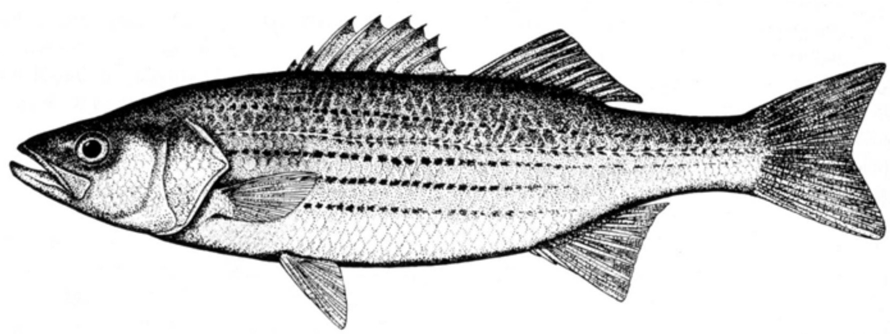
COSEWIC
Assessment and Status Report

on the

Striped Bass
Morone saxatilis

in Canada

Southern Gulf of St. Lawrence Population
St. Lawrence Estuary Population
Bay of Fundy Population



SOUTHERN GULF OF ST. LAWRENCE POPULATION - THREATENED
ST. LAWRENCE ESTUARY POPULATION - EXTIRPATED
BAY OF FUNDY POPULATION - THREATENED
2004

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

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

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Striped Bass — Drawing from Scott and Crossman, 1973.

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COSEWIC
Assessment Summary

Assessment Summary – November 2004

Common name
Striped Bass **(**Southern Gulf of St. Lawrence Population**)**

Scientific name
Morone saxatilis

Status
Threatened

Reason for designation
This fish was once commercially important and is still highly prized by anglers. Threats include bycatch in various fisheries such as gaspereau and rainbow smelt. Illegal take, particularly during ice fishing, is also believed to be a threat.

Occurrence
Quebec, New Brunswick, Prince Edward Island, Nova Scotia

Status history
Designated Threatened in November 2004. Assessment based on a new status report.

Assessment Summary – November 2004

Common name
Striped Bass **(**St. Lawrence Estuary Population**)**

Scientific name
Morone saxatilis

Status
Extirpated

Reason for designation
The population from the St. Lawrence Estuary has disappeared as a consequence of illegal fishing, with the last record dating from 1968.

Occurrence
Quebec

Status history
Designated Extirpated in November 2004. Assessment based on a new status report.

Assessment Summary – November 2004

Common name
Striped Bass **(**Bay of Fundy Population**)**

Scientific name
Morone saxatilis

Status
Threatened

Reason for designation
Repeated spawning failures led to the disappearance of the Annapolis and Saint John River populations. These disappearances are thought to be due to changes in flow regime and poor water quality. In the Shubenacadie River population, the presence of the introduced chain pickerel in overwintering sites may constitute a threat. Another threat to the population is bycatch from various commercial fisheries. The Bay of Fundy is also used by striped bass breeding in rivers in the United States. These fish were not assessed.

Occurrence
New Brunswick, Nova Scotia

Status history
Designated Threatened in November 2004. Assessment based on a new status report.

COSEWIC
Executive Summary

Striped Bass
Morone Saxatilis

Species information

The striped bass, *Morone saxatilis*, is a species typical of eastern North American estuaries and coastal waters. It is anadromous, i.e., spawning, incubation and early larval development occur in freshwater and the juveniles migrate downstream to brackish water and eventually salt water to feed and grow for several years before reaching maturity.

The striped bass has an elongated, laterally compressed body, a triangular head and a large mouth, with protruding lower jaw. It has two separated dorsal fins, the first of which is spiny. It has a dark olive-green to black back, paling on the sides to silvery, and a white belly. It has seven or eight horizontal dark stripes along its sides following the scale rows. Males reach sexual maturity at about three-years-of-age, which corresponds to a total length of over 30 cm in Canadian waters. Females reach sexual maturity at about four- or five-years-of-age (over 40 cm in length).

Distribution

The natural range of the striped bass extends along the Atlantic coast of North America, from the St. Lawrence Estuary to the St. Johns River in northeast Florida. Native striped bass populations have also existed in the tributaries of the Gulf of Mexico, from the Suwannee River in northwestern Florida to Lake Pontchartrain in Louisiana.

The species was introduced on the U.S. Pacific coast in the late 1800s, where it became established. The striped bass can live and, in some cases, complete its entire life cycle in freshwater. Many lakes and reservoirs in the southern U.S. have been stocked with striped bass to promote the sport fishery.

There is historical evidence of striped bass spawning in five rivers of Eastern Canada: the St. Lawrence Estuary, the Miramichi River in the southern Gulf of St. Lawrence, and the Saint John, Annapolis and Shubenacadie rivers in the Bay of Fundy. Striped bass still spawn in the Miramichi (southern Gulf) and Shubenacadie (Bay of Fundy) rivers. These two populations are isolated and genetically distinct. The most recent evidence of spawning activity in the three other rivers (St. Lawrence, Saint John and Annapolis) dates back some 20 years or more. Striped bass from the Shubenacadie River may come into contact with bass from U.S. rivers, which feed in the Bay of Fundy in summer, but they do not appear to reproduce with them.

Habitat

In striped bass, spawning occurs in freshwater and occasionally brackish water. Egg incubation and larval and young-of-the-year development correspond to a gradual movement downstream to saltwater. In summer, immature and adult bass feed in estuaries and coastal waters.

A particular feature of Canadian striped bass populations is that they overwinter in rivers in order to escape the cold ocean waters.

Biology

In Canada, mature striped bass spawn in late May or early June. Egg incubation lasts two to three days. On hatching, the larvae have a yolk sac. The yolk reserves are used for about one week. When they begin to feed, their survival is closely dependent on the quantity of zooplankton available in the water column. The abundance of offspring produced by a given spawning population can vary from year to year, depending on whether the early development stages find conditions favourable to their survival. On completion of the larval stage, which lasts approximately one month, a series of morphological changes occur until the juveniles attain the characteristic shape of the species, which they keep as adults. In eastern Canada, young-of-the-year that reach approximately 100 mm in length seem to have a better chance of surviving their first winter than smaller individuals.

Fish over one year require an abundant food supply – invertebrates or fish – in order to grow, but they are able to move to the food source to meet their food requirements. Striped bass travel along the coast in schools of same-size fish to feed, and can cover tens of kilometres a day.

The first maturation of reproductive organs can occur at about four-years-of-age in some females. However, most do not spawn until of five-years-of-age. Males reach reproductive age a little earlier, at three- or four-years-of-age.

Population sizes and trends

On three of the five Canadian rivers that have supported striped bass populations (Saint John, Annapolis and St. Lawrence), no evidence of spawning has been observed and no catches of local bass have been authenticated for over two decades. In contrast, the Shubenacadie River population still appears to produce new individuals.

The only spawning site of the southern Gulf striped bass population is a limited section of a branch of the Miramichi River. Outside the spawning season, individuals from this population move along the east coast of New Brunswick where, until recently, they were taken in fishing gear. The increasingly strict regulation of harvesting followed by the complete closure of the commercial and recreational striped bass fishery seems to have limited fishing mortality and to have allowed the population to begin to recover.

Limiting factors

Canadian and U.S. striped bass studies have shown that overfishing by commercial and recreational fishers may have decimated some populations.

The alteration of spawning, incubation or rearing habitat can also compromise reproduction in this species.

Special significance of the species

Striped bass are prized for their fight and their meat. Bones of this species have been found during archaeological digs of Amerindian camp sites or inns dating back to the beginning of European colonization. Today, many fishers in the United States and Canada still fish striped bass. The species supports a recreational/tourism activity that has major economic benefits for some regions.

Apart from its interest as a long-standing fisheries species, striped bass is an important component of the biodiversity of aquatic ecosystems. The species is typically associated with estuaries and coastal waters, where it is one of the most important piscivorous species. An abundant striped bass population is an indicator that a river and its estuary are in good condition: the species requires high quality spawning and nursery habitat and abundant aquatic species for food.

Existing protection

Canadian and U.S. experience has shown that conservation considerations should be taken into account in the harvesting of striped bass. The evidence of a decline in striped bass abundance in the southern Gulf in the 1980s and 1990s led to the gradual introduction, beginning in 1992, of measures designed to limit catches. Commercial striped bass fisheries were closed and the recreational fishery was regulated for the first time. In 1993, the principle of a conservation requirement of 5,000 spawners was introduced. Population estimates below that level led to the complete closure of the commercial fishery, including bycatch, and to mandatory catch and release by recreational anglers in 1996. In 2000, all recreational striped bass fisheries were closed and First Nations' allocations for social and ceremonial purposes were suspended. As a result of the increasingly stringent measures, the population appears to have begun to recover in 2001. The same approach is expected to be adopted to manage the harvesting of the Shubenacadie River striped bass population.

Three of the five Canadian populations have not shown evidence of spawning activity for over 20 years. No Canadian populations have been designated.

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 5th 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 agencies (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 members and the co-chairs of the species specialist and the Aboriginal Traditional Knowledge subcommittees. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(NOVEMBER 2004)

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 it is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for atleast 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 wildlife species for which there is inadequate information to make a direct, or indirect, assessment of its 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.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

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

COSEWIC Status Report

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Bay of Fundy Population

2004

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SPECIES INFORMATION

Name and classification

Scientific name: *Morone saxatilis* (Walbaum 1792)

Family: Moronidae

Synonyms:

Perca saxatilis	Walbaum 1792: 330 (type locality New York)
Labrax notatus	Richarson 1836: 8
Perca labrax	Perley 1852: 22
Labrax lineatus	Perley 1852: 181
Labrax lineatus	Fortin 1864: 60
Roccus lineatus	Adams 1873: 248
Roccus lineatus	Gill Adams 1873: 304
Roccus lineatus	(Bloch) Gill Cox 1896b: 70
Morone	Whitehead and Wheeler 1967: 23
Roccus saxatilis	(Walbaum) Scott and Crossman 1969: 22

French common names: Bar rayé
Bar d'Amérique
Bar du Saint-Laurent

English common names: Striped bass
Striper bass
Striper
Rockfish
Rockfish striper
Rock
Linesides

Description

Body elongate, laterally compressed. Head rectangular. Mouth large, lower jaw protruding. Fins: two dorsals, entirely separated, first dorsal spiny; caudal forked; anal of three spines; pelvics thoracic. Scales on cheeks and opercles.

Back dark olive-green to black, sides pale to silvery, belly white. Seven or eight dark horizontal stripes on the sides, following the scale rows. No stripes extend onto the head.

The onset of gonad maturation generally occurs at three-years-of-age in males, at a total length of over 30 cm. Females mature later, at about age four or five years, at a length of over 40 cm.

