

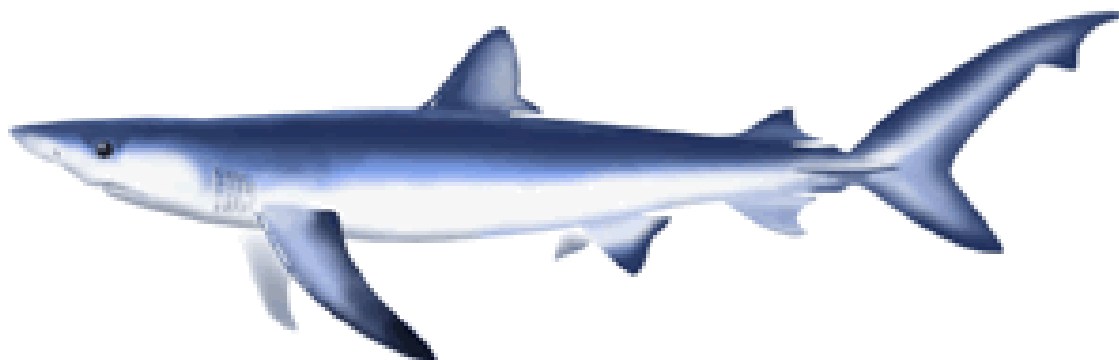
COSEWIC **Assessment and Status Report**

on the

Blue Shark *Prionace glauca*

North Atlantic population
North Pacific population

in Canada



NOT AT RISK
2016

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:

COSEWIC. 2016. COSEWIC assessment and status report on the Blue Shark *Prionace glauca*, North Atlantic population and North Pacific population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 50 pp. (<http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1>).

Previous report(s):

COSEWIC 2006. COSEWIC assessment and status report on the blue shark *Prionace glauca* (Atlantic and Pacific populations) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 46 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note:

COSEWIC would like to acknowledge Howard Powles for writing the status report on the Blue Shark. This report was prepared under contract with Environment and Climate Change Canada and was overseen by John Neilson and John Reynolds, Co-chair and former Co-chair of the COSEWIC Marine Fishes Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Requin bleu (*Prionace glauca*), population de l'Atlantique Nord et population du Pacifique Nord, au Canada.

Cover illustration/photo:
Blue Shark — International Commission for the Conservation of Atlantic Tunas.

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Catalogue No. CW69-14/463-2017E-PDF
ISBN 978-0-660-07767-3



COSEWIC Assessment Summary

Assessment Summary – November 2016

Common name

Blue Shark – North Atlantic population

Scientific name

Prionace glauca

Status

Not at Risk

Reason for designation

This species is productive, relative to other pelagic shark species. The species has a single highly migratory population in the North Atlantic, of which a portion is present in Canadian waters seasonally. Catch rates from the Canadian fishery from 1995 to 2013 are stable or slightly increasing, and there is no trend in the updated size composition of the catch from 2001 to 2016. Bycatch issues identified in the previous assessment have been reduced through management measures. Eight fishery-dependent indices used in a recent (2015) stock assessment show no overall trend. Most population models integrating those indices showed no decline in spawning-stock biomass.

Occurrence

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

Status history

Designated Special Concern in April 2006. Status re-examined and designated Not at Risk in November 2016.

Assessment Summary – November 2016

Common name

Blue Shark – North Pacific population

Scientific name

Prionace glauca

Status

Not at Risk

Reason for designation

This species is productive, relative to other pelagic shark species. The species has a single highly migratory population in the North Pacific, of which a portion is present in Canadian waters seasonally. Fishery-dependent abundance indices from smaller areas show various trends from the mid-1970s to 2013. A population assessment that integrates these indices suggests abundance has recently increased. There are no significant threats to this species in Canadian waters.

Occurrence

British Columbia, Pacific Ocean

Status history

Species considered in April 2006 and placed in the Data Deficient category. Status re-examined and designated Not at Risk in November 2016.



COSEWIC Executive Summary

Blue Shark *Prionace glauca*

North Atlantic population
North Pacific population

Wildlife Species Description and Significance

Blue Shark, a member of the family Carcharhinidae (requiem sharks), is recognized by its distinctive colouration – dark blue dorsally, bright blue laterally, white ventrally. The body is slender, reaching 3.8 m in length. It is one of the most abundant and widespread shark species worldwide, is among the most fecund (capable of producing relatively many offspring) and fast-growing shark species, and is the only member of the requiem shark family regularly occurring in temperate as well as tropical waters.

Distribution

Blue Shark is distributed worldwide in temperate and tropical oceans, primarily in surface waters and offshore. A single migratory population exists in each of the North Atlantic and North Pacific Oceans, of which individuals found in Canada are part. Off Atlantic Canada, Blue Shark are most abundant in Gulf Stream waters off the continental shelf, but they are also common on shelf waters off Nova Scotia and Newfoundland, and may occur in the Gulf of St. Lawrence and north of the Grand Banks. Off Pacific Canada, they are common on the continental shelf and in oceanic waters.

Blue Sharks are highly migratory with complex movement patterns and population spatial structure related to life cycle events (age, sex, maturity stage) and distribution of prey.

Two discrete DUs (designatable units)¹ are proposed, one in Atlantic Canada, another in Pacific Canada.

¹ Designatable unit (DU): Species, subspecies, variety, or geographically or genetically distinct population that may be assessed by COSEWIC, where such units are both discrete and evolutionarily significant.

Habitat

Blue shark occur in oceanic pelagic and continental shelf pelagic habitats, ranging from the surface to at least 600m depth and preferring temperatures of 12-20° C. Individuals show seasonal migrations – for example sharks found on the continental shelf in the northwest Atlantic in summer move into deeper off-shelf areas in November, where they pass the winter. Individuals in oceanic waters show a striking diel migration from surface waters at night to deep (about 400 m) waters during the day.

Biology

Brood size ranges from 4 to 135 young with a mean of about 30, relatively high among pelagic sharks. Birth length is 35-50 cm, and the length at maturity is 200-220 cm. Gestation lasts 9-12 months; breeding may be annually or every two years. Longevity has been estimated at 15, 20 or 30 years by different studies. Age at maturity has variously been estimated at 4-6 years for males and 6-7 years for females, or 6-7 years for both sexes. Natural mortality is not well known; available estimates converge around an instantaneous rate of about 0.2 but range from 0.07 to 0.48. Based on an age at maturity of 7 yr and a natural mortality of 0.2, generation time is estimated at 12 yr, but this could range from 7 to 21 yr. Blue Shark is considered to be a relatively productive species, compared with other pelagic Atlantic sharks.

Blue Shark prey on a wide range of fishes and cephalopods (squids and octopi), primarily pelagic, but also on demersal species when in the shelf habitat.

Population Sizes and Trends

Population trend data are based on fishery catch per unit effort, principally from incidental catch in commercial longline fisheries targeting Swordfish and tunas. Shark catch data from these fisheries are imprecise or nonexistent, particularly prior to the mid-1990s, so Blue Shark catches have often been estimated using various techniques. Changes in commercial CPUE may not reflect changes in population size, as they are a measure of local density within a part of the distribution of the species.

Catch per unit effort series are available from Atlantic and Pacific Canadian waters, but show high variability and are not considered to represent population abundance trends well.

For the North Atlantic population, eight catch per unit effort series covering different fisheries, areas, and periods show no overall trend over the period 1970-2013. Results of a population assessment by the International Commission for the Conservation of Atlantic Tunas (ICCAT) (2015) suggest that abundance is currently high and fishing pressure low, but these results are considered uncertain because of problems with the input data. No estimates of total population numbers are available.

For the North Pacific population, the two abundance index series considered best to reflect population trends show a decline from 1976 to the late 1980s, followed by an increase to the early 2000s and a subsequent decline. A population assessment by the International Scientific Committee for Tuna and Tuna-like species in the North Pacific Ocean (ISC) (2014) showed that stock biomass was high in 1971, fell to its lowest level in the late 1980s/early 1990s, and subsequently increased to its level of the early 1970s. Female spawning stock biomass in 2011 was estimated at 450,000 t, and total spawning biomass at 622,000 t, by two models. Stock abundance was estimated to be above the level that would produce maximum sustainable yield (MSY), a common reference level indicating the maximum yield that a renewable resource can provide without impairing its renewability through natural growth and reproduction.. Results are considered somewhat uncertain because of input data problems.

Threats and Limiting Factors

Catch in commercial longline fisheries targeting pelagic tunas and Swordfish is the principal source of anthropogenic mortality. Smaller amounts are taken in recreational fisheries and by commercial fisheries using other kinds of gear. The species is generally not valued for its meat, although it is retained in some areas. Blue Shark is by far the most common species in the international shark fin trade. Estimates of total Blue Shark removals worldwide based on quantities of fins traded were of the order of 200,000-500,000 t/yr for the early/mid-2000s. Although Canada has prohibited shark “finning” (removing fins and discarding the carcass at sea), it allows export of Canadian fins to international markets but to what extent remains unknown.

Many Blue Sharks taken are discarded. Studies have estimated discard mortality after hooking at 23% or 15% in commercial fisheries, and 10% in recreational fisheries.

In the North Atlantic, estimated total catches have varied around 35,000 t/yr since the early 1980s; catches have been increasing since the early 1990s. Mortality from Canadian fisheries is estimated at approximately 400 t/yr since the mid-1990s, taking into consideration catches and discard mortality.

In the North Pacific, estimated catches for 2000-2010 were relatively stable, averaging around 46,000 t/yr. Peak catches were around 113,000 t in 1981. Recorded Canadian catches are very low, less than 20 t/yr in recent years, from commercial fisheries (and a few from recreational fisheries) on the continental shelf.

Protection, Status, and Ranks

Management strategies for Blue Shark in Canada are summarized in a National Plan of Action for Conservation and Management of Sharks (2007). Finning (removing fins and discarding the carcass at sea) has been prohibited in Canada since 1994. However, Canada allows the sale of Canadian shark fins within its own borders, as well as their export to international markets.

In Atlantic Canada, an Atlantic Conservation Action Plan for Selected Pelagic Shark Species has been drafted. Pelagic sharks are voluntarily discarded in Maritimes pelagic longline fisheries, and use of circle hooks, which is expected to reduce shark mortality, has been mandatory since 2012 (except in NL fisheries). Discarding, or landing and reporting, are mandatory in other fisheries. Sharks taken in recreational fisheries must be released, except in Nova Scotian fishing derbies, where individuals over 244 cm in length can be retained.

In Pacific Canada, retention of Blue Shark is prohibited in commercial tuna and groundfish fisheries and in recreational fisheries.

Internationally, the FAO (Food and Agriculture Organization of the United Nations) International Program of Action on Conservation and Management of Sharks (1999) has encouraged development of management measures, such as finning bans and improved catch data for sharks, by regional organizations managing North Atlantic and North Pacific oceanic pelagic fisheries.

Blue Shark was assessed as “Not at Risk” in the North Atlantic and in the North Pacific by COSEWIC in 2016. Blue Shark is listed as globally “near threatened” on the IUCN (International Union for the Conservation of Nature) Red List.

TECHNICAL SUMMARY

Prionace glauca

Blue Shark – North Atlantic population

Requin bleu – Population de l'Atlantique Nord

Range of occurrence in Canada (province/territory/ocean):

Atlantic Ocean; New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador, Quebec

Demographic Information

Generation time <ul style="list-style-type: none"> • based on $G = \text{age at maturity} + 1/\text{natural mortality}$ • female age at maturity taken as 7 yr but estimates range from 5 to 7 yr • natural mortality taken as 0.2 but estimates range from 0.07 to 0.48 • generation time could range from 7 to 21 yr based on the above estimates 	12 yrs
Is there an observed continuing decline in number of mature individuals?	No, Future trend unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or three generations]. <ul style="list-style-type: none"> • inferred from time series of fishery catch per unit effort: eight time series show varying trends depending on period and area, but no overall trend 1970-2013 • one population model run shows a 65% decline early 1980s to mid-1990s, stable abundance since • other population models show population has been stable over the available time series (1970-2013) 	No overall trend
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or three generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or three generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible and understood and ceased?	Threats are known and reversible but not ceased
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence in Canada	900,420 km ²
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Index of area of occupancy (IAO) <ul style="list-style-type: none"> note: actual IAO would be much higher, but stating this IAO value is consistent with COSEWIC practice 	>2,000 km ²
Is the population severely fragmented?	No
Number of locations	>10, as they are caught in a diverse set of fisheries under different management regimes
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of populations?	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 population)

Population	Unknown
Total	

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. <ul style="list-style-type: none"> population model shows abundance is above MSY level and fishing mortality is below MSY level 	No analysis
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Threats (actual or imminent, to populations or habitats)

Catch in fisheries, principally commercial longline fisheries; some recent improvements to management may have reduced mortality rates, although retention may be increasing in some fisheries.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	Single population of which individuals in Canada are part
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Is immigration known or possible?	Known
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Yes

Data Sensitive Species

Is this a data sensitive species?	No
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Status History

Designated Special Concern in April 2006. Status re-examined and designated Not at Risk in November 2016.

Status and Reasons for Designation:

Status: Not at risk.	Alpha-numeric codes: Not applicable
Reasons for designation: This species is productive, relative to other pelagic shark species. The species has a single highly migratory population in the North Atlantic, of which a portion is present in Canadian waters seasonally. Catch rates from the Canadian fishery from 1995 to 2013 are stable or slightly increasing, and there is no trend in the updated size composition of the catch from 2001 to 2016. Bycatch issues identified in the previous assessment have been reduced through management measures. Eight fishery-dependent indices used in a recent (2015) stock assessment show no overall trend. Most population models integrating those indices showed no decline in spawning-stock biomass.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criteria, population stable or increasing.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criteria, EOO and IAO exceed limits.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criteria, population size exceeds limits.
Criterion D (Very Small or Restricted Population): Does not meet criteria.
Criterion E (Quantitative Analysis): Not done.

TECHNICAL SUMMARY

Prionace glauca

Blue Shark – North Pacific population

Requin bleu – Population du Pacifique Nord

Range of occurrence in Canada (province/territory/ocean): Pacific Ocean, British Columbia

Demographic Information

Generation time <ul style="list-style-type: none"> • based on $G = \text{age at maturity} + 1/\text{natural mortality}$ • female age at maturity taken as 7 yr but estimates range from 5 to 7 yr • natural mortality taken as 0.2 but estimates range from 0.07 to 0.48 • generation time could range from 7 to 21 yr based on ranges in biological parameters above 	12 yrs
Is there an observed continuing decline in number of mature individuals?	No, Future trend unknown
Estimated percent of continuing decline in total number of mature individuals within [Five years or two generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or three generations]. <ul style="list-style-type: none"> • Inferred from commercial catch per unit effort - indices show no overall trend, some declines and increases in individual indices • Estimated by population model - population increasing over past three generations 	No overall trend
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or three generations].	Unknown, although fishing mortality has recently been declining (from population model)
[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.	N/A
Are the causes of the decline clearly reversible and understood and ceased?	Threats are known and reversible but not ceased
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence in Canada	544,900 km ²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	>2,000 km ²
Is the population severely fragmented?	No

Number of locations	>10, as they are caught in a diverse set of fisheries under different management regimes
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of populations?	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 population)

Population <ul style="list-style-type: none"> female spawning stock biomass from model was 450,000 t in 2011; total spawning biomass was estimated at 622,000 t in 2011 at a rough estimate of 100 kg/individual, this would produce an order of magnitude of 4.5 m spawning females, or 6.2 m total spawners 	Lower estimate, very approximate, 6 million individuals (entire Pacific population)
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. <ul style="list-style-type: none"> available population model shows recent population increase 	No formal PVA but available population model suggests low probability
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Threats (actual or imminent, to populations or habitats)

Catch in fisheries, principally commercial longline fisheries; some recent improvements to management have reduced mortality rates
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Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	Single population of which individuals in Canada are part
Is immigration known or possible?	Known
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Yes

Data Sensitive Species

Is this a data sensitive species?	No
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Status History

Species considered in April 2006 and placed in the Data Deficient category. Status re-examined and designated Not at Risk in November 2016.

Status and Reasons for Designation:

Status: Not at Risk	Alpha-numeric code: Not applicable
Reasons for designation: This species is productive, relative to other pelagic shark species. The species has a single highly migratory population in the North Pacific, of which a portion is present in Canadian waters seasonally. Fishery-dependent abundance indices from smaller areas show various trends from the mid-1970s to 2013. A population assessment that integrates these indices suggests abundance has recently increased. There are no significant threats to this species in Canadian waters.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criteria, population stable or increasing.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criteria, EOO and IAO exceed limits.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criteria, population size exceeds limits.
Criterion D (Very Small or Restricted Population): Does not meet criteria.
Criterion E (Quantitative Analysis): Not done.

