsula, Mexico (n=12) and off Maryland, United States (n=14) displayed region-specific movement with little distributional overlap, providing evidence of some spatial structuring at scales smaller than currently considered (Vaudo *et al*. 2016).

There are no accepted models of Shortfin Mako migration in the North Atlantic. Maia *et al.* (2007) summarized what is known in the North Atlantic with respect to dispersal and migration. It appears that females migrate to latitudes of 20°-30°N to give birth based on evidence that no pregnant females have been caught outside of this range (although such inferences are limited by the availability of scientific observer data). Males tend to be more common at higher latitudes than females based on frequency in observed catch data, but this may be in part due to segregation in the water column, with females spending more time at depth, or possibly an effect of fishing gear selectivity. Schrey and Heist (2003) have suggested females may be philopatric to yet-to-be identified pupping grounds while males may undertake longer distance movements, based on microsatellites and mtDNA population structure (described in Population Spatial Structure section). An accepted migration model is hindered by the lack of evidence of pupping grounds and insufficient understanding of movement patterns of both male/female and immature/mature individuals through an annual cycle.

Interspecific Interactions

Shortfin Mako adults prey upon a wide variety of species, primarily bony fish (Osteichthyes) including tunas, mackerels, bonitos, and Swordfish (*Xiphias gladius*), and also squid (Bowman *et al.* 2000). There is some suggestion that larger individuals shift towards consuming larger prey including other sharks, small cetaceans and turtles. Based on two sampling methodologies carried out in the western North Atlantic, Bluefish (*Pomatomus saltatrix*) and Butterfish (*Peprilus triacanthus*) were found to be the most important prey, comprising 78% and 31% of their diet respectively (Bowman *et al.* 2000). There is some evidence of seasonal prey switching from squid to Bluefish in spring (MacNeil *et al*. 2005).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Information on abundance and trends is derived primarily from fishery-dependent indices and catch records. Shortfin Mako are in greatest abundance in Canadian waters from June to December associated with the warmest water temperatures and this comprises only about 2.5% of the overall geographic distribution of the North Atlantic-wide population. Therefore, indices and assessments from outside of Canada are relevant for assessing status in Canada. Both DFO (Showell *et al.* 2017) and ICCAT (ICCAT 2017b) have provided summary documents of biological, fishery and stock assessment data from throughout the North Atlantic range of Shortfin Mako and these have provided the primary sources for this assessment.

The Canadian fishery takes place at the periphery of the distribution of the North Atlantic population and therefore the indices should not be considered in isolation of indices covering the full range of the North Atlantic Shortfin Mako. At-sea observer coverage in the pelagic longline fishery has been approximately 5% since 2004 and bycatch of Shortfin Mako for 1996 to 2014 is the only available information to index abundance and to understand the demographics of the population in Canada (Showell *et al.* 2017). Other fisheries that interact with Shortfin Mako (e.g., gillnet and trawl) have between 1-18% observer coverage depending on region and gear type (Showell *et al*. 2017).

There are several catch rate indices from commercial longline landings in other parts of the range. The most recent analysis of catch rate data was reviewed and published by ICCAT (2017). The ICCAT analysis identified six catch rate series that were deemed suitable for use in stock assessment models: Japanese longline fishery (1994-2015), two from the US longline fishery (observer data 1992-2015, logbook data 1986-2015); Portuguese longline fishery (2000-2015), Spanish longline fishery (1990-2015) and Chinese-Taipei longline fishery (2007-2015) (Figure 8).

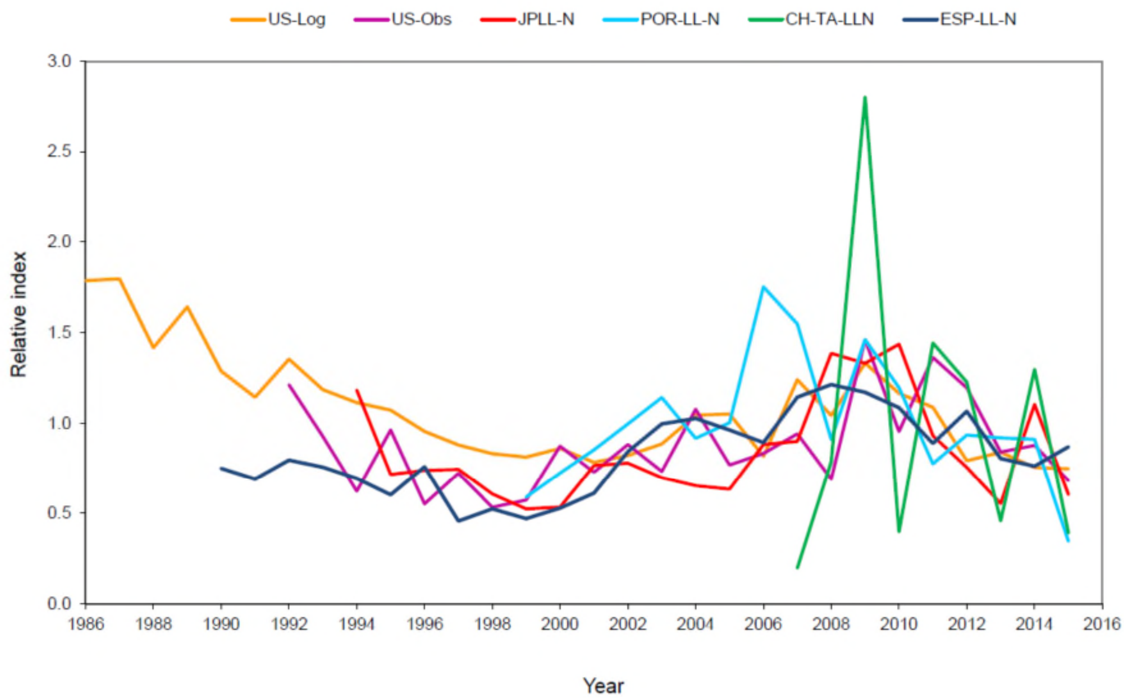


Figure 8. Indices of CPUE for North Atlantic Shortfin Mako shark; US-Log=US pelagic longline logbook data; US-Obs=US pelagic longline observer program; JPLL=Japanese pelagic longline logbook data; POR-LL=Portuguese pelagic longline logbook data; CH-TA-LL=Chinese Taipei longline data; ESP-LL=Spanish pelagic longline logbook data. Figures from ICCAT 2017a.

ICCAT (2017b) accepted three population models. These models utilize catch rate series, biological data, and catch information to form the basis of their assessment. The three models used were (1) a Bayesian surplus production model, (2) a Bayesian biomass assessment, and (3) a stock synthesis model. To better inform the models, ICCAT refined its catch estimation factor to account for inaccurate catch reporting in historical datasets. From these three modelling approaches nine stock assessment model runs were selected to provide stock status and management advice. The summary results of these models are found in Table 1.

Table 1. Summary of indices and assessments used to understand status of the North Atlantic Shortfin Mako population.

Index or Assessment	Location	Run	Years	Conclusions
Canadian Catch rate GLM model	Canadian waters	NA	1996-2014	Non-significant decline
ICCAT CPUE indices (six series)	North Atlantic	CPUE data	Various	Decreasing trend since 2010.