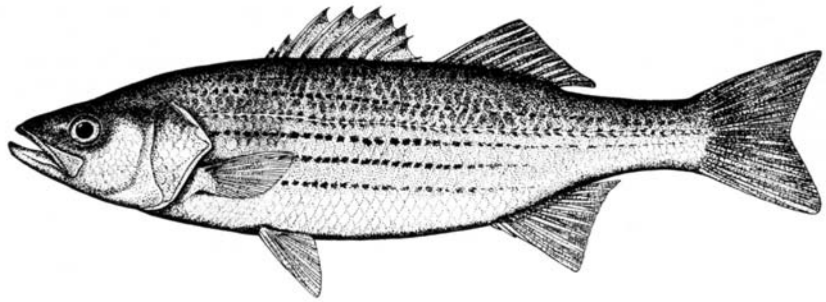

Figure 1. Striped bass, *Morone saxatilis*. Drawing from Scott and Crossman 1973.

Designatable Units

Three designatable units are recognized. The Southern Gulf DU comprises the Miramichi population in New Brunswick. The St. Lawrence Estuary DU comprises the St. Lawrence Estuary population in Quebec. The Bay of Fundy DU comprises the Saint John River population in New Brunswick and the Annapolis River population and Shubenacadie population in Nova Scotia.

The Bay of Fundy and southern Gulf groups can be distinguished on the basis of meristic and morphometric characters (Melvin 1978) or, for the two extant populations (Miramichi and Shubenacadie), by analysis of their mitochondrial and nuclear DNA (Wirgin *et al*. 1993, 1995; Diaz *et al*. 1997; Robinson 2000). Exchanges between these groups appear to be limited.

With respect to the St. Lawrence Estuary population that has disappeared, the distribution of recaptures in a mark-release program between 1944 and 1962 suggests that it was isolated from the other Canadian populations (Beaulieu 1962; Robitaille 2001). Of the 3,009 individuals tagged, 310 were recaptured, all in an approximately 300 km section of the St. Lawrence Estuary from Lake Saint-Pierre to Kamouraska, the same section in which all commercial and recreational striped bass catches were taken.

DISTRIBUTION

Global range

The natural range of the striped bass extends along the Atlantic coast of North America from the St. Lawrence Estuary to the St. Johns River in northern Florida. Native striped bass populations have existed in the tributaries of the Gulf of Mexico, from the Suwannee River in northwestern Florida to Lake Pontchartrain in Louisiana (Lee *et al.* 1980; Bain and Bain 1982).

The species was introduced into the estuary of the Sacramento and San Joaquin rivers in California in 1879 (Bonn *et al*. 1976). From this initial group, populations gradually became established in rivers on the U.S. Pacific coast (Hart 1973; Lee *et al*. 1980; Setzler *et al*. 1980).

The species can live and, in some cases, complete its life cycle in freshwater (Scruggs 1957). It has been introduced, as a sport fishery species, into several lakes and reservoirs in the United States, Russia, France and Portugal, with varying success (Lee *et al*. 1980; Setzler *et al*. 1980). At some locations, naturally reproducing populations have become established. Elsewhere, bass grows well but cannot reproduce. Ongoing stocking programs are therefore required to support fishing activity (Lee *et al*. 1980).

Canadian range

This status report covers the only known native striped bass populations, which spawned in five rivers in eastern Canada: the St. Lawrence, Miramichi, Shubenacadie, Annapolis and Saint John rivers (Figure 2). Catches of immature or adult striped bass have been reported at several locations in the Maritime provinces (Table 1). However, the presence of these individuals does not necessarily mean that distinct local populations occur and reproduce at each location. The presence of eggs or larvae is the most common indicator of spawning.

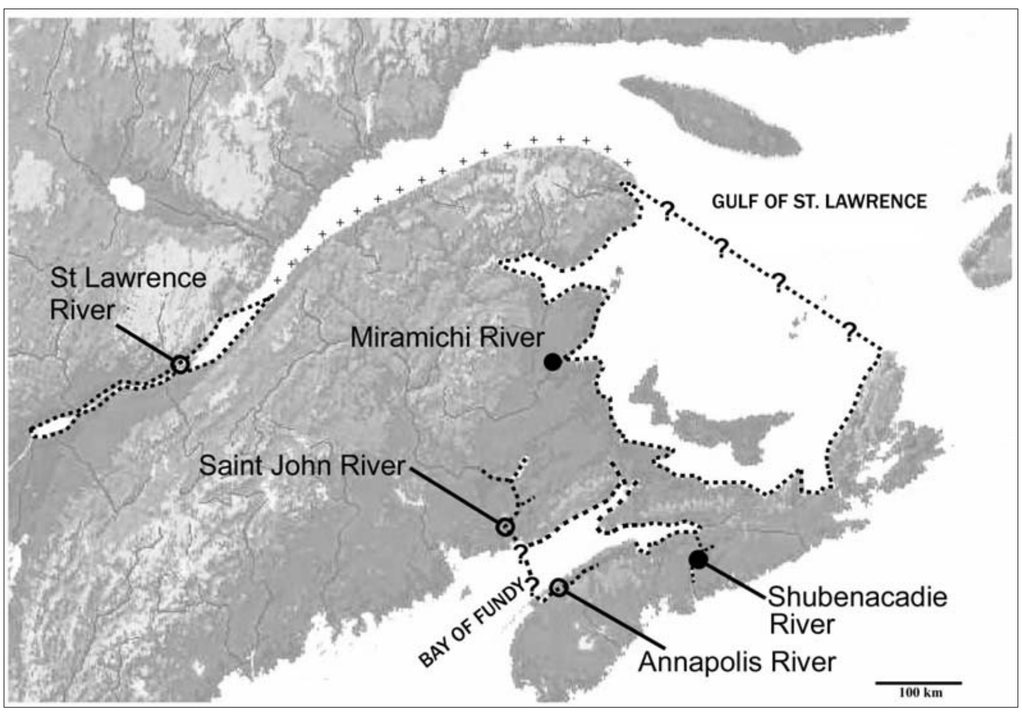

Figure 2. Location of five rivers in Eastern Canada that have supported spawning striped bass populations. The filled-in circles indicate extant populations and the open circles indicate rivers for which no spawning activity has been observed for 20 years or more. The dotted line defines the probable extent of occurrence, or at least the known part of it. In the case of Bay of Fundy populations, striped bass catch records are not enough to define the extent of occurrence in the bay, because it is also used by bass from U.S. rivers. On the south shore of the St Lawrence Estuary, about 200 specimens were collected between 1975 and 1994 (depicted by the "+" symbols in the figure). These are believed to be vagrants that originated from the Miramichi River.

Table 1. Localities in the Maritime provinces where striped bass catches have been reported (Scott and Crossman 1973; Scott and Scott 1988; R. Curley, Protected Areas and Biodiversity Conservation, Conservation and Management Division, PEI Dept. Environment and Energy, P.O. Box 2000, Charlottetown PEI C1A 7N8, pers. comm.). Striped bass occurs in the southern half of the region of Atlantic Canada. It does not appear to be present in the waters of Newfoundland or the northern Gulf.

Province	Location
Prince Edward Island	Malpeque Bay; Summerside; Tignish; Midgell River, Morell River and Hillsborough River and its tributaries, West River and Lake St. Peters; several coastal lagoons.
Nova Scotia	Cheticamp; River Philip; Canso; Mira Bay, Chedabucto Bay, Mahone Bay; Minas Basin; Yarmouth County; Shubenacadie and Annapolis rivers; Shubenacadie and Grand lakes.
New Brunswick	Nepisiguit, Richibucto, Miramichi, Tabusintac, Tracadie, Pokemouche, Kouchibouguac, Saint John and Aroostook rivers; Grand Lake; Long Reach; Nerepis, Hammond and Kennebecasis rivers; Grand Bay.

Canadian striped bass populations occur in the northern portion of the species' range. They form three groups: 1) the Bay of Fundy group, 2) the southern Gulf of St. Lawrence group, and 3) the St. Lawrence Estuary group. The Bay of Fundy group comprises three spawning populations: those of the Saint John, Annapolis and Shubenacadie rivers. In summer, the three populations fed in the Bay of Fundy and contact between them may have been possible. They also used waters in which migratory bass from U.S. rivers were present. The simultaneous presence of bass of Canadian and U.S. origin in the Bay of Fundy has been demonstrated by analysis of meristic and morphometric characters, recaptures of tagged specimens, the frequency of certain parasites, blood protein electrophoresis and DNA analysis (Melvin 1978; Dadswell *et al.* 1984; Hogans 1984; Harris and Rulifson 1988; Waldman *et al.* 1988; Wirgin *et al.* 1993, 1995; Diaz *et al.* 1997; Robinson 2000).

There is only one known spawning population in the southern Gulf, that of the Miramichi River. Striped bass have been captured in several New Brunswick estuaries that flow into the southern Gulf of St. Lawrence, e.g., the estuaries of the Nepisiguit, Miramichi, Kouchibouguac, Kouchibouguacis (Saint-Louis), Tabusintac, Tracadie and Richibucto rivers (Melvin 1991). However, these fish all seem to originate in the Miramichi River, where the only known striped bass spawning ground in the entire southern Gulf is found (Bradford *et al.* 1995; Robichaud-LeBlanc *et al.* 1996; Douglas *et al.* 2003). The southern Gulf population is believed to be isolated both from Bay of Fundy populations and from migratory bass from U.S. rivers. All recaptures of striped bass tagged in the southern Gulf were reported in this sector, except for one in Maryland (Hogans and Melvin 1984).

The population in the St. Lawrence Estuary, occurred in a roughly 300 km stretch of the fluvial and estuarine portion of the river between Sorel and Kamouraska. According to all available data, the St. Lawrence striped bass were isolated from the other Atlantic coast populations. There have been no reports of recaptures downstream from Kamouraska of bass tagged in the St. Lawrence (Beaulieu 1962; Robitaille 2001). This does not rule out the possibility of contacts, but they appear to be the exception. In the early 1980s, the capture of several dozen bass around the Gaspé Peninsula and in the middle St. Lawrence Estuary suggested the recovery of the local population. It appears that the fish were actually Miramichi River bass (R. Bradford, Department of Fisheries and Oceans, Science Branch, Maritimes Region, P.O. Box 1006, Dartmouth, Nova Scotia, B2Y 4A2, pers. comm.; Bradford and Chaput 1996; Douglas *et al*. 2003).

There are no known freshwater striped bass populations in Canada.

HABITAT

Habitat requirements

Of the various habitats used by striped bass during its life cycle, the most important to the maintenance of a population seems to be its spawning, incubation and rearing habitat (Jessop 1990, 1991; Melvin 1991; Dudley and Black 1978; Van den Avyle and Maynard 1994).