PREFACE

There has been a substantial increase in knowledge of Blue Shark since the previous COSEWIC (2006) assessment. New compilations of tagging data in the North Atlantic and North Pacific have elucidated movements and population structuring at the ocean basin level, and a genetic study has confirmed a single population in the North Pacific. Popup satellite archival (PSA) tag studies have provided information on habitat use, movements, and post-release mortality. New estimates of mortality rates of caught and discarded individuals have been produced. In both Atlantic and Pacific basins, population assessments have been conducted, using data from most fisheries taking the species and several modelling approaches. For both Atlantic and Pacific Canada, catch data have been compiled in some detail; for the former (where catches are higher), estimates of mortality incorporating both catch data and discard survival have been produced.

There has been no listing decision since the 2006 COSEWIC status recommendation.



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 (2016)

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
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Canada

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

COSEWIC Status Report

on the

Blue Shark *Prionace glauca*

North Atlantic population
North Pacific population

in Canada

2016

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Blue Shark, *Prionace glauca* (Linnaeus, 1758), the only species in the genus *Prionace*, belongs to the family Carcharhinidae or requiem sharks (Compagno 1984). The family has 12 genera and 48 species. Blue Shark is the only species of this family regularly found in temperate waters, the others being largely restricted to tropical environments. In French this species is called *Requin bleu*.

Morphological Description

The Blue Shark is recognized by its distinctive colouration. The dorsal region is a vibrant dark blue, the sides bright blue, the belly abruptly white (Nakano and Stevens 2008). The body is long and slender, reaching 3.8 m in length, with the most obvious anatomical features being a long pointed snout and long sickle-shaped pectoral fins (Mecklenburg *et al.* 2002) (Figure 1). The caudal fin bears the distinctive notch of the requiem sharks just below the end of the upper lobe. The eyes are large with a nictitating lower eyelid (i.e., able to open and close). There are five moderate-sized gill openings with the middle one the largest and the last two positioned over the pectoral fin. Tooth appearance differs between jaws: on the upper jaw, teeth are triangular with finely serrated edges, and curve backwards, while on the lower jaw they are smooth-edged, dagger-like, and straight (Compagno *et al.* 2005).

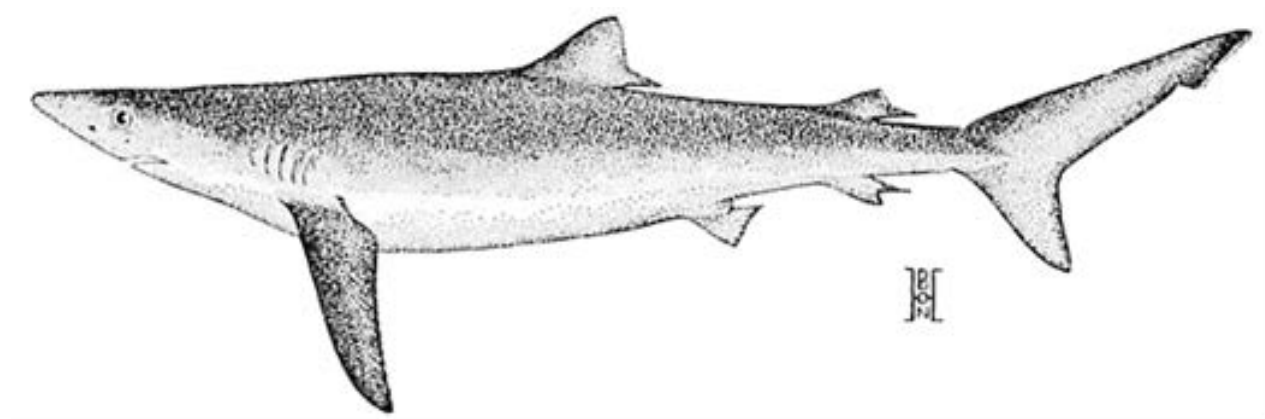


Figure 1. Blue Shark, *Prionace glauca*. Source: Hart (1973).

Population Spatial Structure and Variability

Atlantic

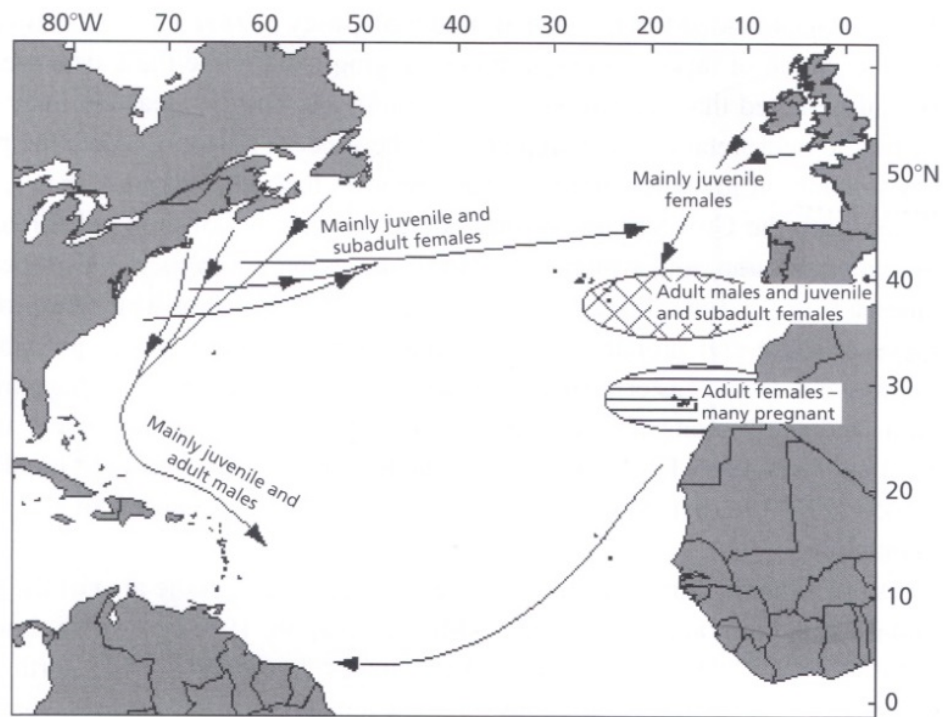
Blue Shark are the best-studied oceanic shark species in terms of tagging, with well over 100,000 tags applied in Canada, the USA, Ireland, the Azores, the Japanese pelagic longline fleet, and other countries (Kohler and Turner 2008; ICCAT¹ 2009). Long-distance movements are well documented. For sharks tagged off the USA, movements to the eastern North Atlantic were common, with average movement between point of tagging and point of retrieval 857 km, and average time at liberty 0.9 yr (Kohler and Turner 2008). Few sharks tagged and released in the North Atlantic have been recovered in the South Atlantic (ICCAT 2009). Kohler and Turner (2008) note that, of all the many individuals tagged and recaptured, only five individuals have been recorded as moving from the North to South Atlantic. Based on the tagging studies, Blue Shark in the North Atlantic is considered a single population (Kohler and Turner 2008; ICCAT 2009).

Within the single North Atlantic population there is considerable spatial substructure related to age, sex and maturity stage (Figure 2) (Nakano and Stevens 2008). Juveniles of both sexes, subadult females and adult males predominate in the western North Atlantic, where mature females are rare. Adult females, many pregnant, are found in the area of the Canary Islands and the west African coast at around 27-32° N. Mating occurs around 32-35° N in spring and summer. Juveniles remain in nursery areas which cover large parts of the North Atlantic, and do not undertake the extensive adult migrations until reaching lengths of 130 cm. While the patchy nature of the observations, in particular the tagging sites, introduces some uncertainty into these findings, recent studies confirm the general picture (e.g., Vandeperre *et al.* 2014).

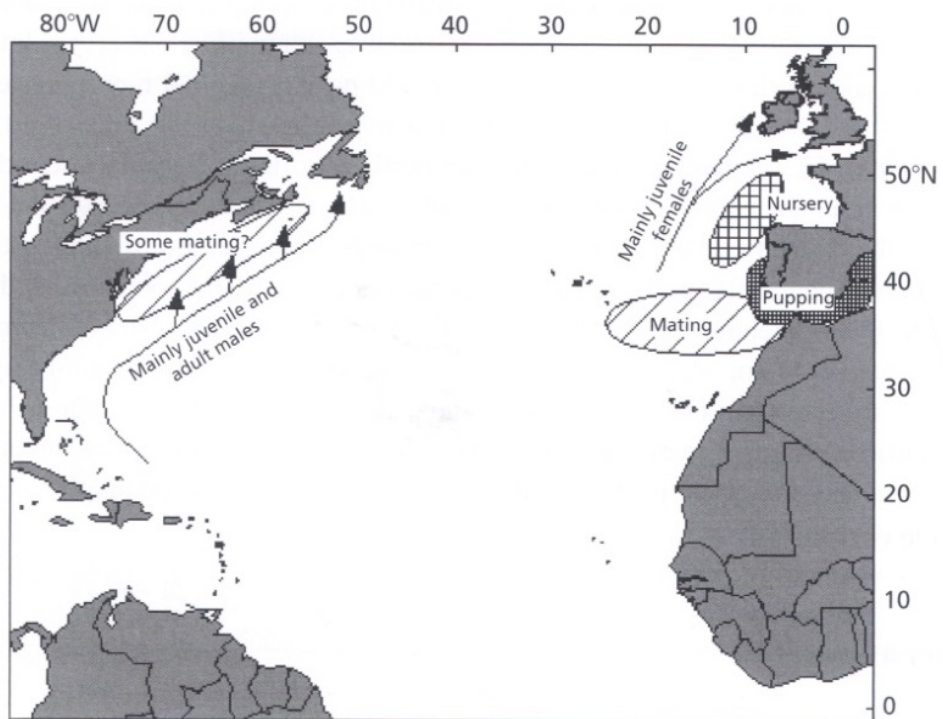
Pacific

Blue Shark has a pan-Pacific distribution. King *et al.* (2015), based on a survey of nuclear genetic diversity at microsatellite loci covering locations throughout the North Pacific distribution of Blue Shark, concluded that there is a single population of Blue Shark in the North Pacific. Extensive tagging in the eastern, central and western North Pacific indicates that this species undertakes wide movement throughout the North Pacific, but no tagging data have yet demonstrated movement across the equator, based on 31,954 individuals tagged and 489 recaptures since the 1970s (Sippel *et al.* 2011). Overall, available information indicates a single population in the North Pacific, distinct from individuals in the South Pacific.

¹ ICCAT = International Commission for the Conservation of Atlantic Tunas.



(a)



(b)

Figure 2. Blue Shark population substructure for (a) autumn-winter and (b) spring-summer. Source: Nakano and Stevens (2008).

In the North Pacific, the population is spatially structured by sex and maturity stage (ISC¹ 2014). The smallest males and females (<50 cm pre-caudal length) co-occur on parturition grounds between approximately 35 and 40° N. Subadult males and females (100-150 cm pre-caudal length) are found at 30-40°N and 35-50° N respectively, while larger subadults and adults occur further south, with mating thought to occur at 20-30° N.

Designatable Units

Based on tagging results summarized by Kohler and Turner (2008) and ICCAT (2009), a single designatable unit is proposed for Blue Shark in Atlantic Canada. Individuals in Canada would be part of the larger North Atlantic population.

Based on the tagging results summarized by ISC (2014) and the genetic work of King *et al.* (2015), a single designatable unit is proposed for Blue Shark in Pacific Canada. Individuals in Canada would be part of the single North Pacific population.

Considering COSEWIC's criteria for designatable units, there is ample evidence for "discreteness" of the two proposed designatable units based on discreteness and geographic separation at the ocean basin scale. The criterion of "significance" is also met for the proposed Pacific designatable unit, where a study of microsatellite diversity strongly supported the existence of a single population of Blue Shark in the North Pacific (King *et al.* (2015)).

Special Significance

Blue Shark is one of the most abundant and widespread shark species worldwide, and is undoubtedly a significant component of pelagic oceanic ecosystems throughout the tropical and temperate oceans. It is also among the most fecund and fast-growing shark species (Nakano and Stevens 2008). It is the only species of the large family Carcharhinidae (requiem sharks) regularly occurring in temperate as well as tropical waters.

Blue Shark has not been selected to go through the formal Aboriginal Traditional Knowledge gathering process of COSEWIC at this time (Jones pers. comm. 2014).

¹ ISC = International Scientific Committee for Tuna and Tuna-like species in the North Pacific Ocean

DISTRIBUTION

Global Range

Blue Shark is distributed worldwide in temperate and tropical oceans, primarily in surface waters and offshore (Figure 3). There is no evidence of either a reduction or expansion in the global range.

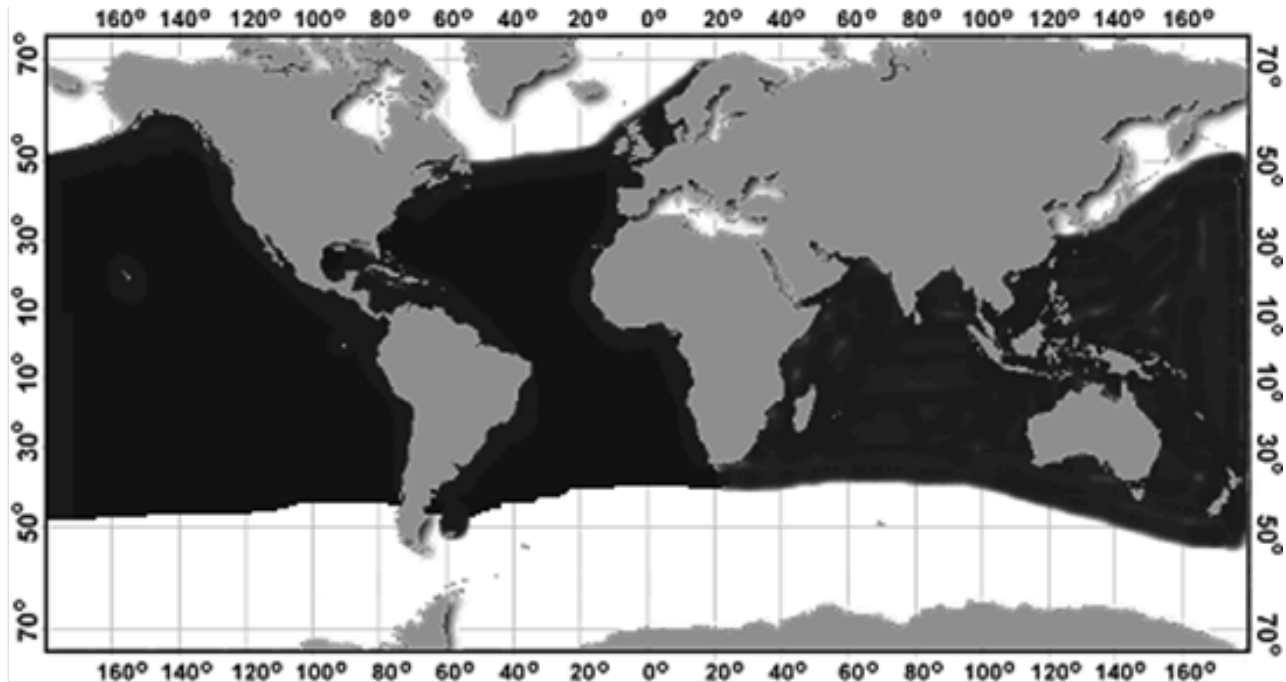


Figure 3. Global distribution of Blue Shark (Map source: FAO 2004).

Canadian Range

Atlantic

Based on the catch of Blue Shark by commercial pelagic longline fisheries and recreational fisheries, the range in Canada includes Gulf Stream-associated waters off Nova Scotia and Newfoundland (Figures 4, 5). They are also recorded on the Newfoundland shelf north to about latitude 49°N. The species has been recorded from the Gulf of St. Lawrence, including the west coast of Newfoundland (Campana *et al.* 2015; Cormier pers. comm. 2014; Mallet pers. comm. 2014) and on the Labrador Shelf (Figure 5).

