Fisheries and Oceans Canada Pêches et Océans Canada
Science Sciences

C S A S **S C C S**

Canadian Science Advisory Secretariat **Secrétariat canadien de consultation scientifique**

Research Document 2012/021 **Document de recherche 2012/021**

Maritimes Region **Région des Maritimes**

Update Status Report on Bay of Fundy Striped Bass (*Morone saxatilis*)

Mise à jour du rapport sur l'état du bar rayé de la baie de Fundy (*Morone saxatilis*)

R.G. Bradford[1], P. LeBlanc[1], and P. Bentzen[2]

[1]Department of Fisheries and Oceans
Science Branch, Maritimes Region
P.O. Box 1006
Dartmouth, Nova Scotia, B2Y 4A2

[2]Department of Biology
Dalhousie University
Halifax, N.S.

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

This document is available on the Internet at

La présente série documente les fondements scientifiques des évaluations des ressources et des écosystèmes aquatiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

Ce document est disponible sur l'Internet à

www.dfo-mpo.gc.ca/csas-sccs

ISSN 1499-3848 (Printed / Imprimé)
ISSN 1919-5044 (Online / En ligne)
© Her Majesty the Queen in Right of Canada, 2012
© Sa Majesté la Reine du Chef du Canada, 2012

Canada

TABLE OF CONTENTS

Correct citation for this publication:
La présente publication doit être citée comme suit :

Bradford, R.G., P. LeBlanc, and P. Bentzen. 2012. Update Status Report on Bay of Fundy Striped Bass (*Morone saxatilis*). DFO Can. Sci. Advis. Sec. Res. Doc. 2012/021: iv + 46p.

ABSTRACT

Bay of Fundy striped bass, is one of the three Designatable Units of striped bass recognized by the Committee on the Status of Endangered Wildlife in Canada. The status of the Designatable Units which consists of the Saint John River population in New Brunswick, and the Shubenacadie River and Annapolis Rivers populations in Nova Scotia, is to be assessed by COSEWIC in 2011. Available data indicates that the Shubenacadie River population continues to produce new individuals annually. There is no evidence that striped bass any longer are produced in the Annapolis River. Genetic data indicates the inter-annual presence in the Saint John River of a grouping of striped bass that can not be assigned to a known spawning population. These fish may represent a native Saint John River population.

RÉSUMÉ

Le bar rayé de la baie de Fundy constitue l'une des trois unités désignables (UD) de bar rayé reconnues par le Comité sur la situation des espèces en péril au Canada. L'état de l'UD qui correspond à la population se trouvant dans la rivière Saint-Jean, au Nouveau-Brunswick, et les populations se trouvant dans la rivière Annapolis et la rivière Shubenacadie doivent être évaluées par le COSEPAC en 2011. Les données accessibles indiquent que la population se trouvant dans la rivière Shubenacadie continue de se reproduire chaque année. Il n'existe aucune preuve de reproduction de la population de bar rayé dans la rivière Annapolis. Les données génétiques indiquent que la présence d'une année à l'autre d'un regroupement de bars rayés dans la rivière Saint-Jean ne peut pas être attribuée à une population reproductrice connue. Il est possible que ces poissons constituent une population indigène de la rivière Saint-Jean.

INTRODUCTION

The striped bass (*Morone saxatilis*) is an anadromous percoid that spawns in many estuaries along the eastern seaboard of North America from the St. Lawrence River in Québec, Canada, to the St. John's River in Florida (Scott and Scott 1988). Highest concentrations of striped bass occur in the middle of the species range; specifically in the Chesapeake Bay and the Delaware River areas of the State of Maryland and the Hudson River of the State of New York. Striped bass are an important high order predator in the coastal and estuarial zones wherever they occur.

Striped bass are common in the coastal and estuarial waters, and in certain freshwater bodies, of the Maritimes Region (Figure 1). They support directed recreational angling fisheries and aboriginal ceremonial fisheries of local importance. Both migrant striped bass from spawning populations occurring along the eastern seaboard of the United States of America and resident striped bass occur in the Region (Wirgin et al. 1995; Rulifson and Dadswell 1995; Bradford et al. 2001; Bentzen and Patterson 2005). The spawning populations that occur within the Canadian portion of the Bay of Fundy represent one of the three Designatable Units (DU) of striped bass defined in 2004 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2004). The DU is comprised of three spawning populations; the Saint John River population in New Brunswick (Figure 2), and the Shubenacadie River and Annapolis River populations in Nova Scotia (Douglas et al 2003; COSEWIC 2004) (Figure 2).

Bay of Fundy striped bass were designated as Threatened (TH) by COSEWIC in November 2004 on the basis that the Annapolis and Saint John River populations may no longer exist (COSEWIC 2004). No evidence of spawning, and no catches of local bass, had been authenticated on either river during the two decades preceding the 2004 COSEWIC review. Lack of spawner success on both rivers was attributed to deleterious changes in flow regime and poor water quality (COSEWIC 2004). The Shubenacadie River population was considered to be producing new individuals on an annual basis (Douglas et al. 2003; COSEWIC 2004). Threats to the Shubenacadie River population were defined as the presence of the introduced chain pickerel (*Esox niger*) in overwintering sites and bycatch from various commercial fisheries (COSEWIC 2004).

The Bay of Fundy striped bass Designatable Units (DU) is under consideration for listing as Threatened on Schedule 1 of Canada's *Species at Risk Act* (*SARA*). A Recovery Potential Assessment completed in 2006 defined a recovery target for the DU based upon area of occupancy; namely to reestablish annual spawning in at least one of the locations known historically to have supported spawning (DFO 2006). Neither the severity of stated threats nor the specific mechanisms contributing to the reported loss of the Annapolis River and Saint John River populations were considered to be known (DFO 2006). Research to assess the present status of Saint John River striped bass has occurred since COSEWIC (2004) and DFO (2006). Activity to resolve the status of Annapolis River striped bass has been limited.

This update on the status of Bay of Fundy striped bass was conducted in support of a scheduled national assessment of the status of striped bass by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The document contains information available from DFO Maritimes Region concerning:

1) Life History Characteristics
2) Management
2) Review of Designatable Units
3) Review the COSEWIC Criteria

4) Description of Habitat and Threats to Habitat
5) Application of the Concept of Residence to Bay of Fundy Striped Bass
6) Threats
7) Other

The document also discusses indicators that would be relevant to evaluating the risk of extinction of the species. This includes the likelihood of imminent or continuing decline in the abundance or distribution of the species, or that would otherwise be of value in preparation of COSEWIC Status Reports.

LIFE HISTORY CHARACTERISTICS

Striped bass spawning occurs in the spring with a progression that generally begins at the south of the species distribution and ends in the north. Striped bass spawn as early as the end of March in the Savannah River, Georgia (Van den Avyle and Maynard 1994). Age of first spawning among the Canadian populations is generally 3-4 years for males and 4-6 for females at body lengths of about 32 cm Fork Length (FL) and 50 cm FL for males and females respectively (Douglas et al. 2003). Striped bass can remain reproductively active for 20 years or more (Secor 2000), although not all fish will spawn every year (Waldman et al. 1990). Spawning usually begins on Canadian rivers in mid-May as water temperatures rise to about 15 ^{0}C (Robichaud-LeBlanc et al. 1996) and can continue into mid-June. Eggs and milt are broadcast simultaneously into the water column, float freely, and hatch in a few days (2-3) depending on water temperature (Scott and Scott 1988). Newly hatched larvae exhaust their yolk reserves in five to 10 days then move to the near shore shallows of the estuary, where they feed on zooplankton and grow rapidly during the summer (Robichaud-LeBlanc et al. 1998). Many post-spawned adults, along with Age 2+ years and older juveniles, initiate a coastal feeding migration that lasts for the summer and autumn. As predators, striped bass are generalists, and consume both macro-invertebrates and fish (Scott and Scott 1988). At the onset of winter, adult striped bass in the Maritimes re-enter estuaries, river mouths, and at least one head water lake, presumably to avoid low potentially lethal sea water temperatures (Douglas et al. 2003).

SHUBENACADIE RIVER POPULATION

Spawning

Shubenacadie River striped bass are the only population of striped bass that uses a tidal bore estuary for spawning (Rulifson and Dadswell 1995). Adult fish that have wintered in Grand Lake (Figure 3) descend the river, at night, to assemble near the confluence of the Stewiacke and Shubenacadie rivers (Figure 3) with adults that have migrated from other wintering areas. The pre-spawning migration from Grand Lake begins around the first week of May (Figure 4), but the date of first appearance of downstream migrant fish varies among years (Figure 4). The migration from the lake can extend into early June (Figure 4).

The majority of spawning activity occurs in the tidal Stewiacke River in areas of low salinity (<1 ppt) at water temperatures >15-16 ^{0}C (Figure 5). The combined influence of tidal action and weather results in variable timing of the onset of spawning activity among years; approximately the first week of June in both 2000 and 2001 (Figure 5), and around mid-May in both 2009 and 2010 (Jim Duston, Nova Scotia Agricultural College, Truro, N.S., personal communication), for example. Spawning appears to be largely complete by mid-June (Figure 5) but may extend into July in some years (Jim Duston, personal communication).

Fecundity of Shubenacadie River striped bass has been estimated as 53,000 to 1,464,000 eggs per female at fork lengths of 44.9 cm and 91.0 cm respectively (or approximately four to 11 years of age) (Paramore 1998).

Early Life-History

Shubenacadie River striped bass eggs are susceptible to extensive dispersal resulting from tidal action during the brief (≤72 hour; Cook et al. 2010) incubation period. They possess several traits that have been interpreted as local adaptations to a high energy and variable environment. Traits include, large water-hardened diameters (3.67 mm± 0.10 mm), large diameter oil globules (0.83 mm ± 0.02 mm), low specific gravity (1.0018 $g\cdot cm^{-3}$) (Bergey et al. 2003) and tolerance of a broad range of salinity (2 ppt – 20 ppt) than is typical for populations occurring elsewhere (Cook et al. 2010). Yolk-sac larvae up to 7 days post hatch tolerate salinities of up to 30 ppt (Cook et al. 2010) and can tolerate temperature decreases that are lethal to other populations (Cook et al. 2010).

Following metamorphosis, juveniles exhibit both a greater scope for growth for temperatures between 10 ^{0}C and 26 ^{0}C (Cook et al. 2010) and higher thermal tolerance (618 $^0C^2$) than populations that occur to the south of the Shubenacadie River (Cook et al. 2006). Somatic growth rate is independent of salinity by 55 days post hatch and approaches an optimum around 26^{0}C-30^{0}C (Cook et al. 2010). Accordingly, young of the year striped bass can be found within the tidal portions of the river throughout the summer (Table 1), but a seaward range extension by late summer to Cobequid Bay and into Minas Basin as far as Five Islands (Figure 6) occurs in most years (Table 1).

Assays of the calcium/strontrium composition of the hyaline zones deposited on saggital otoliths during the first winter have indicated that young of the year striped bass overwinter in tidal brackish water (Cook and Bradford 2004); the specific overwintering sites are not known. Many Age 2+ years and older juveniles overwinter in Grand Lake and descend the river the following spring along with pre-spawning adults (Douglas et al. 2003).

Sub-Adults and Post-Spawn Adults

Compilation of recaptures to the end of 2005 (Table 2) of striped bass marked during the years 1999 to 2002 as they descended the Shubenacadie River from Grand Lake (see Douglas et al. 2003 for a description of the sampling protocol) suggest 1) inter-annual use of the lake as an overwintering area by some fish, and 2) a relatively small marine distribution for the contingent of the Shubenacadie population that ascends the river to overwinter in freshwater. None of the 1,862 striped bass marked while descending from the lake during the years 1999-2002 have been recaptured outside of Minas Basin (Table 2; Figure 7). Previous studies had suggested that larger-bodied and older members of the local spawning population migrate from the Minas Basin area between spawnings (Rulifson and Dadswell 1995).

The relatively small geographic distribution of recaptured Shubenacadie striped bass (Figure 7) is, however, inconsistent with both an earlier (Wirgin et al. 1995) and current (DFO 2011) genetic assessment of population membership of the summer assemblage of striped bass occurring within the Saint John River, New Brunswick. Both studies detected the presence of Shubenacadie-origin fish. Explanations for the inconsistencies between the mark-recapture and genetic assignment tests may include 1) a low likelihood of striped bass being recaptured outside of Minas Basin because of a low search effort (e.g., lower recreational angling activity or lower bycatch in licenced fisheries), 2) non-reporting of recaptures, or 3) that Shubenacadie striped bass are organized to some extent into local and coastal contingents, each exhibiting a variety of migration behaviours, as has been shown for other striped bass populations (Secor et al. 2001; Pautzke et al. 2010).

ANNAPOLIS RIVER POPULATION

Spawning

Historically, spawning occurred during May-June in the freshwater tidal and non-tidal portions of the Annapolis River between Middleton and Bridgetown (Figure 8) (Williams et al. 1984; Jessop 1990; Jessop 1995).

Early Life-History

Information is limited to reported occurrences of eggs and larvae upstream of Bridgetown (Williams et al. 1984) and only eggs in years following construction of the causeway at Annapolis Royal (Jessop 1990). No young of the year striped bass older than post-larvae have ever been collected from the Annapolis River.

Sub-Adults and Post-Spawn Adults

Unknown.

SAINT JOHN RIVER POPULATION

Current Origins of Striped Bass

A recent genotyping (11 microsatellite loci) of 810 striped bass sampled from the Saint John River between 1999 and 2008 (DFO 2011) identified the presence of both USA-origin and Shubenacadie River striped bass, as was shown previously by Wirgin et al. (1995). No Miramichi River fish were identified. The assessment further identified the inter-annual presence of a genetically discrete contingent (Table 3) that could not be assigned to a known population of origin. Both juvenile and adult fish were represented within this contingent (DFO 2011). These data lend support to the suggestion of Douglas et al. (2003) that native striped bass may still be present within the Saint John River.

Spawning

Neither the historical or possible current locations of striped bass spawning areas on the Saint John River are known with certainty. Spawning was reported by Cox (1893) and Rogers (1936) to occur during June in the section of the Saint John River lying above tidal influence, upstream of Fredericton. Neither report appears to have been substantiated with either samples of ripe and running adults or collections of eggs or larvae. Further, it is not clear if Rogers (1936) was reporting on observations that were independent of Cox (1893). Dadswell (1982)[1] collected eggs from the inner portions of Belleisle Bay (Figure 9) during 1979. Surveys were unsuccessful in collecting eggs, larvae or juveniles during 1992 and 1994 (Jessop 1995), or in collecting young-of-the-year (YOY) striped bass in 2000 and 2001 (Douglas et al. 2003).