Egg survival to hatching is closely tied to the physicochemical properties of the incubation habitat, particularly temperature, dissolved oxygen and the presence of a moderate current (Cooper and Polgar 1981). The duration of incubation is a function of temperature. The highest hatching rates (87%) and larval survival rates in the first 24 hours (76%) are obtained at 18°C (Morgan *et al*. 1981). At that temperature, the eggs hatch approximately 48 hours after fertilization (Pearson 1938; Raney 1952). Egg survival rapidly declines when the water temperature exceeds 23°C and gradually declines as water temperature drops below 17°C, with few eggs surviving at temperatures below 12°C (Morgan and Rasin 1973; Rogers *et al*. 1977).

The two other factors, i.e., sufficient dissolved oxygen levels and the presence of a current, may have a combined effect on egg survival. The eggs are generally heavier than water and, in the absence of current, sink to the bottom, where they are more exposed to anoxia (Chittenden 1971; Rawstron *et al*. 1989). The presence of a moderate current creates low turbulence levels, which keep the eggs in suspension in the water column during incubation.

The survival of the larvae, like the eggs, also depends on physical variables, including temperature and dissolved oxygen. However, an additional requirement, i.e., a sufficiently abundant food supply, comes into play upon resorption of the yolk sac and the onset of feeding (Cooper and Polgar 1981). This key period occurs on about the eighth day of existence of the larvae, when they measure 6 to 7 mm. In natural environments, the rate of survival of larvae that have exhausted their yolk reserves is directly related to the abundance of zooplankton in their environment (Kernehan *et al*. 1981).

In most striped bass populations, spawning, incubation and early larval development occur in fresh or slightly brackish waters. However, the Shubenacadie

River population spawns in a section of the river affected by a tidal bore: the initial stages of development seem to be adapted to these conditions and tolerate greater temperature and salinity variations than U.S. striped bass populations (Cook 2003).

Immature and adult striped bass frequent coastal and estuarine habitats (Bain and Bain 1982). During their first two years, they feed primarily on invertebrates, but gradually become piscivorous. In summer, striped bass movements seem to be associated primarily with those of their preferred prey.

Canadian striped bass populations migrate upstream in the fall and overwinter in fresh or brackish water. The reason for this behaviour appears to be to avoid the low ocean temperatures in winter (see “Biology, Movements/Dispersal”). Southern Gulf striped bass enter a number of estuaries along the New Brunswick coast in the fall. Telemetric tracking of striped bass overwintering under the ice in the Kouchibouguac and Kouchibouguacis rivers has revealed that they moved about little (less than one kilometre) and selected areas where the temperature remained above –0.4°C and where salinity did not exceed 15 ppm (Bradford *et al*. 1997a).

The confinement of striped bass to overwintering sites could increase the risk of mortality due to environmental conditions or illegal fishing. St. Lawrence striped bass, for example, were the target of a major ice fishery on Lake Saint-Pierre. This fishery was prohibited in 1951, but some fishers reportedly continued to fish illegally (A. Michaud, pers. comm.; Robitaille 2001).

Trends

In recent decades, habitat changes in three rivers may have limited striped bass abundance and contributed to the decline in its populations.

Striped bass spawning grounds in the Saint John and Annapolis rivers appear to have been affected by changes in water quality or physicochemistry, related perhaps to changes in flow due to the construction of impoundments (see the section “Limiting Factors and Threats”). On both rivers, the cessation of spawning has been attributed to inadequate physicochemical conditions, namely high levels of PCBs or DDTs on the Saint John River, and agricultural pollution or overly low pH on the Annapolis River. However, changes in the circulation of water masses due to impoundments may have affected spawning and rearing habitat quality (Douglas *et al.* 2003).

The disappearance of the St. Lawrence Estuary striped bass population also seems to be associated with habitat changes. In this case, however, the spawning, incubation and rearing habitat does not appear to have been affected, but rather the summer rearing habitat of immature fish, located off several islands in the St. Lawrence. These areas appear to have been modified by the dumping of dredged material (Robitaille 2001). As a result of the habitat changes, striped bass became concentrated at several locations along the south shore which quickly become very popular fishing sites. Biologists tried unsuccessfully to persuade fishers to limit their catches and fishing continued without any real restrictions until 1968, the year of the last catches (Robitaille and Girard 2002).

Protection/ownership

See the section “Existing protection or other status” on page 25.

BIOLOGY

An anadromous species, the striped bass moves between freshwater spawning habitats and brackish or salt water feeding sites in estuaries or marine coastal waters to complete its life cycle.

Spawning

Striped bass spawn in the spring in fresh or slightly brackish water (Raney 1952). Spawning is triggered by the increase in water temperatures. The reproductive behaviour of striped bass has been described in U.S. populations (Pearson 1938; Merriman 1941; Raney 1952; Karas 1974; Setzler *et al.* 1980). The males are the first to reach the spawning grounds in the rivers. The females, which are generally larger and less numerous than the males, follow. Spawning begins when the water temperature rises above 10°C. When there are large numbers of spawners, spawning can last three to four weeks, with several distinct peaks if the water temperature fluctuates. Spawning occurs near the surface, at twilight. Groups of males surround each female and fertilize the eggs released (McLaren *et al.* 1981).

In rivers in the Maritimes, the spawning grounds are located in fresh water, sometimes in areas subject to tidal influence. They are further from the ocean in the three Bay of Fundy tributaries than in the Miramichi River in the southern Gulf. On the Shubenacadie River, a tidal bore travels upstream as far as the spawning sites (Rulifson and Tull 1999). The striped bass spawning ground in the St. Lawrence Estuary has never been located, but various sources suggest that it is in Lake Saint-Pierre or downstream from it, in the adjacent section of the upper estuary (Montpetit 1897; Vladykov and Brousseau 1957; Beaulieu 1962; Cuerrier 1962; Magnin and Beaulieu 1967; Robitaille 2001).

Incubation and rearing

The translucent green eggs measure 1.3 mm when they are released and fertilized. They swell and harden in the water in approximately 12 hours, reaching 3.4 to 3.8 mm in diameter (Pearson 1938). The eggs are semi-pelagic and require a moderate current to remain suspended in the water column throughout the entire incubation period.

On hatching, the yolk-sac larvae measure between 2.0 and 3.7 mm. The larval stage can last from 35 to 50 days, depending on the water temperature and food abundance. The feeding of the larvae changes as they grow (Humphries and Cumming 1973). They initially feed on the nauplii stages of zooplanktonic crustaceans; once they exceed 10 mm, they gradually begin feeding on larger zooplanktonic species or stages (Robichaud-LeBlanc *et al.* 1997).

Depending on the state of the tide, vertical migration of larvae in the water column enables them to maintain their position in the estuary and even to move downstream (Setzler-Hamilton *et al.* 1981).

Growth, maturation, fecundity

The larval stage ends with metamorphosis, at approximately 20 mm, at which point it takes its adult form (Mansueti 1958). Juvenile striped bass are more tolerant to changes in temperature or salinity than the eggs or larvae. Large numbers of young-of-the-year are found in the sheltered bays of estuaries, where they feed primarily on small invertebrates during their first year (Robichaud-LeBlanc *et al.* 1997). They gradually begin feeding on fish at about two-years-of-age (Rulifson and McKenna 1987).

The duration of the striped bass growing season has a significant effect on the size and weight reached at a given age. Canadian striped bass are smaller than U.S. bass of the same age. Size and age at maturity also vary as a function of latitude (Merriman 1941; Raney 1952; Austin 1980; Setzler *et al.* 1980; Bain and Bain 1982). Striped bass generally do not reach sexual maturity until three-years-of-age in males and four-, five- or even six-years-of-age in females (Berlinsky *et al.* 1995; Douglas *et al.* 2003; Powles 2003). The adults survive spawning and can spawn again, sometimes with a year of rest between successive contributions. In some rivers, fish have spawned up to their 14th year (Setzler *et al.* 1980). Gonad maturation in the weeks preceding spawning is dependent on the increase in water temperature (Setzler *et al.* 1980).

The striped bass is a highly fecund fish. In populations on the U.S. coast, estimates of the number of developing eggs range from 14,000 for a 1.4 kg female to over 3 million for a 22.7 kg female (Raney 1952). Striped bass from northern populations generally have a slightly lower fecundity, at a given size, than those in the southern part of its range (Olsen and Rulifson 1992). In Canadian populations, the fecundity of 4- to 11- year-old females (45 to 91 cm) ranges from 53,000 to 1,464,000 eggs (Paramore 1998).

Survival

Most striped bass populations undergo fluctuations in abundance, a characteristic of species in which the survival of the early life stages, i.e., eggs and larvae, is a key factor in recruitment (May 1974; Dahlberg 1979). Striped bass are highly fecund and can spawn several times during their lives. However, the combination of conditions that results in optimum egg and larvae survival does not occur every year in most systems. Survival to the larval stage seems to be a key factor in year-class strength (Cooper and Polgar 1981; Rago *et al.* 1989), and thus in adult abundance several years later

(Goodyear 1985; Rago *et al.* 1989; Ulanowicz and Polgar 1980). In the structure of the adult population, year classes that were produced in years in which conditions were favourable for spawning often dominate (Cooper and Polgar 1981; Goodyear 1985; Douglas *et al.* 2001).

The start of feeding, at the end of the yolk-sac stage, appears to be a determining stage. This key period is believed to occur around the eighth day after hatching, when the larvae measure 6 to 7 mm. In natural environments, the survival rate of larvae that exhaust their yolk reserves depends on the abundance of zooplankton in the environment (Kernehan *et al.* 1981). The physical condition of the larvae is correlated with the density of copepods and water fleas in the environment (Miller 1977; Martin *et al.* 1985). Starting at the juvenile stage, striped bass are better able to tolerate changes in environmental conditions. Moreover, they can move to estuarine or coastal habitats, often in schools of same-size fish, to meet their food requirements.

A particular characteristic of the northernmost populations is that climatic conditions seem to cause selective mortality in young-of-the-year. Individuals that have not reached a total length of 100 mm by the fall apparently do not survive their first winter of the prolonged fasting under the ice as well as larger individuals (Bernier 1996; Bradford and Chaput 1997; Hurst and Conover 1998).

Striped bass is long-lived (up to 30 years) (Secor 2000). The largest known specimen, captured in North Carolina in 1891, weighed 56.8 kg and measured 1.82 m (Raney 1952). The growing conditions in Canadian waters are such that the maximum size of striped bass is less than 1 m. This figure is an estimate because very few individuals survive long enough to reach their maximum size. The largest striped bass caught in the St. Lawrence Estuary measured 91.5 cm (total length) and weighed 10.9 kg (Vladykov 1953).

Physiology

See “Behaviour/adaptability” on page 15.

Movements/dispersal

The striped bass undertakes migrations of varying distances, depending on its development, feeding, spawning and overwintering.