Index or Assessment	Location	Run	Years	Conclusions
ICCAT Bayesian Surplus Production	North Atlantic	Schaefer Catch Series 1	1950-2015	B_{2015}/B_{MSY} 0.85 (CV=0.2) H_{2015}/H_{MSY} 2.97 (CV=0.47) Prob. of Overfished and Overfishing=82%
		Schaefer Catch Series 2	1971-2015	B_{2015}/B_{MSY} 0.75 (CV=0.21) H_{2015}/H_{MSY} 3.58 (CV=0.45) Prob. of Overfished and Overfishing=92%
		Generalized Catch Series 1	1950-2015	B_{2015}/B_{MSY} 0.78 (CV=0.23) H_{2015}/H_{MSY} 1.93 (CV=0.48) Prob. of Overfished and Overfishing=98%
		Generalized Catch Series 2	1971-2015	B_{2015}/B_{MSY} 0.63 (CV=0.24) H_{2015}/H_{MSY} 2.41 (CV=0.44) Prob. of Overfished and Overfishing=97%
ICCAT Bayesian Biomass	North Atlantic	Schaefer Catch Series 1	1950-2015	B_{2015}/B_{MSY} 0.76 (95% Range=0.51 to 1.09) H_{2015}/H_{MSY} 3.7 (95% Range=1.46 to 10.6) Prob. of Overfished and Overfishing=92.6%
		Pella Catch Series 1	1950-2015	B_{2015}/B_{MSY} 0.61 (95% Range=0.41 to 0.87) H_{2015}/H_{MSY} 4.1 (95% Range=1.6 to 11.4) Prob. of Overfished and Overfishing=99.9%
		Schaefer Catch Series 2	1950-2015	B_{2015}/B_{MSY} 0.69 (95% Range=0.43 to 1.04) H_{2015}/H_{MSY} 4.38 (95% Range=1.61 to 12.4) Prob. of Overfished and Overfishing=95.8%
		Pella Catch Series 2	1950-2015	B_{2015}/B_{MSY} 0.57 (95% Range=0.35 to 0.85) H_{2015}/H_{MSY} 4.17 (95% Range=1.57 to 11.4) Prob. of Overfished and Overfishing=99.3%
ICCAT Stock Synthesis Model	North Atlantic	Run 3	1950-2015	F_{2015}/F_{MSY} 4.38 (CV=0.11) SSF_{2015}/SSF_{MSY} 0.95 (CV=0.48) Prob. of Overfished and Overfishing=56%

Fluctuations and Trends

Canadian Index

An index of abundance using standardized Canadian catch rates from the longline fishery was developed by Campana *et al.* (2004a) and has been used subsequently to update the catch rate series (Figure 9; Fowler and Campana 2009; Showell *et al.* 2017). The most recent update (Figure 9) shows a decline in catch rate compared to earlier in the series but still not statistically significant. Variables contributing to the limited utility of the Canadian index include a small number of annually observed trips with Shortfin Mako catches (range:11-95) and limited spatial coverage relative not only to the Canadian distribution but also the entire North Atlantic distribution.

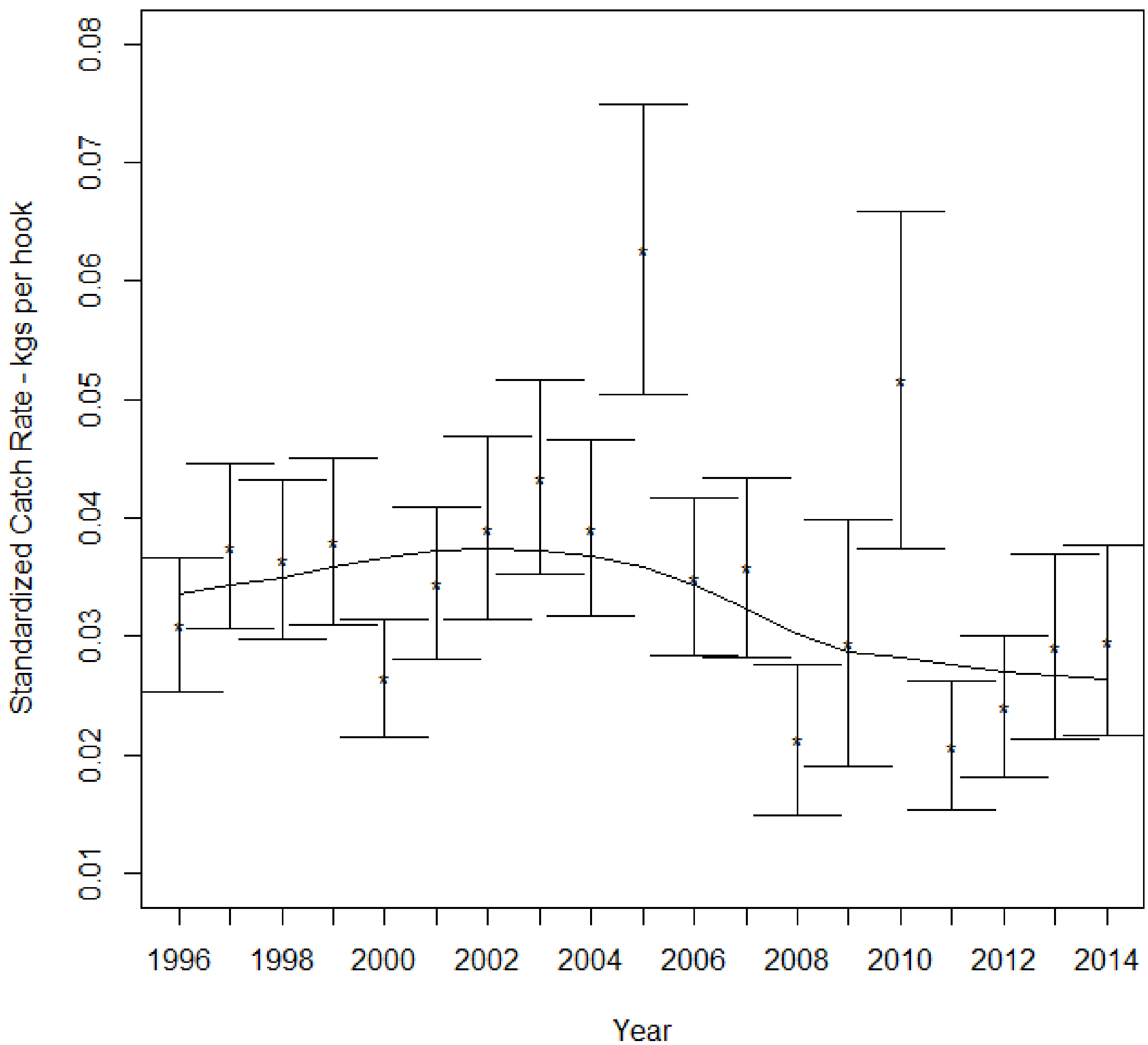


Figure 9. Standardized Shortfin Mako catch rates from the DFO Maritimes Region pelagic longline fishery (1996-2014) on the Scotian Shelf. Smooth line is a lowess fit. Source (Showell *et al.* 2017).

North Atlantic CPUE Indices

The catch per unit effort (CPUE) indices used in the 2012 ICCAT stock assessments were reviewed and updated by ICCAT in preparation for the 2017 assessment. The resulting six CPUE series used for the 2017 stock assessment showed generally decreasing trends since approximately 2010 for the North Atlantic stock (Figure 8).

Abundance

The most recent assessment of the north Atlantic Shortfin Mako population was undertaken by ICCAT (2017b) and utilizes two catch data series to 2015, updated growth parameters, and three different population models. A total of nine accepted model runs were used to inform ICCAT about the status of the population.

An accurate portrayal of catch is an important model input. Due to inconsistent reporting and non-reporting of all sharks especially in the early part of the time series, the reported catches of Shortfin Mako were not considered to accurately reflect the actual catch. A new catch series was reconstructed, based on ratios of Shortfin Mako to targeted tuna and Swordfish species in the more recent part of the time series under the assumption that the historical ratio holds true for the present-day ratio. The 2017 ICCAT assessment used both the estimated and reported time series for various model runs (Figure 10).

Estimates of abundance were provided with the metrics of population biomass and Spawning Stock Fecundity. Both can be considered reasonable proxies for the number of mature individuals in the population. The population size structure in the Atlantic is thought be stable over the assessment period (Coelho *et al.* 2017).