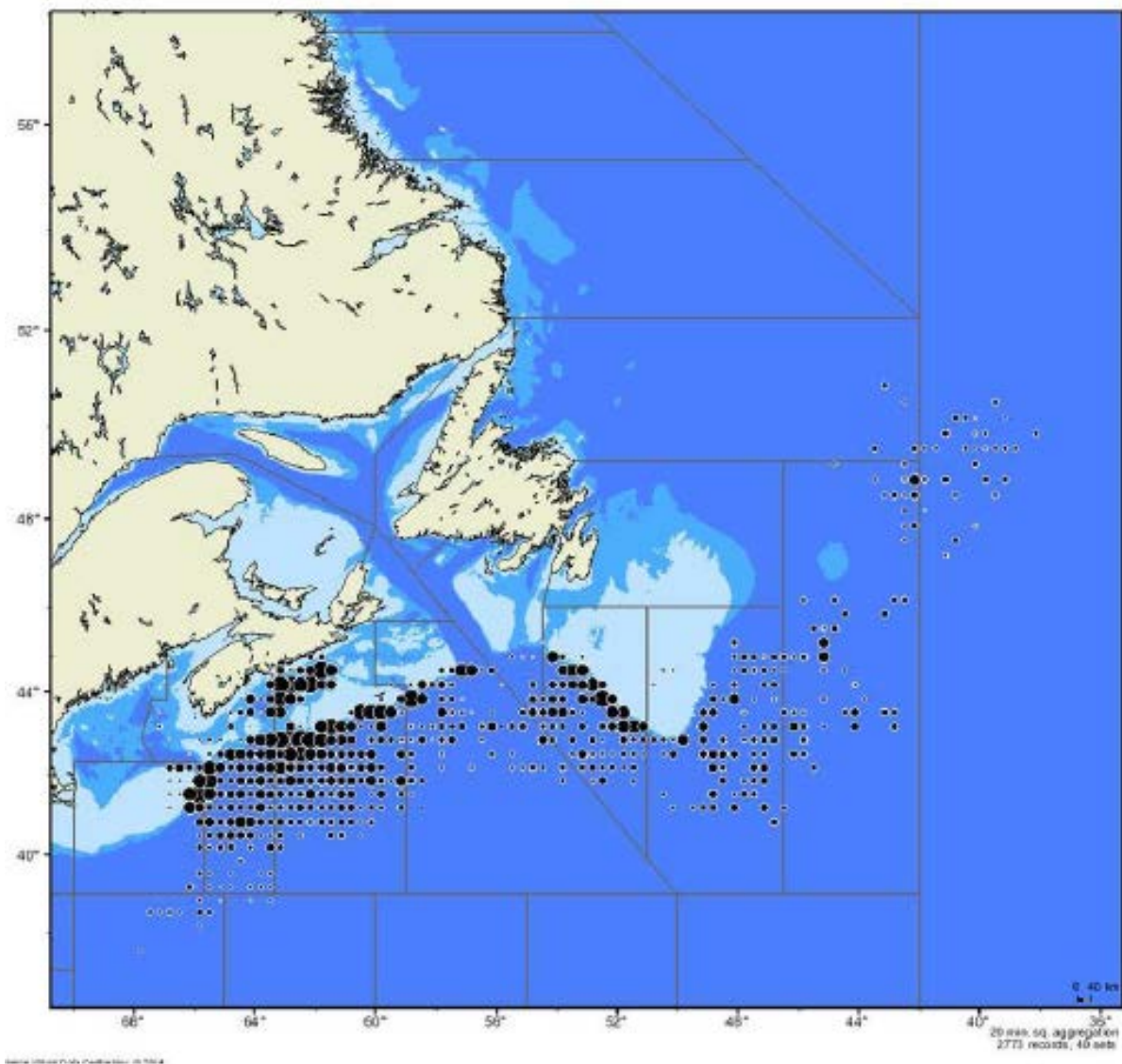


Figure 4. Blue Shark catch locations between 1998 and 2014 as recorded by Canadian at-sea fisheries observers on all commercial vessels. Source: Campana *et al.* (2015).

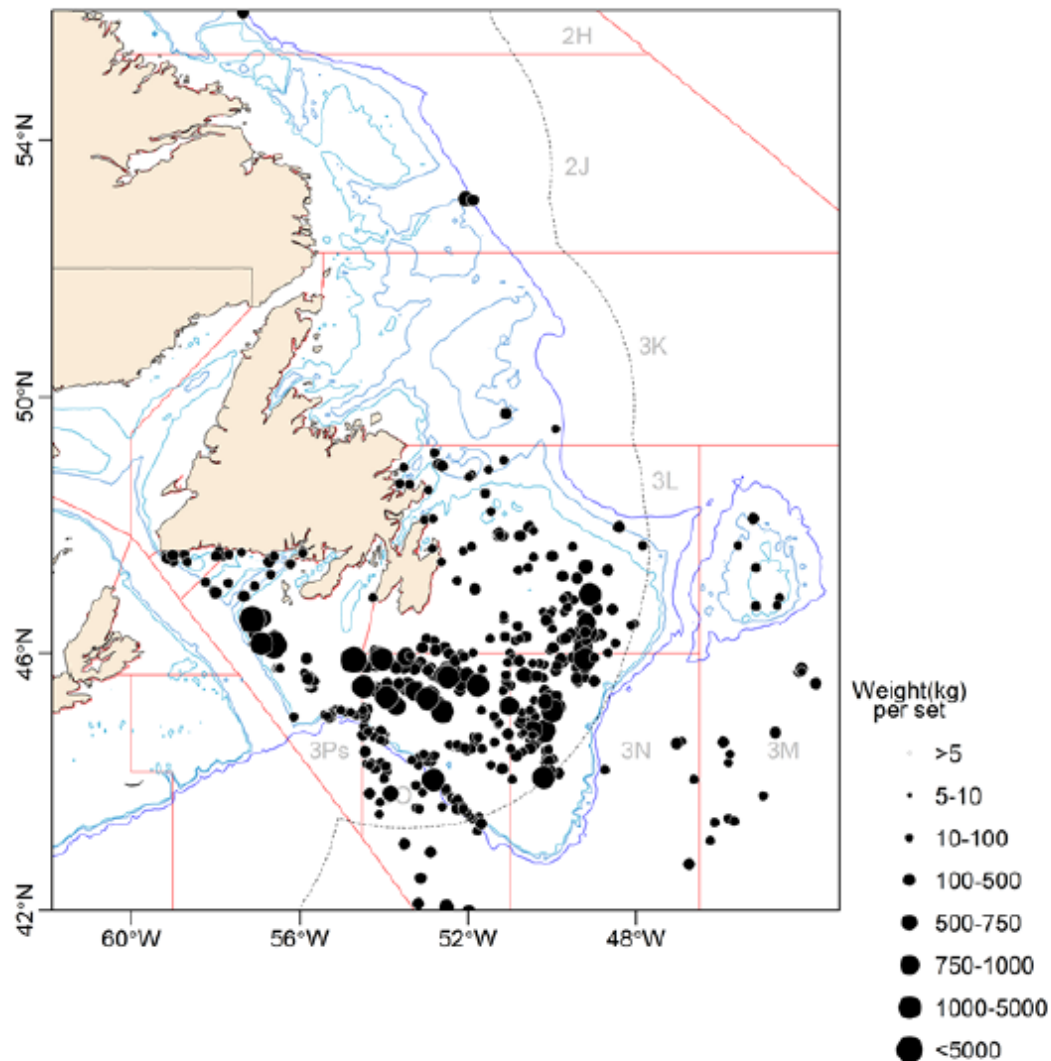


Figure 5. Observed Blue Shark catch locations between 1980 and 2012 as recorded by DFO Newfoundland and Labrador Region at-sea observers on all commercial vessels. Source: Campana *et al.* (2015).

Pacific

Blue Shark are caught in bottom longline fisheries in offshore areas of the Canadian Pacific continental shelf, and are also occasionally taken in inner shelf areas (Figure 6). As an oceanic pelagic species, their distribution extends from the continental shelf offshore beyond Canada's Exclusive Economic Zone (EEZ).

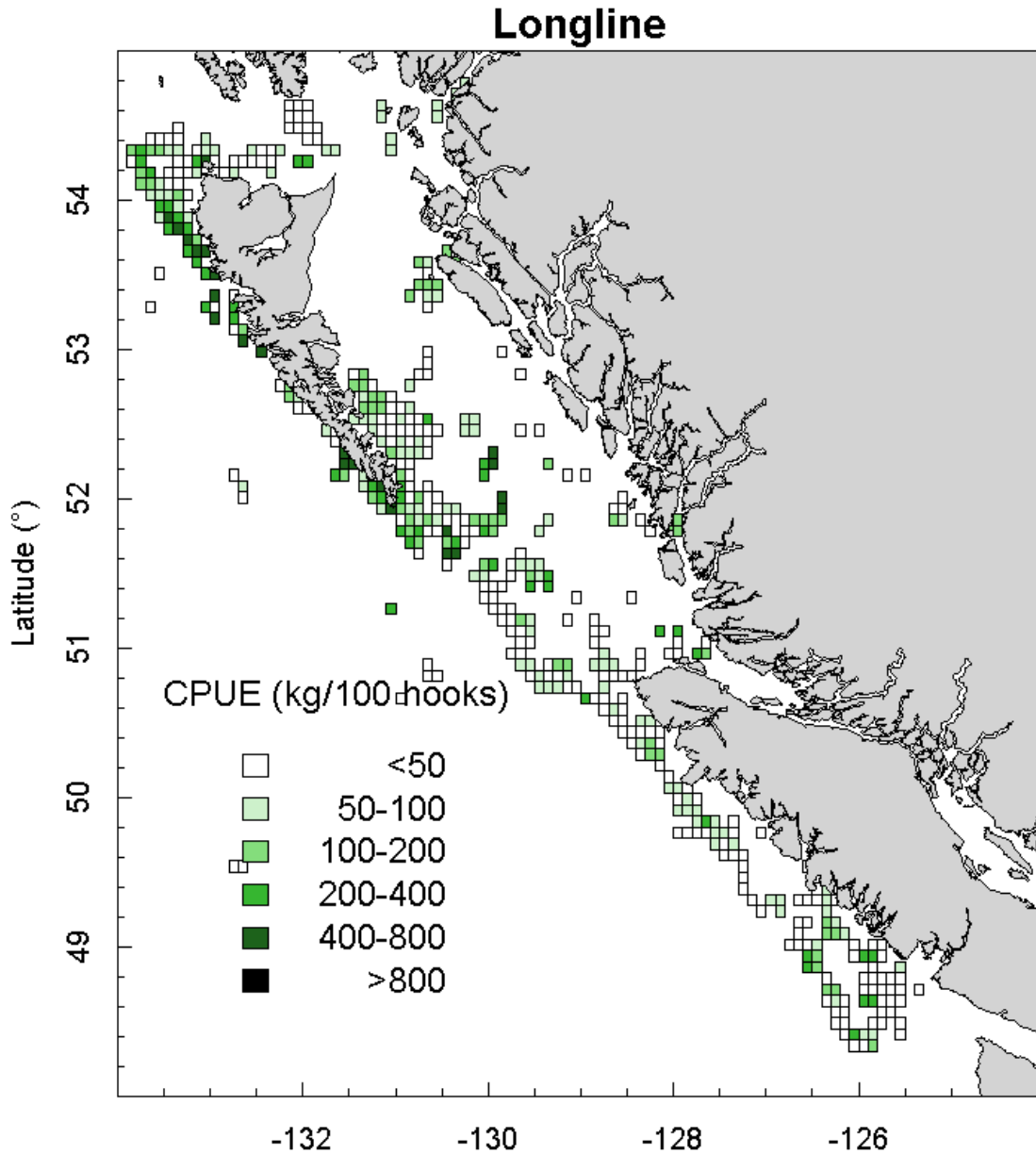


Figure 6. Mean catch per unit effort (kg per 100 hooks) of Blue Shark in the Canadian Pacific groundfish longline fishery from 1998-2010. Grid squares are 0.2° x 0.2°. Source: King 2011.

Williams *et al.* (2010) described a large aggregation of oceanic sharks consistently observed near the shelf break of Queen Charlotte Sound during three summers (2004-2006), of which a significant portion (15%) was Blue Shark (the dominant species, making up 63% of identified individuals, was Salmon Shark (*Lamna ditropis*)). Based on a total abundance estimate of around 10,000 individual sharks, around 1,500 Blue Shark would have been in this aggregation, an estimate biased low as it was based on counts at the surface.

Occurrence of Blue Shark varies seasonally in Canada's Pacific waters. The species is taken year-round in the groundfish trawl fishery, and from May to October in the groundfish longline fishery, with records in both fisheries concentrated in August and September (King 2011). No Blue Shark were observed in spring on the marine mammal surveys of Williams *et al.* (2010), the aggregation described above having been observed in July and August.

Extent of Occurrence and Area of Occupancy

In Atlantic Canada, extent of occurrence (EOO) is 900,420 km²; this calculation excludes occasional occurrences in the Gulf of St. Lawrence and on the Labrador Shelf. Index of area of occupancy (IAO) is greater than 2,000 km² (a threshold used in the quantitative criteria for status determination)

In Pacific Canada, extent of occurrence is 544,900 km². Index of area of occupancy is greater than 2,000 km².

Search Effort

Information on distribution of Blue Shark comes almost exclusively from fisheries. The species is taken as bycatch in a wide range of commercial fisheries and in recreational fisheries (see "**Threats**" Section). Fisheries which take the species are sufficiently intensive and widely distributed to provide an accurate general picture of distribution in Canada and worldwide.

HABITAT

Habitat Requirements

One of the most wide-ranging of all sharks, Blue Shark are distributed in oceanic pelagic and continental shelf pelagic habitats (Nakano and Stevens 2008). They range from the surface to at least 600 m depth and may occur close inshore (Nakano and Stevens 2008), although rarely where depth is less than 50 m (Campana *et al.* 2015). The species prefers temperatures of 12-20°C.

Blue Sharks off Atlantic Canada show a seasonal change in habitat use, based on information from 23 individuals with popup satellite archival tags in 2003-2007. Individuals remain in near-surface waters for most of the summer and fall, moving into deeper waters (mainly 100-300 m) near the end of November. In deep Gulf Stream waters off Atlantic Canada, the species showed a striking diel migration, from a mean night-time depth of 74 m to a mean daytime depth of 412 m, as sharks pursued vertically migrating squid and fish prey (Campana *et al.* 2011). Similarly extensive diel vertical movements were described by Musyl *et al.* (2011) in the central Pacific.

BIOLOGY

Life Cycle and Reproduction

Brood size in Blue Shark ranges from 4 to 135 young (Snelson *et al.* 2008) with a mean of around 30 (Nakano and Stevens 2008), relatively high among pelagic sharks. Birth size is usually 35-50 cm total length (Nakano and Stevens 2008). Reproduction is seasonal in most areas, with most young born in spring and summer, although parturition may be extended (Nakano and Stevens 2008). Gestation lasts 9-12 months. There is some evidence to suggest that females breed annually (Snelson *et al.* 2008) but breeding every two years, as in other pelagic sharks, may be the norm (Nakano and Stevens 2008).

Blue Shark have been aged using vertebral rings, but age estimates have not been validated (Nakano and Stevens 2008). Based on age and growth studies in the North and South Atlantic and in the North Pacific, Nakano and Stevens (2008) concluded that longevity of this species was about 20 years, while ICCAT (2009, their Table 1) provides an estimate of 15 years and ISC (2014, their Table 4) 30 years.

Table 1. 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 (2013).