In the St. Lawrence Estuary, the downstream migration of young-of-the-year occurs over several weeks. Catches of juvenile striped bass measuring 20 to 35 mm have been reported near Neuville in early July (Vladykov and Brousseau 1957). In early September, individuals measuring 75 mm could be caught at the mouth of the Ouelle and Saint-Jean-Port-Joli rivers (J. Brousseau, retired biologist, 302 des Pins, Loretteville, Quebec, G2A 2L3, pers. comm.). Young-of-the-year have also been reported in large numbers in fixed gear on the Beaupré coast, north of Île d’Orléans (Vladykov 1945; Trépanier and Robitaille 1995; V. D. Vladykov, unpublished manuscript).

In the southern Gulf, first year growing habitats (40 to 200 mm) are found in estuaries and lagoons along the coast (Rulifson and Dadswell 1995; Douglas 2003). The presence of young-of-the-year striped bass has been reported in eel, smelt and tomcod fishing gear set in the estuaries of several rivers (Douglas *et al.* 2003).

With respect to the Bay of Fundy group, the growing habitats of juvenile bass are known primarily for the population of the Shubenacadie-Stewiacke system; young-of-the-year are caught in the lower reaches of the river in the early summer, and later on the north shore of Cobequid Bay in August and September (Rulifson *et al.* 1987; Douglas *et al.* 2003). Little data are available on the development and movements of young striped bass in the Annapolis River (Williams *et al.* 1984; Stokesbury 1987).

In summer, Bay of Fundy striped bass populations mix with migratory populations from the U.S. Several large populations from the U.S. eastern seaboard undertake long coastal migrations between the Bay of Fundy and northern Florida. In early spring, some individuals originating in Chesapeake Bay tributaries leave the bay and move northward along the coast to the Bay of Fundy (Melvin 1978, 1991; Waldman *et al.* 1990). These migratory bass are believed to congregate in the eastern part of the Bay of Fundy, along the coast of Nova Scotia, for the first half of the summer, and then in the western part for the latter half (Dadswell *et al.* 1984). Some enter the Saint John River estuary and migrate to the Reversing Falls area, where they remain until the end of summer (Dadswell 1976). In September, these migrants return south. Some individuals tagged in the Saint John River have been recaptured along the states of Massachusetts, New Jersey, New York, Delaware and Maryland (Melvin 1978). There is no indication that these individuals can breed with striped bass from Canadian rivers.

Southern Gulf of St. Lawrence striped bass populations also move along the coasts in summer (Bradford and Chaput 1996; Douglas *et al.* 2003), but they migrate over shorter distances than bass from the U.S. Movements of some fish beginning in the spring from the Kouchibouguac River to Miramichi Bay, 50 km to the north, or to Tabusintac, 125 km, have been reported (Hogans and Melvin 1984). At the end of summer, they enter Nepisiguit Bay, in southern Chaleur Bay, where fishing, when permitted, was at its best in September. These individuals are part of the population that spawns in the Miramichi River (Douglas *et al.* 2003).

Movements related to feeding have been observed in several rivers. Prior to the construction of the Mactaquac Dam on the Saint John River, immature bass that appeared to be foraging were reported to migrate upstream to fresh water, 320 km from the mouth (Jessop 1991). On the Miramichi River, bass catches in a Millbank index trapnet show three peaks in abundance. The largest peak is observed in the spring (May-June) and corresponds to spawning; a second peak in summer and a third in fall are believed to correspond to movements for feeding (Chaput and Randall 1990).

Movements of bass from the St. Lawrence have been described on the basis of recaptures of tagged fish (Beaulieu 1962; Magnin and Beaulieu 1967; Robitaille 2001). In the fall, spawners migrated up the river to Lake Saint-Pierre, where they overwintered

(Montpetit 1897; Vladykov 1947; Vladykov and Brousseau 1957; Magnin and Beaulieu 1967). It is assumed that spawning took place in this sector or downstream, between mid-May and mid-June; the spawners then migrated downstream to the estuary, where they fed and regained condition during the entire summer. The fall upstream migration to Lake Saint-Pierre seemed to be made by fish that were preparing to spawn, because bass under three-years-old did not undergo this migration. Rather, they overwintered in the estuary, downstream from Quebec City, in the freshwater plume of the river (Montpetit 1897; Robitaille 2001).

Striped bass from the southern Gulf and Bay of Fundy also migrate upstream to freshwater in the fall. However, in their case, bass of all ages undertake the migration seemingly to escape the cold marine waters during the winter, which would be fatal (Rulifson and Dadswell 1995; Bradford *et al.* 1995; Douglas *et al.* 2003). Fishers differentiate Shubenacadie River striped bass that have overwintered in fresh water by their black colour; fish that are newly arrived from the sea are greenish in colour (Rulifson and Dadswell 1995; Paramore and Rulifson 2001).

In the southern Gulf, striped bass of all sizes entered several rivers along the coast in the fall. It was long believed that this movement was made by bass originating in each of these rivers (Rulifson and Dadswell 1995). However, it is now known that all of these fish were part of the Miramichi River population (Bradford *et al.* 1995; Robichaud-LeBlanc *et al.* 1996; Douglas *et al.* 2003). In the Kouchibouguac River, adult bass overwinter in deep sections of the river (Hogans and Melvin 1984). When the ice breaks up, they migrate downstream to salt water, where they feed during the summer. Movements along the river and in the estuary seem to be relatively closely related to temperature and availability of prey. When the water temperature begins to fall, the bass gradually migrate upriver where they overwinter.

Striped bass from the Shubenacadie River migrated upstream to overwinter in Grand Lake, where they can be caught in the winter ice fishery (Jessop 1991). In May, they migrate downstream to Minas Basin in the southern Bay of Fundy. Striped bass spawn in the Stewiacke River, a tributary of the Shubenacadie River.

Local migrations of striped bass from the Saint John River followed the same general pattern. Striped bass from this river also overwintered in freshwater, in Belleisle Bay, Washademoak Lake and in other deep sectors of the estuary. In May and June, they spawned in the tributaries, upstream from the tidal influence zone, and then migrated downstream to saltwater to feed for the entire summer (Dadswell 1976). In the fall, they returned to the river and, as their activity slowed, gathered in deep waters (Melvin 1978).

The Annapolis River striped bass were found primarily in the vicinity of the Royal Annapolis dam, in summer and fall (Jessop and Doubleday 1976). Some individuals from this population migrated upstream to fresh water to overwinter (Dadswell *et al.* 1984).

Nutrition and interspecific interactions

Striped bass initially feed primarily on invertebrates and, as they grow, on fish (Rulifson and McKenna 1987; Boynton *et al.* 1981; Robichaud-LeBlanc *et al.* 1997; Brousseau 1955; Robitaille 2001).

In their feeding and prespawning rearing areas, striped bass move in groups along the coasts, chasing schools of fish, particularly juvenile clupeids (Manooch 1973). The species found in bass stomach contents vary depending on location and season. The primary prey of Hudson River bass are blueback herring (*Alosa aestivalis*), American sand lance (*Ammodytes americanus*) and bay anchovy (*Anchoa mitchilli*) (Gardinier and Hoff 1982; Dew 1988). Other coastal populations feed primarily on blueback herring or Atlantic menhaden (*Brevoortia tyrannus*) (Manooch 1973; Trent and Hasler 1966). Tomcod (*Microgadus tomcod*) can often be found in the stomach contents at certain periods, but not throughout the annual cycle.

In the Kouchibouguac River estuary, the preferred prey of striped bass are mummichog (*Fundulus heteroclitus*), juvenile clupeids, threespine stickleback (*Gasterosteus aculeatus*), sand shrimp (*Crangon septemspinosa*) and marine worms (Hogans and Melvin 1984).

The organisms most frequently found in the stomach contents of St. Lawrence striped bass over two-years-old were Atlantic tomcod, rainbow smelt (*Osmerus mordax*), juvenile clupeids (American shad, *Alosa sapidissima*, gaspereau, *Alosa pseudoharengus*, Atlantic herring, *Clupea harengus*) and flounders (*Pseudopleuronectes americanus* and *Liopsetta putnami)* (Brousseau 1955; Robitaille 2001).

Behaviour/adaptability

There are two different points of view on the adaptability of striped bass, depending on their life stage, i.e., early life stages (eggs and larvae) or the stages after metamorphosis (juveniles and adults).

Adult bass tolerate and withstand variations in salinity, temperature, pH or turbidity (Talbot 1966; Auld and Schubel 1978; Setzler *et al.* 1980). The striped bass is highly fecund, opportunistic in its feeding habits and fast growing; these characteristics facilitate the rapid increase in its numbers in favourable environments. However, adult bass appear to avoid temperatures over 24°C, which may result in their confinement, on the hottest days of summer, to small refuges in certain reservoirs and estuaries in the United States (Coutant 1985). A similar phenomenon, but at the other end of the range of temperatures tolerated by this species, is believed to explain the river overwintering behaviour typical of Canadian populations. By overwintering in rivers, they appear to avoid the cold ocean waters in winter (Rulifson and Dadswell 1995).

By comparison with the adults, striped bass eggs and larvae are sensitive to minor changes in environmental variables (Cooper and Polgar 1981). Ambient conditions can therefore have a significant effect on the population dynamics of this species.

The abundance of progeny for a given number of spawners can vary from year to year (Merriman 1941; Raney 1952; Koo 1970; Van Winkle *et al.* 1979). The most important factor in year-class strength appears to be egg and larval survival. The abundance of a year class is reported to be already largely determined at the time of metamorphosis, i.e., at the end of the larval stage (Chadwick *et al.* 1977).

Bass populations are often characterized by variable recruitment (Merriman 1941; Raney 1952; Koo 1970; Van Winkle *et al.* 1979; Setzler *et al.* 1980; Ulanowicz and Polgar 1980; Kernehan *et al.* 1981; Cooper and Polgar 1981; Polgar 1982). Catch data show significant interannual variability; years in which catches are high correspond to the passage of strong year classes through the exploited segment of the population.

Periodicities of 6, 8 and 20 years have been detected in commercial striped bass landings on the Atlantic coast of the U.S. (Van Winkle *et al.* 1979). Abundance peaks in U.S. populations are not necessarily in phase with peaks in Canadian populations. Some biologists believe that heavy fishing can either cause or amplify variations in the abundance of bass populations.

POPULATION SIZES AND TRENDS

For the purposes of this section, the five known spawning populations are discussed separately.

Mark-recapture experiments to estimate population abundance have been conducted on only two of the five populations, those of the Miramichi and Shubenacadie rivers, and in only the last ten years. For populations or periods not covered by the estimates, only indirect abundance indices are available, e.g., records of commercial or recreational catches, sporadic surveys or experimental fisheries.

There are a number of reservations about the use of recreational or commercial catches to describe abundance trends in harvested fish species. The reservations are due, among other things, to the following factors: the data are not always collected and compiled in a consistent manner; the measurement of fishing effort is often lacking; and only the exploited segment of the populations is taken into account. Despite the constraints limiting the scope of their interpretation, catch statistics are often the only indices available for describing major trends in certain populations.