Records for the years 1960-1965 of striped bass bycatch by month and Fishery Statistical District (FSD; Table 4, Figure 10) in the commercial Atlantic salmon (*Salmo salar*), gaspereau (*Alosa aestivalis, A. pseudoharengus*) and American shad (*A. sapidissima*) fisheries on the

[1] M.J. Dadswell, DFO memorandum, 2 February 1982

Saint John River were compiled by Smith (1969). These records which pre-date the 1968 construction of the Mactaquac Dam above Fredericton offer no evidence for a May-June spawning run of striped bass on the main river (FSD's 57 and 58; Figure 10). Trapnets (Table 5) deployed in these districts were successfully intercepting Atlantic salmon (Table 6), American shad (Table 7) and gaspereau (Table 8).

Estimates by Fisheries Officers of the number of striped bass landed by recreational anglers for the years 1951-1967 (Tables 9 and 10) indicate that the relatively few striped bass that were landed during May-June occurred in the Kennebecasis River, a tributary in the lower Saint John River (Figure 9).

Early Life-History

The early life-history of Saint John River striped bass is unknown. There are no authenticated captures of Age 0+ striped bass from the river.

Sub-Adults and Post-Spawn Adults

A recent assessment of the populations of origin of striped bass occurring in the Saint John River that integrated genetic analyses with mark-recapture data (DFO 2011) indicated that the summer-autumn distribution of potentially native Saint John River fish includes all of the Saint John River lying below the Mactaquac Dam and the inner portions of the Bay of Fundy, including Minas Basin.

STRIPED BASS MANAGEMENT IN MARITIMES REGION

Striped bass are managed under the *Canada Fisheries Act*. The Maritime Provinces Fishery Regulations (SOR/93-55) provide the regulatory framework within which fishery managers regulate harvests in the fisheries.

Recreational angling is permitted in tidal waters year round, with the exception of the inner portion of the Annapolis River estuary which is closed to striped bass angling between April 1st and June 30th.

There are no conservation reference points to guide either directed harvests (recreational angling, aboriginal food, social and ceremonial fisheries) or bycatch allowances for striped bass in the Maritimes Region. Instead, fisheries managers have implemented conservation measures within the regulatory framework following multi-stakeholder consultations. The chronology of measures implemented since 1978 is as follows:

1978
- Commercial licensing for striped bass ceased, only incidentally captured striped bass could be retained and sold.

1994
- Recreational bag limits were reduced from 5 to 1 per day and minimum size limits phased in over the next 3 years, i.e., ≥48 cm, ≥58 cm and then ≥ 68 cm (Total Lengths).

1996
- Federal regulations amended to prohibit the retention and sale of any striped bass incidentally captured in licenced commercial harvest fisheries.

- Recreational angling fishery bag limit was maintained at 1 striped bass per day and the phased in minimum size limit ≥ 68 cm TL was achieved for first time in 1996.

1997

- Consultations with commercial licence holders who historically caught and retained striped bass incidental to their other licensed fishing activities resulted in the following amendments that were implemented via licence conditions:
  - Shubenacadie/ Stewiacke shad and gaspereau drift net fishers permitted to retain 3 striped bass < 8 lbs (3.6 kg) per day.
  - Stewiacke River upstream from Stewiacke Landing closed to gill net fishing all year and the shad drift net fishery closed 2 weeks early (May 31st).
  - Gaspereau dip stand operators on the Shubenacadie River required to release all striped bass.
  - Minas Basin weir fishers permitted to retain 1 striped bass per day, 68 cm or more in total length.
  - Saint John River shad and gaspereau drift net and trap net fishers permitted to retain 1 striped bass per day, 68 cm or more in total length.

2003

- Gaspereau dip stand fishery on the Shubenacadie River closed at night during the height of the striped bass migration from Grand Lake.

2008

- Aboriginal people are supportive of stock rebuilding efforts and have been in agreement with a number of restrictions.
- Following public consultations, angling restrictions were implemented in and around the striped bass spawning and staging grounds in the Shubenacadie and Stewiacke rivers.
  - Hook and release only of striped bass from about mid-May to mid-June for the following waters:
    - the inland and tidal waters of Grand Lake and the Shubenacadie River downstream to its confluence with the Stewiacke River, and
    - the inland and tidal waters of the Stewiacke River downstream from the highway bridge (Pollock Bridge) in Stewiacke East to its confluence with the Shubenacadie River.
  - Artificial fly and single hook, unbaited lures, regardless of the species being fished, from about mid-May to mid-June for:
    - the tidal waters of the Shubenacadie River downstream from the CN Railway Bridge at East Milford to its confluence with the Stewiacke River, and
    - the inland and tidal waters of the Stewiacke River downstream from the highway bridge (Pollock Bridge) in Stewiacke East to its confluence with the Shubenacadie River.
- Minas Basin weir fishers limited to a maximum seasonal catch of between 10 and 40 striped bass 68 cm or more in total length. The number is based on site and personal use requirements and is intended to cap retention across a 3-4 month season.

2009

- Shubenacadie shad drift net fishers reduced from 3 striped bass < 8 lbs (3.6 kg) per day to 1 striped bass per day, 68 cm or more in total length.

The transition with time to a common retention limit of one striped bass ≥ 68 cm in total length per day, in all fisheries, and seasons where retention is authorized, is intended to allow for striped bass surviving to maturity to have the chance to spawn at least once before their removal from the population.

DESIGNATABLE UNITS

Douglas et al. (2003) concluded from a review of the known genetic, biological, ecological and demographic traits of the extant native Canadian striped bass populations that the Southern Gulf of St. Lawrence and Bay of Fundy populations (specifically the Shubenacadie River population) met the criteria for Designatable Units (DU). Both populations were discrete and each unit represented an important component of the evolutionary legacy of the species as a whole and if lost would likely not be replaced through natural dispersion (COSEWIC 2009).

Recent re-assessment of the population structure of striped bass (DFO 2011) and recent research on the ecological attributes of at least some of the Canadian populations (see Life-History Characteristics) lend continued support to the designation of the Southern Gulf of St. Lawrence and Shubenacadie River contingent of the Bay of Fundy DU as discrete units. The possible persistence of the native Saint John River population (DFO 2011) justifies a re-consideration of the grouping of all known spawning populations occurring within the Bay of Fundy into a single DU.

The attributes of Discreteness and Significance, as defined in COSEWIC 2009, are therefore applied as follows to a putative Saint John River population.

DISCRETENESS

1. Evidence of genetic distinctiveness including, but not limited to, inherited traits (e.g. morphology, life history, behaviour) and/or neutral genetic markers (e.g. allozymes, DNA microsatellites, DNA restriction fragment length polymorphisms (RFLPs), DNA sequences).

   Applicable: Genetic distinctiveness is apparent from neutral genetic markers (DNA microsatellites. Unbiased FST values between the suspected Saint John River and the Miramichi, and Shubenacadie, and USA populations are 0.1218, 0.0630, and 0.0457 respectively (Table 3). All FST estimates are significant at $p<0.001$.

2. Natural disjunction between substantial portions of the species' geographic range, such that movement of individuals between separated regions has been severely limited for an extended period of time and is not likely in the foreseeable future and where the disjunction is likely to favour the evolution of local adaptations.

   Not Applicable: Striped bass of USA-origin and Shubenacadie River-origin occur with regularity within the Saint John River (Table 3; Wirgin et al. 1995) and striped bass possessing the genotype of the suspected Saint John population that were marked (tagged) and released on the Saint John River been recaptured in Minas Basin (R.G. Bradford, unpublished data).

3. Occupation of differing eco-geographic regions that are relevant to the species and reflect historical or genetic distinction, as may be depicted on an appropriate ecozone or biogeographic zone map. Some dispersal may occur between regions, but it is insufficient to prevent local adaptation.

Not Applicable: Putative Saint John River striped bass share occupation of the Atlantic National Ecological Area and the Maritimes National Freshwater Biogeographic Zone with both Southern Gulf of St. Lawrence striped bass and Shubenacadie River striped bass.

SIGNIFICANCE

1. Evidence that the discrete population or group of populations differs markedly from others in genetic characteristics thought to reflect relatively deep intraspecific phylogenetic divergence. Such differences would typically be manifested as qualitative genetic differences at relatively slow-evolving markers (e.g. fixed differences in mitochondrial or nuclear DNA sequences or fixed differences in alleles at multiple nuclear loci). Quantitative (frequency) differences of shared alleles, especially for rapidly-evolving markers such as microsatellites, generally would not be sufficient to meet this criterion.

   Not applicable. Available (microsatellite) genetic data provide ample evidence of discreteness, but there is no evidence of fixed differences among populations. It is noteworthy, however, that the Shubenacadie River and putative native Saint John River populations of striped bass are at least as divergent from each other as either is from the USA population.

2. Persistence of the discrete population or group of populations in an ecological setting unusual or unique to the species, such that it is likely or known to have given rise to local adaptations.

   May be applicable. The Saint John River and Shubenacadie/Stewiacke Rivers are (arguably) very different environments, and it is reasonable to assume that breeding populations are adapted to local conditions. The evidence (from microsatellites) that the populations are genetically quite distinct, despite the fact that they clearly have the opportunity to interbreed (based on genetic assignment and tagging data) suggests that they actively avoid interbreeding, or that hybrids have reduced fitness. Further, the Saint John River possess the greatest quantity of both fresh water under tidal influence and brackish water of any of the rivers in Canada where native populatons of striped bass persist. Putative Saint John River striped bass are also members of the most diverse assemblage of freshwater and estuarial fishes to be found in the Maritimes National Freshwater Biogeographic Zone (DFO 2007, 2009). While these attributes establish the river as a <u>unique ecological setting</u>, likely to result in local adaptations that differ from those of other native Canadian populations, their application against USA rivers supporting striped bass (e.g., Hudson River, New York State) indicate broad similiarity (see Waldman et al. 2006a,b).

3. Evidence that the discrete population or group of populations represents the only surviving natural occurrence of a species that is more abundant elsewhere as an introduced population outside of its historical range.

   Not applicable.

4. Evidence that the loss of the discrete population or group of populations would result in an extensive gap in the range of the species in Canada.

   Possibly applicable. The Saint John River and Shubenacadie Rivers represent one third, each, of the remaining number of breeding sites in Canada. However, in simple terms of species range loss of the Saint John River population would not result in an extensive gap in the range because both Shubenacadie River striped bass and USA-origin striped bass would continue to occur within the Saint John River and Bay of Fundy.

REVIEW OF THE COSEWIC CRITERIA

DATA SOURCES

Shubenacadie River Population

Adult Abundance

Spawner abundance has not been assessed since Douglas et al. (2003) reported a minimum 2002 spawner abundance of no less than 15 thousand age (years) 3^+ fish, of which no less than seven thousand were ≥age 4^+.

The contingent of the population descending the Shubenacadie River from Grand Lake was monitored during May-June of 2008 and 2009. Mark-recapture experiments were not attempted in either year to estimate adult population size owing to an earlier than anticipated migration from the lake (Figure 4), and logistic constraints in 2009. Catch per effort (number of striped bass per night) and length frequency data are available.

Adult Distribution

Information to help establish the extent of occurrence of Shubenacadie River striped bass is available from several sources:

- Reported recaptures up to the year 2005 of striped bass marked with external individually numbered tags while descending the Shubenacadie River during the years 1999-2002,
- Genotyping of striped bass sampled from the Saint John River during the years 1999-2006 (DFO 2011), and
- Genotyping using DNA extracted from archived epithelial tissue removed from striped bass sampled from the Atlantic Coast of Nova Scotia (DFO 2011).

Young-of-the-Year (YOY): Abundance and Distribution

Shubenacadie YOY striped bass have been monitored annually since 1999, except for 2008, via beach seine surveys of the tidal Shubenacadie River and the north shore of the Minas Basin (Figure 6). Briefly, seven to eight sites have been visited at least once per year, and on subsequent occasions at approximately 7-10 day intervals when logistically feasible, during August-September (Table 1). Two 50m sweeps of the shoreline are made at each site per visit. The data for the two sweeps are pooled and reported as the average number per 50m. Both the arithmetic and stratified geometric ($\ln(n_{50m} + 1)$) mean abundances are calculated for the week of sampling, and for the season (Table 1). The most seaward of the standard sites (Partridge Island, near Parrsboro, N.S., Figure 6) is not included in the abundance estimate, no striped bass have ever been captured at this site in any year. Water temperature (0.1 ^{0}C), salinity (0.1 ppt), and turbidity (NTU) are recorded for each site.

Annapolis River

Adults

There has been no attempt to establish persistence of native adult Annapolis River striped bass via directed sampling.

Young-of-the-Year (YOY): Abundance and Distribution

Beach seine surveys of the Annapolis River and Basin during 2000 and 2001 (previously reported by Douglas et al. (2003)) did not capture any YOY striped bass.

Ichthyoplankton was sampled from the river during May-June 2009 and 2010 by the Clean Annapolis River Project (CARP) in an attempt to establish presence of striped bass eggs and larvae.

The beach seine sites occupied during the 2000 and 2001 surveys were re-visited by CARP in August-September, 2010 in an attempt to establish presence of YOY striped bass.

Saint John River

Adults

A recent genotyping (11 microsatellite loci) of 810 striped bass sampled from the Saint John River between 1999 and 2008 (DFO 2011) identified the inter-annual presence of a genetically discrete contingent (Table 3) that could not be assigned to a known population of origin. Both juvenile and adult fish were represented within this contingent (DFO 2011). These data lend support to the suggestion of Douglas et al. (2003) that native striped bass may still be present within the Saint John River.

Young-of-the-Year (YOY): Abundance and Distribution

Attempts to capture with a beach seine YOY striped bass in the Saint John River during 2000 and 2001 were previously reported by Douglas et al. (2003) as having been unsuccessful.

A beach seine survey of the river, comparable in method, timing and scope to those reported in Douglas et al. (2003) was conducted in 2009.

Application of COSEWIC Criteria

Shubenacadie River striped bass produce new individuals annually (Table 1; Figure 12). Higher spawner abundance since 2001 has not resulted in higher sustained production of young of the year (Table 1; Figure 13). Both egg and larval striped bass survival are sensitive to climate (Ulanowicz and Polgar 1980; Rutherford and Houde 1995; Rutherford et al. 1997).

Overall, Shubenacadie River striped bass spawner abundance has likely increased since the 2002 assessment reported in Douglas et al. (2003). However, the elapsed time of 8 years is less than either the 10-year time periods or 3 generations which, while not known with precision, would likely be 15 years in light of the later age of reproduction for females.

Annapolis River

Probable Extirpatation

Viable spawning by striped bass in this system has evidently not occurred since 1976 (Williams et al. 1984; Jessop 1990; Jessop 1995) even though eggs have been collected from the river as late as 1990 (Jessop 1995). Hence, survival beyond the egg stage is thought to be very low to negligible (Jessop 1990).