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. (<i>Pteroplatytrygon violacea</i>)	0.230	0.181	0.279	6.2
Smooth Hammerhead (<i>Sphyrna zygaena</i>)	0.225	0.213	0.237	13.4
Tiger Shark (<i>Galeocerdo cuvier</i>)	0.190	0.180	0.200	15.6
Oceanic Whitetip Shark (<i>Carcharhinus longimanus</i>)	0.121	0.104	0.137	10.4
Scallop Hammerhead S. Atl. (<i>Sphyrna lewini</i>)	0.121	0.110	0.132	21.6
Thresher Shark (<i>Alopias vulpinus</i>)	0.121	0.099	0.143	11.0
Scallop Hammerhead N. Atl.	0.096	0.093	0.107	21.6
Silky Shark N. Atl. (<i>Carcharhinus falciformis</i>)	0.078	0.065	0.090	14.4

Stock	Productivity (r)	LCL	UCL	Generation time (yrs)
Great Hammerhead (<i>Sphyrna mokarran</i>)	0.070	0.069	0.071	27.1
Shortfin Mako (<i>Isurus oxyrinchus</i>)	0.058	0.049	0.068	25.0
Porbeagle Shark (<i>Lamna nasus</i>)	0.052	0.044	0.059	20.3
Pelagic Stingray S. Atl.	0.051	0.004	0.096	6.6
Dusky shark (<i>Carcharhinus obscurus</i>)	0.043	0.035	0.050	29.6
Silky Shark S. Atl.	0.042	0.029	0.054	16.5
Night Shark (<i>Carcharhinus signatus</i>)	0.041	0.028	0.053	14.9
Longfin Mako (<i>Isurus paucus</i>)	0.029	0.020	0.038	25.2
Sandbar Shark (<i>Carcharhinus plumbeus</i>)	0.010	0.005	0.024	21.8
Bigeye Thresher (<i>Alopias superciliosus</i>)	0.009	0.001	0.018	17.8

Studies in different ocean basins have found sizes at maturity as follows (Nakano and Stevens 2008): in the western Atlantic 218 cm total length for males, 221 cm for females; in the Gulf of Guinea 221 cm for females; in the North Pacific 200 cm for both sexes; in the South Pacific 229-235 cm for males and 205-229 cm for females.

Studies cited by Nakano and Stevens (2008) generally indicate maturation at 4-6 years for males and 5-7 years for females, while Snelson *et al.* (2008) summarize existing studies as providing a range of 6-7 years for both sexes.

Inferences from studies based on relationships between growth rate and/or longevity and mortality, give instantaneous mortality rates ranging from 0.07 to 0.48, with an overall mean of 0.23 (Campana *et al.* 2015). ISC (2014, their Table 4) estimated age-specific natural mortality over the lifespan of 30 years, with an average over ages of about 0.15. Using the relationship between lifespan and natural mortality of Hewitt and Hoenig (2005) ($M \approx 4.22/t_{\max}$, where t_{\max} is lifespan), natural mortality could range from 0.28 (at 15 yr lifespan) to 0.14 (at 30 yr lifespan). Available estimates converge around about 0.2, but uncertainty remains about both lifespan and natural mortality.

The best estimate of generation time, estimated as $G = t_{\text{mat}} + 1/M$ where t_{mat} is age at maturity (taken as 7 yr, at the higher end of range consistent with a precautionary approach) and M is natural mortality (taken as 0.2), is 12 yr. Generation time could range from 7 yr to 21 yr based on the ranges of female age at maturity and natural mortality provided above.

Blue Shark is the most productive of the species of pelagic sharks and rays assessed by ICCAT in the North and South Atlantic oceans (Table 1).

Physiology and Adaptability

Little has been published on physiology of this species. Based on field observations, the species prefers temperatures of 12-20°C (Nakano and Stevens 2008). Blue Shark is highly adaptable to a wide range of pelagic and shelf habitats, and is found both in tropical and temperate environments. The diel migration pattern observed in open oceanic waters may confer thermoregulatory advantages (Campana *et al.* 2015).

Dispersal and Migration

Blue Sharks are highly migratory, with complex movement patterns and population spatial structuring related to life cycle events and distribution of prey. Tagging studies are the primary source of information. Although many tags have been applied over the years, results of these studies are affected by the relatively restricted areas in which tags have been applied, and by the dependence on fishing for providing recaptures.

North Atlantic

Kohler and Turner (2008) summarized results of the US NMFS cooperative tagging program under which 91,450 Blue Sharks were tagged from 1962 to 2000. Overall recapture rate was 5.9%. Distances travelled ranged from 0 to 6,926 km with a mean of 857 km; 75% of sharks were recaptured less than 1,500 km from their tagging location. Times at liberty ranged from 1 day to 9.1 yr, with a mean of 0.9 yr. Transatlantic migrations were shown by 214 sharks (4.4% of 4,862 tagged) tagged in the western North Atlantic, and by 10 sharks (7.2% of 138 released) tagged in the eastern North Atlantic.

Sharks tagged off Atlantic Canada between 1971 and 2002 (916 individuals) were mostly recovered in the central and eastern Atlantic, as far away as Africa (Figure 7), and a similar pattern was shown in a more recent study (2321 individuals tagged since 2006) (Campana *et al.* 2015). Numerous individuals tagged off the northeast USA have been recaptured in Canadian fisheries (Campana *et al.* 2015).

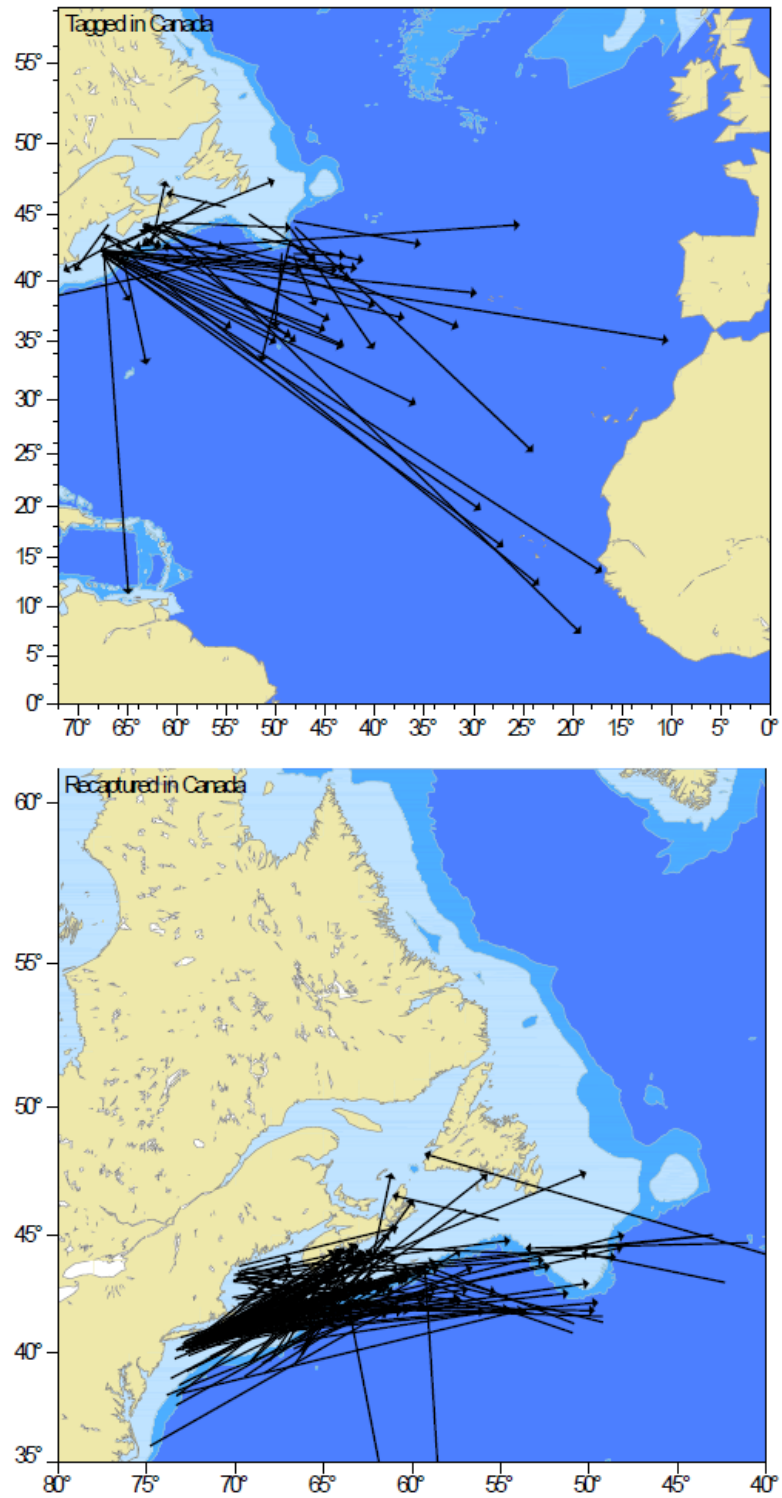


Figure 7. Blue Sharks tagged (upper panel) or recaptured (lower panel) between 1971 and 2002 in Canadian waters by the National Marine Fisheries Service (USA) tagging program. Arrowheads represent the points of recapture. Source: Campana *et al.* (2015).

A general summary of movements for the Atlantic population was provided by Kohler and Turner (2008). In the western North Atlantic, the winter range lies east of the Gulf Stream, including the Sargasso Sea, while in April and May, with warming of shelf waters, sharks move shoreward onto the shelf from North Carolina to Newfoundland. Mating occurs in this area, primarily during summer. In late summer and fall, sharks move south and offshore to areas off the southeastern USA, in the Caribbean, and in the central, eastern and southern North Atlantic. In the eastern North Atlantic similar movements are seen, with individuals found in summer as far north as Ireland and Scotland, the North Sea and outer areas of the Baltic. In the winter sharks are found near the Canary Islands. Small individuals (length 100-110 cm) remain in a more restricted area of the central Atlantic, and do not participate in the extensive north-south migrations. The picture remains incomplete due to the patchy distribution of tagging sites, and tagging effort has been much lower in the eastern than the western North Atlantic, but more recent studies (e.g., Vandeperre *et al.* 2014) confirm the general picture.

North Pacific

Nakano and Stevens (2008) proposed a general movement model based on Nakano (1994). Mating takes place in early summer at 20-30°N, and pregnant females migrate north to the parturition grounds by the next summer. Birth occurs in early summer in pupping grounds at 35-45°N. Males and females 2-5 years old occur on pupping grounds, with females found further north and males further south. The pupping and nursery areas are located in the “sub-Arctic boundary” (latitudes approximately 35° - 50° N) where there is high prey abundance, and juveniles remain in these areas for 5-6 yr. Adults are found mainly from equatorial waters to the south of the nursery grounds.

Nakano’s model predicts that most of the Blue Sharks in Canada’s Pacific waters would be subadult females. A study on Canada’s Pacific coast supported this hypothesis with 93% (n=134) of the observations being immature females (IEC Collaborative Marine Research and Development Limited 1992). Blue Shark tagging studies conducted by DFO offshore of Barkley Sound on the west coast of Vancouver Island in 2007 and 2010 found that 85% of 144 sharks captured in 2007 were subadult females, while 77% of 244 sharks captured in 2010 were subadult females (J. King, unpubl. data).

Interspecific Interactions

Markaida and Sosa-Nishikazi (2010) summarized all available studies of Blue Shark diet (34, including their own), concluding that a wide range of pelagic and benthic prey was consumed. The diet of individuals captured over deep waters was dominated by mesopelagic squid and octopus and bony fishes such as myctophids, while those caught on continental shelves fed on shelf fish species (cods and related species, mackerels, herring-like species) and shelf-dwelling squid and octopus. This pattern holds over a wide range of areas studied and suggests substantial plasticity in diet and in feeding habit. In Canada, Blue Sharks taken in recreational shark derbies were opportunistic predators, consuming a wide range of fish species (McCord and Campana 2003).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Information on abundance and trends for North Pacific and North Atlantic populations is available from within and from outside Canada. Because individuals in Canada are part of wider oceanic populations, information from other parts of the range is relevant for assessing status in Canada. For this reason, information from many parts of the population's range is provided in the sections below.

Almost all information on population trends comes from fishery catches rather than fishery-independent surveys. Fishery catch rates of Blue Shark are influenced by a wide range of factors including variation in overlap between fishery footprint and population distribution, population spatial structuring by sex and life history stage, environmental factors such as temperature, and mode/location/timing of operation of the specific fisheries from which catch data are derived. Thus, indices in specific areas may not represent the overall population well, and trends may differ between areas. The GLM (general linear model) approach has been used in a number of studies to attempt to correct some of these factors and model the “true” catch per unit effort (CPUE) trend.

North Atlantic

For Canadian waters, catch rates in recreational and commercial longline (directed for Swordfish (*Xiphias gladius*) or tunas) fisheries are available (Campana *et al.* 2015). Catch rate in the commercial Swordfish fishery, based on Canadian at-sea fisheries observer records, is available from 1995 to 2013 and has been modelled using the GLM approach (Campana *et al.* 2015). A time series (2001-2016) of estimated mean lengths of individuals discarded before being brought on board, from at-sea observers, is also available (Showell pers. comm. 2014).

Many catch rate indices from commercial fisheries in parts of the range have been published, covering different and sometimes limited periods of time (reviewed by Aires da Silva *et al.* 2008). In its recent population assessment, the International Commission for the Conservation of Atlantic Tunas (ICCAT) (2015a) used what were considered the most representative catch rate series: two from the Japanese longline fishery (1971-1993, 1994-2013); two from the US longline fishery (observer data 1992-2013, combined research survey and commercial fishery observer data 1957-2000); Portuguese longline fishery (1997-2013), Venezuelan longline fishery (1994-2013), Spanish longline fishery (1997-2013) and Chinese Taipei longline fishery (2004-2013) (Appendix 1).

ICCAT (2015a) applied two population modelling approaches to the data available – a Bayesian surplus production model, and a Stock Synthesis model. Accurate catch data were not available from all fleets and years and in these cases catches were estimated by various means. As part of this assessment, different combinations of input parameters were used to explore model results, and sensitivity of the models to variations in inputs was also explored.

North Pacific

For Canadian waters, two survey-based abundance indices are available: the annual demersal longline survey of the International Pacific Halibut Commission (IPHC) (Appendix 2), and the Pacific Halibut Management Association (PHMA)-DFO rockfish longline survey (Yamanaka *et al.* 2011) (Appendix 3). Catch per unit effort data are available from commercial fisheries (King 2011) but show large annual variations without trend so are not informative about population abundance trends.

For the North Pacific population as a whole, the International Scientific Committee for Tuna and Tuna-like species in the North Pacific Ocean (ISC) (2014) provides the most recent overall assessment of abundance and trends. Based on the best available information on species biology, and what are considered to be the most reliable fishery-based catch rate indices, this assessment used two population models (stock synthesis and surplus production) and considered many alternative formulations of these which took into account a wide range of uncertainties in the input data. Results of the reference cases (most likely formulations) showed similar trends for the two modelling approaches (ISC 2014).

Abundance, Fluctuations and Trends

North Atlantic

Canadian indices

Catch rate in the Canadian recreational fishery is not considered a useful abundance indicator, because large sharks are targeted and few records of small released sharks are maintained (Campana *et al.* 2015).

Catch rate in the Canadian commercial Swordfish longline fishery, based on observer records from 1995 to 2013, shows no significant trend and large annual variations from 2001 to 2013 (Figure 8) (Campana *et al.* 2015). Year to year variability was too large to be attributed to changes in population abundance, and was more likely due to annual variations in availability related to oceanographic conditions, to the relatively low level of observer coverage (ca. 5%), or to both. As such this index is not considered a valid measure of population abundance (Campana *et al.* 2015).