Southern Gulf of St. Lawrence (Miramichi River)

A compilation of commercial striped bass landings in the southern Gulf shows that the historical maximum (61 t) was reported in 1917 (LeBlanc and Chaput 1991) and was followed by a significant decline until 1934. No commercial landings were reported in the subsequent 33 years (from 1935 to 1968). This is attributed to the very low abundance of striped bass during that period (Douglas *et al.* 2003). Commercial catches resumed in 1969, peaking in 1981 at 48 t, then falling to less than 1 t in the early 1990s. The commercial striped bass fishery in the southern Gulf was closed in 1996.

Estimates of commercial landings between 1969 and 1996 were made on the basis of fish slips and fishery officer reports, two sources that are known to be incomplete and imperfect (Douglas *et al.* 2003). Research conducted by the Department of Fisheries and Oceans on the Miramichi River has shown that commercial striped bass catches were actually higher at this location than the amounts reported in the fishery statistics (Douglas *et al.* 2003).

Striped bass are taken predominantly as a bycatch in the gaspereau fishery and as a target species in the winter fishery (Douglas *et al.* 2003). Harvests are concentrated primarily along the coasts of Kent County, south of Miramichi (Kouchibouguac, Richibucto and Bouctouche areas). Commercial catches have also been reported in other New Brunswick counties, in the waters of Nova Scotia bordering the Gulf and in Prince Edward Island, but in much smaller quantities than in the Miramichi Bay area (LeBlanc and Chaput 1991).

Spawner estimates obtained in the Miramichi River since 1993 (Bradford *et al.* 1995; Bradford *et al.* 2001; Douglas *et al.* 2001) vary considerably (Figure 3). They show that spawner abundance fell from 50,000 in 1995 to approximately 8,000 in 1996 and 1997, and then to less than 4,000 between 1998 and 2000. It then increased to 24,000 in 2001 and to 29,000 in 2002 (Douglas *et al.* 2003). The sharp decline in spawner abundance in 1996 is believed to be due to the commercial fishery, which was subsequently closed. The recent recovery is believed to be due to the high survival rates of the 1998 year class.

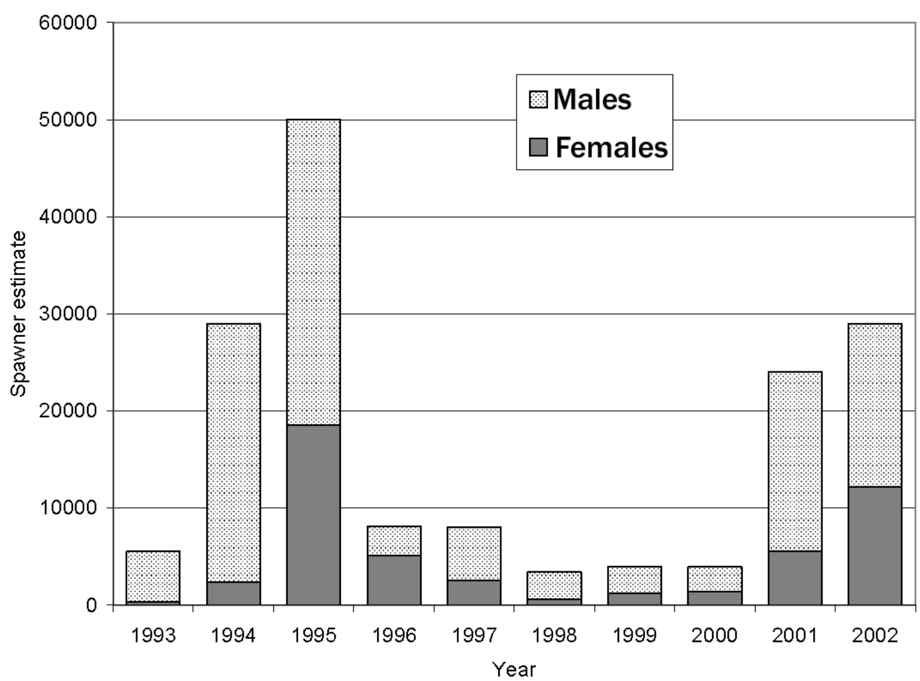

Figure 3. Spawner estimates of northwest Miramichi River striped bass since 1993 based on mark-recapture studies (Douglas *et al*. 2003).

Bay of Fundy tributaries

In summer, striped bass populations that spawn in Bay of Fundy tributaries can mix with migratory bass originating in U.S. rivers. As a result, certain precautions are required when estimating the size of these populations or determining the areas they frequent.

Shubenacadie River

Only indirect abundance indices are available for Shubenacadie River striped bass for years prior to 1999. Sport fishery data suggest that a decline in striped bass abundance occurred in the Shubenacadie River between 1950 and 1975, but that the numbers subsequently remained relatively stable (Jessop 1991).

Immature and adult bass from this population ascend the Shubenacadie River, a tributary of Minas Basin, to overwinter in Shubenacadie and Grand lakes. In the spring, they return downriver. Spawners spawn in the Stewiacke River, a tributary of the Shubenacadie.

Mark-recapture experiments developed since 1999 to estimate the abundance of this population have targeted its downstream run, not only to prevent it from being confused with U.S. bass, which would distort the estimates, but also for practical reasons, i.e., it is easier to capture bass in the river than in the estuary.

Due to methodological and logistical problems in the first three years of the mark-recapture experiments (1999 to 2001), 2002 is the first year for which reliable abundance estimates are available. In 2002, the Shubenacadie River population totalled between 18,000 and 27,000, at least 15,000 of which were of minimum reproductive age (3 years or more) and at least 7,000 of which were 4 years and over.

Like the beach seine surveys of young-of-the-year, recaptures of tagged bass seem to suggest a summer range of this population in the inner portion of Minas Basin (Douglas *et al.* 2003).

This population is the only population of the Bay of Fundy group for which it has been possible to conduct sampling of young-of-the-year in recent years (Rulifson *et al.* 1987; Douglas *et al.* 2003). It is showing no evidence of decline. However, a sufficiently long time series of population estimates is not yet available to formally confirm that its abundance is stable.

Annapolis River

Surveys of recreational striped bass fishers in the Annapolis River suggest that this population declined from 1971 to 1978 (Jessop and Doubleday 1976; Dadswell *et al.* 1984). The data collected show not only significant variations in the number of catches but, more importantly, changes in the characteristics of the fish caught, indicating very low recruitment and an aging of this population since 1971: an increase in average length, weight and age, combined with a sharp decline in the proportion of young fish (Jessop and Vithayasai 1979; Williams *et al.* 1984; Parker and Doe 1981; Jessop 1980, 1990, 1991, 1995). Starting in 1975, the majority of bass captured were adults, with juveniles being rare (Dadswell *et al.* 1984; Jessop and Vithayasai 1979; Jessop 1980; Parker and Doe 1981). There is no evidence that new individuals have been produced since 1976.

Eggs seem to have been released in the river periodically, but very few appear to have survived. In 1994, 400 eggs were found, but no juveniles were captured during the summer and fall (Jessop 1995). There appears to be high mortality during the earliest developmental stages (eggs and larvae). No young-of-the-year were captured in beach seine surveys in the Annapolis River Estuary in 2001 or 2002 (Douglas *et al.* 2003).

Given the species' longevity, it is possible, in principle, that bass from this population are still alive. However, it is believed that they can no longer reproduce due to water quality problems or to changes in water mass circulation, which are reported to cause egg mortality (see the section "Limiting Factors and Threats").

Saint John River

There had been a striped bass fishery in the Saint John River estuary since the early days of colonization. Striped bass spawning was reported in the Saint John River, between Fredericton and Mactaquac, as far back as the late 1800s (Cox 1893).

Sport fishing for striped bass in the Saint John River was carried out primarily in summer in the Reversing Falls area, the rocky limit of the estuary. Bass taken at this location appear to be primarily fish of U.S. origin. Sport catches appeared to show significant annual fluctuations, coinciding with the indices of abundance of migrating populations from the U.S. (Dadswell *et al.* 1984; Douglas *et al.* 2003).

In contrast, the commercial fishery, which was primarily a winter fishery, targeted primarily the resident bass population (Dadswell 1976). At the outset, bass was a bycatch of Atlantic sturgeon fisheries (*Acipenser oxyrhynchus*).   Striped bass catches varied depending on the fishing effort directed at sturgeon. A winter striped bass fishery began in Belleisle Bay in 1930 (Dadswell *et al.* 1984).

Landing statistics, collected since 1875, show significant fluctuations, with peaks generally being separated by 9- to 11-year intervals (Dadswell *et al.* 1984). In the 1970s, commercial catches declined rapidly. An analysis of catch composition showed the absence of recruitment and confirmed that the population was in decline (Dadswell 1983). The commercial fishery in Belleisle Bay was closed in 1978 (Hooper 1991).

The last collection of eggs and of one young individual (1+) in this river dates back to 1979 (M.J. Dadswell, DFO memorandum, 2 February 1982, cited by Douglas *et al.* 2003).

Systematic surveys conducted in 1992 and 1994 to collect eggs in June and juveniles in August were unsuccessful (Jessop 1995). Beach seine surveys in 2000 and 2001 were also unsuccessful (Douglas *et al.* 2003). Given the prolonged absence of evidence of spawning in this river, it must be concluded that this population has disappeared.

St. Lawrence Estuary

There is evidence that striped bass was fished by residents along the St. Lawrence Estuary under the French regime. Striped bass bones have been found, for example, on the site of an inn in Quebec City (Trépanier and Robitaille 1995).

The distribution, seasonal movements and harvesting of bass in the St. Lawrence Estuary were described in detailed at the end of the 19th century (Montpetit 1897). However, biological data on this species was systematically collected between 1944 and 1962 by the team of Dr. V.D. Vladykov, as part of a program to study and tag commercially harvested fish species (Brousseau 1955; Vladykov and Brousseau 1957; Beaulieu 1962; Magnin and Beaulieu 1967; Robitaille 2001).

The St. Lawrence striped bass population was very heavily exploited. The sport fishery was particularly intense around Île d'Orléans and in the Montmagny archipelago during the summer holiday period in July and August.

Striped bass was also caught by commercial fishers using fixed gear set along the shoreline, and by seiners, who used to catch striped bass off several islands in the St. Lawrence, between Île Madame and Île aux Oies. Commercial striped bass catches, which have been reported since 1920, show large fluctuations (from 5 to 50 t), with peaks being separated by approximately 10 years.

Judging from reported commercial landings, the St. Lawrence population appears to have declined significantly since the mid-1950s. In 1957, annual landings, which had always fluctuated between 5 and 50 tonnes, dropped below 3 tonnes, where they remained until 1965, the last year for which commercial catches of this species were reported.

Recreational landings seem to have followed the same trend. The last landings of striped bass in the Montmagny fishing tournament were in 1963. Occasional catches were landed by sport fishers until 1968 (Robitaille and Girard 2002).