A remnant population of old (>20-30 years of age) adult fish may still exist, owing to the general longevity (>25 years) of striped bass (Scott and Scott 1988; Secor 2000) and continuing reports from the public of adult sized striped bass in the river (R.G. Bradford unpublished data).

Monitoring for early life-history stages of striped bass in the Annapolis River and Basin during 2001, 2002, 2009, and 2010 failed to detect any evidence of spawning activity.

Indicator	Endangered	Threatened
A. Decline in Total Number of Mature Individuals		
A1. An observed, estimated, inferred or suspected reduction in total number of mature individual over the last 10 years or 3 generations, whichever is the longer, where the causes of the reduction are: clearly reversible **and** understood **and** ceased, based on (and specifying) any of the following: (b) an index of abundance appropriate to the taxon (c) a decline in index of area of occupancy, extent of occurrence and/or quality of habitat (d) actual or potential levels of exploitation (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.	Reduction of ≥ 70%	Reduction of ≥ 50% (b) Index of Abundance - New information indicates that the Bay of Fundy DU presently consists of two spawning (Shubenacadie, Saint John) populations and not one as was determined by COSEWIC (2004). However, the existence of the Saint John population requires confirmation. There is no evidence of spawning activity on the Annapolis River. Shubenacadie River - No evident reduction of ≥ 50%. - Greater representation of adults >60 cm FL (Figure 11). - Evident variation in year-class strength (Figure 11) attributed to either inter-annual variability in spawner success (Table 1) and/or low likelihood of survival of YOY through the first winter owing to small pre-winter body size (Figure 12). (c) Area of Occupancy - No indication of decline in area of occupancy. Known spawning grounds are used every year, range of migrant striped bass consistently extends to Saint John River. (e) Introduced Taxa - No indications that the Shubenacadie population has declined as a result of an illegal introduction of chain pickerel (*Esox niger*) into Grand Lake.

Indicator	Endangered	Threatened
B. Small Distribution Range and Decline or Fluctuation		
B1. Extent of occurrence estimated to be	< 5,000 km^2	< 20,000 km^2 Extent of occurrence > 20,000 km^2
B2. Index of area of occupancy estimated to be	< 5,000 km^2 < 100 km^2 based on spawning habitat (Shubenacadie and possibly the Saint John)	< 2,000 km^2
C. Small and Declining Number of Mature Individuals		
and (for either B1 or B2) estimates indicating at least two of a – c:		
a. Severely fragmented **or** known to exist at:	≤ 5 locations Of the three rivers that were historically used for spawning, one river is presently used (Shubenacadie), another is suspected but not confirmed to be in use (Saint John) and the other (Annapolis) appears to have been abandoned in recent decades.	≤ 10 locations
b. Continuing decline, observed, inferred or projected, in any of (i) extent of occurrence, (ii) index of area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or populations, (v) number of mature individuals.		i) No evident decline in extent of occurrence. Shubenacadie River striped bass have been reported from the Bay of Fundy and the Gulf of Maine. Extent of decline in area of occupancy, extent of habitat, number of populations and number of mature individuals cannot be assessed until the status of the Saint John River population has been determined.
c. Extreme fluctuations in any of (i) extent of occurrence, (ii) index of area of occupancy, (iii) number of locations or populations, (iv) number of mature individuals.		The number of mature individuals within-populations (i.e., Shubenacadie) likely exceeds 10,000. The number can be expected to vary interannually because of natural variability in recruitment.

Indicator	Endangered	Threatened
D. Very Small or Restricted Total Population		
D2. **For threatened only**: Population with a very restricted index of area of occupancy (typically < 20 km²) or number of locations (typically ≤ 5) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming endangered or extinct in a very short time period.		≤ 5 locations The DU consists of 3 populations

HABITAT

Viability of striped bass spawning populations is linked to the maintenance of suitable habitat for spawning, incubation and rearing (Jessop 1990, Van den Avyle and Maynard 1994). Observations on the Stewiacke River indicate that access to a moderate current of fresh to virtually fresh (e.g., < 1-2 ppt salinity) water is required for fertilization to occur and for the eggs to remain suspended (see Application of Residence (Shubenacadie Population)). Egg survival to hatching is closely tied to the physicochemical properties of the incubation habitat, particularly temperature and salinity (Cook et al. 2010), dissolved oxygen and, again, the presence of a moderate current to maintain the eggs in suspension (Cooper and Polgar 1981). Whether the historical Annapolis River population or the suspected Saint John River population exhibit(ed) adaptations to the local fields of temperature, salinity, and circulation is not known. The relevance of habitat attributes associated with spawning, incubation, and early rearing on the Shubenacadie River to other spawning sites within the Bay of Fundy DU is therefore not known.

Within the Bay of Fundy DU area, immature and adult striped bass can be found in freshwater, estuarine, and coastal habitats throughout the summer-autumn forage season.

Both Shubenacadie River and putative Saint John River striped bass exhibit upstream migrations in the fall to overwinter in fresh or brackish water, potentially to avoid the low ocean temperatures in winter. The winter habitat of the Annapolis River population prior to construction of the Annapolis Royal causeway was never determined. Presence of putative Saint John River striped bass in Belleisle Bay (Bentzen et al., unpublished manuscript) may be an indication that the population was susceptible to fishing mortality in the extensive winter fishery that occurred there during the 19th and early 20th centuries (Rogers 1936), a fishery which accounted for the majority of all striped bass landings reported from the river (Dadswell et al. 1984) in the early years of commercial fishing.

THREATS TO HABITAT

The breadth of the extant distribution of spawning populations along the east coast of North American, and the frequency of the co-occurrence of spawning sites within areas of high human population density, suggest that the species is reasonably tolerant of habitat alterations that can result from a large suite of human activities. They appear to be less tolerant of large scale physical changes that can potentially result from the construction of large barriers, as has been the case on the both the Saint John River and Annapolis River in recent decades. In both cases spawning grounds in the Saint John and Annapolis rivers appear to have been affected by changes in circulation and/or water quantity and quality (Douglas et al. 2003), although this is less certain in the case of the Saint John River population.

APPLICATION OF RESIDENCE CONCEPT (SHUBENACADIE POPULATION)

Residency for any of the extant populations of the Bay of Fundy DU will require further consideration once specific guidelines and criteria to identify residences for aquatic species are established. In the interim the ‘Residence Rationale Template’ provided by Environment Canada is used to help identify how, or whether, the concept of residence may apply to striped bass using the Shubenacadie River population as an example. The template, which has been completed with reference to the “DRAFT Technical Guidelines for Describing Residence - a*s Drafted by Environment Canada* (August 12, 2004), is provided below.

ECOLOGY

(1) Does the ecology of the species include the use of a dwelling place—which is a specific location (or locations) or discrete spatial area that contains features similar to a den or nest, or performs functions similar to a den or nest?

SARA defines residence as:

> “*a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*” [s.2(1)]

<u>Breeding</u>

Shubenacdie striped bass spawn within a remarkably restricted area of the tidal Stewiacke River (Figure 3) located a few kilometers upstream of the confluence with the tidal Shubenacadie River. Spawning is thought to have occurred within the tidal sections of the Shubenacdie River in past years (Rulifson and Dadswell 1995), although there is no direct evidence this either occurred, or that the spawning yielded competent progeny. The tidal inner portions of the river is an area of significant tidal action with the result that flushing rates are high (DeWolfe 1998) and environmental conditions associated with spawning (e.g., temperature, salinity) can change rapidly with time and over short spatial scales (Rulifson and Tull 1999; R.G. Bradford unpublished data). In result, the specific location of spawning within the area is dependent upon where conditions suitable for spawning (tidal freshwater of approximately 16^0C; Figure 14) are located. Eggs do not remain within the area of their release and fertilization for the duration of the incubation period (Rulifson and Tull 1999) nor do they exhibit strong association with the temperature and salinity regime associated with spawning (Figure 14). The egg stage therefore does not meet the criteria of containment.

Available data indicates that yolk-sac and post-yolk sac larvae are of low abundance in the area of confluence of the tidal Shubenacadie and Stewiacke rivers (Rulifson and Tull 1999; R.G. Bradford unpublished data), which indicates as well that the early life stages are not contained within the spawning area. When detected during surveys they tend to be distributed proportionally to the frequency of sampling water of specific temperature or salinity (i.e., they are dispersed by tidal action) (Figure 15). The available data therefore indicates that yolk-sac and post-yolk-sac larvae do not have residences.

Rearing

Young of the year striped bass are clearly not constrained to any particular area of the tidal river or to Minas Basin (Table 1), and while they tend to exhibit a preference for temperatures of between 16 and 20 ^{o}C they show no strong association with salinity (Figure 16), i.e., they are widely dispersed. The available data therefore indicates that young of the year striped bass do not have residences.

Staging

Adult striped bass overwintering in Shubenacadie-Grand Lake descend the river to the estuary beginning around the first of May (Figure 4). Tagging data indicates that individual fish complete the descent to tidal waters within a few days and most of the over-wintered assemblage has descended the river by the third week of May (Figure 4). Time of spawning is not strongly related to the timing of the appearance of the adults on the spawning grounds. Rather, spawning tends to occur as water temperatures warm to about 16 ^{o}C or more. Development of suitable spawning temperatures tends to be episodic (Figure 5) and may not develop at all for several days to weeks after the adults have arrived in the area (Figures 4 and 5). The available data therefore indicates that the inner portions of the tidal estuary potentially function as a staging area for pre-spawned adults and therefore may warrant consideration as a residence under the present criteria.

Wintering

While overwintering of Shubenacadie striped bass in a lake is an inter-annually predictable event, there is no evidence that this represents an obligate behaviour. Gemperline et al. (2002) demonstrated the presence of otolith calcium/strontium signatures among Shubenacadie fish that indicate individual fish overwinter in both freshwater and estuarial/marine habitat over the course of their lives.

An analysis of young of the year otolith calcium/strontium revealed no tendency for wintering in freshwater (Cook and Bradford 2004). The analysis also indicated that YOY are capable of surviving winter in both estuarial and marine habitats (Cook and Bradford 2004). The specific locations where YOY overwinter are not known. It is therefore not possible to assess whether winter habitat is potentially limiting for this life stage.

Feeding

Striped bass are not foraging specialists, and consume a variety of prey items (Scott and Scott 1988).

HABITUAL OCCUPATION

***(2) Are these locations occupied or habitually occupied during all or part of the species' life cycle*?**

The pre-spawning staging area is occupied annually. The duration of residence within the staging area is probably contingent upon the state of gonad maturation of the fish at the time of their arrival and the onset of suitable environmental conditions for spawning.

<u>Function</u>

(3) Are these locations essential to the successful performance of a specific, crucial function of the species' life-cycle?

Immediate access to the spawning area to take advantage of favourable conditions for spawning –as they become available- can be considered an essential function of the Shubenacadie striped bass life-cycle.

There is no evidence to suggest containment within a specific area/region is necessary to fulfill other life-history functions.

LIMITING FACTORS AND THREATS

SHUBENACADIE RIVER STRIPED BASS

Threats to the Shubenacadie River population were assessed by COSEWIC (2004) as presence of the introduced chain pickerel (*Esox niger*) in a fresh water overwintering site and bycatch from various commercial fisheries. A third factor that may now warrant consideration is directed recreational angling for striped bass. These are discussed below.

<u>Chain Pickerel</u>

Chain pickerel are not native to the Maritime Provinces (Bradford et al. unpublished manuscript). They have been present in Nova Scotia for decades, a result of an unauthorized introduction from the State of Maine (Bradford et al. 2004). They are thought to have been illegally introduced into Shubenacadie-Grand Lake, Nova Scotia in 1997.

Chain pickerel meet the definition of an aquatic invader, a non-native species, whose introduction will likely cause (or has already caused) damage to the host ecosystem, existing species therein, the economy, or human well-being. Aquatic invasive species (AIS) thrive in the absence of their native predators and have the potential to drastically alter habitat, rendering it inhospitable for native species[2]. In the case of Shubenacadie River striped bass, the principle concern is for the harmful alteration to the forage base for striped bass residing in Grand Lake. Land-locked rainbow smelt (*Osmerus mordax*), are thought to represent an important componenet of the forage base available to striped bass in the lake.

The assessment of the specific level of threat that chain pickerel represent to striped bass will require information concerning the status of rainbow smelt in Grand Lake. This information is

[2] http://www.dfo-mpo.gc.ca/science/enviro/ais-eae/index-eng.htm (accessed 28 March 2012)

not presently available. However, it can be noted that rainbow smelt are still present in the lake (R.G. Bradford unpublished data) and there have been no indications that striped bass exiting the lake during spring are in poor condition (R.G. Bradford personal observation).

Bycatch

Changes in regulations since the COSEWIC (2004) assessment have reduced the potential quantity of striped bass that can be removed as an authorized bycatch in the principle river- and estuary-based fisheries in Maritimes Region (see Striped Bass Management in Maritimes Region). Neither the quantity of striped bass returned to the water annually from the fisheries (and for the various gear-types deployed in these fisheries) nor the proportion of the population that is intercepted in commercial fisheries is independently monitored by the DFO.

Recreational Angling

Interest in recreational angling for striped bass has become elevated in recent years. During the 2005 Survey of Recreational Fishing in Canada, 5,626 Nova Scotia residents and 2,597 New Brunswick residents identified themselves as striped bass anglers. The cumulative reported catch and effort in the survey year were 141,544 striped bass and 91,438 rod days. Ninety percent of the striped bass were reported released.

The resurgence of the Shubenacadie River striped bass population (as well as the Miramichi River population) has probably been responsible in part for the increased level of participation in the striped bass recreational angling fishery. Pre-spawning, spawning, and summer migrant Shubenacadie River striped bass are all subject to recreational angling pressure. Several of the changes in fishery regulations that have been implemented since 2005 have the intent of limiting recreational mortality during the pre-spawning and spawning stages when the fish are highly susceptible to capture.

Creel survey data for the recreational angling fishery that could be used to estimate fishing pressure and angler success is not presently available. However, some participants have reported instances of high angler success, 30-40 fish per day, for example. Cumulative hook-release mortality may therefore be a source of mortality that warrants greater attention. Diodati and Richards (1996) estimated an average hook and release mortality of 9% for a striped bass angling fishery wherein the angling experience of the participants varied from expert to inexperienced and a variety of baits and lures were in use. Mortality estimates varied from an average of 2% in fisheries where the severity of hooking conditions was low (i.e., proficient anglers using unbaited single hook lures) to as high as an average of 21% when the severity of hooking conditions was high (inexperienced anglers, baited lures, etc.).

Not all of the striped bass removed from coastal waters by anglers after mid-June when the daily bag limit of one fish >68 cm TL per day comes into effect will be Shubenacadie River striped bass. Migrant USA-origin fish (Rulifson and Dadswell 1996) and possibly migrant Saint John River fish could be a component of the landed catch.