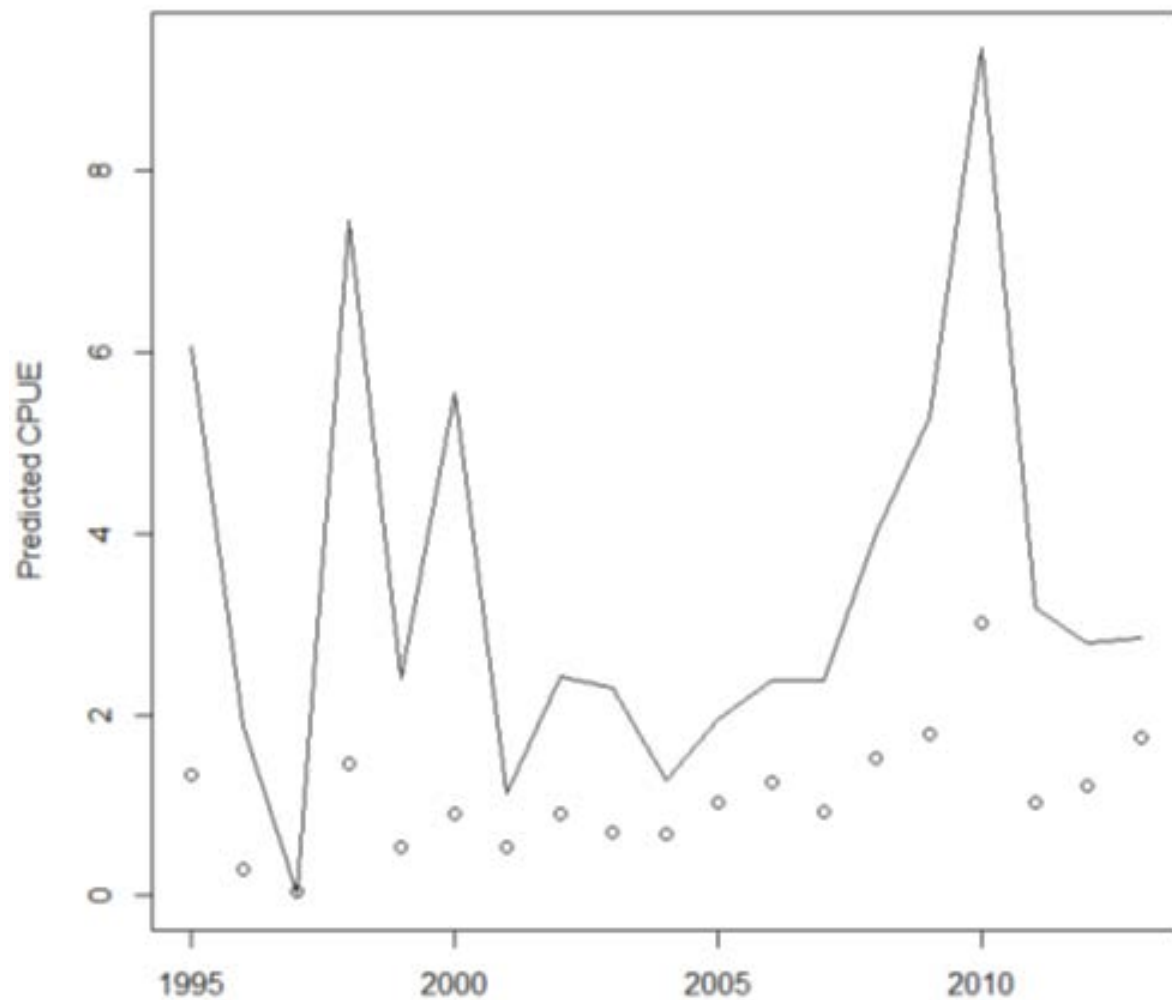


Figure 8. Catch per unit effort of Blue Shark (kg/hook) in the Canadian commercial Swordfish fishery, from Maritime at-sea observer data on June-October sets. Circles are observed values, line represents GLM predicted (modelled) values. Source: Campana *et al.* (2015).

Lengths of individuals discarded from Canadian longline fisheries have shown no significant trend over the period 2001-2016 (Figure 9). COSEWIC (2006) had noted a substantial decrease in mean length of Blue Sharks taken in longline fisheries over a period of 10 years, and had considered this a possible indication of population decline.

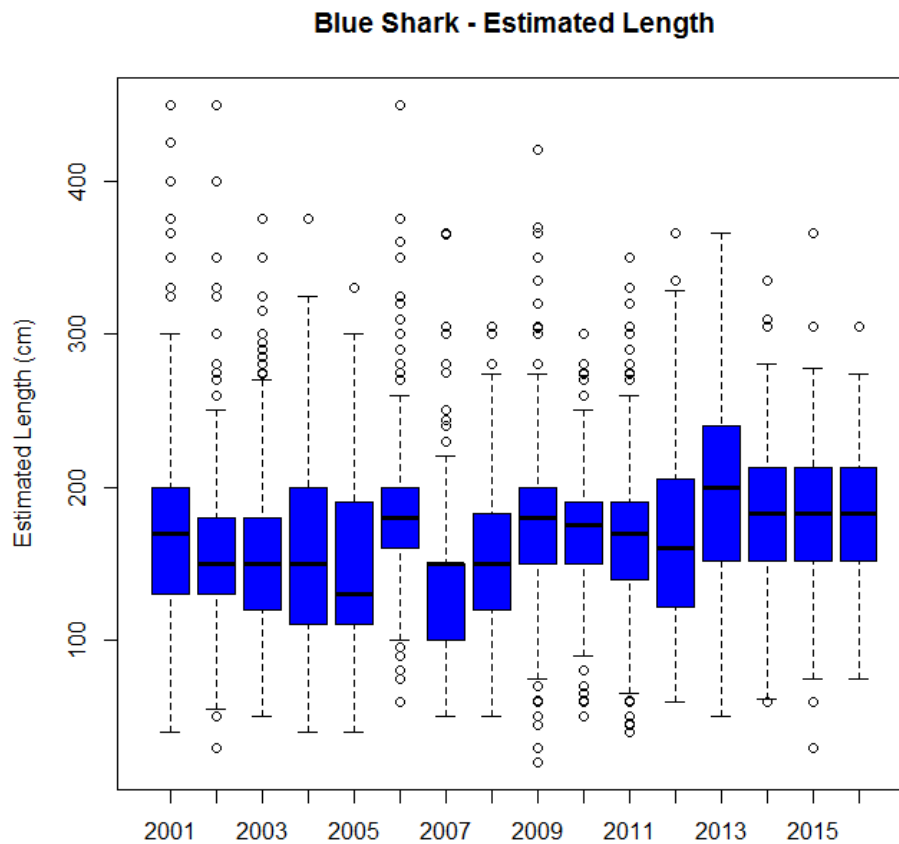


Figure 9. Mean lengths as estimated by observers for blue sharks discarded before being brought on board. Source: M. Showell, pers. comm.

North Atlantic indices

The catch rate series reviewed by Aires da Silva *et al.* (2008) showed a range of trends, varying with area, fishery and period. Overall no significant overall trend was evident, although there were significant declines in some areas, notably the northwest Atlantic.

ICCAT (2015a) presented eight catch rate series in a single figure facilitating comparison (Figure 10), which are considered to best summarize currently available catch rate information. The indices show considerable year-to-year fluctuation and some quasi-cyclical variations, but no overall trend over the total time series. In the most recent years (late 1990s to 2013), two series (Chinese Taipei, Venezuela) might be interpreted as showing a decline, while two others (Portugal, Spain) show an increase. Substantial declines in two indices from the northwest Atlantic (US research/commercial mid-1970s to 1980s; US observer late 1990s to early 2000s) were followed by increases such that there appears to be no long-term trend in the series.

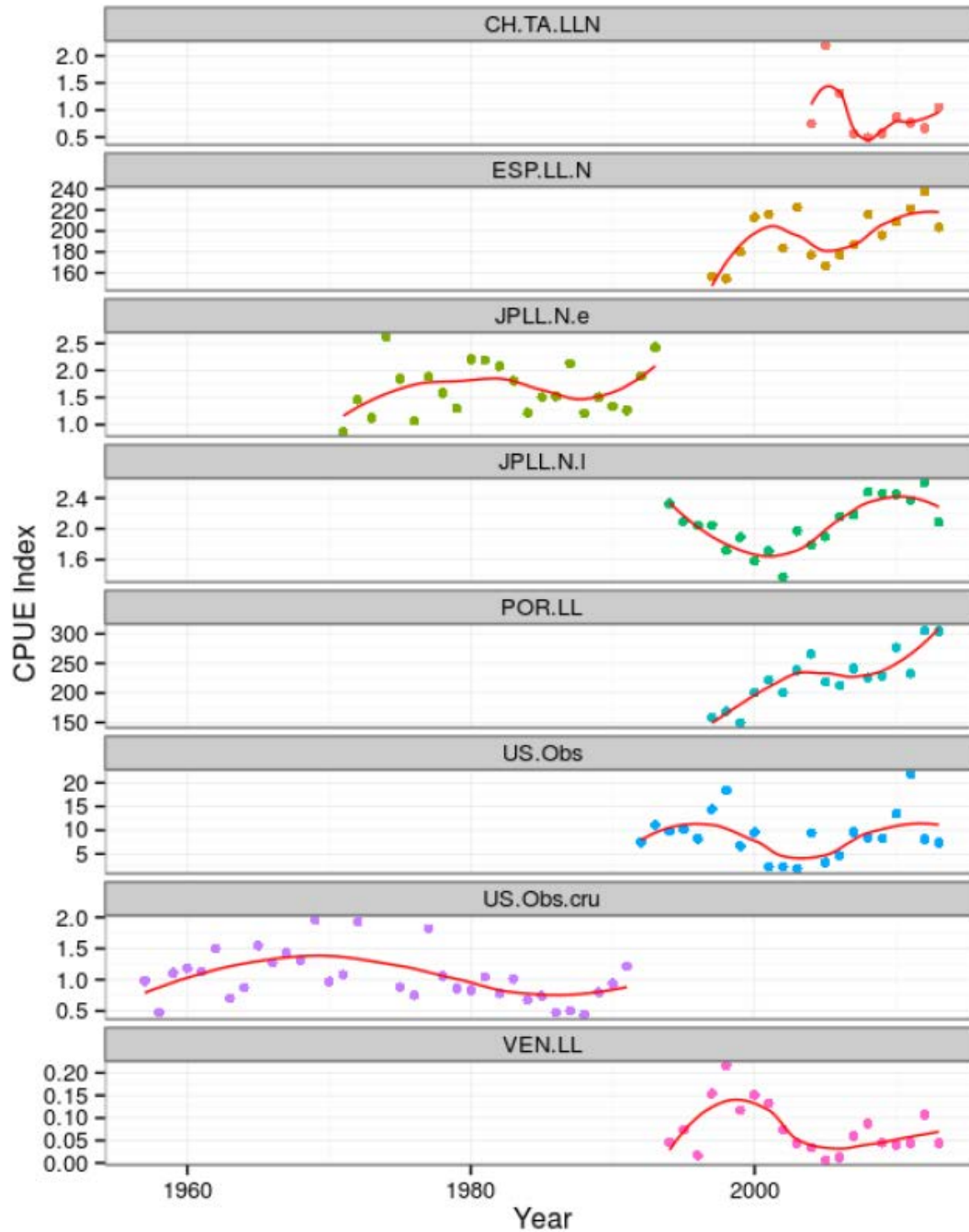


Figure 10. Catch per unit effort (CPUE) series used by ICCAT (2015a). Points are standardized values; lines are lowess smoothed. Series are as follows: CH.TA.LLN, Chinese Taipei longline fishery; ESP.LL.N, Spanish longline fishery; JPLL.N.e, Japanese longline fishery, early series; JPLL.N.l, Japanese longline fishery, late series; POR.LL, Portuguese longline fishery; US.Obs, US longline fishery, observer data; US Obs.cru, combined research survey/longline fishery data; VEN.LL, Venezuelan longline fishery.

North Atlantic population assessment

The Bayesian surplus production model consistently estimated biomass to be near carrying capacity (that is, near the unfished level), with little trend over the time series, and low fishing mortality rates (Figure 11) (ICCAT 2015a). It was also observed that the production models had difficulty fitting the flat or increasing trends in the CPUE series combined with increasing catches (ICCAT 2015a).

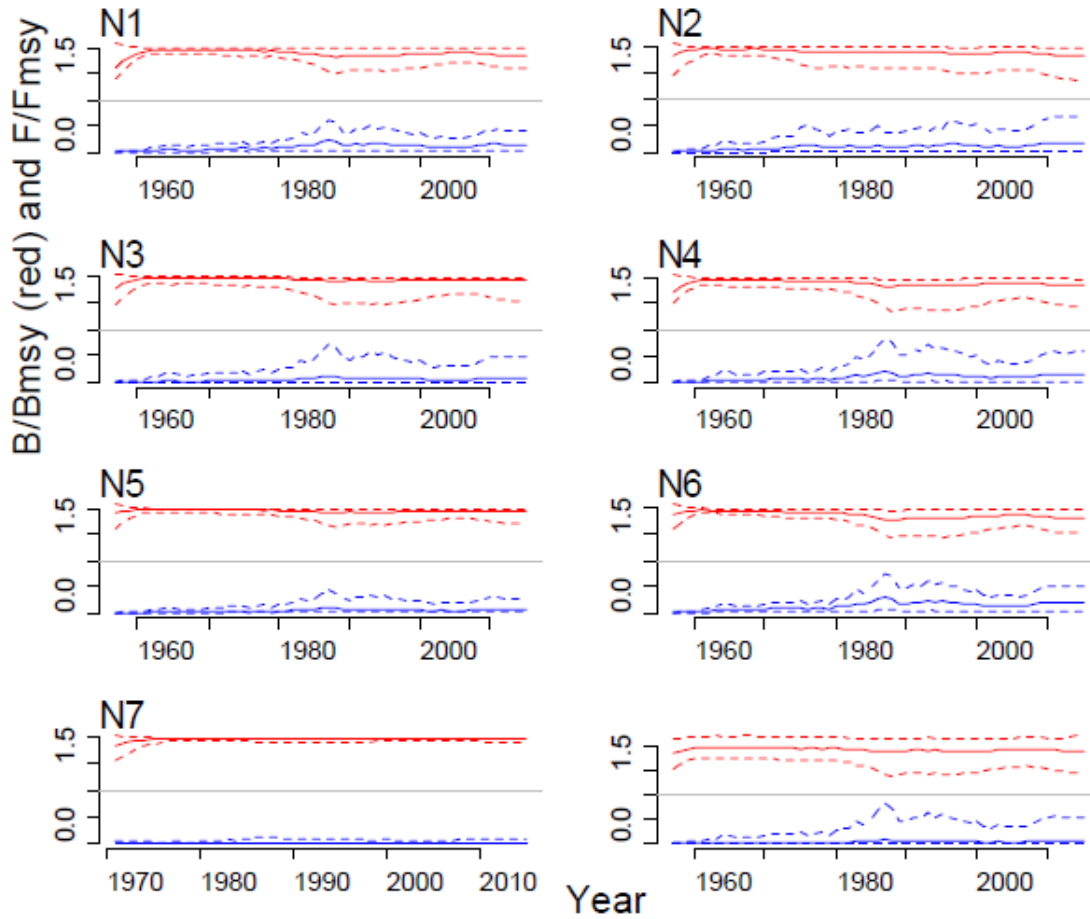


Figure 11. Ratio of estimated biomass to MSY level (upper solid lines, red) and of fishing mortality to MSY level (lower solid lines, blue), with confidence intervals (dashed lines). Panels N1-N8 (N8 is bottom right panel) show results from different runs of the Bayesian Surplus Production model of ICCAT (2015a).

Two runs of the Stock Synthesis model (runs 4 and 6) were considered to best fit the data, with run 6 best of the two (ICCAT 2015a). Run 6 showed a biomass decline of about 65% from the early 1980s to the mid-1990s, with a relatively constant value near the MSY¹ level subsequently, while Run 4 indicated relatively stable biomass, above the MSY level, over the time series (1970-2013) (Figure 12). For Run 6, fishing mortality was at or above the MSY level from 1986-1998 but below this level in earlier and later periods, while for run 4 fishing mortality was substantially below the FMSY level throughout the time series (Figure 13).

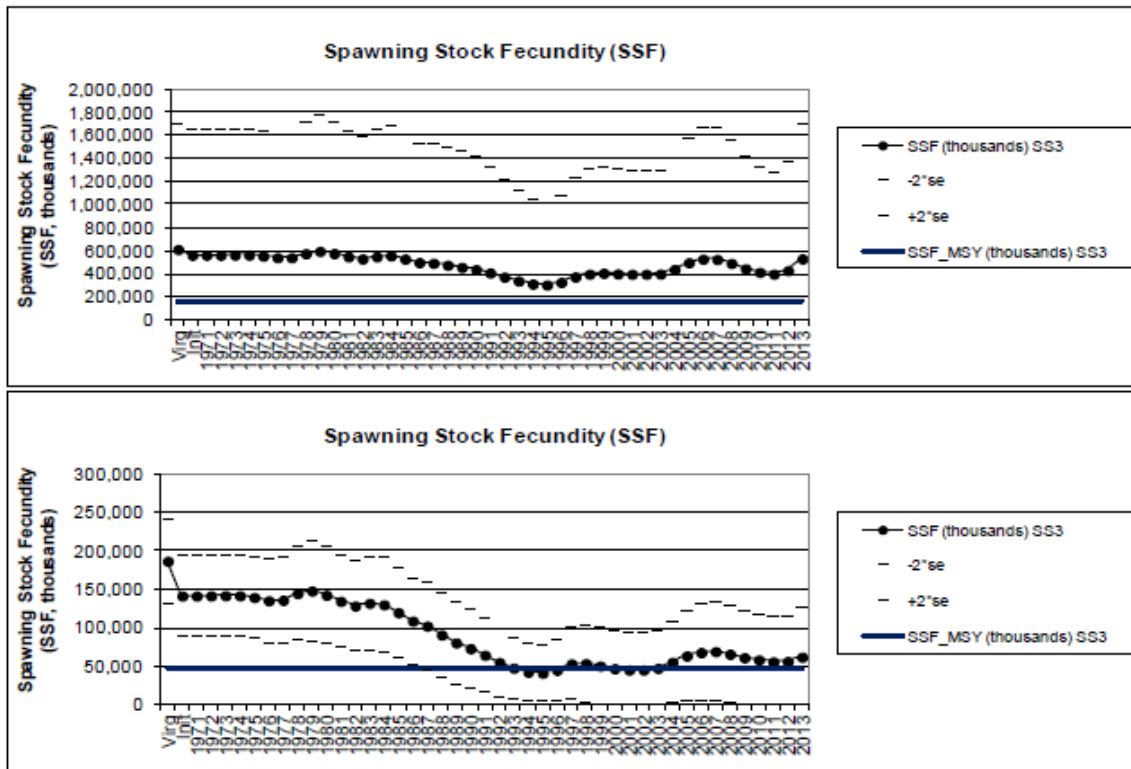


Figure 12. Spawning stock size (given as spawning stock fecundity) from two runs of the Stock Synthesis model of ICCAT (2015a) (Run 4 above, Run 6 below), with approximate 95% asymptotic standard errors. Solid horizontal line is MSY level.