It was briefly believed that this population had recovered in about the early 1980s, when some 100 bass were caught in Quebec, primarily around the Gaspé Peninsula and in the lower estuary. However, various indices, including tags found on a number of individuals, suggested that they were actually bass from the Miramichi River (R. Bradford, pers. comm.).

When bass was present, it was common to catch hundreds of young-of-the-year in fixed gear set around Île d'Orléans. This has not been the case since the mid-1960s. No other evidence of spawning has been observed since then.

Only one abundance estimate is available for this population. In the fall of 1957, between 600 and 1,300 two-year-old bass were surveyed in a coastal segment of approximately 60 kilometres, along the south shore (Robitaille 2001). This estimate is of limited interest because it was made after the striped bass population had already declined significantly. In addition, it applies essentially to the 2-year-old age group and cannot be extrapolated to other years or to the entire population.

LIMITING FACTORS AND THREATS

In the United States, where striped bass populations are more abundant, it is estimated that overfishing, pollution and spawning habitat alteration caused by changes in flow conditions can contribute, to varying degrees, to declines in abundance. It appears that Canadian bass populations are subject to the same threats. In addition, they could be exposed to additional limiting factors because they occur at the northern limit of the species' range. For example, the fact that it overwinters in freshwater could pose risks because the bass are concentrated in small areas for several months, making them vulnerable to poaching and various other mortality factors.

Climatic constraints

Striped bass populations often undergo natural abundance fluctuations due to characteristics of the species' dynamics: the production of large numbers of offspring by a given number of spawners is closely related to the occurrence of favourable climatic and environmental conditions (Ulanowicz and Polgar 1980; Rutherford and Houde 1995; Rutherford *et al.* 1997; Bulak *et al.* 1997), which do not occur every year. However, once they have reached maturity, striped bass may spawn several times, thereby offsetting the effect of variable recruitment (see the section "Survival").

The first critical period for the production of a strong bass cohort seems to occur when the larvae exhaust their yolk reserves and begin to feed. At that time, they must find an abundance of zooplankton (Cooper and Polgar 1981). A second important condition, at least for more northern populations, is believed to be growth during the first summer. In the Gulf, it is estimated that juveniles that reach at least 100 mm in length by the end of their first growing season have a better chance of surviving the prolonged fast of their first winter under the ice than do smaller individuals (Bernier 1996; Bradford and Chaput 1998; Hurst and Conover 1998).

Fishery

Depending on its intensity, fishing can limit the number of individuals that reach maturity and, for those that reach maturity, it can reduce the probability of repeated participation in spawning (Williamson 1974; Jessop and Doubleday 1976; Hogans and Melvin 1984; Secor 2000), thus reducing the capacity of the population to mitigate the impact of irregular recruitment.

The effect of fishing on bass abundance had long been underestimated. For example, migratory populations from Chesapeake Bay were decimated for two entire decades (1970 and 1980). Many studies had been conducted to attempt to identify and address the causes of this decline, without success. Given that the decline in abundance continued and that certain coastal states were little inclined to limit their fishing, the U.S. federal government intervened and imposed a moratorium on all forms of harvesting. The rapid recovery of the populations that followed confirmed that the cause of the problem was the overfishing (Field 1997). It was observed that the rebuilding of these populations began with spawning by large bass, some of which were over 30 years old and were protected by the fishing regulations (Secor 2000). A similar situation may have occurred in southern Gulf bass. Only one population is known; it spawns in the Miramichi River. Outside the spawning season, fish from this population migrate along the coasts, where they can be caught in fishing gear. They overwinter in several rivers, where they are exposed to illegal harvesting (Douglas *et al*. 2003).

The low abundance of bass in the southern Gulf led to the closure of the commercial fishery in 1996, followed by the other fisheries. The number of spawners entering the Miramichi River is reported to have increased considerably when a first strong cohort, produced in 1998, reached maturity (Douglas *et al*. 2003).

However, there continues to be evidence of mortality related to the fishery: a significant bycatch of young-of-the year still occurs in the fall and winter rainbow smelt fisheries (*Osmerus mordax*) and in eel traps (*Anguilla rostrata*) (Bradford *et al*. 1995, 1997). A similar situation has been observed in the St. Lawrence, where large numbers of juvenile bass have perished in eel traps (Trépanier and Robitaille 1995; A. Michaud, pers. comm.)

High mortality may also have been caused by illegal fishing, although this is impossible to assess (S. Douglas, A. Michaud, pers. comm.; Trépanier and Robitaille 1995; Douglas *et al*. 2003). Anecdotal accounts of illegal ice fishing activities have been reported by residents of the east coast of New Brunswick. In some communities, bass is reportedly still offered for sale door-to-door (Douglas *et al*. 2003).

The same problem existed in the St. Lawrence Estuary. When abundance declined sharply in the mid-1950s, managers tightened the regulations to limit bass harvesting, prompting an outcry from fishers, many of whom openly defied the regulations (A. Michaud, pers. comm.). It was common to find bass under the legal size limit for sale in Quebec City. When the winter bass fishery in Lake Saint-Pierre was closed in 1951, several fishers reportedly continued to fish illegally (A. Michaud, pers. comm.).

Habitat changes

Changes to the aquatic environment caused by human activity can increase mortality within populations, particularly in the early life stages (egg, larva). It is estimated that some habitat changes have adversely affected egg and larval survival. Contaminants, such as polychlorinated biphenyls (PCBs), aromatic hydrocarbons, pesticides, heavy metals and several other chemicals, are reported to reduce egg and larval survival in the laboratory (Korn and Earnest 1974; Bonn *et al.* 1976; Benville and Korn 1977; Durham 1980; Cooper and Polgar 1981; Hall 1991). However, their effect on recruitment has not been clearly demonstrated in the field.

For example, the section of the Miramichi River in which bass spawning and early development occur is exposed to pulp and paper mill effluent and municipal wastewater. However, there is no evidence that this has had an impact on bass reproduction, at least not in the recent past (Douglas *et al.* 2003).

One possibility that has been raised is that the cessation of reproduction in the Saint John and Annapolis rivers was due to water quality changes that affected egg and larval survival: non-point source agricultural pollution, pesticides or pH depression (Douglas *et al.* 2003). It has also been suggested that the construction of the Royal Annapolis dam in 1960 and the Mactaquac dam in 1967 on these two rivers may have modified spawning, incubation and rearing habitat. However, there is no consensus on how these changes have affected striped bass reproduction (Dadswell 1976; Jessop and Doubleday 1976; Williams 1978; Jessop and Vithayasai 1979; Jessop 1980; Parker and Doe 1981; Dadswell *et al.* 1984; Williams *et al.* 1984; Douglas *et al.* 2003). Striped bass egg sampling conducted in 1975 on the Saint John River showed that 96% of the eggs captured had ruptured membranes, a phenomenon that may be due to the presence of contaminants or to a sudden change in osmotic conditions. Similarly, on the Annapolis River, spawning occurred several times in the 1980s, but none of the eggs survived in the river. However, when they were transferred to fish farms, they developed normally and produced juveniles (Jessop 1991).

The effects of flow modifications in spawning grounds has been observed in the United States. The striped bass population of the Savannah River, between South Carolina and Georgia, spawned from February to May in the channels of streams located 16 to 50 km from the sea (Van den Avyle and Maynard 1994). The dredging of a navigation channel to serve the industrial port of Savannah and the construction of a tide gate between an island and the coast resulted in displacing the salt wedge upstream and moving bass spawning grounds closer together (Van den Avyle and Maynard 1994). Since those changes, bass eggs are no longer retained in the freshwater sector, but rather transported rapidly to saltwater, which causes their mortality (Winger and Lasier 1994).

It has been suggested that similar modifications affecting incubation or larval rearing habitat may have caused the cessation of bass spawning in the St. Lawrence Estuary (Robitaille and Ouellette 1991). However, the recently rediscovered collection of specimens collected by biologists up until 1962 shows that young-of-the-year were produced in the St. Lawrence as long as spawning striped bass were present there. The analysis of mark-recapture data shows that the disappearance of this population is the result of the reduction in its range due to habitat encroachment, i.e., the sites where striped bass congregated quickly became very popular fishing sites (Robitaille 2001).

The population remained small for 12 years until catches ended completely in 1968 (Robitaille and Girard 2002).

SPECIAL SIGNIFICANCE OF THE SPECIES

The striped bass has an undeniable appeal for commercial and sport fishers because of its delicate, white meat. It was fished by First Nations, and later by the first European settlers, and its bones have been identified on the Lanoraie archaeological site, west of Lake Saint-Pierre, which was occupied by First Nations in the 14th century, and on the nearby site of Champlain's settlement at Quebec City, which dates back to the 17th century (Trépanier and Robitaille 1995). The first settlers along the Saint John and Kouchibouguac rivers also engaged in a subsistence bass fishery (Dadswell 1976; Hogans and Melvin 1984).

Reported commercial landings of striped bass in Canadian waters have never exceeded several tens of tonnes (LeBlanc and Chaput 1991) and are small by comparison with those recorded in the United States, which totalled over 6,000 t in 1973 (Melvin 1991). Most commercial landings in Canada come from the southern Gulf and are taken as bycatch in the gaspereau (*Alosa pseudoharengus*) or rainbow smelt (*Osmerus mordax*) fisheries (LeBlanc and Chaput 1991). However, fisheries directed specifically at striped bass have occurred at several locations in the past.

In the Bay of Fundy, the striped bass commercial fishery had a number of good years, from 1885 to 1888 and again from 1959 to 1970, particularly in Belleisle Bay on the Saint John River. Catches at this site then declined and the fishery had to be closed in 1978 (Dadswell 1983; Hooper 1991).

In the St. Lawrence estuary, commercial catches of striped bass were made primarily in the fall (Montpetit 1897). Although catches never reached levels comparable to those of the American eel (*Anguilla rostrata*), the principal commercial species in this part of the river, they were sufficiently profitable that fishers from certain communities on the south shore directed specifically for the species. Commercial striped bass catches in the estuary reached a maximum of 53 t in 1943. Lake Saint-Pierre, an enlargement of the river upstream of the tidal zone, appears to have long been a winter striped bass fishing ground (Montpetit 1897). After the ice break up, fishing activity intensified in the lake. A period of intense bass fishing, called the "coup du bar", would take place in late April and early May (Cuerrier 1962). The winter bass fishery in the St. Lawrence was closed in 1951, but a number of fishers continued to fish it illegally.

Striped bass is highly prized by anglers, with the level of interest in angling for striped bass varying from region to region.

In the Maritimes, angling for bass is carried out in the estuaries and rivers it enters, but less intensively than in the United States because the bass caught are generally smaller. Nonetheless, the number of anglers has increased over the years. In the southern Gulf, angling was carried out along the entire length of the coast, but was concentrated primarily in the estuaries of the Richibucto, Kouchibouguac, Miramichi, Tabusintac and Nepisiguit rivers, in June, August and September (Hooper 1991).