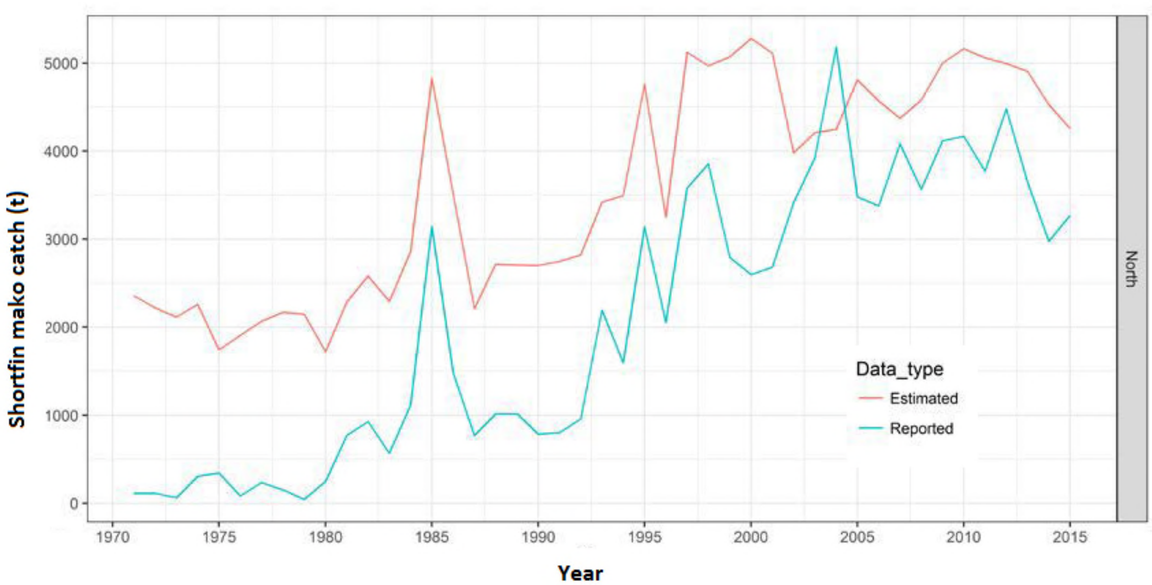


Figure 10. Time series of reported and estimated Shortfin Mako shark catches (t), between 1971 and 2015, for the North Atlantic stock. Source: ICCAT 2017a.

Bayesian Surplus Production Model

A Bayesian surplus production model (BSP) was used to estimate population status, incorporating catch estimates as well as the catch rate indices mentioned above: the US longline logbook series, Japanese longline, Portuguese longline, Spanish longline and Chinese-Taipei longline. Three different software applications were applied with only one of them (BSP2-JAGS) providing four model variations that converged adequately. These four model runs were consistent and concluded that the mean current biomass is below B_{MSY} and the mean H is above H_{MSY} and that the current stock status is predicted to be overfished (B_{2015}/B_{MSY}=0.63 to 0.85) with overfishing occurring (H_{2015}/H_{MSY}=1.93 to 3.58) (Figure 11; Table 1). The probability of the stock being overfished and experiencing overfishing was 82.1-97.8%.

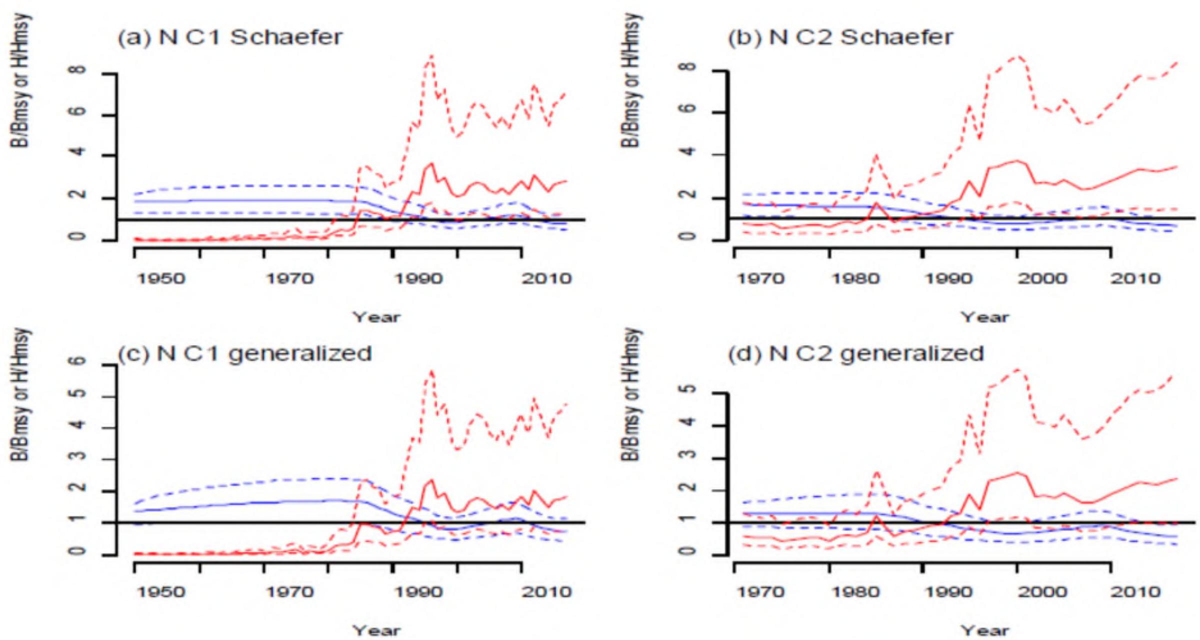


Figure 11. Results of four model variations of a Baysian Surplus Production Model for North Atlantic Shortfin Mako. Biomass (blue) and harvest rate (red) histories for (a) C1 Schaefer, (b) C2 Schaefer, (c) C1 generalized production model, and (d) C2 generalized production model. Source: ICCAT 2017b.