¹ MSY level = population size or fishing mortality which produces Maximum Sustainable Yield. A common reference level in fisheries management, indicating a “desirable” or sustainably productive level of an exploited population.

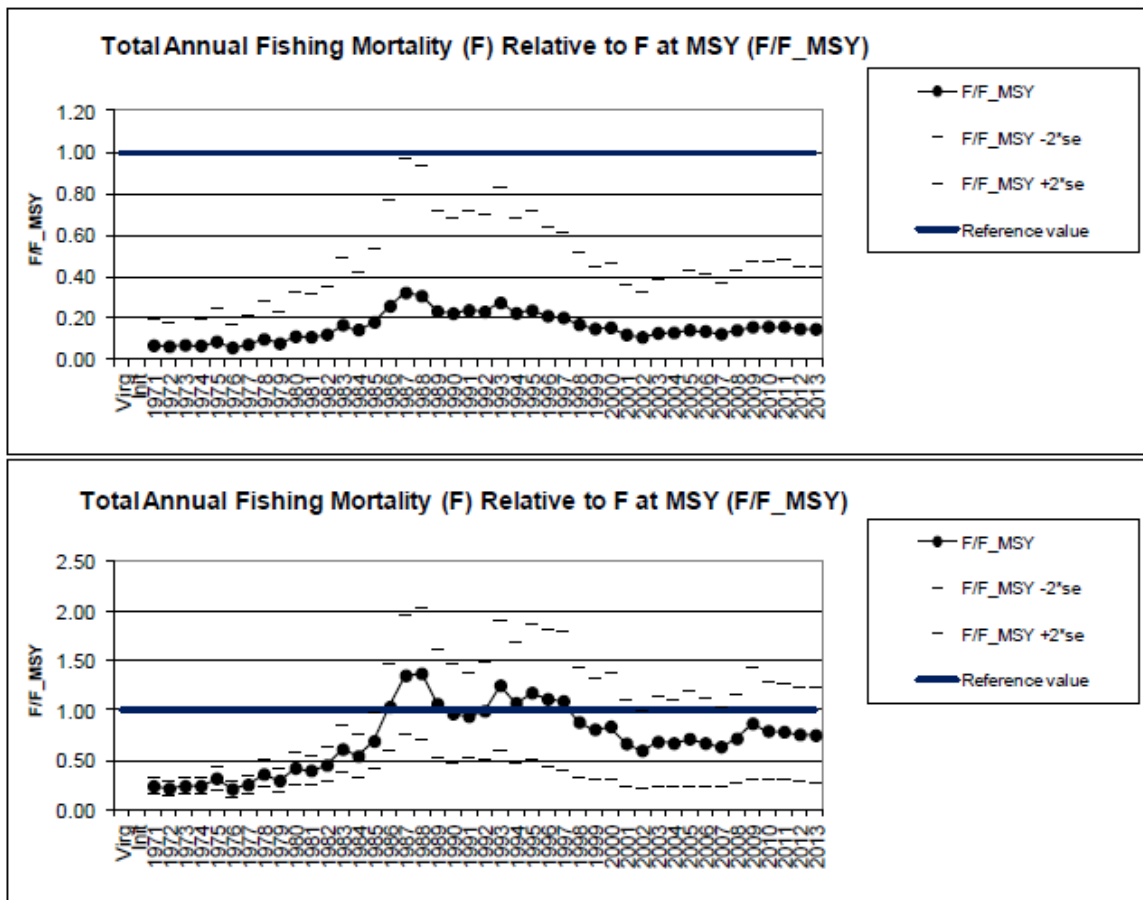


Figure 13. Estimated total annual fishing mortality for all fleets combined from two runs of the Stock Synthesis model of ICCAT (2015a) (Run 4 above, Run 6 below). Solid horizontal line is the MSY level.

ICCAT (2015b) concluded that “assessment results are uncertain... and should be interpreted with caution”. Results from the two models generally indicated that the stock was not overfished (that is, current abundance was above the MSY level) and that overfishing was not occurring (that is, fishing mortality was below the MSY level), but due to uncertainties in data inputs and model structural assumptions, the possibility of the stock being overfished and overfishing occurring could not be ruled out. These results were consistent with those of an earlier (ICCAT 2009) assessment.

ICCAT (2015a) was unable to estimate actual level of abundance for North Atlantic Blue Shark. Estimates of absolute abundance varied by an order of magnitude between models (ICCAT 2015b).

North Atlantic - Summary

Available abundance indices from the different parts of the range do not show consistent trends, and quality or source of information limits interpretation of the information in terms of population trends. Logbook information is based on fisher records (which do not include discards), observer information covers a small proportion of fisheries, and catch data are uncertain, especially in early parts of some time series. Fluctuations in some series are inconsistent with plausible population fluctuations, so must reflect other factors such as catch data quality, environmental influences, changes in fishing practices, or interaction between distribution of fishing and distribution of the population.

Recognizing these caveats, although there have been declines in abundance indices in some areas and at some times, there appears to be no overall trend in the indices.

Results of the population assessment (ICCAT 2015a) suggest that the population is not overfished and that overfishing is not occurring. Depending on model inputs, the population may have experienced a decline during the 1980s and 1990s and subsequent stability, or stability throughout the 1970-2013 time series. The results can be considered to be uncertain.

North Pacific

Canadian indices

Blue Sharks were rare in the IPHC survey in most years, and pattern of occurrence was irregular over the 16-year time series (Appendix 2). Percentage of positive sets ranged from 0% (2 years) to 26.2% (in a single year), with less than 5% of sets showing Blue Sharks in most years. Mean number of individuals per set ranged from 0 to 0.68, with less than 0.05 individuals/set in most years. The low level of catch, and the highly variable annual values, indicate that this index does not represent population abundance well.

Blue Sharks were also rare in the PHMA surveys (2006-2014) (Appendix 3). Percentage of positive sets ranged from 0 to 8.12, while catch per 100 hooks was always below 0.02. CPUE generally increased from 2006 to 2012 but no Blue Sharks were taken in 2014. Catch in 2015 (North) was 12 individuals.

North Pacific indices

For the North Pacific population, two abundance indices from the Japanese longline fishery were considered most representative of population abundance trends by ISC (2014), because of broad spatial and temporal coverage, high proportion of total catch represented, and good statistical performance (diagnostics from standardizations were acceptable). The 1976-1993 Japanese longline CPUE “early” index showed a decline to the late 1980s followed by an increase to the early 1990s; subsequently the “late” index showed a continued increase to the early 2000s followed by a decline (Figure 14). Other abundance indices available for smaller parts of the fishery range, and for shorter and later parts of the time frame, showed considerable variability although the “SPC” index showed a sustained decline from the late 1990s to 2009 (Figure 14).

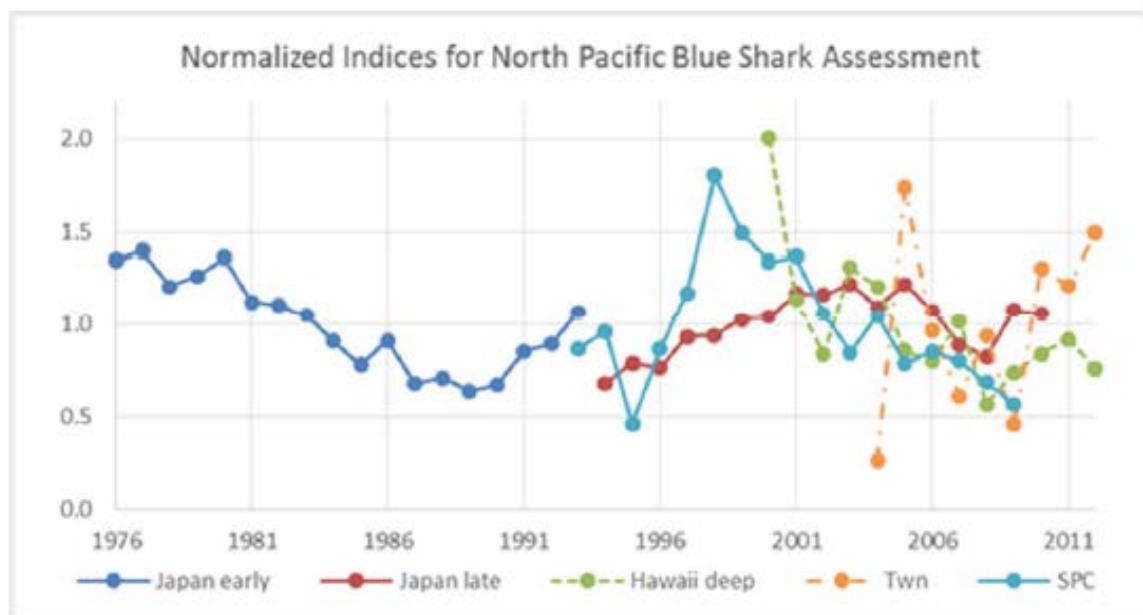


Figure 14. Standardized catch per unit effort series used as abundance indices by ISC (2014). Japan early: Japanese longline fishery 1976-1993; Japan late: Japanese longline fishery 1994-2010; Hawaii deep: Hawaii deep-set longline fishery 2000-2012; Twn: Taiwanese longline fishery 2004-2012; SPC: South Pacific Community members combined longline fisheries 1993-2009.

North Pacific population assessment

The two population models used by ISC (2014) showed that stock biomass was near a time-series high in 1971, fell to its lowest level between the late 1980s and early 1990s, and subsequently increased gradually, levelling off at a biomass level similar to that at the beginning of the time-series (Figures 14, 15). Stock biomass was estimated at 622,000 t in 2011 by the surplus production model, while female spawning stock biomass in the same year was estimated at 449,930 t by the stock synthesis model. Stock biomass in 2011 was 65% higher than the MSY level for the surplus production model (Figure 15), while female spawning biomass was 62% higher than the MSY level for the stock synthesis model (Figure 16).

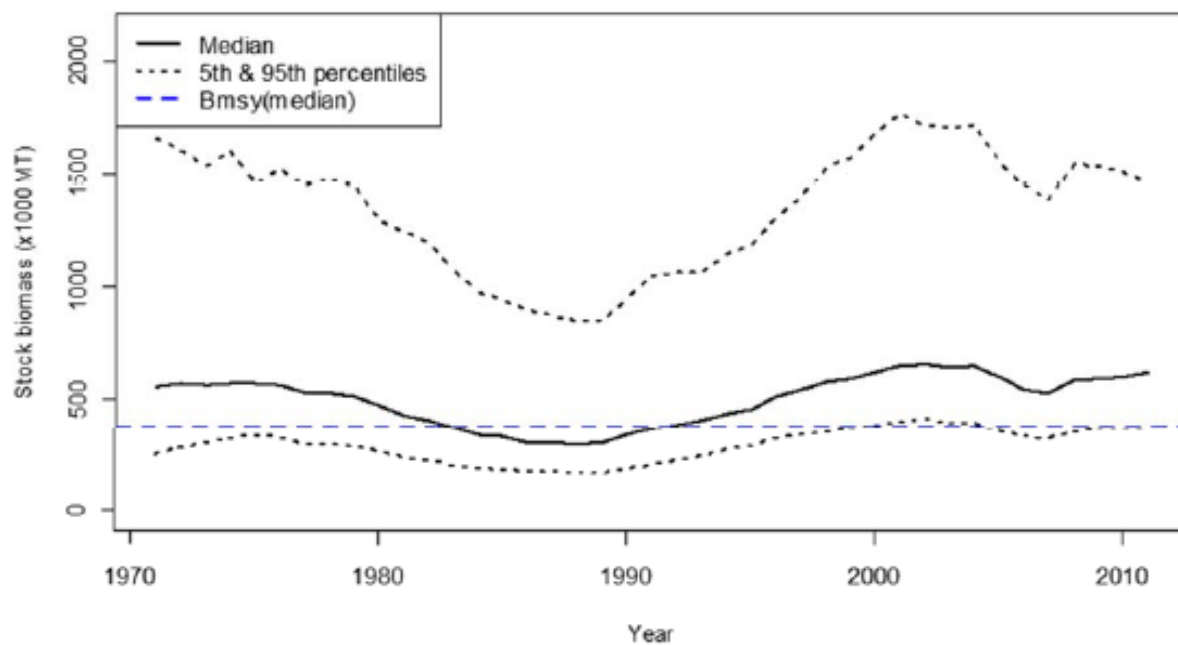


Figure 15. Median and 90% confidence intervals for the estimated historical stock dynamics of North Pacific Blue Shark from the surplus production model reference case run (ISC 2014). The model produces stock abundance relative to estimated biomass at maximum sustained yield (B_{msy}).

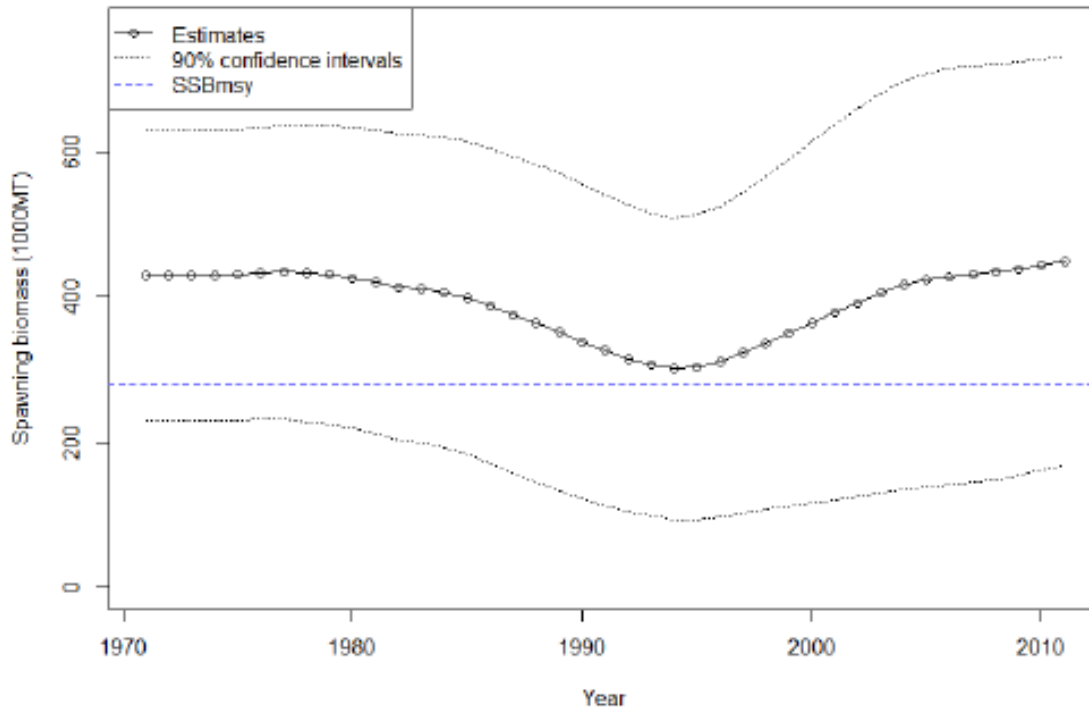


Figure 16. Estimated female spawning biomass and 90% confidence intervals of North Pacific Blue Shark from the stock synthesis model reference case run (ISC 2014). The model produces stock abundance relative to estimated biomass at maximum sustained yield (B_{msy}).