ANNAPOLIS RIVER STRIPED BASS

Disappearance of the Annapolis River population has been attributed to repeated spawning failures (COSEWIC 2004). It was known that eggs spawned naturally by the native population were viable when held in water of suitable quality from sources other than the Annapolis River (Jessop 1990); however, this study did no assess whether water quality within the Annapolis River impeded egg development or larval survival. The suite of potential threats that have been suggested to impede production of juveniles from eggs of obvious viability includes low pH (Douglas et al. 2003), agricultural runoff (Jessop 1995) and alterations to the physical circulation of the estuary (Douglas et al. 2003). These are discussed.

pH

Natural pH depression occurs seasonally on the Annapolis River (Douglas et al. 2003). Hydroelectric impoundments on streams flowing to the Annapolis River near and upstream of the historical spawning site store water from snow melt and therefore of low pH for later release through May and June. The possibility therefore exists that the natural cycle leading to early spring (March-April) depression in water pH has become extended into the spawning season (Douglas et al. 2003).

While striped bass eggs are known to be sensitive to pH, the studies (Hall et al. 1985; Buckler et al. 1987) that have demonstrated high egg mortality at mean pH ≤ 6.3 is not easily transferable to the Annapolis situation. The results of these studies were confounded by the effects of aluminum toxicity which is not a factor in Nova Scotia rivers impacted by acid rain (Watt et al. 2000). Furthermore, presence of multiple age classes of the conspecific white perch (*Morone americana*) was detected in surveys of the rivers fish assemblage in both 2000 and 2001 (R.G. Bradford, unpublished data), a finding which casts doubt on low pH as a vector for local extirpation. White perch are sensitive to pH <6.0 (Stanley and Danie 1983), and are not present or below detection, in many Nova Scotia drainages impacted by acid rain (Smith et al. 1986).

Agricultural Runoff

Alteration of Water quality in the Annapolis River is altered from drainage received from agricultural lands. The river is monitored regularly and compared to standard measures, e.g., coliform load, nitrates, etc. (Clean Annapolis River Project http://www.annapolisriver.ca/index.php (accessed 28 March 2012)). Because egg/larval development success in waters drawn from the Annapolis River was not assessed empirically, it is not possible to state the degree of threat water quality in general presents to recovery of Annapolis River striped bass, or which constituents of land-drainage impede survival.

Estuarial Circulation

A causeway constructed in 1960 across the tidal section of the river at Annapolis Royal resulted in creation of a stratified, salt-wedge type headpond with a dampened tidal amplitude relative to free flowing conditions (Jessop 1976). The impounded section lies immediately downstream of a known spawning location. The causeway was retrofitted with a tidal power generation facility which became operational in 1984. The facility generates electricity as the head differential between the headpond and the seaward side increases on ebbing tides.

The alteration of the section of estuary immediately below the spawning grounds from one in which tidal bores reportedly developed (Rulifson and Dadswell 1995), to a stratified water body raises the issue of whether eggs could remain suspended during incubation. The specific gravity/density of striped bass eggs varies among populations and among-rivers on the basis of the physical properties of the waterbody (Bergey et al. 2003). Eggs collected from high physical energy watersheds tend to be larger and heavier than those from lower energy rivers, for example (Bergey et al. 2003).

The physical properties of naturally produced Annapolis River striped bass eggs were not assessed. Whether the eggs possessed the physical properties necessary to remain in suspension during incubation following creation of the headpond is not knowable.

SAINT JOHN RIVER STRIPED BASS

Habitat Degradation and Loss

Habitat degradation and loss has been attributed to a reduced status for putative native Saint John River striped bass, although direct cause-effect evidence for this specific population has not been gathered. Construction of the large Mactaquac hydroelectric impoundment on and upstream of the spawning grounds is believed to be the single greatest factor contributing to the cessation of spawning (Jessop 1995), although this interpretation must carry the caveat that neither the location(s) of historical spawning sites nor present areas of spawning activity are known from documented spawning activity or the presence of liberated eggs.

Alternatively, Dadswell (1976) attributed the high incidence of membrane rupture and embryo mortality in eggs collected from Belleisle Bay to high levels of organochlorines (DDT, PCB) but high PCB levels may have little effect on striped bass reproduction (ASMFC 1990).

There is uncertainty as to whether the lack of detectable evidence for viable spawning activity (absence of juvenile striped bass in beach seine surveys) indicates chronic low productivity for this population, or whether Saint John River striped bass are susceptible to recruitment failure at the early life-history stage, or that the survey method is not effective at capturing YOY striped bass in this particular river.

ByCatch

As is the case with Shubenacadie River striped bass, the changes in regulations since the COSEWIC (2004) assessment have reduced the potential quantity of putative Saint John River striped bass that can be removed as an authorized bycatch in the principle river- and estuary-based fisheries in the river, and elsewhere within the bay of Fundy (see Striped Bass Management in Maritimes Region). However, neither the quantity of striped bass returned to the water annually from the fisheries (and for the various gear-type deployed in these fisheries) nor the proportion of the population that is intercepted in commercial fisheries is independently monitored by the DFO.

Recreational Angling

Recreational angling for striped bass is a long-established activity on the Saint John River. Neither the status of the suspected Saint John River population or the proportion of the annual catch of striped bass, either released or retained by anglers is known.

ACKNOWLEDGEMENTS

We thank Dollie Campbell, Janet Mossman and numerous volunteers for field assistance and for their many hours of devoted data mining and data assembly. Research activities on Shubenacadie-Stewiacke striped bass for the years 1999-2003 were supported through five Joint Project Agreements with Geostorage Associates and their industry partners as part of a collaborative effort to define the habitat requirements and preferences of this population. Genetic assignment tests on the Saint John River fish were partially supported through Joint

Project Agreements with Kingsclear First Nation and Dalhousie University (Dr. Paul Bentzen, Dept. Biology, Dalhousie University).

LITERATURE CITED

ASMFC (Atlantic States Marine Fisheries Commission). 1990. Source document for the supplement to the striped bass FMP – Amendment #4. Fisheries Management Report No. 16.

Bentzen, P., and I.G. Paterson. 2005. Genetic evidence for the persistance of native striped bass, *morone saxatilis*, in the Saint John River, New Brunswick. Draft report to DFO, Maritimes Region. 27p.

Bergey, L.L., R.A. Rulifson, M.L. Gallagher, and A.S. Overton. 2003. Variability of Atlantic coast striped bass egg characteristics. N.A. J. Fish. Manag. 23: 558-572.

Bradford, R.G., D. Cairns, and B. Jessop. 2001. Update on the status of striped bass (*Morone saxatilis*) in eastern Canada in 1998. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/007: ii + 14 p.

Buckler, D.R., P.M. Mehrle, L. Cleveland, and F.J. Dwyer. 1987. Influence of pH on the toxicity of aluminium and other inorganic contaminants to East Coast striped bass. Water Air Soil Poll. 35: 97-106.

Cook, A.M., and R.G. Bradford. 2004. 2003. Activity report for the Department of Fisheries and Oceans-Geostorage Associates Joint Project concerning winter habitat of young-of-the-year Shubenacadie River striped bass (*Morone saxatilis*) as revealed from analysis of otolith elemental chemistry and field sampling. DFO, Dartmouth, N.S. 22p.

Cook, A.M., J. Duston, and R.G. Bradford. 2006. Thermal tolerance of a northern population of striped bass *Morone saxatilis*. J. Fish Biol. 69: 1482-1490.

Cook, A.M., J. Duston, and R.G. Bradford. 2010. Temperature and salinity effects on survival and growth of early life stage Shunbenacadie River striped bass. Trans. Am. Fish. Soc. 139: 749-757.

Cooper, J.C., and T.T. Polgar. 1981. Recognition of year-class dominance in striped bass management. Trans. Am. Fish. Soc. 110:180-187.

COSEWIC. 2004. COSEWIC assessment and status report on the Striped Bass *Morone saxatilis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa: vii + 43p.

COSEWIC. 2009. Guidelines for Recognizing Designatable Units. http://www.cosewic.gc.ca/eng/sct2/sct2_5_e.cfm (Accessed May 3, 2012)

Cox, P. 1893. Observations on the distribution and habits of some New Brunswick fishes. Bull. Nat. Hist. Soc. of New Brunswick 11: 33-42.

Dadswell, M.J. 1976. Notes on the biology and research potential of striped bass in the Saint John estuary. In: Baseline survey and living resource potential study of the Saint John

River Estuary. Vol. III, Fish and Fisheries. Huntsman Marine Lab., St. Andrews, N.B: 105p.

Dadswell, M.J., R. Bradford, A.H. Leim, D.J. Scarratt, G.D. Melvin, and R.G. Appy. 1984. A review of research on fishes and fisheries in the Bay of Fundy between 1976 and 1983 with particular reference to its upper reaches. In: Gordon, D.C., and M.J. Dadswell. 1984. Update on the marine environmental consequences of tidal power development in the upper reaches of the Bay of Fundy. Can. Tech. Rep. Fish. Aquat. Sci. 1256: vii + 686p.

DeWolfe, D.L. 1998. Year 2 monitoring program for Shubenacadie and Stewiacke Rivers – November 1997-June 1998 and a review of summer 1997 data (Prepraed for Geostorage Associates). Discovery Consultants Ltd., Mahone Bay, N.S.

DFO, 2006. Recovery Assessment Report for the St. Lawrence Estuary, Southern Gulf of St. Lawrence and Bay of Fundy striped bass (*Morone saxatilis*) populations. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/053.

DFO. 2007. Belleisle Bay fish and fish habitat. DFO Can. Sci. Advis. Sec. Sci. Resp. 2007/015.

DFO. 2009. Use of the lower Saint John River, New Brunswick, as fish habitat during the spring freshet. DFO Can. Sci. Advis. Sec. Sci. Resp. 2009/014.

DFO. 2011. Proceedings of the Zonal Advisory Process on the Pre-COSEWIC review of striped bass (*Morone saxatilis*), February 2 and 3, 2011. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2011/041. iv + 29 p.

Diodati, P.J., and R.A. Richards. 1996. Mortality of striped bass hooked and released in salt water. Trans. Am. Fish. Soc. 125: 300-307.

Douglas, S.G., R.G. Bradford, and G. Chaput. 2003. Assessment of striped bass (*Morone saxatilis*) in the Maritime Provinces in the context of species at risk. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/008: 48 p.

Gemperline, P.J., R.A. Rulifson, and L. Paramore. 2002. Multi-way analysis of trace elements in fish otoliths to track migratory patterns. Chemometrics and Intelligent Laboratory Systems 60: 135-146.

Hall, Jr., L.W., A.E. Pinkney, and L.O. Horseman. 1985. Mortality of striped bass larvae in relation to contaminants and water quality in a Chesapeake Bay tributary. Trans. Am. Fish. Soc. 114: 861-868.

Jessop, B.M. 1976. Physical and biological survey of the Annapolis River, 1975. Dept. of the Environment, Fisheries and Marine Service, Resource Branch Data Record Series No. MAR/D-76-8. 29p.

Jessop, B.M. 1990. The status of striped bass in Scotia-Fundy Region. DFO CAFSAC Res. Doc. 90/36: 22 p.

Jessop, B.M. 1995. Update on striped bass status in Scotia-Fundy Region and proposals for stock management. DFO Atl. Fish. Res. Doc. 95/8: 8 p.

Paramore, L.M. 1998. Age, growth, and life history characteristics of striped bass, *Morone saxatilis*, from the Shubenacadie-Stewiacke River, Nova Scotia. M.Sc. thesis, East Carolina University, Greeneville, NC. 91 p.

Pautzke, S.M., M.E. Mather, J.T. Finn, L.A. Deegan, and R.M. Muth. 2010. Seasonal use of a New England estuary by foraging contingents of migratory striped bass. Trans. Am. Fish. Soc. 139: 257-259.

Robichaud-LeBlanc, K.A., S.C. Courtenay, and A. Locke. 1996. Spawning and early life history of a northern population of striped bass (*Morone saxatilis*) in the Miramichi River estuary, Gulf of St. Lawrence. Can. J. Zool. 74: 1645-1655.

Robichaud-LeBlanc, K.A., S.C. Courtenay, and T.J. Benfey. 1998. Distribution and growth of Young-of-the-Year striped bass in the Miramichi River Estuary, Gulf of St. Lawrence. Trans. Am. Fish. Soc. 127: 56–69.

Rogers, H.M. 1936. The estuary of the Saint John River. Its physiography, ecology, and fisheries. M. A. Thesis. University of Toronto.

Rulifson, R.A., and K.A. Tull. 1999. Striped bass spawning in a tidal bore river: the Shubenacadie Estuary, Atlantic Canada. Trans. Am. Fish. Soc. 128: 613-624.

Rulifson, R.A., and M.J. Dadswell. 1995. Life history and population characteristics of striped bass in Atlantic Canada. Trans. Am. Fish. Soc. 124: 477-507.

Rutherford, E.S., and E.D. Houde. 1995. The influence of temperature on cohort-specific growth, survival, and recruitment of striped bass, *Morone saxatilis*, larvae in Chesapeake Bay. Fish. Bull. U.S. 93: 315-332.

Rutherford, E.S., E.D. Houde, and R.M. Nyman. 1997. Relationship of larval-stage growth and mortality to recruitment of striped bass, *Morone saxatilis*, in Chesapeake Bay. Estuaries 20: 174-198.

SARA Public Registry http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=830 (Accessed May 3, 2012)

Scott, W.B., and M.G. Scott. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219.

Secor, D.H. 2000. Spawning in the nick of time? Effect of adult demographics on spawning behavior and recruitment of Chesapeake Bay striped bass. ICES J. Mar. Sci. 2000, 56: 403-411.

Secor, D.H., J.R. Rooker, E. Zlokovitz, and V.S. Zdanowicz. 2001. Identification of riverine, estuarine, and coastal contingents of Hudson River striped bass based upon otolith elemental fingerprints. Mar. Ecol. Prog. Ser. 211: 245-253.

Smith, K.E.H. 1969. Compendium St. John River system, N.B. Unpublished DFO report, Dartmouth, N.S. 238p.

Smith, D.L., J.K. Underwood, J.G. Ogden III, and B.C. Sabean. 1986. Fish species distribution and water chemistry in Nova Scotia lakes. Water, Air and Soil Pollution 30: 489-496.

Stanley, J.G., and D.S. Danie. 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates . White perch. FWSIOBS-82111.7.

Ulanowicz, R.E., and T.T. Polgar. 1980. Influences of anadromous spawning behaviour and optimal environmental conditions upon striped bass (*Morone saxatilis*) year-class success. Can. J. Fish. Aquat. Sci. 37: 143-154.

Van den Avyle, M.J., and M.A. Maynard. 1994. Effects of saltwater intrusion and flow diversion on the reproductive success of striped bass in the Savannah River estuary. Trans. Am. Fish. Soc. 123: 886-903.