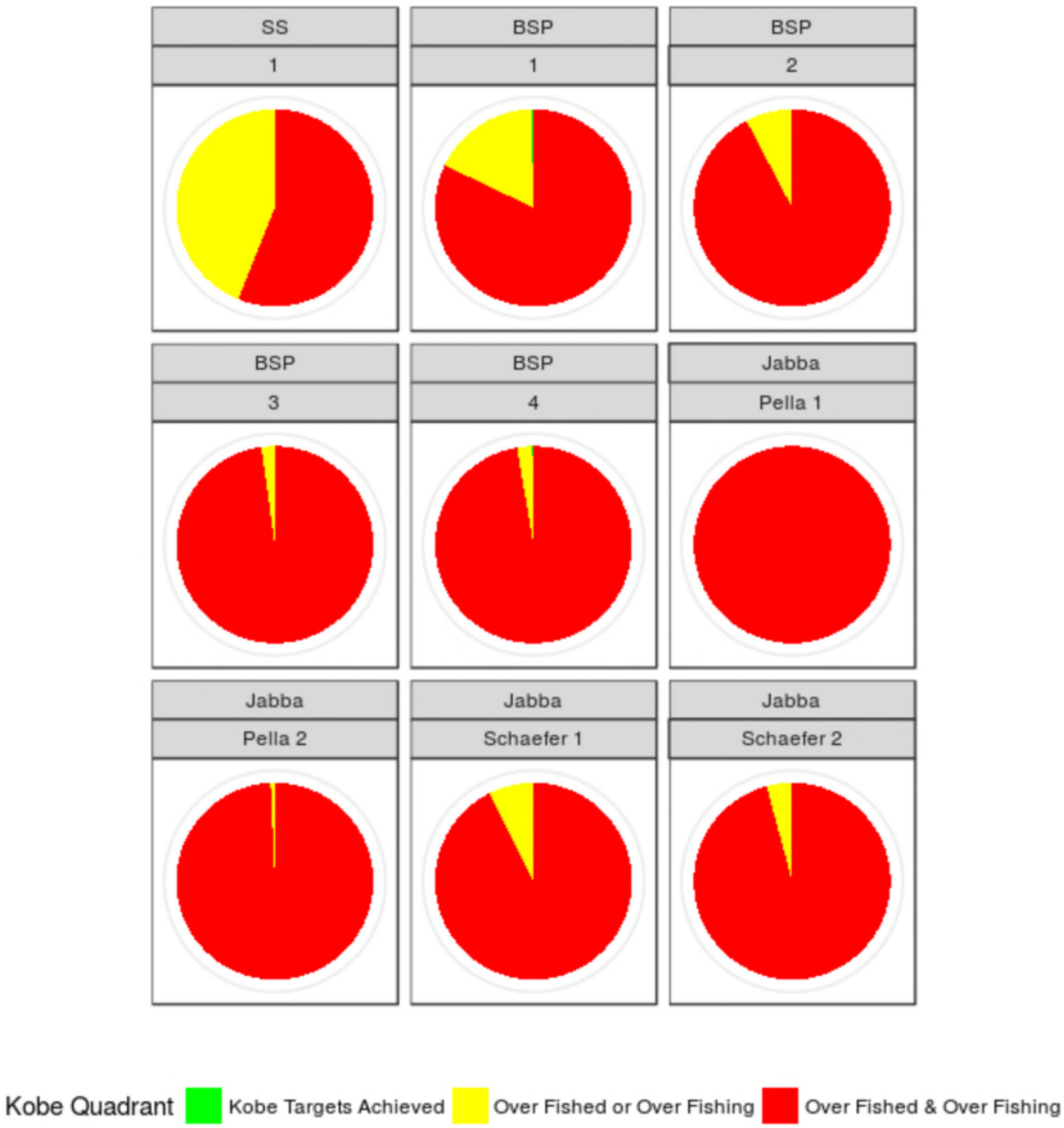
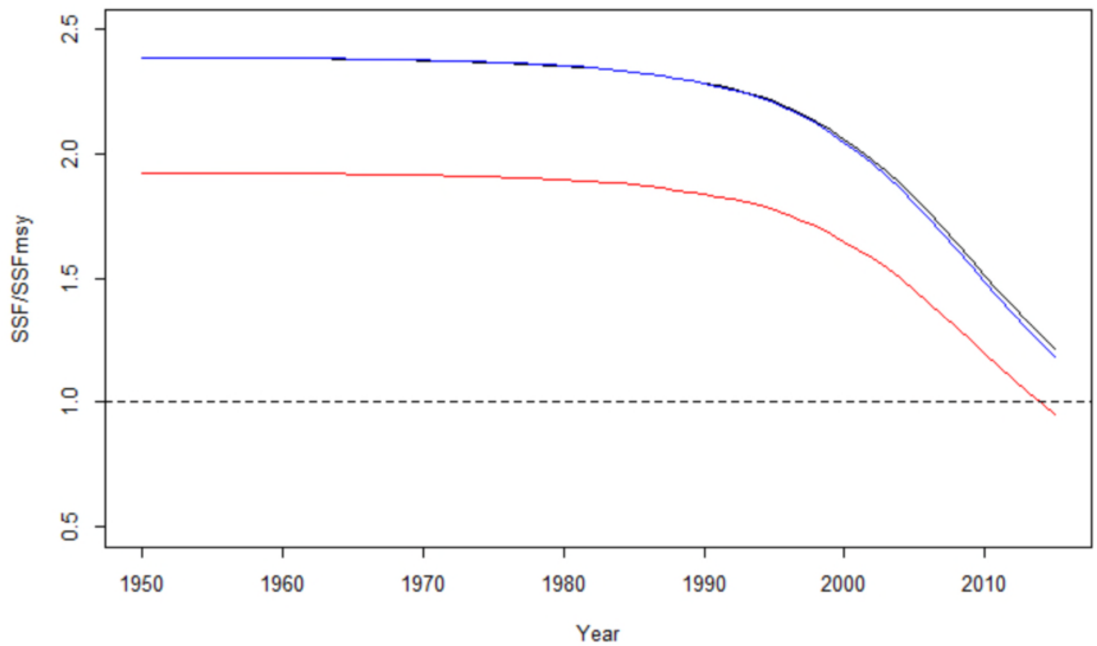


Figure 12. Summary of the nine individual model runs used by ICCAT (2017b) to assess the North Atlantic Shortfin Mako population. From left to right, models are: SS=Stock Synthesis; BSP1=BSP2JAGS, Catch 1, Schaefer; BSP2= BSP2JAGS, Catch 1, Schaefer; BSP3= BSP2JAGS, Catch2, Generalized; BSP4=BSP2JAGS, Catch 2, Generalized; JABBA Pella, with Catch 1; JABBA Pella with Catch 2; JABBA Schaefer with Catch 1; JABBA Schaefer with Catch 2.



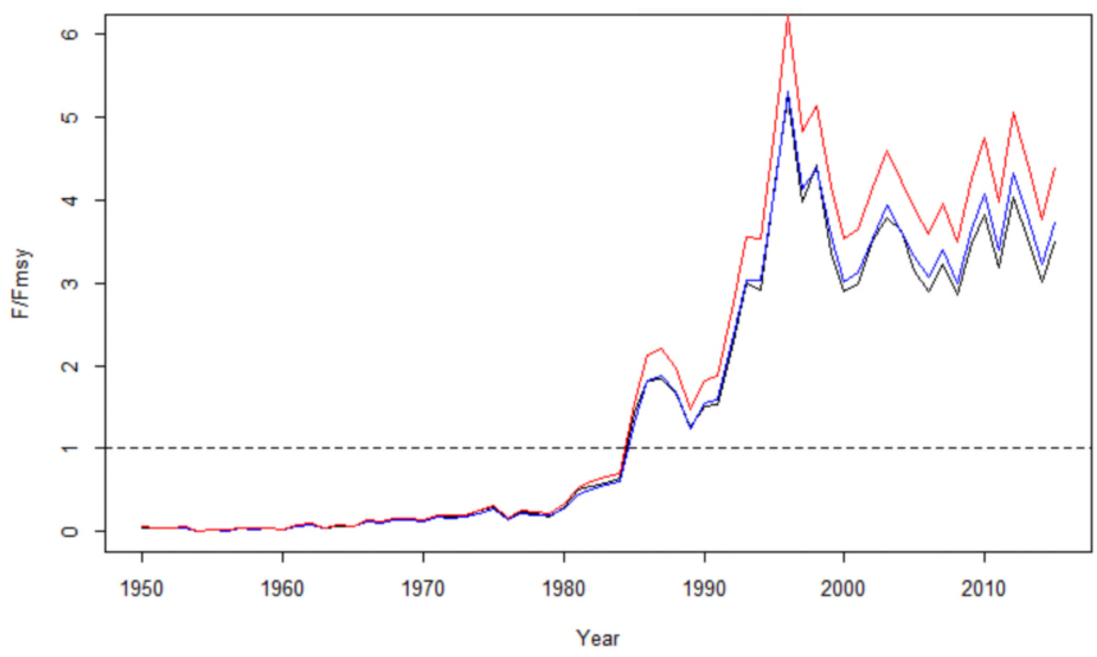


Figure 13. SSF/SSF$_{MSY}$ and F/F$_{MSY}$ for Stock Synthesis model run 1 (black line), model run 2 (blue line), and model run 3 (red line) relative to the values at MSY (dashed line). ICCAT (2017b) used model run 3 (red) as the basis for the assessment. Source: ICCAT 2017b.