Both models show that stock abundance has recently been increasing and that fishing mortality has been declining (ISC 2014).

North Pacific - Summary

Taken together, the information suggests that this population is not in decline and may have been recently increasing, although there may have been localized declines (as suggested by the “SPC” index from the western Pacific). Modelling results indicate that the population has recently been at a relatively high abundance.

Rescue Effect

For both Atlantic and Pacific, Canadian individuals are part of a single population in the northern half of the ocean basin. As such, extirpation of the species from threats in Canada is highly unlikely, and it can be considered that a “rescue effect” from the broader population would act unless the entire ocean population declined precipitously.

THREATS AND LIMITING FACTORS

Incidental catch in commercial longline fisheries targeting pelagic tunas and Swordfish is the principal source of anthropogenic mortality for Blue Shark. Recreational fisheries exploit the species in some areas. Some individuals are taken in commercial fisheries targeting other species, for example trawl or longline fisheries for bottom-living species.

Blue Shark are not targeted by commercial longline fisheries in most areas, as the meat has relatively low value. They may be retained for consumption in some areas, and proportion of catch retained may have increased recently in some fleets (for example, Spanish longline fleet, ICCAT 2015a). Fins are valued and commonly traded. Blue Shark was by far the most common shark species in the international fin trade in the early/mid-2000s, with estimates of removals (round weight equivalent) worldwide based on quantities of fins traded of the order of 200,000-500,000 t/yr (Clarke *et al.* 2006). More recently, Cosandey-Godin and Worm (2010) found that global catches of large sharks have been steadily increasing over the past two decades, largely due to the rising demand for shark fins in Asian markets, plus significant declines in the abundance of “traditional” fish species. Those authors estimated that 26-73 million sharks of all species were traded annually for their fins (i.e., exceeding official statistics by 3-4 times).

Because many Blue Shark are discarded at sea, survival rate of discards influences overall catch mortality. Survival of individuals discarded at sea depends on condition at capture and condition at release, which vary with capture method, gear setting techniques, duration on/in the gear before it is retrieved, animal size, handling on board, and environmental conditions (Musyl *et al.* 2011; Campana *et al.* 2015). Four studies summarized by Musyl *et al.* (2011), based on popup satellite archival tags, showed post-release mortality of 78 individuals was low (around 15%), although small sample size and differing experimental conditions could have affected results. Based on studies of condition of Blue Sharks taken by longline vessels, and on popup tagging studies of post-release survival in relation to condition on release, Campana *et al.* (2015) estimated mortality of Blue Sharks discarded after capture in the Canadian longline fishery at 23%. Post-release mortality in recreational fisheries has been estimated at approximately 10% (Campana *et al.* 2015). Given that this species must swim to breathe (ram-ventilator), Blue Shark bycatch mortality is 100% in gillnets and otter trawls.

Another anthropogenic threat to large pelagic sharks is marine pollution, such as accumulating microplastic litter and floating looped plastics (e.g., discarded plastic strapping from bundles of new seafood product bags or boxes; Depledge *et al.* 2013). However, no data currently exist regarding impacts of other anthropogenic activities (e.g., seismic surveys, oil and gas drilling) on Blue Shark or its habitat. In addition, environmental effects due to climate change (e.g., increasing water temperatures and ocean acidification) on the life stages (e.g., pups, breeding adults), prey abundance, and habitat (e.g., pupping grounds/nursery areas) of this species remain unknown.

North Atlantic

Large quantities of Blue Shark are taken in pelagic longline fisheries operating over large areas of the North Atlantic by fleets based in the European Union (Spain, France, Portugal, UK), Japan, USA, Canada, Venezuela, and other countries (ICCAT 2015a,c).

For the North Atlantic, estimated catches in these fisheries have varied around approximately 35,000 t/yr since the early 1980s and have shown a stable trend since the early 1990s (Figure 17) (ICCAT 2015c). These figures assume that no discarded individuals survive. Reliable catch data are not available for much of this time period, particularly in the earlier years, and not all countries that discard Blue Sharks report such catches (including Canada). However, the most recent stock assessment includes catch (landings + discard) throughout the assessment period, although the estimates are considered highly uncertain. Several methods have been used to estimate catches when data are not available (ICCAT 2015c), including applying a ratio of Blue Shark to target species catches in recent years (based on observer information) to reported historical catches of the target species. Campana *et al.* (2015) suggest that the increase in reported North Atlantic catch in the last decade is due to increased reporting of discards rather than increased catches.

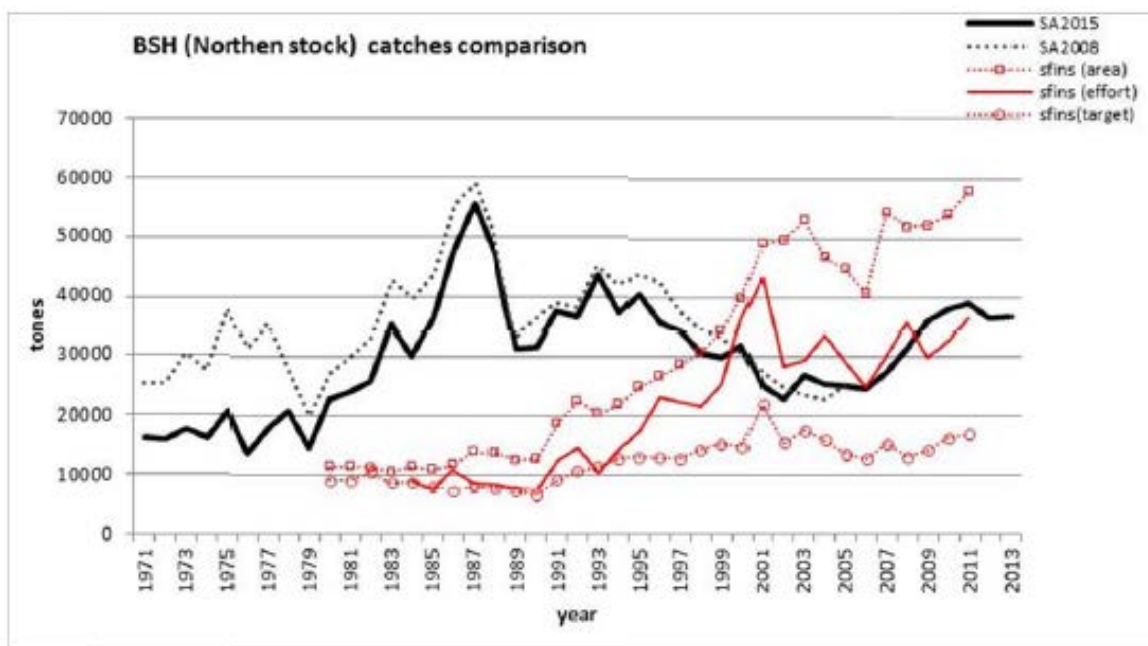


Figure 17. Estimated catches of Blue Shark in the North Atlantic (heavy solid line, "SA 2015"), as used in the population assessment of ICCAT (2015a). Catches as estimated in a previous assessment, ICCAT (2009) (dotted line, "SA 2008") and catch estimates based on data on fins in trade (using different estimation methods), are also shown. Source for figure: ICCAT (2015c).

The ICCAT catch estimates for longline fisheries do not account for catches in other gears (recreational fisheries, commercial trawl, hook and line, or other), but pelagic longline fisheries account for the majority of total Blue Shark catch.

ICCAT (2015a), based on two modelling approaches, estimated that fishing mortality had been below the MSY level over the available time series (1970-2013), although one model run suggested that fishing mortality had been near the MSY level for the past two decades (Figure 13).

For Canadian waters, Blue Shark landings and/or nominal catch are known only for Canadian vessels landing their catch or for foreign vessels operating under 100% observer coverage (Campana *et al.* 2015). Landings have averaged about 10t/yr since 2004 (Campana *et al.* 2015).

Campana *et al.* (2015) estimated total catches and catch mortality of Blue Shark in Atlantic Canada from 1986 to 2014, based on catch and discard estimates from observer reports on commercial pelagic longline fisheries, from recreational catches, and from estimates of hooking and post-release mortality rates (Table 2; Figure 18). Commercial longline vessels from Japan, the Faroe Islands and Canada accounted for 95% of all catches. Foreign vessel catches are based on 100% observer coverage, while Canadian catch estimates are based on approximately 5% observer coverage. Estimated total catches in Canada have ranged between 1200 and 1800 t/yr since 2002. Total estimated mortality (accounting for survival of discards) peaked in the early 1990s, prior to the introduction of the finning ban, and has averaged around 400 t/yr since the mid-1990s (Table 2; Figure 18).

Table 2. Total Blue Shark catch, discards and mortality (t) in Atlantic Canada by source. Source: Campana *et al.* (2015).

Year	Derbies	Recreational (1)	Landed commercial (2)	Observed foreign catch (3)	Observed foreign discards (4)	Canadian catch and discards (5)	Total estimated catch mortality (6)
1986				13	32	801	446
1987				28	123	367	345
1988				6	146	2421	1363
1989				10	172	2446	1405
1990			8	13	125	1680	986
1991			31	11	207	1857	1178
1992			101	60	285	2940	1916
1993	4	3	21	91	205	4190	2416
1994	5	3	133	116	210	3118	1020

Year	Derbies	Recreational (1)	Landed commercial (2)	Observed foreign catch (3)	Observed foreign discards (4)	Canadian catch and discards (5)	Total estimated catch mortality (6)
1995	6	4	145	73	100	3505	1054
1996	5	3	18	173	61	852	406
1997	10	7	9	36	0	1133	316
1998	10	7	4	17	17	955	255
1999	15	10	53	11	282	985	372
2000	16	11	19	0	3	881	240
2001	8	13	0	0	0	985	236
2002	19	13	5	0	4	1202	303
2003	12	13	0			1296	311
2004	10	7	0			1512	359
2005	6	4	0			1745	408
2006	10	10	0			1637	387
2007	8	8	0			1461	345
2008	13	13	0			1365	328
2009	10	10	0			1184	284
2010	12	12	0			1451	347
2011	9	9	0			1618	382
2012	13	13	0			1657	395
2013	10	10	0			1700	402
2014	8	8	0			1692	398

1: Catch and release fishery, excluding derbies; 2001-2005 estimated from rec logs and phone survey; before 2001 assumed to be 0.66 of derby catches based on tag recaptures and 2002-2003 ratios 2006+ assumed to be equal to derby catches based on recent tag recaptures

2: Canadian landings only

3: Scotia-Fundy Observer Program estimates of all foreign kept catch

4: Scotia-Fundy Observer Program estimates of all foreign discarded catch

5: Sum of estimated bycatch from all Canadian fisheries

6: Sum of landed catches, plus hooking and post-release mortality from Canadian fisheries; foreign discards prior to 1994 assumed to be dead due to finning

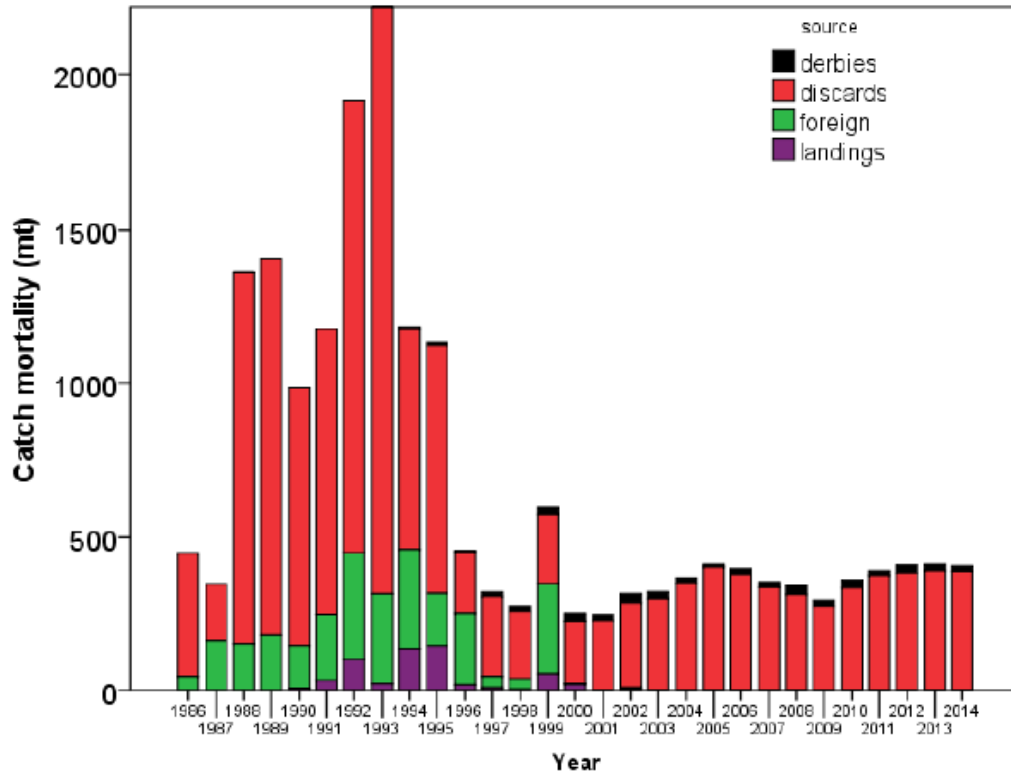


Figure 18. Total catch mortality (mt) of Blue Shark taken in Canadian Atlantic waters, 1996-2014. Numbers are based on Maritimes at-sea observer information for landings and discards, and on estimates of hooking and post-release mortality for discards. “Derbies” are Nova Scotian recreational fishing derbies; “discards” are from Canadian fisheries; “foreign” represents retained and discarded catch in foreign fisheries within Canada’s EEZ; “landings” are Canadian commercial landings. Source: Campana *et al.* (2015).

Recorded catches in Canadian fisheries other than pelagic longline fisheries are very low, generally a maximum of under 2 t/yr (Campana *et al.* 2015). The species is recorded from fisheries in the Gulf of St. Lawrence in small numbers – 10 records in 2009-2013 in DFO Québec Region (northern Gulf of St. Lawrence, Gaspésie) (Cormier pers. comm. 2014), 6 in 2007-2013 in DFO Gulf Region (southern Gulf of St. Lawrence) (Mallet pers. comm. 2014). DFO Newfoundland and Labrador (NL) Region estimated total Blue Shark catch in NL groundfish fisheries, using at-sea observer records and logbook landings at an average of 10 t over 2002-2010 and 21 t in 2011-2012 (Campana *et al.* 2015). Atlantic Cod (*Gadus morhua*) gillnet and longline fisheries accounted for most catches, while Blue Sharks were also found to a lesser extent in Yellowtail Flounder (*Limanda ferruginea*) trawl and White Hake (*Urophycis tenuis*) gillnet fisheries. Discarded sharks are not recorded in commercial fisheries in the absence of at-sea observers, so with observer coverage at 0-5% for fisheries taking Blue Shark, these reports underestimate total annual removals of Blue Shark in these fisheries in Atlantic Canadian waters.

North Pacific

For the North Pacific as a whole, fisheries prosecuted by Japan, Chinese Taipei, Mexico and the USA have accounted for 95% of the estimated catch of Blue Shark since 1971, when reasonable estimates of catch began. Estimated catches were highest from 1976 to 1989 with a peak of some 113,000 t in 1981 (Figure 19). Over the past decade estimated catches have remained relatively stable at an average of some 46,000 t/yr. Accurate catch reporting for Blue Shark has been limited, and where necessary catches have been estimated using a range of information sources and models. Catch data described above refer to total dead removals, including retained catch and dead discards (ISC 2014).