Waldman, J.R., K. Limburg, and D. Strayer. 2006a. Hudson River Fishes and their Environment. American Fisheries Society Symposium 51: 365p.

Waldman, J.R., T. Lake, and R.E. Schmidt. 2006b. Biodiversity and zoogeography of Hudson Estuary Fishes. American Fisheries Society Symposium Series 51:129-150.

Waldman, J.R., D.J. Dunning, Q.E. Ross and M.T. Mattson. 1990. Range dynamics of Hudson River striped bass along the Atlantic Coast. Trans. Am. Fish. Soc. 119: 910-919.

Watt, W. D., Scott, C. D., Zamora, P. J., & White, W. J. (2000). Acid toxicity levels in Nova Scotian rivers have not declined in synchrony with the decline in sulfate levels. *Water Air and Soil Pollution, 118*(3-4), 203-229.

Williams, R.R.G., G.R. Daborn, and B. Jessop. 1984. Spawning of the striped bass (*Morone saxatilis*) in the Annapolis River, Nova Scotia. Proc. N.S. Inst. Sci. 34: 15-23.

Wirgin, I.I., B. Jessop, S. Courtenay, M.. Pedersen, S. Maceda, and J.R. Waldman. 1995. Mixed-stock analysis of striped bass in two rivers of the Bay of Fundy as revealed by mitochondrial DNA. Can. J. Fish. Aquat. Sci. 52: 961-970.

Table 1. Standardized beach-seined catches of young of the year striped bass (number per 50m) by year, date, and site.

		Number of Striped Bass per 50m by Location								
Year	**Start Date**	**Tidal Shubenacadie**	**Inner Cobequid**	**Bass River**	**Economy Point**	**Lower Economy**	**Five Islands**	**Sites Sampled**	**Mean**	**Variance**
1999	05-Aug	12.3			72.0	51.5		3	45.3	921.8
	12-Aug	20.0			99.5	177.5		3	99.0	6,201.8
	19-Aug	3.0			95.5	0.0	0.0	4	24.6	2,234.6
	25-Aug	5.0			48.5	99.0	0.5	4	38.3	2,108.8
								Arithmetic Mean	**51.8**	**2,866.7**
								Geometric Mean	19.4	
2000	11-Aug	254.7			0.0	0.0	0.0	4	63.7	16,214.2
	14-Aug	75.0	6.3	0.0		0.0	0.0	5	16.3	1,085.9
	29-Aug	15.3	1.0	0.6	0.5	0.0	0.0	6	2.9	37.3
								Arithmetic Mean	**27.6**	**5,779.1**
								Geometric Mean	2.1	
2001	02-Aug	516.5	0.0	1.0	0.0	0.0	0.0	6	86.3	44,427.1
	13-Aug	21.0	2.1	0.0	2.3	0.0	0.0	6	4.2	68.6
	20-Aug	94.9	1.7	0.0	0.6	0.0	0.0	6	16.2	1,486.9
	05-Sep	4.6		0.6	116.2	33.3	4.4	5	31.8	2,395.2
								Arithmetic Mean	**34.6**	**12,094.5**
								Geometric Mean	3.0	
2002	08-Aug	75.6	5.4	0.0	7.1	0.0	0.0	6	14.7	901.0
	16-Aug	102.0	5.7	2.9	0.0	0.0	0.0	6	18.4	1,682.8
	23-Aug		3.5	0.0	0.0	0.0	0.0	5	0.7	2.5
	04-Sep	14.2		63.0	18.3		0.0	4	23.9	741.7
	06-Sep		4.4	1.6	31.8	0.0	0.0	5	7.6	187.0
								Arithmetic Mean	**13.1**	**703.0**
								Geometric Mean	2.8	
2003	12-Aug	20.6	4.5	10.6	12.7	0.6	0.0	6	8.2	63.8
	26-Aug	1.6	0.0	0.0	3.3	1.2	0.0	6	1.0	1.7
								Arithmetic Mean	**4.6**	**32.7**
								Geometric Mean	2.1	
2004	04-Aug	19.1	0.0	0.0	0.0	0.0	0.0	6	3.2	61.0
	16-Aug	13.9	1.8	0.0	0.0	0.0	0.0	6	2.6	30.9
	01-Sep	7.4		2.6	0.0	0.0	0.0	5	2.0	10.4
								Arithmetic Mean	**2.6**	**34.1**
								Geometric Mean	0.8	
2005	17-Aug	43.3	1.5	0.0	0.0	0.0	0.0	6	7.5	309.0
	23-Aug	9.5	6.0	1.3	1.3	0.0	0.0	6	3.0	15.1
	31-Aug	9.5			1.9	0.0	0.0	4	2.9	20.5
	01-Sep	3.3		1.0	24.0			3	9.4	160.3
								Arithmetic Mean	**5.7**	**126.2**
								Geometric Mean	2.0	
2006	28-Aug	48.3	2.0		5.8			3	18.7	661.5
								Arithmetic Mean	**18.7**	**661.5**
								Geometric Mean	9.0	
2007	27-Aug	17.4	9.1		40.6	17.3	1.0	5	17.1	218.1
								Arithmetic Mean	**17.1**	**218.1**
								Geometric Mean	11.4	
2008	No Survey									
2009	20-Jul	2.2	2.5	0.0	0.0	0.0	0.0	6	0.8	1.5
	05-Aug	2.5	0.5	0.0	0.0	0.0	0.0	6	0.5	1.0
	18-Aug	15.7	0.0	0.0	0.0	0.0	0.0	6	2.6	41.2
								Arithmetic Mean	**1.3**	**14.5**
								Geometric Mean	0.5	
2010	10-Aug	18.5	42.5	15.3	143.0	8.5	0.5	6	38.1	2,843.4
	24-Aug	19.0	13.5	0.5	3.0	136.5	3.0	6	29.3	2,812.1
	10-Sep	1.4		1.1	2.5	1.5	6.0	5	2.5	4.1
								Arithmetic Mean	**23.3**	**1,886.5**
								Geometric Mean	7.2	

Table 2. Summary of recaptures of striped bass marked and released from DFO science traps installed in the Shubenacadie River during the years 1999-2002. Recaptures are reported by years since marking and according to area of recapture. Grand Lake refers to Shubenacadie-Grand Lake.

			Area of Recapture					
Year	**Marks Applied**	**Years at Large**	**Science Trap**	**Tidal Shubenacadie**	**Grand Lake**	**Minas Basin**	**Elsewhere**	**Totals**
1999	526	0	5	8		2		15
		1	20	8		2		30
		2	4	1		2		7
		3	7	3		1		11
		4				2		2
		5				1		1
		6						0
	1999 Totals		36	20	0	9	0	**66**
2000	1037	0	23	16	1	5		45
		1	20	3	1	7		31
		2	11	2		2		15
		3	1		1	4		6
		4				3		3
		5		1		1		2
	2000 Totals		55	22	3	22	0	**102**
2001	9	0	3					3
		1						0
		2			1			1
		3						0
		4						0
	2001 Totals		3	0	1	0	0	**4**
2002	290	0	44	3				47
		1				1		1
		2						0
		3						0
	2002 Totals		44	3	0	1	0	**48**
	Grand Totals		138	45	4	32	0	**220**

Table 3. F_{ST} values for pair-wise comparisons between known spawning populations (United States (US), Shubenacadie, Miramichi) and the groupings of striped bass sampled from the Saint John River (SJR) identified from unrooted Bayesian assignment tests. SJR/Saint John = suspected Saint John River population, SJR/Shubenacadie = probable Shubenacadie striped bass, SJR/US = probable USA-origin striped bass.

	Shubenacadie	Miramichi	SJR/Saint John	SJR/Shubenacadie	SJR/US
US	0.0481	0.092	0.0457	0.0546	0.0036
Shubenacadie		0.1271	0.063	0.0013	0.0551
Miramichi			0.1218	0.1364	0.1128
SJR/Saint John				0.0625	0.0476
SJR/Shubenacadie					0.0597

•All pairwise Fst estimates are statistically significant; all comparisons except Shu vs. SJR/SHU are p < 0.001

Table 4. Commercial striped bass landings (pounds) by year, month, and statistical district within the Saint John River (1960-1965).

		Month										
Year	**District**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**December**
1960	48											
	49					166	304	32				
	55	3190	860	5900								1500
	56	300	100									
	57											
	58											
1960 Total		3490	960	5900		166	304	32				1500
1961	48					35	254	300				
	49											
	55	500	500	700								200
	56	300	100									
	57											
	58											
1961 Total		800	600	700		35	254	300				200
1962	48					67	178	257				
	49											
	55	5300	2500	500								4100
	56	200	200									
	57											
	58											
1962 Total		5500	2700	500		67	178	257				4100
1963	48						2397	54				
	49											
	55	2800	1000	1600								700
	56	100	300									
	57											
	58											
1963 Total		2900	1300	1600			2397	54				700
1964	48						58	11				
	49											
	55	600	7500	4200								100
	56		200	500								100
	57											
	58											
1964 Total		600	7700	4700			58	11				200
1965	48					9	5	259				
	49											
	55	200	300	200								250
	56	150	450	300								600
	57											
	58											
1965 Total		350	750	500		9	5	259				850

Table 5. Gear-types licenced to fish commercially for Atlantic salmon within the Saint John River by statistical district.

Statistical	Gill Nets				Trap Nets						
District	**Fixed**	**Pivot**	**Drift**		**Hooked**	**Spear**	**Diamond**	**Box**	**Star**	**Combined**	**Total**
48		2	94		22			2		3	123
49			54								54
55	11					15					26
56	8				5						13
57					16						16
58					6						6
Totals	19	2	148	0	49	15	0	2	0	3	**238**

Source: Dunfield (1971)

Table 6. Commercial Atlantic salmon landings (pounds) by year, month, and statistical district within the Saint John River (1960-1965).

		Month										
Year	**District**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**December**
1960	48					400	16,800	14,500	5,400			
	49					200	44,500	35,200	10,600			
	55					200	3,500	6,700	4,100			
	56					100	900	600	600			
	57					300	1,400	1,500	1,800			
	58					300	1,300	2,000	800			
1960 Total						1,500	68,400	60,500	23,300			
1961	48					500	18,000	19,100	4,500			
	49					150	38,700	32,500	6,500			
	55					20	1,900	4,500	6,200			
	56					100	600	600	600			
	57					0	500	1,000	1,000			
	58					50	840	1,100	1,000			
1961 Total						820	60,540	58,800	19,800			
1962	48					2,800						
	49					200						
	55					400	1,600	3,100	1,200			
	56					0	300	300	300			
	57					300	700	700	600			
	58					200	900	1,000	600			
1962 Total						3,900	3,500	5,100	2,700			
1963	48											
	49											
	55					100	2,300	5,500	3,900			
	56					0	500	1,100	800			
	57					0	800	1,300	1,600			
	58					100	2,200	2,100	400			
1963 Total						200	5,800	10,000	6,700			
1964	48											
	49											
	55					300	5,900	6,011	4,353			
	56					100	500	600	400			
	57					0	600	800	600			
	58					14	1,600	2,288	1,170			
1964 Total						414	8,600	9,699	6,523			
1965	48											
	49											
	55					1,200	3,700	9,200	11,200			
	56					300	1,500	1,260	910			
	57					0	550	1,500	1,600			
	58					54	1,595	1,534	1,024			
1965 Total						1,554	7,345	13,494	14,734			

Table 7. Commercial American shad landings (pounds) by year, month, and statistical district within the Saint John River (1960-1965).

		Month										
Year	**District**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**December**
1960	48											
	49					101,177	34,099	32				
	55					15,500	25,800					
	56					12,500	20,000					
	57					5,000	30,000					
	58					1,400	3,400					
1960 Total						135,577	113,299	32				
1961	48					133,750	109,169					
	49											
	55					1,000	12,200					
	56						20,000					
	57					1,500						
	58						2,400					
1961 Total						136,250	143,769					
1962	48					63,053	18,310	1,032				
	49											
	55					14,600	9,000					
	56					1,500	12,500					
	57					1,000	12,500					
	58						3,400					
1962 Total						80,153	55,710	1,032				
1963	48					750	92,396	152				
	49					1,750						
	55					9,900	5,100					
	56					3,000	5,000					
	57					1,000	5,000					
	58					200	500					
1963 Total						16,600	107,996	152				
1964	48					25,466	10,166					
	49					650	1,000					
	55					7,932	540					
	56					3,000	3,000					
	57					2,000	4,000					
	58					100	1,737					
1964 Total						39,148	20,443					
1965	48					20,593	16,787					
	49					1,475						
	55					13,461	6,900					
	56					22,500	6,000					
	57					4,500	2,500					
	58					500	2,370					
1965 Total						63,029	34,557					

Table 8. Commercial gaspereau landings (pounds) by year, month, and statistical district within the Saint John River (1960-1965).

		Month										
Year	**District**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**December**
1960	48											
	49		5,000	9,574	233,027	475,724	26,445					
	55				29,000	48,700	20,300					
	56				30,000	846,000	2,520,600					
	57				10,000	444,000	404,000					
	58						300					
1960 Total			5,000	9,574	302,027	1,814,424	2,971,645					
1961	48	275	492	6,814	135,695	885,097	321,992					
	49					1,005,000	436,500					
	55				5,500	15,000	199,700					
	56					30,000	2,085,000					
	57					200,000	800,000					
	58					100	200					
1961 Total		275	492	6,814	141,195	2,135,197	3,843,392					
1962	48			13,064	240,025	2,055,343	2,000	48,736				
	49				7,000		13,350					
	55			7,400	27,000	44,000	231,900					
	56				10,000	1,160,000	900,000					
	57				30,000	730,000	800,000					
	58											
1962 Total				20,464	314,025	3,989,343	1,947,250	48,736				
1963	48		2,000	32,672	60,884	5,000	1,035,399					
	49					360,000	62,500					
	55			4,300	9,900	13,000	119,200					
	56				1,000	560,000	900,000					
	57				1,000	80,000	200,000					
	58											
1963 Total			2,000	36,972	72,784	1,018,000	2,317,099					
1964	48		9,000	15,050	106,353	659,347	20,600					
	49											
	55			6,800	32,200	517,000	20,000					
	56				500	200,000	1,100,000					
	57				500	180,000	250,000					
	58				250							
1964 Total			9,000	21,850	139,803	1,556,347	1,390,600					
1965	48			6,500	27,250	566,540	640,557					
	49					365,000						
	55			3,000	139,815	89,819	32,000					
	56				10,000	894,000	2,466,000					
	57				20,000	1,293,000	707,000					
	58				100	500						
1965 Total				9,500	197,165	3,208,859	3,845,557					

Table 9. Fishery officer estimates of striped bass landed by recreational anglers by county within the Saint John River (Years 1951-1967).