Bayesian Biomass Assessment Model

A Bayesian biomass assessment (JABBA) was applied to the North Atlantic CPUE series using different model inputs and catch series to produce four scenarios (ICCAT 2017b). All scenarios consistently predicted biomass depletion at close to 50% below B_{MSY} for the final year of the assessment, 2015. The range of 95% credibility intervals falls entirely below B_{MSY} for all scenarios (ICCAT 2017b). The JABBA model indicated that the stock was both overfished and that overfishing was occurring (H_{2015}/H_{MSY}=3.75 to 4.37), resulting in a 92.6 to 99.9% probability of being in an overfished state and still experiencing overfishing (Table 1). The estimated H/H_{MSY} trajectories imply that sustainable harvest rates were already exceeded before the 1990s and in 2015 are three to four times higher than sustainable levels.

Stock Synthesis Model

Three stock synthesis model runs were evaluated and tested for model sensitivities (ICCAT 2017b). ICCAT ultimately selected a base model (SS3) as one that converged reasonably well and produced results consistent with the available fishery and biological data (Figure 13). The SS3 run predicted that the stock was likely overfished (SSF_{2015}/SSF_{MSY}=0.95; where SSF is spawning stock fecundity) and that overfishing was occurring (F_{2015}/F_{MSY}=4.38, CV=0.11) with a probability of 56.1% of being overfished and experiencing overfishing (Figure 13). The model estimated a B_{1950} of 277,435 t declining to a B_{2015} of 110,638 t for a total reduction of 60% with most of the reduction occurring since 1983 (Figure 14; ICCAT 2017b). Similarly, the spawning stock fecundity was estimated to have declined by 50% between 1950 and 2015 (Figure 14).

Overall, ICCAT (2017b) concluded that there was a 90% combined probability from all the models that the North Atlantic Shortfin Mako population is overfished and undergoing overfishing (Figure 13).

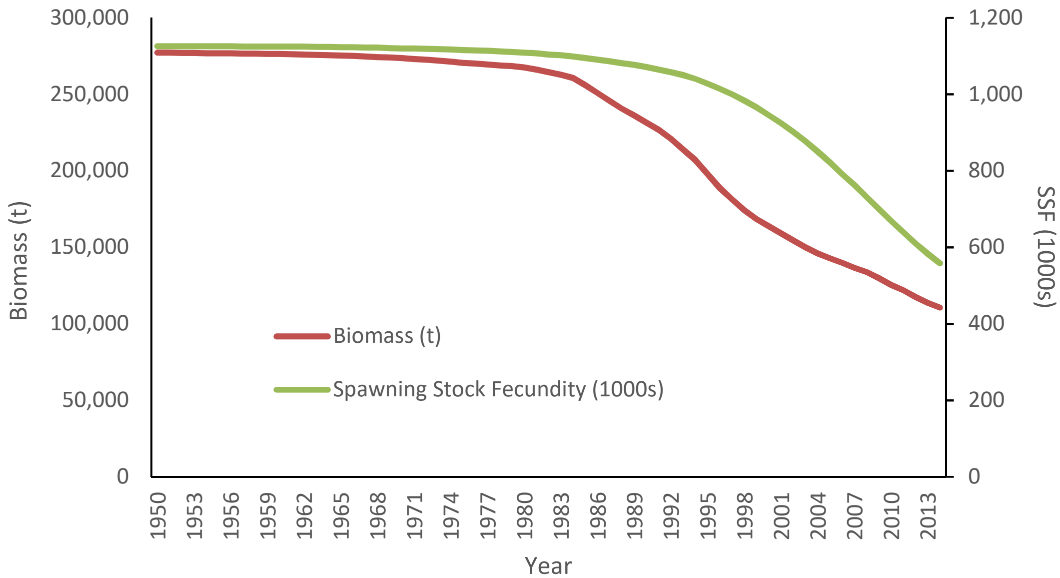


Figure 14. Stock Synthesis model annual estimates of total biomass (t) and spawning stock fecundity (SSF, 1000s). Figure constructed using data in ICCAT (2017b; Table 7) based on model run 3.

Rescue Effect

Individuals are part of a single population distributed widely in the northern half of the Atlantic Ocean. Canadian waters are considered to represent only a peripheral 2.5% of their total geographical range and Canadian threats represent a small portion of the threats (Showell *et al.* 2017). Therefore, extirpation from Canada is highly unlikely, but if it were to happen, a “rescue effect” from the broader population would be possible unless the entire North Atlantic population was also experiencing a severe decline.

THREATS AND LIMITING FACTORS

Threats

Biological Resource Use – Fishing and Harvesting Aquatic Resources

Fishing mortality is the only identified threat to Shortfin Mako. The species is not targeted in Canada but bycatch in pelagic longline fisheries targeting tunas and Swordfish is the main cause of mortality, with lesser reported interactions in groundfish gillnet and otter trawl fisheries (Table 2; Figure 15a). Recreational catches in Canadian waters are considered insignificant (Campana *et al.* 2004b). In 2018, DFO Maritimes Region, prohibited the landing of Shortfin Mako from shark fishing tournaments. Approximately 89% of the reported landings in Canada between 1994 and 2014 are from the Scotian Shelf and landed in the Scotia Fundy (Maritimes) Region (Figure 15b). Landings data in Canada underestimate bycatch mortality because most (dead) discards are unreported.

Table 2. Canadian landings (t) of Shortfin Mako Shark by year, fishing gear, and region calculated from ZIFF and MARFIS databases. Showell *et al.* (2017).

Year	Region	Longline	Handline	Gillnet	Otter trawl	Other	Derby	Regional total	Annual total
1993	Maritimes			0.3				0.3	3.71
	NF	1.1		2.3		0.0		3.41	
	Quebec							0	
	Gulf							0	
1994	Maritimes	117.6	2.3	9.5	1.7	0.1		131.2	142.4
	NF	6.5		4.5				11	
	Quebec		0.2					0.2	
	Gulf							0	
1995	Maritimes	88.0	0.2	13.4	0.7	0.5		102.8	111.2
	NF	5.9		2.4				8.3	
	Quebec							0	
	Gulf	0.1						0.1	
1996	Maritimes	50.5	0.3	7.8	1.0		0.1	59.6	67.51
	NF	5.6		2.3		0.0		7.91	
	Quebec						0.0	0	
	Gulf							0	
1997	Maritimes	90.2	0.2	9.3	1.5			101.2	109.5
	NF	4.0		4.0	0.1			8.1	
	Quebec							0	
	Gulf	0.2						0.2	
1998	Maritimes	46.2	0.2	8.0	2.2	0.6		57.2	70.9
	NF	9.5		4.0				13.5	
	Quebec							0	
	Gulf	0.2						0.2	
1999	Maritimes	45.8		4.8	1.8	0.7		53.1	70.4
	NF	7.8	0.1	9.2	0.1			17.2	
	Quebec	0.0						0	
	Gulf	0.1						0.1	
2000	Maritimes	48.2	0.1	5.3	0.4	0.8	0.49	54.8	79.5
	NF	10.7		12.9	0.1	0.5		24.2	
	Quebec	0.0					0.3	0.3	
	Gulf						0.2	0.2	
2001	Maritimes	51.2	0.2	5.2	0.2	0.4		57.2	69.7
	NF	8.6		3.6	0.1			12.3	
	Quebec	0.0	0.1			0.0		0.1	
	Gulf	0.0				0.1		0.1	