In the Bay of Fundy, sport catches are concentrated within a specific period and to a limited number of sites. On the Annapolis River, bass was fished primarily at the base of the Royal Annapolis dam from mid-June to early October. In contrast, catches on the Shubenacadie River are distributed over a longer section of the river accessible to bass, but over a shorter time period, i.e., from April to June. Sport fishing on the Saint John River lasts all summer but is concentrated at Reversing Falls (Jessop and Vithayasai 1979). At this site, catches consist primarily of migrants from U.S. rivers, which are larger than local bass.

In the St. Lawrence Estuary, the best angling sites are between Batture au Loup-Marin, off L'Islet, and Cap Tourmente (Montpetit 1897). In the 1940s, 1950s and 1960s, the striped bass was subject to an intense seasonal sport fishery in several communities along the estuary. Large numbers of anglers took part in the fishing tournaments that were held annually in August and September in Montmagny, Rivière-Ouelle, Château-Richer and Île d'Orléans.

Apart from its interest as a long-standing fisheries species, striped bass is an important component of the biodiversity of aquatic ecosystems. The species is typically associated with estuaries and coastal waters, where it is one of the most important piscivorous species. An abundant striped bass population is an indicator that a river and its estuary are in good condition: the species requires high quality spawning and nursery habitat and abundant aquatic species for food.

EXISTING PROTECTION OR OTHER STATUS

Habitat protection

The federal Fisheries Act contains several fish habitat protection provisions. For example, under sections 34, 35 and 38, it is prohibited to carry on any work or undertaking or to deposit deleterious substances that result in the harmful alteration, disruption or destruction of fish habitat. As defined by the Act, "fish habitat" encompasses a wide variety of sites, including "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes".

In the St. Lawrence Estuary, striped bass habitat may also be protected under Quebec legislation. The Environment Quality Act (R.S.Q., c. Q-2) gives the Department of Environment and the Wildlife and Parks Corporation (Société de la faune et des parcs) responsibility for protecting the environment, living organisms and property (section 2). Sections 20 and 22 regulate the emission, deposition issuance and discharge of contaminants into the environment. The measures made available to the

Minister to enforce the Act are set out in a series of sections and in the Regulation Respecting Environmental Impact Assessment and Review. Chapter 4.1 of the Act Respecting the Conservation and Development of Wildlife (R.S.Q., c. C-61.1) and a related regulation, the Regulation Respecting Wildlife Habitats, provide for the protection of 11 types of wildlife habitat, two of which could apply to striped bass, namely fish habitat and habitat of threatened and vulnerable species.

Management of striped bass fisheries

Management of the striped bass fishery in the Maritimes is based on the premise that there are currently only two populations, i.e., that of the Miramichi River and that of the Shubenacadie River. They fall under the jurisdiction of two administrative regions of the Department of Fisheries and Oceans. Fisheries in the Maritime provinces are subject to the Fisheries Act and the Maritime Provinces Fishery Regulations (SOR/93-55).

Southern Gulf of St. Lawrence

Given the evidence of a marked decline in striped bass abundance in the southern Gulf in the 1980s and 1990s, measures limiting harvesting were gradually introduced beginning in 1992 (Douglas *et al*. 2003). In 1992, directed commercial striped bass fisheries were closed and the first ever recreational regulations were introduced. In 1993, a minimum conservation requirement of 5,000 spawners was introduced. Abundance estimates below this level led to the complete closure of the commercial fishery, including zero tolerance for any bass bycatch, and mandatory hook and release for anglers in 1996. In 2000, all recreational fisheries were closed and all First Nations allocations for social and ceremonial purposes were suspended (Douglas *et al*. 2003).

Bay of Fundy

To date, there are no conservation reference points for Bay of Fundy striped bass. Recreational fishing is permitted in tidal waters year round, with the exception of the Annapolis River estuary. Recreational fishers are permitted to keep one bass over 68 cm total length per day.

There is no directed commercial striped bass fishery. However, commercial fishers of other species may keep, depending on the location, all or part of their striped bass bycatch (Douglas *et al*. 2003).

St. Lawrence Estuary

In Quebec, the management of anadromous and catadromous fisheries falls under provincial jurisdiction. In 1951, the commercial harvesting of striped bass was regulated to protect the species near the spawning grounds. Provincial fishing regulations prohibited striped bass fishing between December 1 and May 31. In 1951, a minimum size requirement of 30 cm was introduced, which was raised to 40 cm in 1960. Few commercial or recreational fishers complied with the regulations, and fishery officers responsible for monitoring the fisheries did not receive sufficient support from the authorities.

From 1975 to 1984, there were no regulations prohibiting recreational or commercial harvesting of striped bass. Since 1984, commercial striped bass fishing has been prohibited under the Quebec Fisheries Plan. In 1993, amendments were made to Quebec's Fishing Regulations to prohibit recreational fishing and sale of striped bass.

Status

The striped bass population in Quebec has disappeared (Trépanier and Robitaille, 1995). In 2002, a program was launched to reintroduce striped bass to the St. Lawrence Estuary using fish collected from the Miramichi River starting in 1999. The fish were reared in fish culture stations to artificially produce fry to be used to stock the St. Lawrence Estuary.

The striped bass populations of the Saint John and Annapolis rivers have also disappeared (Douglas *et al*. 2003). To date, no plan has been established for the recovery of striped bass in these rivers.

No Canadian striped bass populations have been designated under federal legislation. In the United States, striped bass does not appear on the list of threatened species prepared by the U.S. Fish and Wildlife Service.

NatureServe ranks for the species (NatureServe, 2004) are G5 for the global rank, N3? for Canada, and N5 for the United States. Provincial ranks are S2 for New Brunswick, S1 for Nova Scotia, S2N for Prince Edward Island, and SX for Quebec. State ranks along the Atlantic coast are mostly S4 and S5, although in Connecticut, the rank is S3. Detailed information is presented in the Technical Summaries.

TECHNICAL SUMMARY

Southern Gulf of St. Lawrence Population
Morone saxatilis
Striped bass — Bar rayé
A population spawning in the northwest Miramichi River.
Range of occurrence in Canada: Southern Gulf of St. Lawrence (particularly the east coast of New Brunswick, but also Prince Edward Island and part of the coast of Nova Scotia).

Extent and Area information	
• *Extent of occurrence (EO)(km²)* (Estimated from the southern Gulf of St. Lawrence population shown in Figure 2)	93,000 km^2
• *Specify trend (decline, stable, increasing, unknown)*	Stable
• *Are there extreme fluctuations in EO (> 1 order of magnitude)?*	No
• *Area of occupancy (AO) (km²)* (Based on spawning habitat)	<100 km^2
• *Specify trend (decline, stable, increasing, unknown)*	Stable
• *Are there extreme fluctuations in AO (> 1 order magnitude)?*	No
• *Number of extant locations*	A single spawning ground, in the NW Miramichi River.
• *Specify trend in # locations (decline, stable, increasing, unknown)*	Stable
• *Are there extreme fluctuations in # locations (>1 order of magnitude)?*	No
• *Habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	Appears stable.
Population information	
• *Generation time (average age of parents in the population)*	12 years.
• *Number of mature individuals*	50,000 (1995). < 4,000 (1998-2000) 29,000 (2002).
• *Total population trend*	Declining from 1995 to 2000, increasing in 2001 and 2002.
• *If decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	93% decrease from 1995 to 1998 (50,000 to 3,400), then 853% increase from 1998 to 2002 (3,400 to 29,000).
• *Are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	Yes
• *Is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	No. The population is fragmented among several rivers to overwinter, but all spawners congregate on the same spawning grounds.
• *List each population and the number of mature individuals in each*	A single population. See figures above.
• *Specify trend in number of populations (decline, stable, increasing, unknown)*	Stable
• *Are there extreme fluctuations in number of populations (>1 order of magnitude)?*	No

Threats (actual or imminent threats to populations or habitats)	
- Heavy exploitation: it appears that this factor is in the process of being controlled; the commercial, sport and ceremonial (First Nations) fisheries were limited, and subsequently closed, when the estimate of the number of spawners on the spawning ground fell below a predetermined threshold of 5,000 spawners. Numbers began to increase starting in 2001. Mortality of juveniles caught as bycatch in gear intended for other species still occurs (smelt, eel). Finally, the confinement of bass in the estuaries of several rivers where they overwinter could increase the risks of poaching and exposure to other mortality factors. - Habitat changes: indeterminate risk associated with the presence of industrial and municipal effluent near spawning and nursery habitats. However, there is no evidence of mortality due to this factor in recent years.	
Rescue Effect (immigration from an outside source)	Very unlikely. Mark-recapture data indicate very little contact with populations to the south.
• *Does species exist elsewhere (in Canada or outside)?*	Yes
• *Status of the outside population(s)?*	In the west, the St. Lawrence population is extirpated. In the south, two of three Bay of Fundy populations have disappeared. The third (Shubenacadie) is extant but appears to be found primarily in Minas Basin. Further south, several U.S. populations are abundant but do not appear to migrate further north than the Bay of Fundy.
• *Is immigration known or possible?*	Very unlikely.
• *Would immigrants be adapted to survive here?*	Yes?
• *Is there sufficient habitat for immigrants here?*	Yes?
Quantitative Analysis	Not available

Current Status	**NatureServe Ranks** (NatureServe 2004) <u>Global Status</u>: G5 <u>National Status</u>: **Canada** – N3?; **USA** – N5 <u>Provincial / State Status</u>: **Canada**: NB (S2), NS (S1), PE (S2N), QC (SX). **USA (selected states)**: Connecticut (S3), Delaware (S5), Maine (S5), Maryland (S5), Massachusetts (SU), New Hampshire (S4), New Jersey (S4), New York (S4), Rhode Island (SNR), Virginia (S4)

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** Met criteria for Endangered, B2ac(iv), but designated as Threatened, B2ac(iv); D2, because of the high degree of resilience evident in recent spawner abundance estimates.
Reasons for Designation: This fish was once commercially important and is still highly prized by anglers. Threats include bycatch in various fisheries such as gaspereau, and rainbow smelt. Illegal take, particularly during ice fishing, is also believed to be a threat.	
Applicability of Criteria **Criterion A** (Declining Total Population): The thresholds are not met. **Criterion B** (Small Distribution, and Decline or Fluctuation): It meets the threshold for Endangered B2ac(iv), in terms of area of occupancy, small number of locations, and extreme fluctuations in number of mature individuals. **Criterion C** (Small Total Population Size and Decline): The thresholds are not met. **Criterion D** (Very Small Population or Restricted Distribution): Qualifies as Threatened under D2 because it is only known from only one spawning location. **Criterion E** (Quantitative Analysis): Data are not available.	

TECHNICAL SUMMARY

St. Lawrence Estuary Population
Morone saxatilis
Striped bass — Bar rayé
Range of occurrence in Canada: Quebec, St. Lawrence River and Estuary, from Lake Saint- Pierre to the Kamouraska area.