		Month				
Year	**County**	**May**	**June**	**July**	**August**	**September**
1951	Kings		500	500	600	130
1951 Total			500	500	600	130
1952	Kings			400	500	1,400
	Queens					485
1952 Total				400	500	1,885
1953	Kings		75	500	900	600
1953 Total			75	500	900	600
1954	Kings	100	150	600	600	200
1954 Total		100	150	600	600	200
1959	Kings	100				
1959 Total		100				
1962	Kings		50	75	125	50
1962 Total			50	75	125	50
1963	Kings				125	50
	Queens	20	100			100
1963 Total		20	100		125	150
1965	Kings		75		250	375
1965 Total			75		250	375
1966	Kings		100	75	150	75
1966 Total			100	75	150	75
1967	Kings		100	150	75	95
	St. John		50	250	300	75
1967 Total			150	400	375	170

Table 10. Fishery officer estimates of striped bass landed by recreational anglers by tributary within the Saint John River (Years 1951-1967).

		Month				
Year	**Tributary**	**May**	**June**	**July**	**August**	**September**
1951	Kennebecasis		500	500	400	100
	Saint John + Tributaries				200	30
1951 Total			500	500	600	130
1952	Kennebecasis			400	500	900
	Saint John					985
1952 Total				400	500	1,885
1953	Kennebecasis		75	500	900	600
1953 Total			75	500	900	600
1954	Kennebecasis	100	150	600	600	200
1954 Total		100	150	600	600	200
1959	Saint John	100				
1959 Total		100				
1962	Kennebecasis		50	75	125	50
1962 Total			50	75	125	50
1963	Gaspereau River	20	100			50
	Kennebecasis				125	50
	Salmon River					50
1963 Total		20	100		125	150
1965	Kennebecasis				150	200
	Saint John		75		100	175
1965 Total			75		250	375
1966	Kennebecasis					25
	Saint John		100	75	150	50
1966 Total			100	75	150	75
1967	Kennebecasis			50		35
	Saint John		150	350	375	135
1967 Total			150	400	375	170

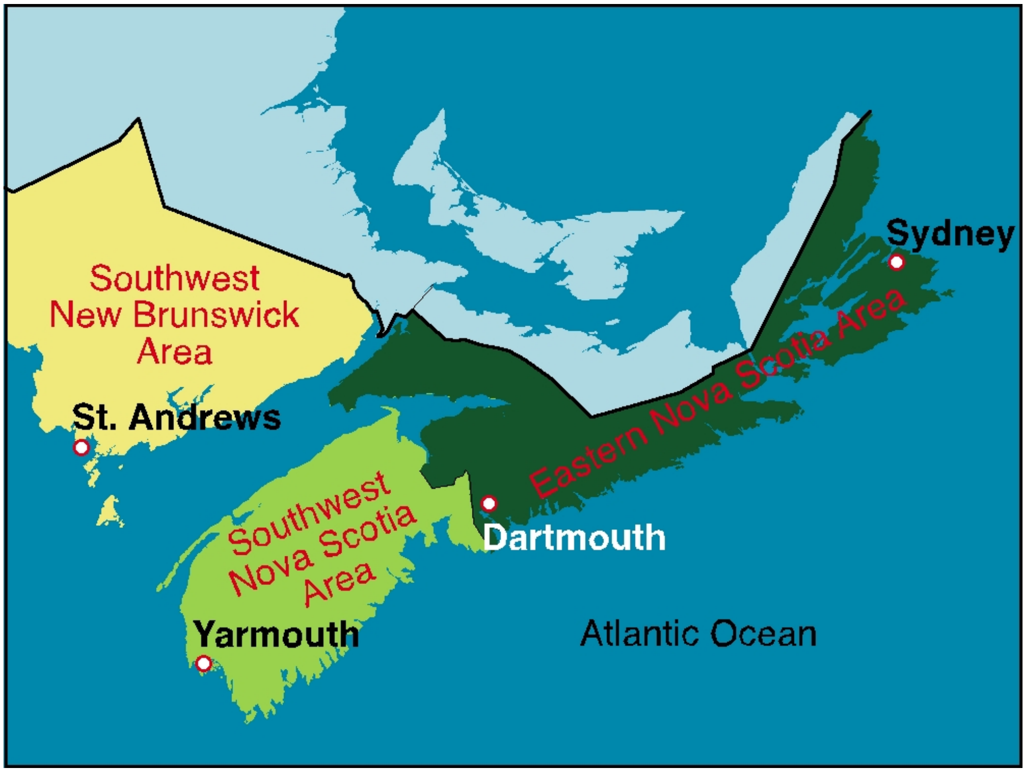

Figure 1. Map of DFO-Maritimes Region.

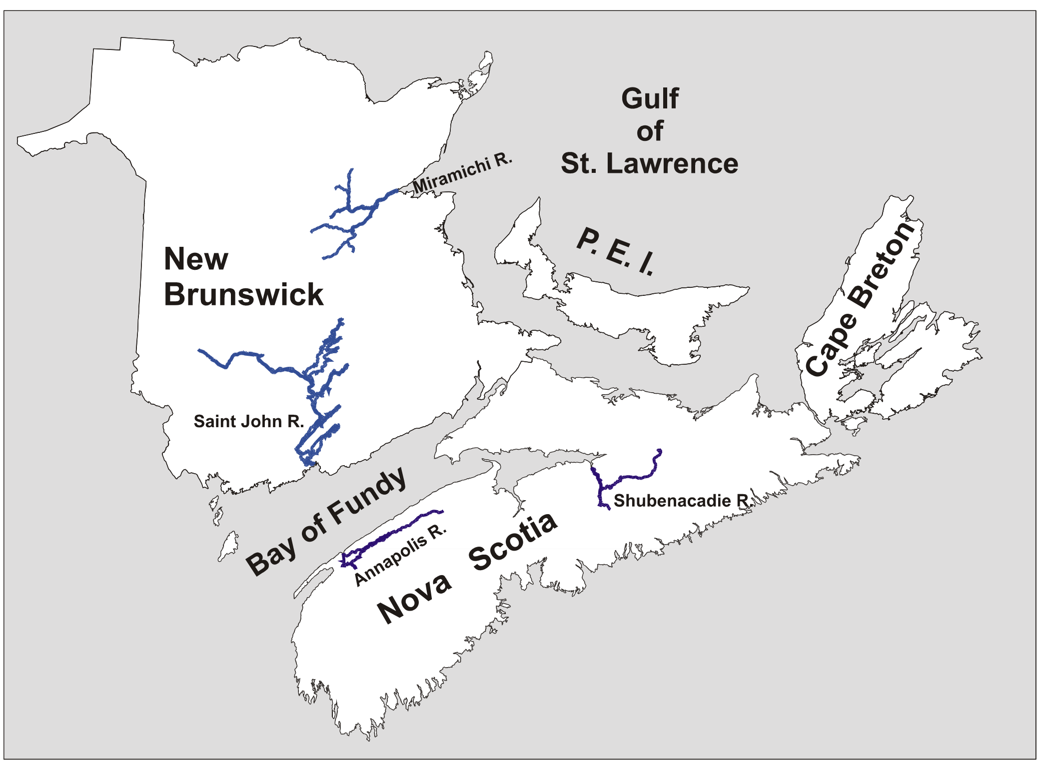

Figure 2. The four confirmed spawning locations for striped bass in the Canadian Maritimes.

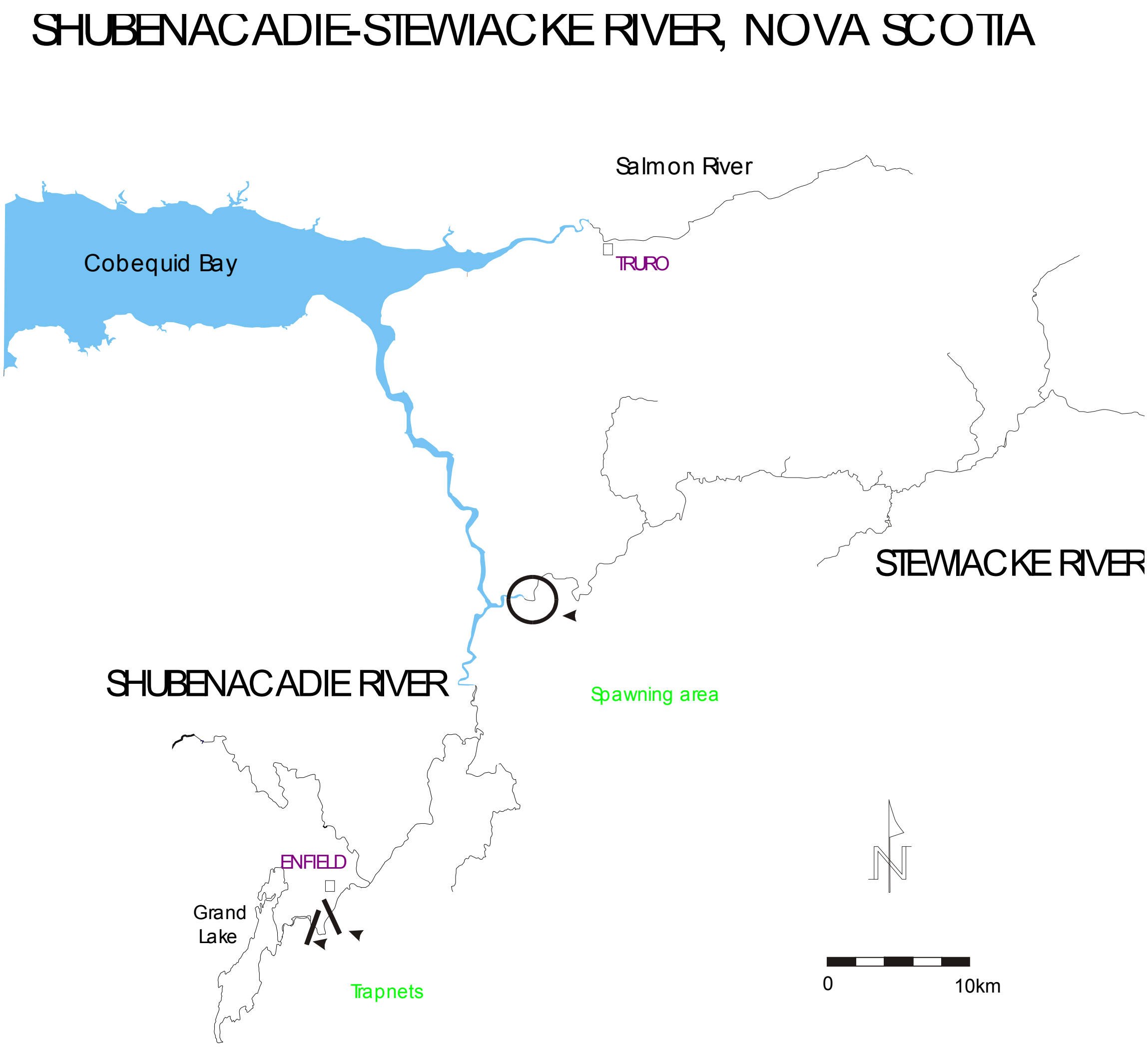

Figure 3. Map of Shubenacadie-Stewiacke River system indicating the location (circle) of the spawning area.

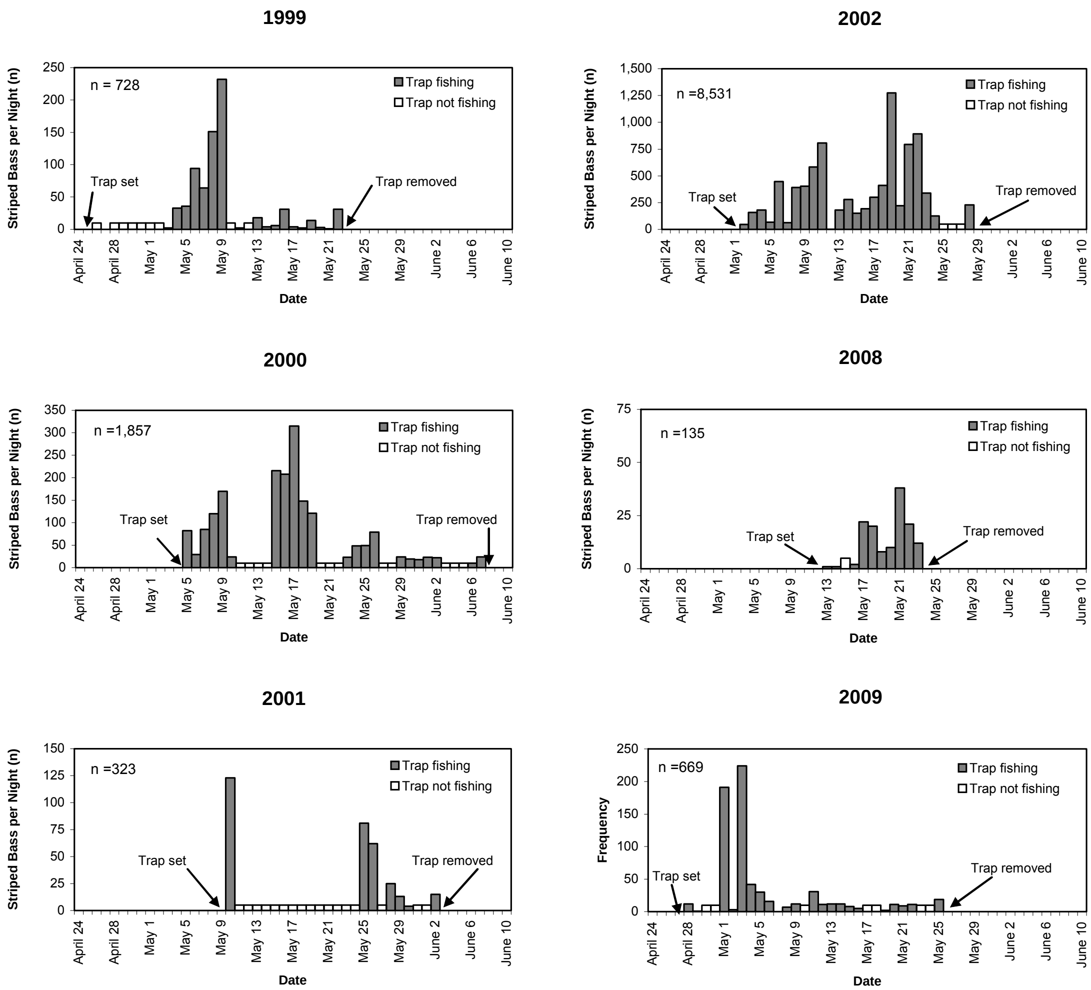

Figure 4. Number of striped bass captured per night in a research trapnet installed in the Shubenacadie River at Enfield, by date for the years 1999 – 2002, and 2008-2009. The dates that the trapnet was installed, removed, and not fished are indicated.