Year	Region	Longline	Handline	Gillnet	Otter trawl	Other	Derby	Regional total	Annual total
2002	Maritimes	54.3	0.3	9.8	0.8	1.3	0.67	66.5	79.3
	NF	6.4	0.1	4.5				11	
	Quebec			0.1				0.1	
	Gulf	0.8		0.2			0.7	1.7	
2003	Maritimes	57.6	0.2	6.8	0.5	1.4	0.40	66.5	74
	NF	6.0		1.4		0.1		7.5	
	Quebec	0.0						0	
	Gulf							0	
2004	Maritimes	62.1	0.2	6.8	0.1	1.0	1.00	70.2	81.4
	NF	8.0		3.0				11	
	Quebec							0	
	Gulf	0.2						0.2	
2005	Maritimes	71.3	0.5	11.9	0.9	0.9	0.39	85.5	95.7
	NF	5.3		4.4	0.1			9.8	
	Quebec							0	
	Gulf	0.4						0.4	
2006	Maritimes	61.5		4.9	0.3		0.39	66.7	70.4
	NF	2.4		1.2				3.6	
	Quebec							0	
	Gulf					0.1		0.1	
2007	Maritimes	61.3		6.0	0.8		0.20	68.1	71.3
	NF	1.9		1.0		0.0		2.9	
	Quebec							0	
	Gulf	0.2				0.1		0.3	
2008	Maritimes	39.3		2.3	0.7	1.3		43.6	45.8
	NF	2.0		0.1				2.1	
	Quebec	0.1						0.1	
	Gulf							0	
2009	Maritimes	46.6		1.7	0.2		0.49	48.5	53
	NF	3.5		0.9				4.4	
	Quebec							0	
	Gulf	0.1						0.1	
2010	Maritimes	37.0		0.5	0.1	0.3	0.25	37.9	41.3
	NF	1.5		1.5				3	
	Quebec							0	
	Gulf	0.2		0.2				0.4	
2011	Maritimes	35.6		0.1		0.1	0.15	35.8	37.6
	NF	1.3						1.3	
	Quebec	0.2						0.2	
	Gulf	0.2				0.1		0.3	
2012	Maritimes	28.4		0.2	0.5		0.42	29.1	29.7
	NF			0.4				0.4	
	Quebec					0.1		0.1	
	Gulf	0.1						0.1	

Year	Region	Longline	Handline	Gillnet	Otter trawl	Other	Derby	Regional total	Annual total
2013*	Maritimes	34.4		0.4			0.32	35.1	35.3
	NF							0	
	Quebec	0.1						0.1	
	Gulf	0.1						0.1	
2014*	Maritimes	53.2		1.5			0.32	35.1	35.3
	NF								
	Quebec								
	Gulf								

*NF, Quebec and Gulf data incomplete at time of publication

There has been a reduction in Canadian landings since 2008. One explanation for the decline may be a result of the pelagic longline fleet changing from J-hooks to circle hooks (DFO 2016). Outside of Canada, international commercial longline fleets are the primary sources of mortality to this population with lesser mortalities associated with other gear types and fisheries, including the US recreational fishery (Figure 16).

Beginning in 2015, the Canadian longline fleet operating in the DFO Maritimes Region has voluntarily supported management measures to release Shortfin Mako that are still alive when the fishing gear has been retrieved. A mandatory release of live Shortfin Mako caught in the pelagic longline fishery has been in place since 2018. Survivorship of individuals released at sea depends on condition at capture and release and this varies with capture method, gear setting techniques, duration hooked before gear is retrieved, animal size, handling on board, and environmental conditions (Campana *et al.* 2015). Mortality of released Shortfin Mako in the Canadian longline fishery is 49% varying with condition upon release (dead, injured, or healthy). Post-release survival of injured and healthy individuals was estimated to be 31% using satellite tags (n=33) (Figure 17; Campana *et al.* 2015).

For the DFO Maritimes Region, total annual mortality (1996-2014) was calculated by applying a 49% mortality rate to estimates of total discards in pelagic longline fisheries, groundfish otter trawl, groundfish longline, and groundfish gillnet fisheries (Showell *et al.* 2017). The estimate of dead discards was added to the reported landings for a resultant average total mortality of 69 t/year (Range 42-115 t; 1996-2014) (Showell *et al.* 2017).

In the Newfoundland and Labrador Region, bycatch estimates of Shortfin Mako were calculated by extrapolating ratios found in observed trips to non-observed trips between 1998-2010 for a variety of fisheries (Figure 15; Showell *et al*. 2017). Very low observer coverage (0-3%) resulted in a high degree of uncertainty and estimates range from near zero to 174 t with an annual average of 80 t (Figure 18). Most of this estimated catch was from cod-directed gillnet fisheries which would have 100% mortality. Therefore, total Canadian annual mortality is estimated to be 150 t/yr.

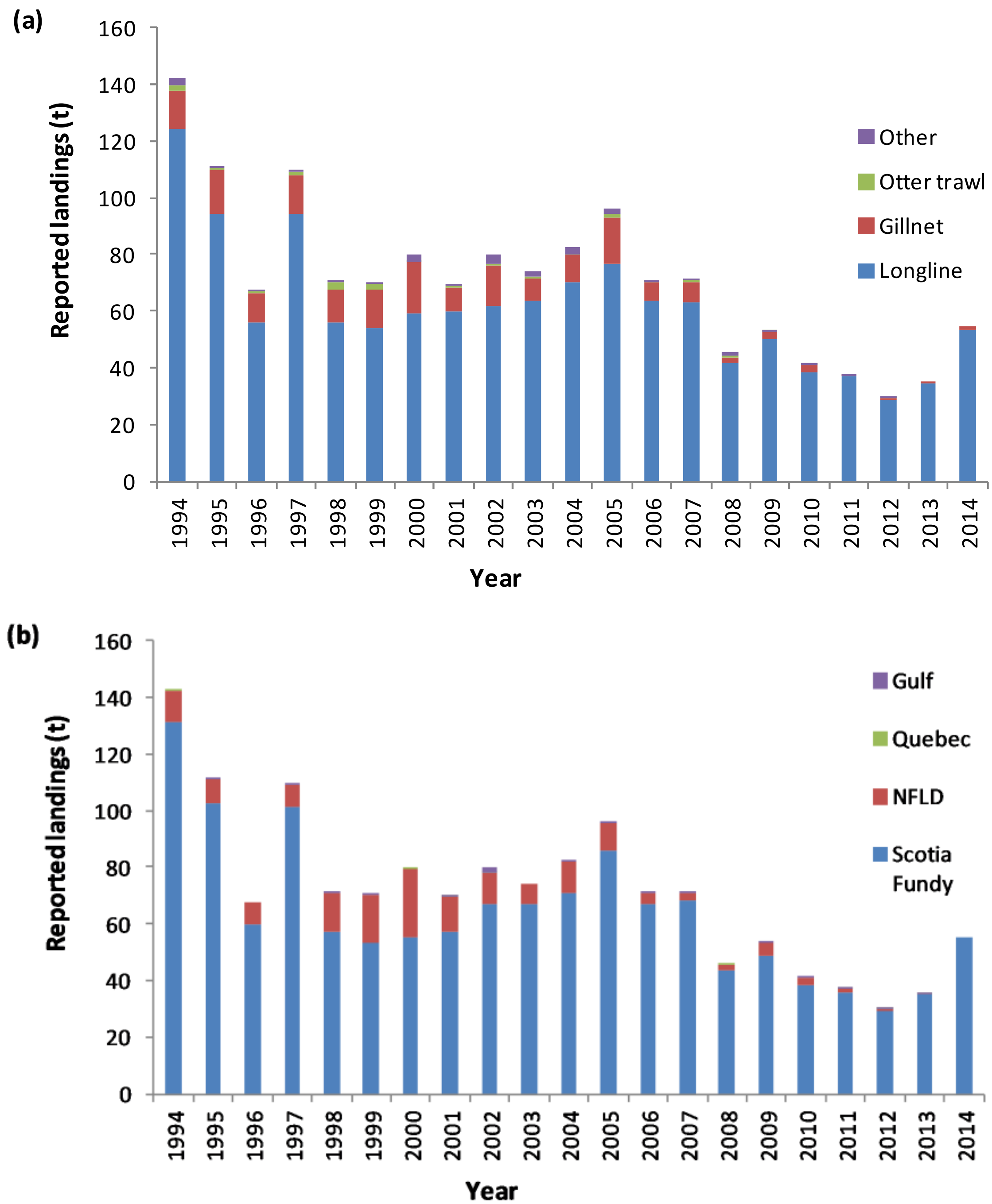


Figure 15. Canadian reported Shortfin Mako landings (t) by (a) gear type; 'other' includes derby, handline, and miscellaneous (from ZIFF and MARFIS databases) and (b) management region. Data do not include discards at sea. Source: (Figure made from Table 2 in Showell *et al.* 2017).