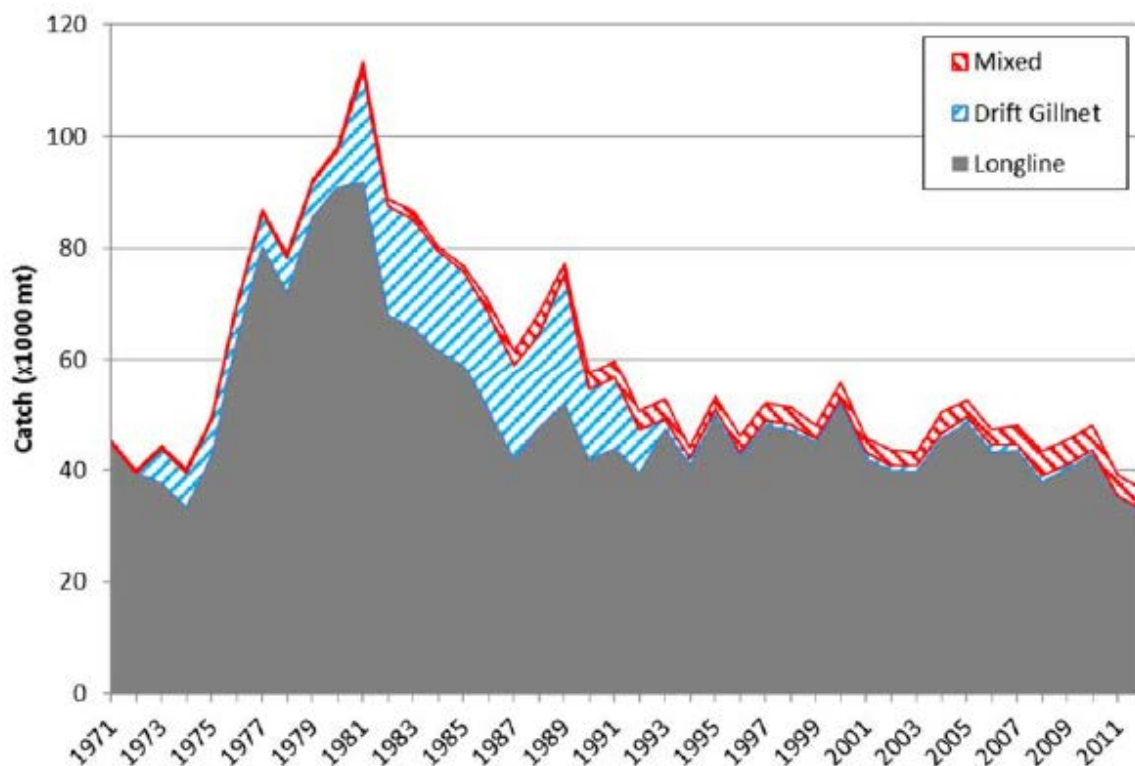


Figure 19. Total estimated catch of North Pacific Blue Shark by gear type 1971-2012. "Mixed" represents a combination of longline, gillnet, pole and line, trap and purse seine. Source: ISC (2014).

ISC (2014) estimated that annual fishing mortality in 2011 was well below the MSY level (32-34% of the MSY level, depending on the population model). Fishing mortality has been declining in recent years. Projections of future biomass trends using catch and fishing mortality values 20% higher than those observed recently indicated that biomass would remain above MSY levels at these harvest levels.

In Canada, Blue Shark are taken in a number of Pacific fisheries including groundfish trawl and longline, salmon troll, gillnet and seine, tuna troll, and recreational fisheries (King 2011). There are no directed fisheries for Blue Shark in Pacific Canada. Catch data are based on observer or logbook records, depending on fishery and year. Recorded catches from 1996 to 2015 were low and variable from year to year (Table 3): on average 8.29 t/yr in groundfish longline fisheries, 0.15 t/yr in groundfish trawl fisheries, 0.24 t/yr in all salmon fisheries (2011-2011). A total of 11 Blue Shark were recorded in the Pacific Albacore (*Thunnus alalunga*) Tuna fishery for 2011-2013 (Mah pers. comm. 2014), 43 in the Pacific recreational fishery for 2007-2014 (Collicutt, pers. comm. 2014), and 18 in the commercial salmon fishery in 2012-2014 (subsequent to records in Table 3) (Patten pers. comm. 2014).

Table 3. Catch of Blue Shark in Canadian Pacific commercial fisheries. Source: 1996-2010, King (2011); 2011-2015, J. King pers. comm.

Year	Bycatch (t)		
	Groundfish trawl ¹	Groundfish longline ²	Salmon all gears ³
1996	0.34		
1997	0.37		
1998	0.46	0.93	
1999	0.26	0.42	
2000	0.44	0.74	
2001	0.09	3.79	0.86
2002	0.09	5.66	0.13
2003	0.04	7.76	0.32
2004	0.05	4.04	0.04
2005	0.01	0.08	0.08
2006	0.26	19.15	0.57
2007	0.13	8.90	0.25
2008	0	5.56	0
2009	0	8.09	0.11
2010	0.12	7.02	0
2011	0.04	11.59	0.25
2012	0.09	8.62	
2013	0.11	25.37	
2014	0.08	8.98	
2015*	0	22.67	
Average	0.149	8.29	0.24

*as of December 17, 2015

¹ From at-sea observer data (100% coverage).

² From logbook records, subject to video verification.

³ Fisher reported, not expanded to the whole fleet.

Number of Locations

Under IUCN criteria, locations are defined by threats. Considering that a number of different fisheries operating under different management regimes catch this species, there are multiple locations for this species. The number has not been calculated but would be greater than 10 for each ocean basin.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Management strategies for Blue Shark in Canada are summarized in Canada's "National Plan of Action for Conservation and Management of Sharks" (DFO 2007) and in a progress report on its implementation (DFO 2012). In Atlantic Canada the first management plan for all sharks was published in 1995, with subsequent improvements and development of specific integrated fishery management plans for pelagic sharks (DFO 2007). In both Atlantic and Pacific Canada, shark management measures are included in management plans for specific fisheries (e.g., pelagic longline, groundfish).

In Canada, shark finning (removal of fins and discarding of the carcass at sea) was prohibited in 1994, and mandatory dockside landings monitoring is in force to ensure that fins are no more than 5% of landed weight of sharks, and that the number of fins corresponds to the number of carcasses landed (DFO 2012; DFO 2015).

In Atlantic Canada, no directed commercial fisheries for Blue Shark are permitted. Exploratory licences issued in the mid-1990s were all withdrawn by 2013 (DFO 2015). Pelagic shark management measures are included in management plans for Maritimes longline fisheries for Swordfish/other tunas, and for Bluefin Tuna (*Thunnus thynnus*) (DFO 2013). Under these management plans fishers have agreed to voluntarily release live sharks. Maritimes pelagic longline fishers also began voluntary adoption of circle hooks prior to 2012, when use of circle hooks was made mandatory under the Swordfish management plan (DFO 2015); although this is not expected to reduce shark bycatch, it should reduce injuries to hooked sharks and thus reduce discard mortality (S. Campana pers. comm.). In other commercial fisheries where Blue Shark are taken (gillnet and otter trawl groundfish and others), various regulatory measures are in place to control mortality such as mandatory live release (Maritimes fisheries), or mandatory landing with a catch cap (for example in Newfoundland and Labrador fisheries, shark bycatch can be retained up to 10% by weight of the catch of target groundfish species). Such management measures do not reduce the frequency of shark interactions with fishing gear, and shark bycatch mortality is 100% in gillnets and otter trawls. In recreational fisheries, all Blue Sharks taken must be released, except for fishing derbies where individuals over 244 cm total length can be retained; maximum allowed landings for all species in derbies is 20t.

In Quebec, Blue Shark is included in the Liste des espèces susceptibles d'être désignées menacées ou vulnérables (list of wildlife species likely to be designated threatened or vulnerable). This list is produced according to the "Loi sur les espèces menacées ou vulnérables" (RLRQ, c E-12.01) (LEMV) (Act respecting threatened or vulnerable species) (CQLR, c E-12.01). Link :

<http://www3.mffp.gouv.qc.ca/faune/especes/menacees/liste.asp#poissons> and <http://www3.mffp.gouv.qc.ca/faune/vertebree/consultation/index.asp?Espece=79>.

In Pacific Canada, retention of Blue Shark is not permitted in commercial groundfish and tuna fisheries and in recreational fisheries (King 2011; Mah pers. comm. 2014).

Internationally, there has been considerable attention to improving shark conservation and research over the past decade, although directed effective conservation measures remain relatively rare (Camhi *et al.* 2008). Regional fisheries management organizations which manage pelagic fisheries impacting Blue Shark in the North Atlantic (ICCAT - International Commission for Conservation of Atlantic Tunas) and North Pacific (IATTC - Inter-American Tropical Tuna Commission; WCPFC - Western and Central Pacific Fisheries Commission) have enacted finning bans, along with minimum fin/carcass standards at landing, encourage full use of sharks and live release of individuals, and require reporting of shark landings by species. These measures are to be applied by vessels from countries which are members of the regional fisheries management organizations (in effect, most of the countries active in the pelagic longline fisheries).

Non-Legal Protection, Status and Ranks

An "Atlantic Conservation Action Plan for Selected Pelagic Shark Species" (DFO 2015) has recently been drafted and submitted for approval. WWF-Canada has developed a "Shark Fishing - Best Catch, Handle and Release Practices" guide provided to shark derbies and Maritimes region fishery groups with a view to further reducing mortality of individuals caught and released (WWF n.d.).

In the Pacific, a "Code of Conduct" for fishers encountering sharks has been published, encouraging reporting of shark encounters with fishing gear and providing extensive recommendations on handling and discarding protocols to maximize survival. (DFO n.d.).

Blue Shark has been assessed as globally "near threatened" on the IUCN (International Union for Conservation of Nature) Red List (IUCN 2009).

The FAO (Food and Agriculture Organization of the United Nations) International Plan of Action for the Conservation and Management of Sharks (FAO 1999) was a response to increasing concern about the impacts of fishing on sharks and related species worldwide. The Plan encourages State members of FAO to develop national shark conservation and management plans and to carry out regular assessments of shark stock status, with a view to ensuring sustainable use.

Habitat Protection and Ownership

Marine habitat in Canada's Exclusive Economic Zone (EEZ) off the Atlantic and Pacific coasts is managed by Fisheries and Oceans Canada. There are no specific protection measures for habitat occupied by Blue Sharks. Pelagic habitat in the open ocean beyond national EEZs is not under the mandate of any authority and is not protected.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

The following provided contacts, information and/or advice relevant to completing this document - many thanks!

Conservation Data Centre - British Columbia
Katrina Stipec

Conservation Data Centre - Atlantic
James Churchill

COSEWIC Secretariat
Neil Jones, Bev McBride, Jenny Wu

Department of Fisheries and Oceans

National Headquarters - Christie Whelan, Science Advisor, Science Sector

Pacific Region - Lorne Collicutt, Manager, Integrated Fishery Data, Fisheries Management; Jackie King, Research Scientist, Science Branch; Jordan Mah, Tuna Manager; Bruce Patten, Salmon Biologist, Science Branch

Québec Region - Vincent Cormier, Coordonnateur des statistiques, Direction des statistiques et permis

Gulf Region - Pierre Mallet, Gestion des pêches

Maritimes Region - Michael Eagles, Senior Advisor, Fisheries Management

Newfoundland and Labrador Region - Mark Simpson, Science Branch

Quebec

Isabelle Gauthier, Ministère des Forêts, de la Faune et des Parcs, Coordonnatrice provinciale des espèces fauniques menacées ou vulnérables.

International Pacific Halibut Commission
Tom Kong, Biologist

WWF-Canada
Aurélié Cosandey Godin, Tonya Wimmer

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Howard Powles has worked in fishery science, stock assessment, and conservation and management of fishery resources since the mid-1960s, as a working scientist, science manager, program manager, and consultant. He was responsible for coordination of species at risk activities in Canada's Department of Fisheries and Oceans from 1998 to 2005. He was a member of COSEWIC from 1998 to 2003 and 2006-2010, the latter period as Co-Chair of the Marine Fishes SSC, and is currently a member of the SSC.

Appendix 1. Abundance index values for Atlantic Blue Shark (source: ICCAT 2015a)

Year	US Observer	Japan Longline Early Series	Japan Longline Late Series	US LL	Portuguese LL	Venezuelan LL	Spain LL	Chinese Taipei LL
1957				0.98				
1958				0.48				
1959				1.11				
1960				1.18				
1961				1.13				
1962				1.5				
1963				0.7				
1964				0.87				
1965				1.55				
1966				1.27				
1967				1.43				
1968				1.31				
1969				1.96				
1970				0.97				
1971		0.87		1.08				
1972		1.46		1.93				
1973		1.12						
1974		2.62						
1975		1.85		0.88				
1976		1.07		0.75				
1977		1.89		1.82				
1978		1.58		1.06				
1979		1.3		0.860				
1980		2.21		0.830				
1981		2.19		1.050				
1982		2.08		0.780				
1983		1.81		1.010				
1984		1.22		0.680				
1985		1.51		0.740				
1986		1.52		0.480				
1987		2.13		0.500				
1988		1.21		0.440				
1989		1.51		0.800				
1990		1.34		0.940				
1991		1.26		1.220				
1992	7.455	1.9		0.63				
1993	11.076	2.43		0.95				
1994	9.717		2.33	0.98		0.047		
1995	10.17		2.1	0.73		0.073		
1996	8.208		2.05	0.47		0.017		
1997	14.439		2.05	1.25	158.14	0.154	156.83	
1998	18.408		1.72	1.16	169.02	0.216	154.45	
1999	6.663		1.89	0.76	149.83	0.117	179.91	
2000	9.541		1.58	0.78	201.44	0.151	213.05	
2001	2.306		1.71		222.14	0.133	215.63	
2002	2.277		1.37		200.86	0.074	183.94	

Year	US Observer	Japan Longline Early Series	Japan Longline Late Series	US LL	Portuguese LL	Venezuelan LL	Spain LL	Chinese Taipei LL
2003	1.876		1.97		238.77	0.044	222.88	
2004	9.503		1.79		266.16	0.034	177.27	0.749
2005	3.193		1.9		218.55	0.006	166.82	2.195
2006	4.674		2.16		212.63	0.013	177.11	1.308
2007	9.645		2.18		241.32	0.060	187.06	0.561
2008	8.512		2.48		225.68	0.088	215.80	0.495
2009	8.322		2.46		228.30	0.045	196.08	0.570
2010	13.545		2.45		276.76	0.040	209.03	0.877
2011	21.806		2.37		233.29	0.044	221.13	0.765
2012	8.128		2.6		305.53	0.107	238.00	0.668
2013	7.374		2.09		304.08	0.044	203.49	1.045

Appendix 2. IPHC (International Pacific Halibut Commission) groundfish longline survey

Although this is not designed for pelagic species, data were obtained and analyzed for the sake of completeness of information (source: Tom Kong, IPHC).

The survey has fished 100-hook standardized skates (units) of bottom longline gear at a predetermined grid-based set of stations, with a standard sampling design since 1998. In most years 183 stations were sampled in Canadian waters, with 142 sampled in 1998 and 2000. Number of skates fished at a given station varies from year to year so use of the data to develop an abundance index would require standardizing results over stations and years. However, this analysis has not been done as abundance estimates for relatively rare species such as Blue Shark are unlikely to be informative with respect to trends.

Information on Blue Shark occurrences on the annual IPHC longline survey stations in Canadian waters is provided below. Occurrences are generally rare, there are no evident trends, and there are large fluctuations which would not represent population abundance.

Year	Sets	Positive Sets	Total Caught	Percent Positive sets	Mean Number per set
1998	142	7	7	4.9	0.05
1999	184	8	8	4.3	0.04
2000	142	5	5	3.5	0.04
2001	183	2	2	1.1	0.01
2002	183	1	1	0.5	0.01
2003	183	15	20	8.2	0.11
2004	183	48	125	26.2	0.68
2005	183	10	13	5.5	0.07
2006	183	0	0	0.0	0.00
2007	183	3	3	1.6	0.02
2008	183	1	1	0.5	0.01
2009	183	6	8	3.3	0.04
2010	183	12	15	6.6	0.08
2011	183	0	0	0.0	0.00
2012	183	10	10	5.5	0.05
2013	183	3	3	1.6	0.02
Total		131	221		
Average		8.2	13.8		

Appendix 3. PHMA (Pacific Halibut Management Association) rockfish longline survey

This survey has covered northern and southern areas of the continental shelf off British Columbia in alternate years from 2006 to 2014 (analysis of 2015 data has not been completed). Designed to sample rockfish, the survey targets 200 sets per year covering depths 20m to 260 m. Details of survey design and operation are provided by Yamanaka *et al.* (2012).

Information on Blue Shark from these surveys is provided in the table below

Area	YEAR	Blue Shark (pieces)	Percentage of sets with blue shark catch	CPUE (pieces/100 hooks)
North	2006	9	4.08	0.0097
North	2008	4	2.05	0.0048
North	2010	8	3.55	0.0082
North	2012	18	7.14	0.0194
South	2007	6	2.55	0.0069
South	2009	9	3.23	0.0108
South	2011	17	8.12	0.0193
South	2014	0	0	0.0000