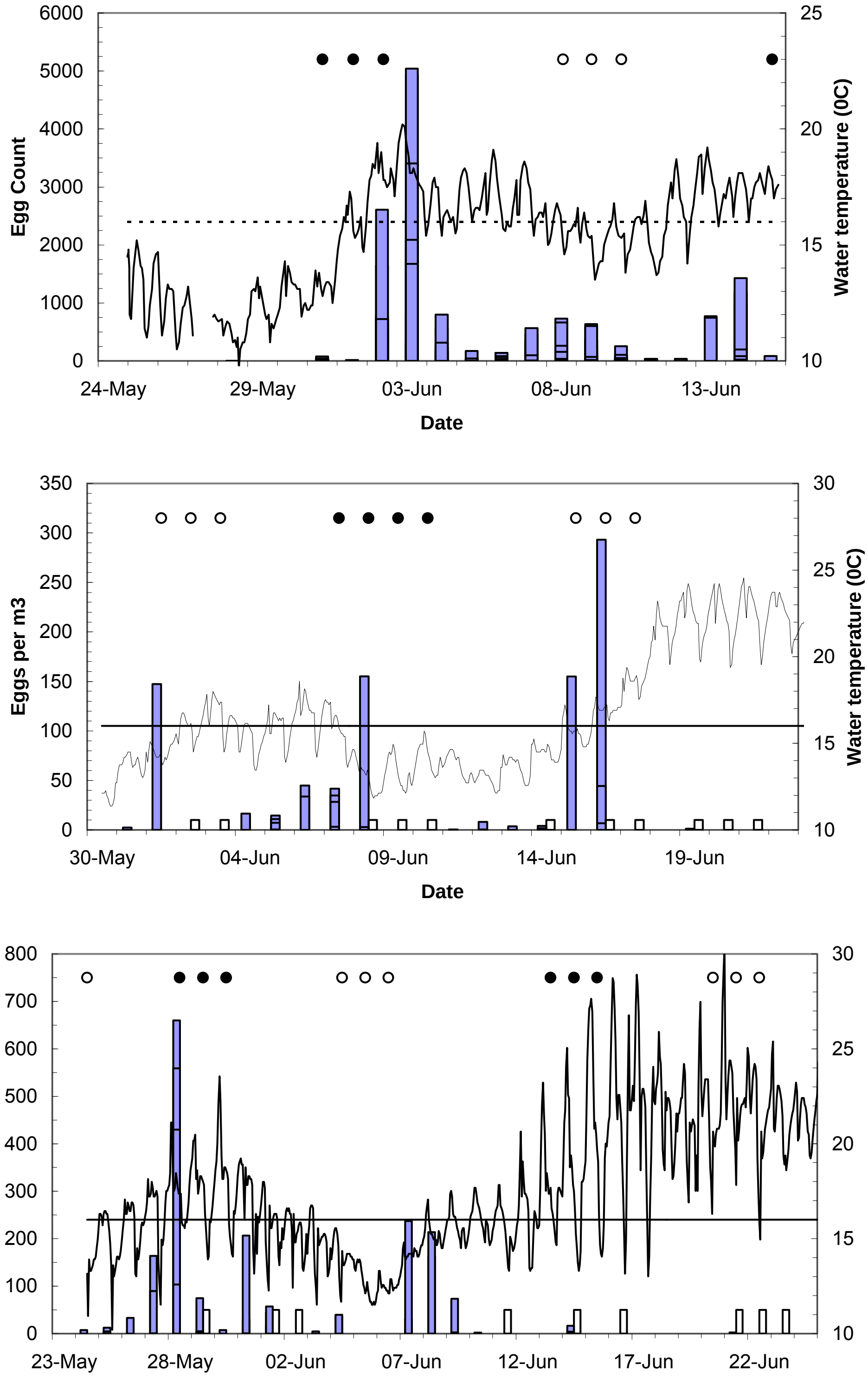

*Figure 5. Shubenacadie striped bass egg production, occurrences of spring (open circles) and neap (closed circles) tides, and hourly water temperature during 1994 (upper), 2000 (middle) and 2001 (lower). Open bars represent days without sampling**.***

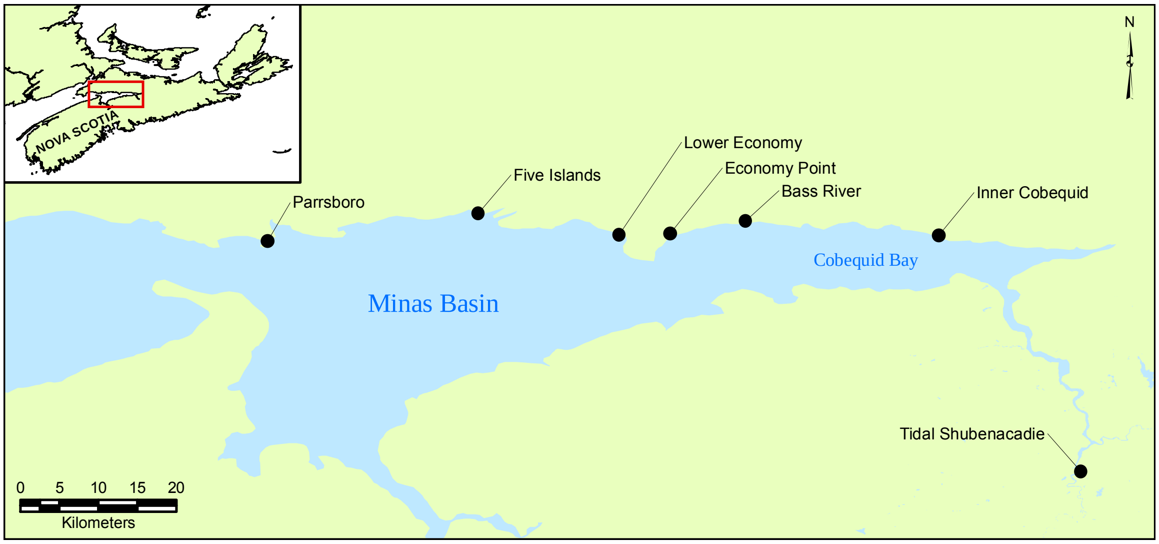

Figure 6. Beach seine sites sampled within Minas Basin (Bay of Fundy), Nova Scotia In the years 1999-2005.

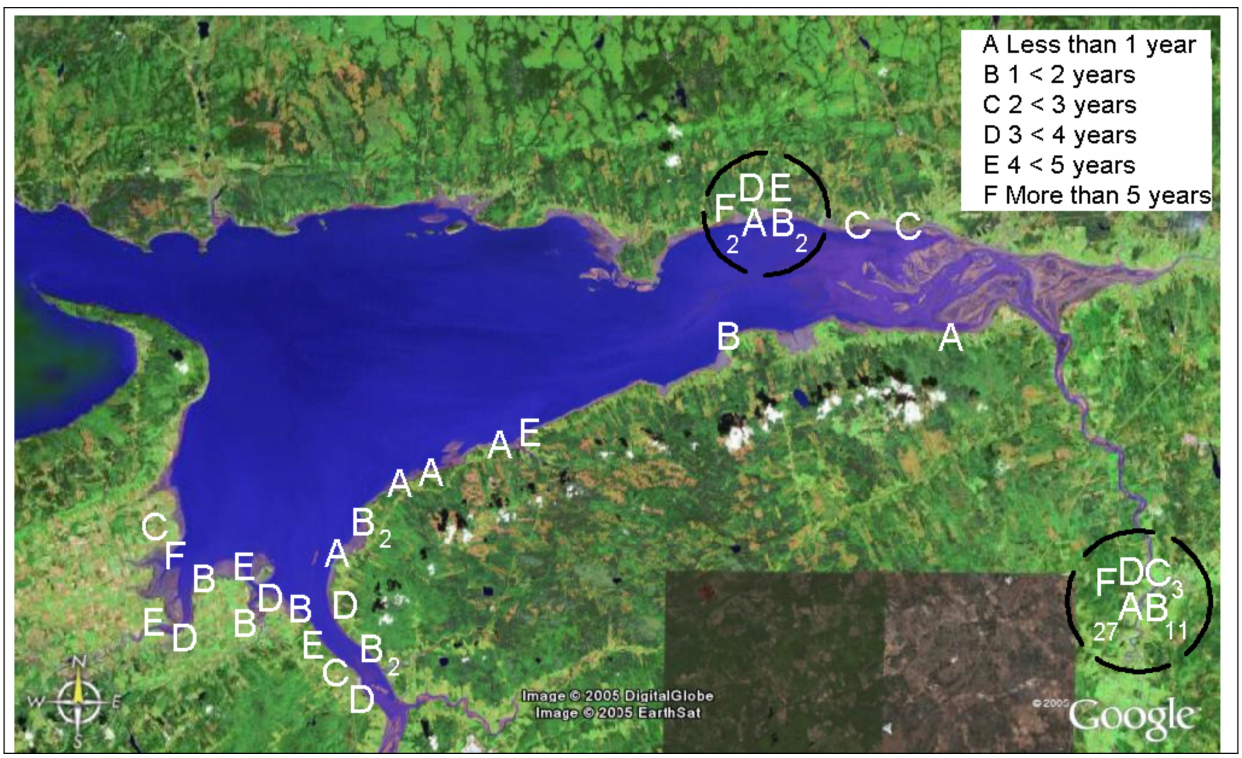

Figure 7. Location of recaptures reported to DFO of striped bass marked and released from science traps installed on the Shubenacadie River during 1999-2002. The recaptures are reported according to years since the fish was released.

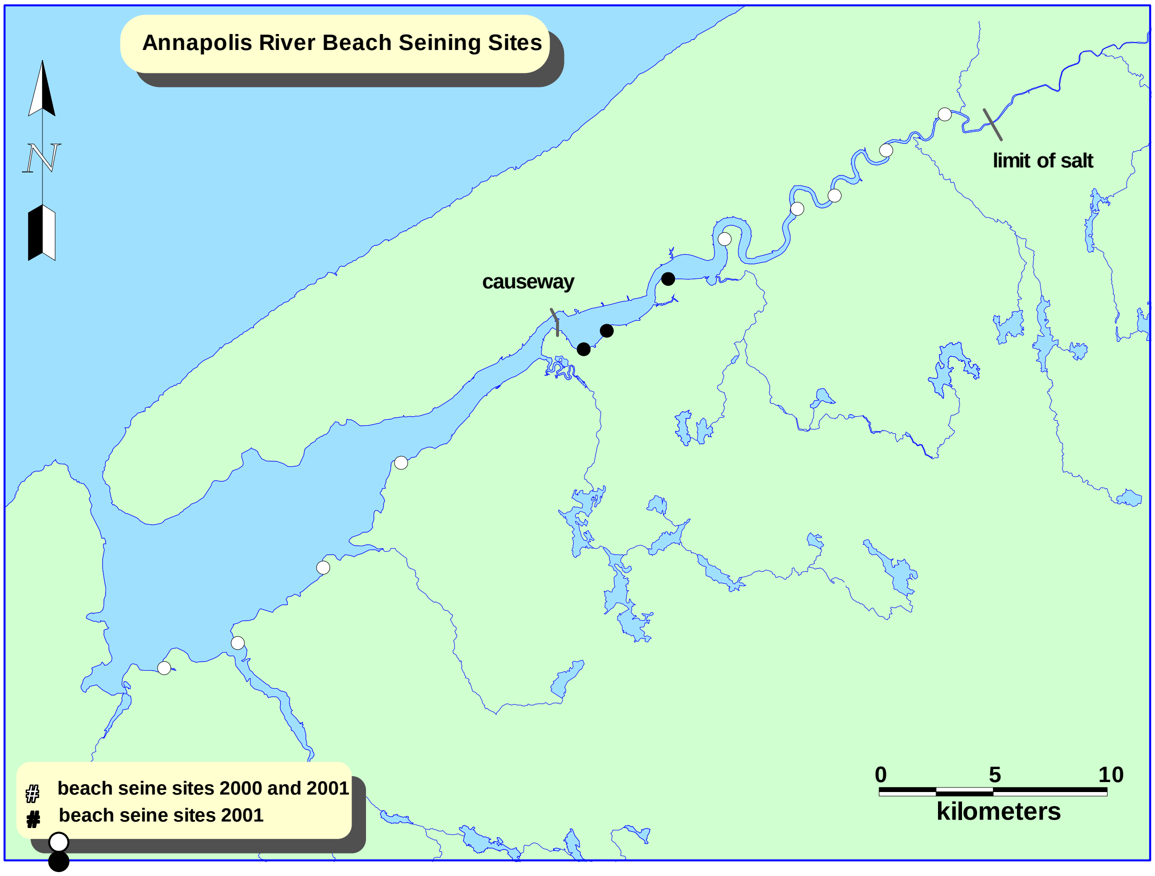

Figure 8. Map of the Annapolis River showing the location of beach seine sites sampled in 2000 and 2001. Spawning activitiy was reported to have occurred historically upstream of the limit of salt (shown).

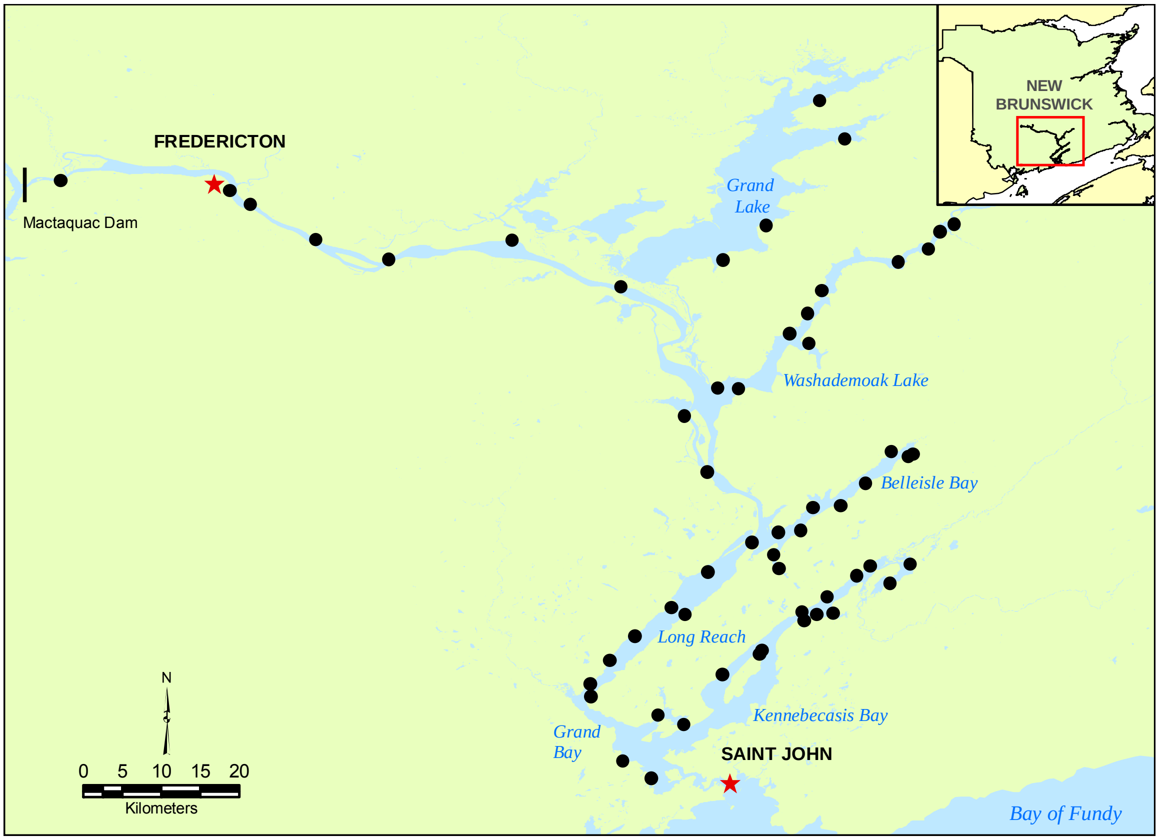

Figure 9. Map of Saint John River below Mactaquac Dam showing subdrainages and beach seining sites sampled in 2009.