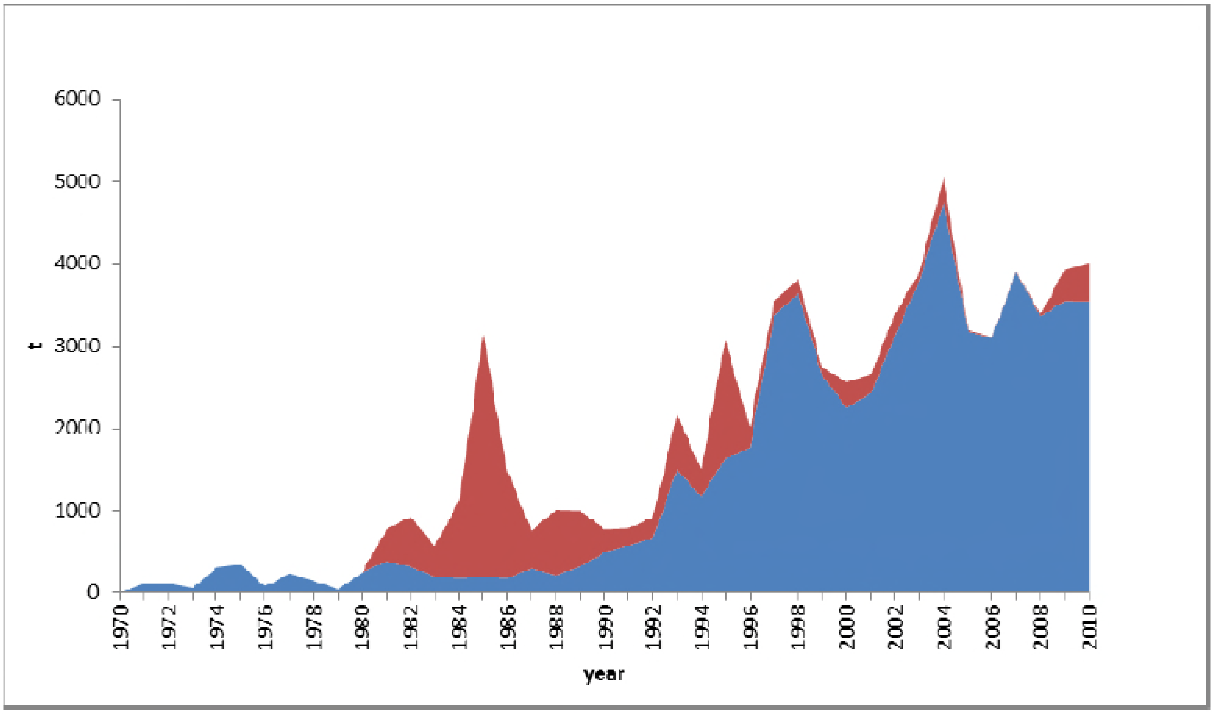


Figure 16. Estimated Shortfin Mako catch (landings and discards) in North Atlantic by longline gear (blue) and other (red). Source: ICCAT (2012).

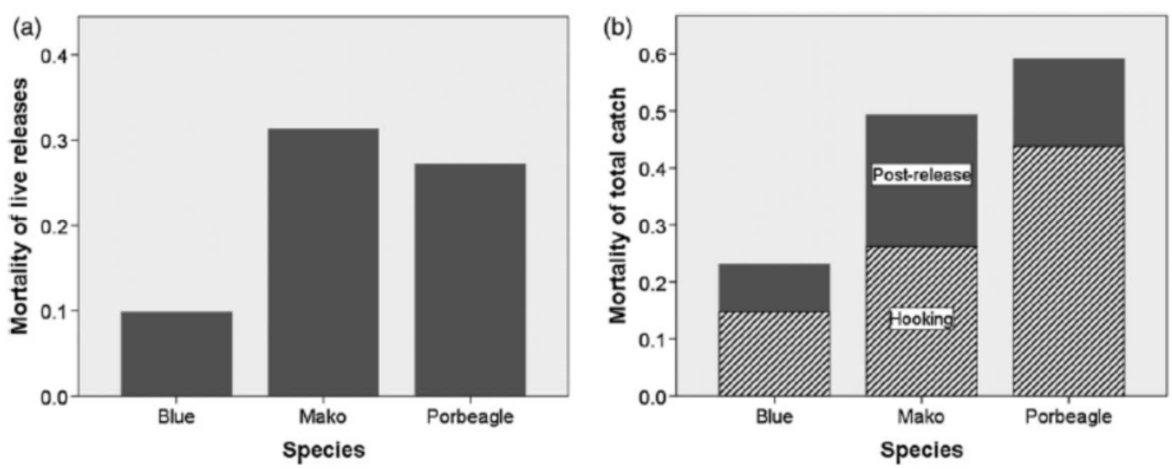


Figure 17. Shark mortality due to capture or hooking mortality in Canadian commercial pelagic longline fishing in DFO Maritimes Region broken down by species: (a) proportion that die after release as recorded by PSATs; (b) proportion of the total catch that die during hooking (striped) and after release (solid grey). Source: Campana *et al.* 2015.

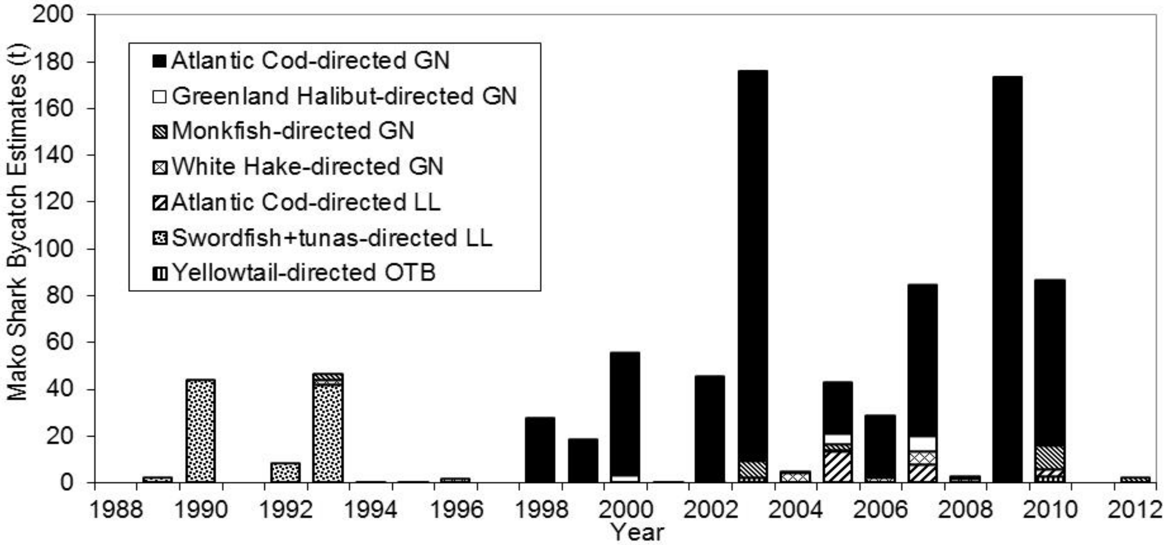


Figure 18. Estimated annual total bycatch (t) of Shortfin Mako by directed species and gear (GN=gillnet; LL=longline; OTB=otter trawl-bottom) in Canada's EEZ of Div. 3LNOP, 1998-2010. Data are from Canadian Fisheries Observers and DFO-NL ZIFF in comparable years. Note that these unweighted estimates are scaled up to the entire fishery, and contingent on whether Canadian landings were reported in ZIFF, and the annual degree of NL-ASO coverage of each fishery. Source: Showell *et al.* 2017.