Extent and Area information	
• *Extent of occurrence (EO)(km²)* (Estimated from Figure 2)	Formerly <3000 km^2
• *Specify trend (decline, stable, increasing, unknown)*	Not applicable
• *Are there extreme fluctuations in EO (> 1 order of magnitude)?*	No
• *Area of occupancy (AO) (km²)*	Unknown
• *Specify trend (decline, stable, increasing, unknown)*	Not applicable
• *Are there extreme fluctuations in AO (> 1 order magnitude)?*	No
• *Number of extant locations*	None
• *Specify trend in # locations (decline, stable, increasing, unknown)*	Not applicable
• *Are there extreme fluctuations in # locations (>1 order of magnitude)?*	No
• *Habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	Not applicable
Population information	
• *Generation time (average age of parents in the population)*	12 years
• *Number of mature individuals*	Nil
• *Total population trend*	Based on commercial catches from 1920 to 1965, presence highly variable. Significant decline in the 1950s and extirpation in the 1960s.
• *If decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	Not applicable
• *Are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	Not applicable
• *Is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	Not applicable
• *List each population and the number of mature individuals in each*	Nil
• *Specify trend in number of populations (decline, stable, increasing, unknown)*	Not applicable
• *Are there extreme fluctuations in number of populations (>1 order of magnitude)?*	No
Threats (actual or imminent threats to populations or habitats)	
- Heavy exploitation: all data and observations on the issue are consistent. The commercial and sport fisheries were very intense and the regulations were not respected. - Habitat alterations: the disposal of dredge material in a section of the seaway is believed to have contributed to confining immature bass to a limited area along the south shore where fishing subsequently became concentrated.	

Rescue Effect (immigration from an outside source)	Unknown
• *Does species exist elsewhere (in Canada or outside)?*	Yes
• *Status of the outside population(s)?*	In the east, one population in the Southern Gulf (Miramichi River). In the south, two of three Bay of Fundy populations have disappeared. The third (Shubenacadie) is extant but appears to be found primarily in Minas Basin. Further south, several U.S. populations are abundant but do not appear to migrate further north than the Bay of Fundy.
• *Is immigration known or possible?*	Very unlikely
• *Would immigrants be adapted to survive here?*	Yes?
• *Is there sufficient habitat for immigrants here?*	Yes?
Quantitative Analysis	Not available

Current Status	**NatureServe Ranks** (NatureServe 2004) Global Status: G5 National Status: **Canada** – N3?; **USA** – N5 Provincial / State Status: **Canada**: NB (S2), NS (S1), PE (S2N), QC (SX). **USA (selected states)**: Connecticut (S3), Delaware (S5), Maine (S5), Maryland (S5), Massachusetts (SU), New Hampshire (S4), New Jersey (S4), New York (S4), Rhode Island (SNR), Virginia (S4)

Status and Reasons for Designation

Status: Extirpated	**Alpha-numeric code:** Not applicable
Reasons for Designation: The population from the St. Lawrence Estuary has disappeared as a consequence of illegal fishing, with the last record dating from 1968.	
Applicability of Criteria **Criterion A** (Declining Total Population): Not applicable. **Criterion B** (Small Distribution, and Decline or Fluctuation): Not applicable. **Criterion C** (Small Total Population Size and Decline): Not applicable. **Criterion D** (Very Small Population or Restricted Distribution): Not applicable **Criterion E** (Quantitative Analysis): Not applicable.	

TECHNICAL SUMMARY

Bay of Fundy Population
Morone saxatilis
Striped bass Bar rayé
Three populations spawning in the Saint John (N.B.), Annapolis and Shubenacadie (N.S.) rivers.
Range of occurrence in Canada: For the existing population: Nova Scotia, Minas Basin and Shubenacadie-Stewiacke system. Range of occurrence undetermined for the two populations that have disappeared. It was probably limited to the interior Bay of Fundy.

Extent and Area information	
• *Extent of occurrence (EO)(km²)* (estimated from Figure 2)	29,000 km^2
• *Specify trend (decline, stable, increasing, unknown)*	Current trend unknown: No indication that it is currently declining, but it has declined in recent decades with the disappearance of two of the three populations. The freshwater habitats and estuaries of the Annapolis and Saint John rivers are no longer used by their respective bass populations. The areas used in the Bay of Fundy in summer have also likely decreased, but this is impossible to assess.
• *Are there extreme fluctuations in EO (> 1 order of magnitude)?*	No evidence of extreme fluctuations in EO, apart from changes indicated above.
• *Area of occupancy (AO) (km²)* (based on spawning habitat)	<100 km^2
• *Specify trend (decline, stable, increasing, unknown)*	Two of three spawning areas have been lost.
• *Are there extreme fluctuations in AO (> 1 order magnitude)?*	No evidence of extreme fluctuations.
• *Number of extant locations*	1
• *Specify trend in # locations (decline, stable, increasing, unknown)*	The number of spawning populations declined from three to one over the last three decades of the 20th century.
• *Are there extreme fluctuations in # locations (>1 order of magnitude)?*	No
• *Habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	Areas historically used for spawning, incubation and rearing in the Saint John and Annapolis rivers appear to have been altered, which may be the cause of the disappearance of these two populations. No evidence of change in Shubenacadie River spawning habitats or in feeding areas in the Bay of Fundy.
Population information	
• *Generation time (average age of parents in the population)*	12 years.
• *Number of mature individuals*	Total size of the three populations, when they co-existed: unknown. See on next page, total size of the Shubenacadie River population.

• *Total population trend*	The total number of striped bass of Canadian origin in the Bay of Fundy likely declined in the 20th century, since two of the three populations are now extirpated. However, the size of the extirpated populations areas never estimated.
• *If decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	Unknown
• *Are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	Unknown
• *Is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	No, not currently, because there is only one extant population.
• *List each population and the number of mature individuals in each*	Shubenacadie River: In 2002, over 15,000 bass of age 3+ years, 7,000 of which were of age 4+ years.
• *Specify trend in number of populations (decline, stable, increasing, unknown)*	Shubenacadie River: only one population estimate. Trend not yet determined.
• *Are there extreme fluctuations in number of populations (>1 order of magnitude)?*	Unknown
Threats (actual or imminent threats to populations or habitats)	
- Exploitation: In the Bay of Fundy, undetermined effect on the Shubenacadie population, which is taken along with U.S. bass; bycatch in gear set in Minas Basin. - Habitat alterations: undetermined risk related to mining activities (titanium) in the Shubenacadie River and Cobequid Bay. - Introduction of species: Chain pickerel *(Esox niger)* in Grand Lake (in the Shubenacadie River system), bass overwintering site; possible effect not yet determined.	
Rescue Effect (immigration from an outside source)	Likely low, according to available information.
• *Does species exist elsewhere (in Canada or outside)?*	Yes
• *Status of the outside population(s)?* • USA	In the northwest, the St. Lawrence population has disappeared. In the north, there is one extant population in the southern Gulf (Miramichi River). Along the Atlantic coast of the US, the species is abundant (see NatureServe rankings below).
• *Is immigration known or possible?*	Mark-recapture data indicate very little contact with the population to the north. Individuals from US populations feed during the summer in the Bay of Fundy, but there is no evidence that these individuals spawn in Canadian waters.
• *Would immigrants be adapted to survive here?*	Unknown.
• *Is there sufficient habitat for immigrants here?*	See comments above.
Quantitative Analysis	Data not available.

Current Status	**NatureServe Ranks** (NatureServe 2004) Global Status: G5 National Status: **Canada** – N3?; **USA** – N5 Provincial / State Status: **Canada**: NB (S2), NS (S1), PE (S2N), QC (SX). **USA (selected states)**: Connecticut (S3), Delaware (S5), Maine (S5), Maryland (S5), Massachusetts (SU), New Hampshire (S4), New Jersey (S4), New York (S4), Rhode Island (SNR), Virginia (S4)

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** Met criteria for Endangered, A2bc, but designated Threatened, A2bc; D2, because the one remaining spawning population does not appear to be at imminent risk.
Reasons for Designation: Repeated spawning failures led to the disappearance of the Annapolis and Saint John River populations. These disappearances are thought to be due to changes in flow regime and poor water quality. In the Shubenacadie River population, the presence of the introduced chain pickerel in overwintering sites may constitute a threat. Another threat to the population is bycatch from various commercial fisheries. The Bay of Fundy is also used by striped bass breeding in rivers in the United States. These fish were not assessed.	
Applicability of Criteria **Criterion A** (Declining Total Population): In the last 2 generations, two of three spawning populations have been lost. Qualifies for Endangered under A2(bc). **Criterion B (**Small Distribution, and Decline or Fluctuation): Although it meets the threshold for Endangered in terms of area of occupancy and small number of locations, neither a continuing decline nor extreme fluctuations can be demonstrated. **Criterion C** (Small Total Population Size and Decline): Does not meet thresholds. **Criterion D** (Very Small Population or Restricted Distribution): Qualifies as Threatened under D2 because it is only known from one spawning location. **Criterion E** (Quantitative Analysis): Data are not available.	

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Jean Robitaille has worked in the field of ecology for 30 years. After completing graduate studies, he taught biology at the National University of Rwanda, in Central Africa. On returning to Quebec, he worked as a biologist for the provincial and federal governments and the private sector. In 1988, he founded the Bureau d'écologie appliquée, a cooperative of environmental consultants, where he still works today.

His professional activities and achievements are primarily in the areas of aquatic ecosystems and fisheries. He conducted a study of the salmon population of the Koksoak River in Nunavik. This population is characterized by the existence of a group of estuarine salmon that do not migrate to the sea. These estuarine salmon can be distinguished, in several ways, from typical salmon living in the same river that migrate to the ocean.

He has conducted several studies on the St. Lawrence River, its aquatic habitats and its fish populations. He has worked on the conservation of several species at risk in Quebec, including the American shad, striped bass, American eel, rainbow smelt and muskellunge. He is the author of a historical analysis of eel catches in the 20th century, which presented the first evidence that overfishing affects eel recruitment. Through a review of reported commercial catches along the St. Lawrence from 1945 to 1984 as well as habitat changes that occurred during that same period, he demonstrated the major impact of navigation developments on migratory fish in the estuary. Since 1989, he has written several reports on the striped bass of the St. Lawrence and is frequently consulted on this subject. He was a member of the scientific committee on the reintroduction of striped bass and made a substantial contribution to the reintroduction plan. He re-analyzed the biological data gathered between 1944 and 1962 on the St. Lawrence striped bass population, which enabled him to shed light on the circumstances leading to its disappearance.

He has long been interested in species at risk and, in 1979, he and his colleagues formed the first Quebec working group on species at risk, called the Comité pour la sauvegarde des espèces menacées au Québec (COSEMEQ). He is also a founding member and director of the Fondation Carcajou. He has been an advisor on the impact of projects on aquatic resources and, in recent years, has often served on expert panels or worked for various organizations as a scientific writer, analyst or communicator in his field of expertise and in other related fields.