Substantial uncertainties regarding fishing mortality for the entire North Atlantic result from poor catch reporting, with virtually no estimates of discards at sea and incomplete reporting of landings. Accuracy of reported landings improved after 1996 when ICCAT requested that landings of sharks be reported.

The large majority of removals come from fisheries outside of Canada. From 1996-2015, annual average reported landings were 2395 t but this number is considered to be an underestimate. Due to under-reporting of landings and discards, ICCAT (2012; 2017) provided better estimates by calculating the ratio of Shortfin Mako landings to the total landings of tuna and Swordfish from each fleet in recent years, and multiplying this ratio times the tuna plus Swordfish landings in each historical year (Figure 10). Between 1996 and 2015 the ratio-based estimates of annual landings were on average 4673 t (Range 3247-5278 t). However, these landings-based estimates do not account for shark discards at sea and thus represent only minimum mortality levels. Using the total Canadian annual average mortality estimate (150 t), Canadian fisheries may contribute to approximately 4% of the overall mortality by weight. Recent management measures for the Canadian pelagic longline fishery are anticipated to further decrease the mortality in Canadian waters.

As described in the 'Biology' section above, mature females are seldom caught in Canadian fisheries. Observer records from 2006 to 2015 indicate that only 1% of the observed females caught are reproductively mature. However, this must be interpreted with caution, as low observer coverage of Canadian fisheries results in highly uncertain estimates.

Shortfin Mako contain significant levels of contaminants, including PCBs, DDTs, pesticides, and mercury (Lyons *et al*. 2013). It is not known if these contaminant levels represent a source of mortality for the population.

Limiting Factors

Shortfin Mako populations, in comparison to other shark species, have relatively low productivity, limiting capacity to recover once the population is depleted. ICCAT (2012) conducted a productivity-susceptibility analysis (PSA) of 20 shark populations and identified that the low productivity in comparison to the other shark species is primarily due to the long length of time for females to reach maturity and their three-year reproductive cycle (Table 3; ICCAT 2012).

Table 3. Productivity (r, intrinsic rate of population increase, yr^{-1}) and generation time for 20 stocks of pelagic sharks and rays listed from highest to lowest values of productivity. Productivity estimates are medians, along with 80% upper and lower confidence limits. Source: ICCAT 2012.

Stock	Productivity (r)	LCL	UCL	Generation time (yrs)
Blue Shark N. Atl.	0.314	0.279	0.345	8.2
Blue Shark S. Atl.	0.299	0.264	0.327	9.8
Pelagic Stingray N. Atl.	0.230	0.181	0.279	6.2
Smooth Hammerhead	0.225	0.213	0.237	13.4
Tiger Shark	0.190	0.180	0.200	15.6
Oceanic Whitetip Shark	0.121	0.104	0.137	10.4
Scallop Hammerhead S. Atl.	0.121	0.110	0.132	21.6
Thresher Shark	0.121	0.099	0.143	11.0
Scallop Hammerhead N. Atl.	0.096	0.093	0.107	21.6
Silky Shark N. Atl.	0.078	0.065	0.090	14.4
Great Hammerhead	0.070	0.069	0.071	27.1
Shortfin Mako	0.058	0.049	0.068	25.0
Porbeagle Shark	0.052	0.044	0.059	20.3
Pelagic Stingray S. Atl.	0.051	0.004	0.096	6.6
Dusky Shark	0.043	0.035	0.050	29.6
Silky Shark S. Atl.	0.042	0.029	0.054	16.5
Night Shark	0.041	0.028	0.053	14.9
Longfin Mako	0.029	0.020	0.038	25.2
Sandbar Shark	0.010	0.005	0.024	21.8
Bigeye Thresher	0.009	0.001	0.018	17.8

Number of Locations

Shortfin Mako are broadly distributed throughout the North Atlantic, and are subject to capture in a number (probably >10) of international fisheries. In a COSEWIC sense, each fishery could be considered a “location”, with a specific threat to the population associated with each location although most “locations” occur outside Canada.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

There is no directed fishery for Shortfin Mako in Atlantic Canada, and there is no longer an Integrated Fisheries Management Plan (IFMP) to oversee the management of sharks. Shortfin Mako is instead managed within the IFMPs of the fisheries that catch sharks as bycatch (e.g., DFO Maritimes Region pelagic longline Swordfish fishery). In addition, the Atlantic Canada Conservation Action Plan for Selected Shark Species (CAP) has recently been approved. This action plan was developed to update the National Plan of Action for Conservation and Management of Sharks (DFO 2007) in response to FAO’s International Plan of Action for sharks (FAO 1999). The CAP has a management focus on ensuring that human activity does not have unacceptably adverse effects on the ecosystem, but it does not provide any plan of action to help conserve pelagic shark species.

At present, there is a non-restrictive annual catch limit for Shortfin Mako of 100 t for the pelagic longline fishery in the DFO Maritimes Region. The Canadian pelagic longline fishery in the DFO Maritimes Region has recently required mandatory release of live Shortfin Mako which is anticipated to reduce landings and mortality in the coming years but not shark interactions with fishing gear. To support this mandatory measure, a Shark Fishing - Best Catch, Handle and Release Practices guide has been developed by the World Wildlife Fund-Canada and provided to shark derbies and fishery groups in DFO Maritimes Region to help decrease shark post-release mortality. Since 2018 Shortfin Mako are no longer permitted to be retained in derbies. For the Canadian pelagic longline fishery in the DFO Maritimes Region, Shortfin Mako must be recorded in logbooks as condition of licence and there is a requirement to use corrodible circle hooks to reduce bycatch and post-release mortality. In the Newfoundland and Labrador Region groundfish (fixed gear) fisheries, shark landings are regulated to 10% of the catch of the directed groundfish species by weight with no additional protective measures.

Shortfin Mako taken as bycatch is landed as a food product and is more valuable than Blue Shark (Prionace glauca) that are often caught in the same fisheries. For Atlantic Canadian fisheries using gillnets or longlines, Canada has adopted a mandatory “fins-attached” policy, in which pelagic sharks have their fins naturally attached until weighed and recorded by a Dockside Monitor at port of landing. Atlantic Canadian fisheries (as per the Atlantic Fisheries Regulations) using bottom trawls or purse seines are not permitted to retain shark bycatch; although this prohibition does not reduce shark interactions with fishing gear. Shark finning (i.e., removing and retaining fins while discarding the shark's body, sometimes still alive, at sea) has been banned since 1994 in Canada, although the value of Shortfin Mako as a meat has made finning less of an issue with this particular species. However, it must be noted that Canada allows the sale of Canadian shark fins within its own borders, as well as their export to international markets.

Non-Legal Status and Ranks

Shortfin Mako was first assessed as threatened by COSEWIC in 2006 but was not given legal protection under Canada's *Species at Risk Act*. COSEWIC re-assessed the population as "Special Concern" in 2017 prior to the comprehensive ICCAT assessment (ICCAT 2017b). Shortfin Mako (Atlantic) was last assessed in 2018 by the International Union for Conservation of Nature (IUCN) as "Endangered". The US National Oceanographic and Atmospheric Administration (NOAA) describes the population status as "overfished and subject to overfishing" (NOAA 2018).

Habitat Protection and Ownership

Shortfin Mako habitat is within Canada's Exclusive Economic Zone (EEZ) off the Atlantic coast and is managed primarily by Fisheries and Oceans Canada. There are presently no specific protection measures for habitat occupied by Shortfin Mako. In international waters outside of Canada there are currently no areas identified for habitat protection for Shortfin Mako.

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