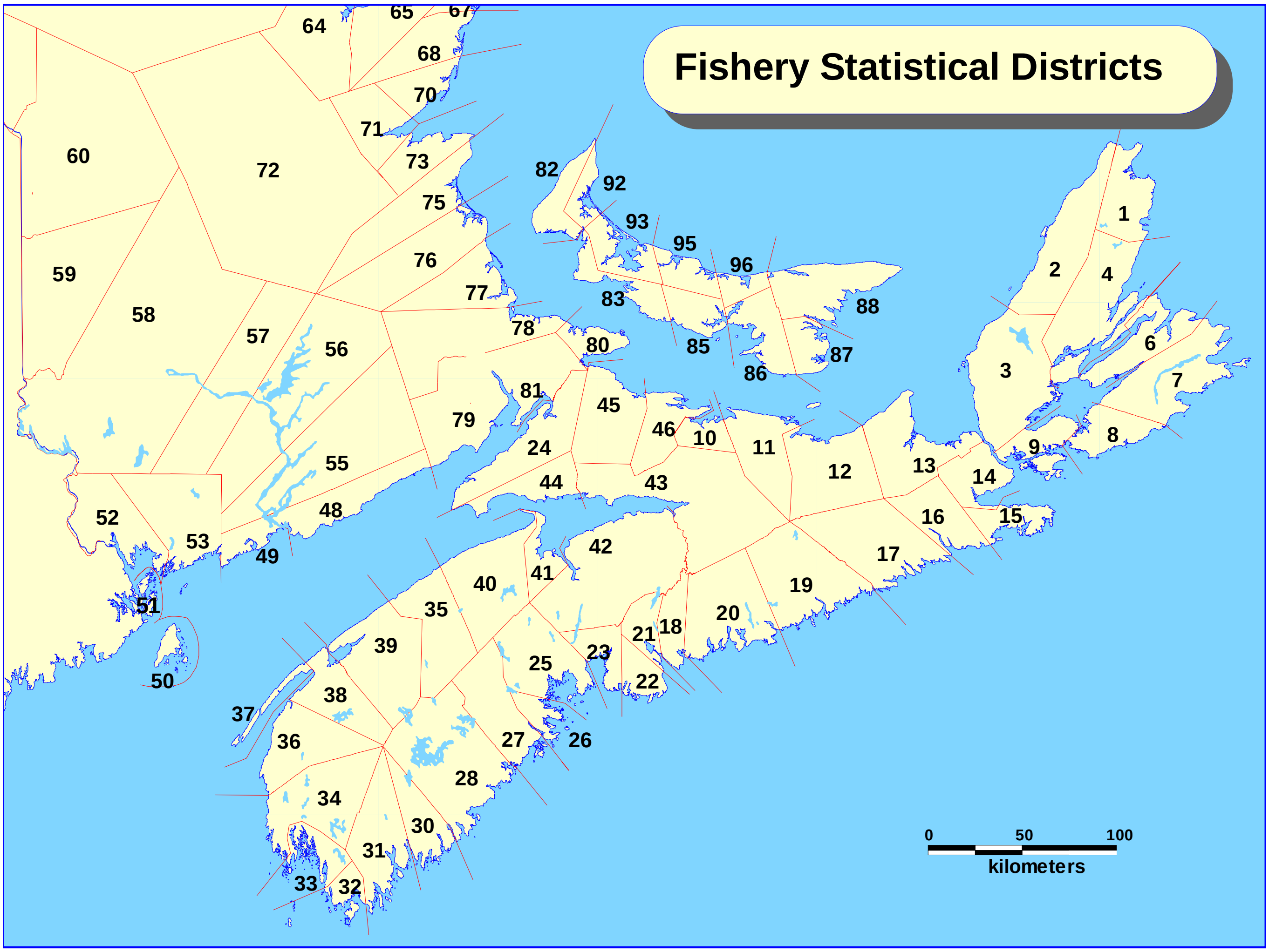

Figure 10. Fisheries Statistical Districts of the Maritime Provinces.

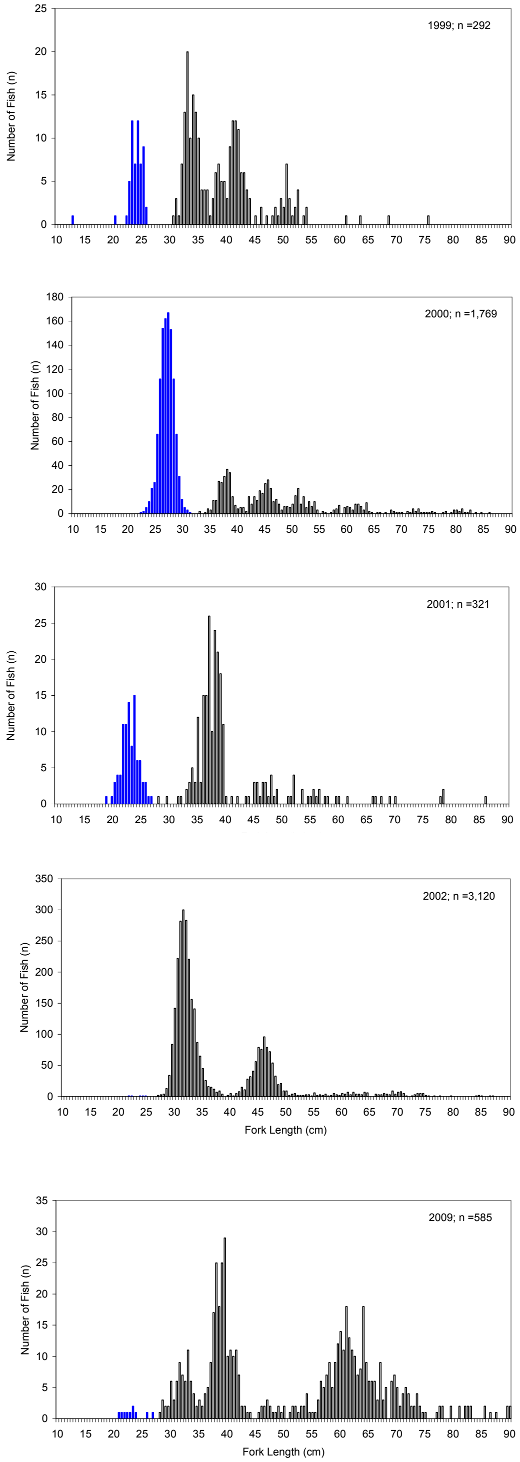

Figure 11. Length frequency distributions of striped bass sampled at Enfield, N.S, during May-June, 1999-2002 and 2009. Dark bars =adults, Blue bars = juveniles.

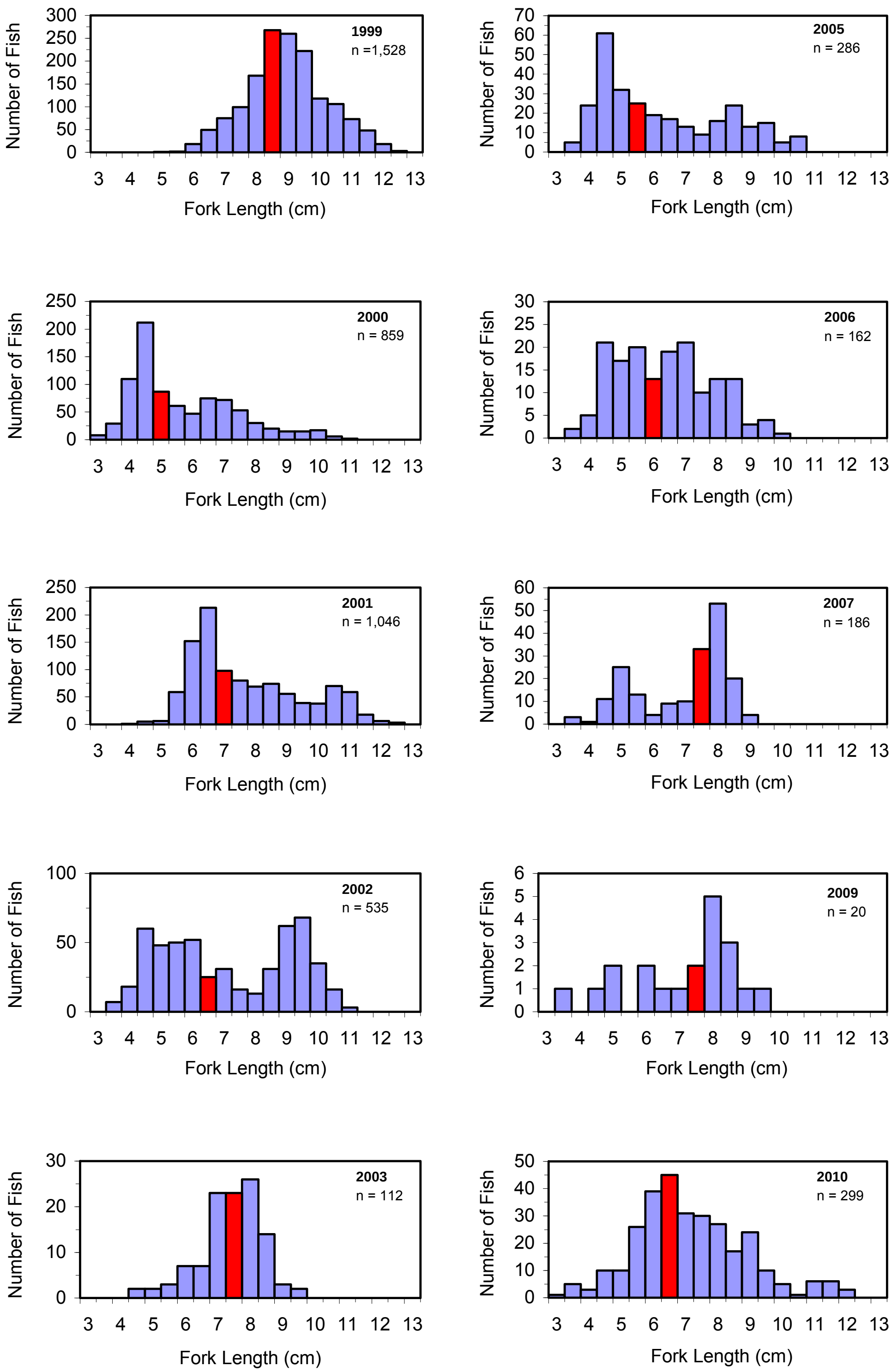

Figure 12. August-September fork length frequency distributions of young of the year Shubenacadie River striped bass by year of sampling (n = sample size; red bar = median 2.5 cm length increment).

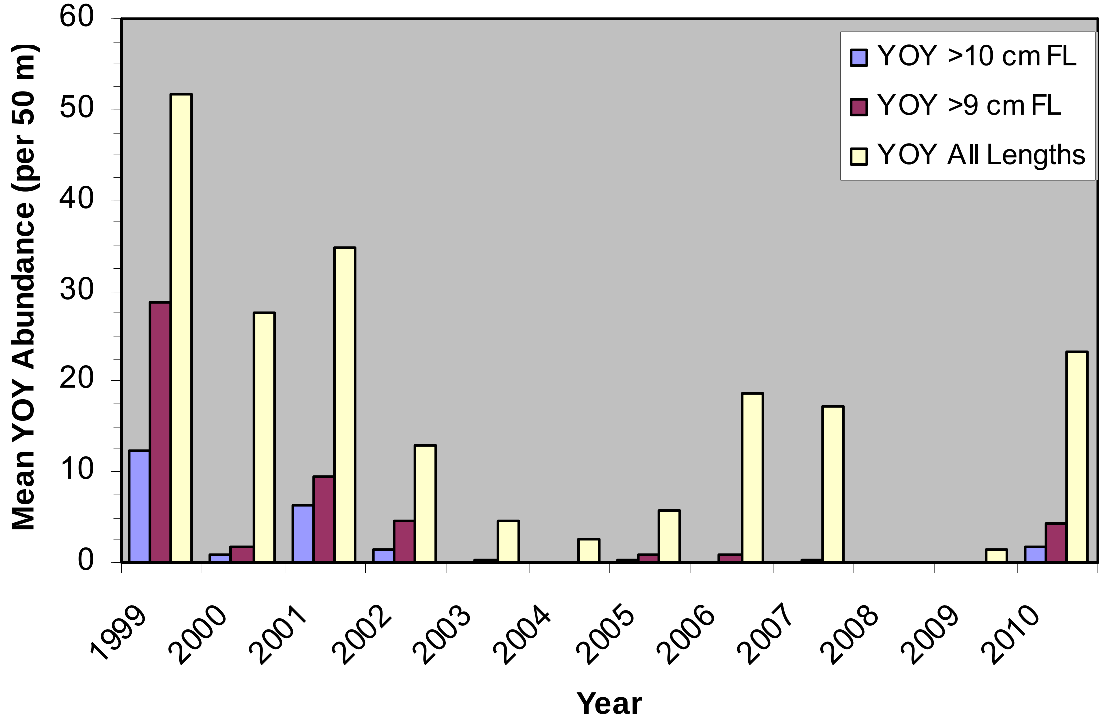

Figure 13. Mean annual abundance of young of the year (YOY) Shubenacadie River striped bass in beach seine surveys. Yellow bar = all YOY: Red bar = YOY >9 cm FL: Blue bar =YOY >10 cm FL.

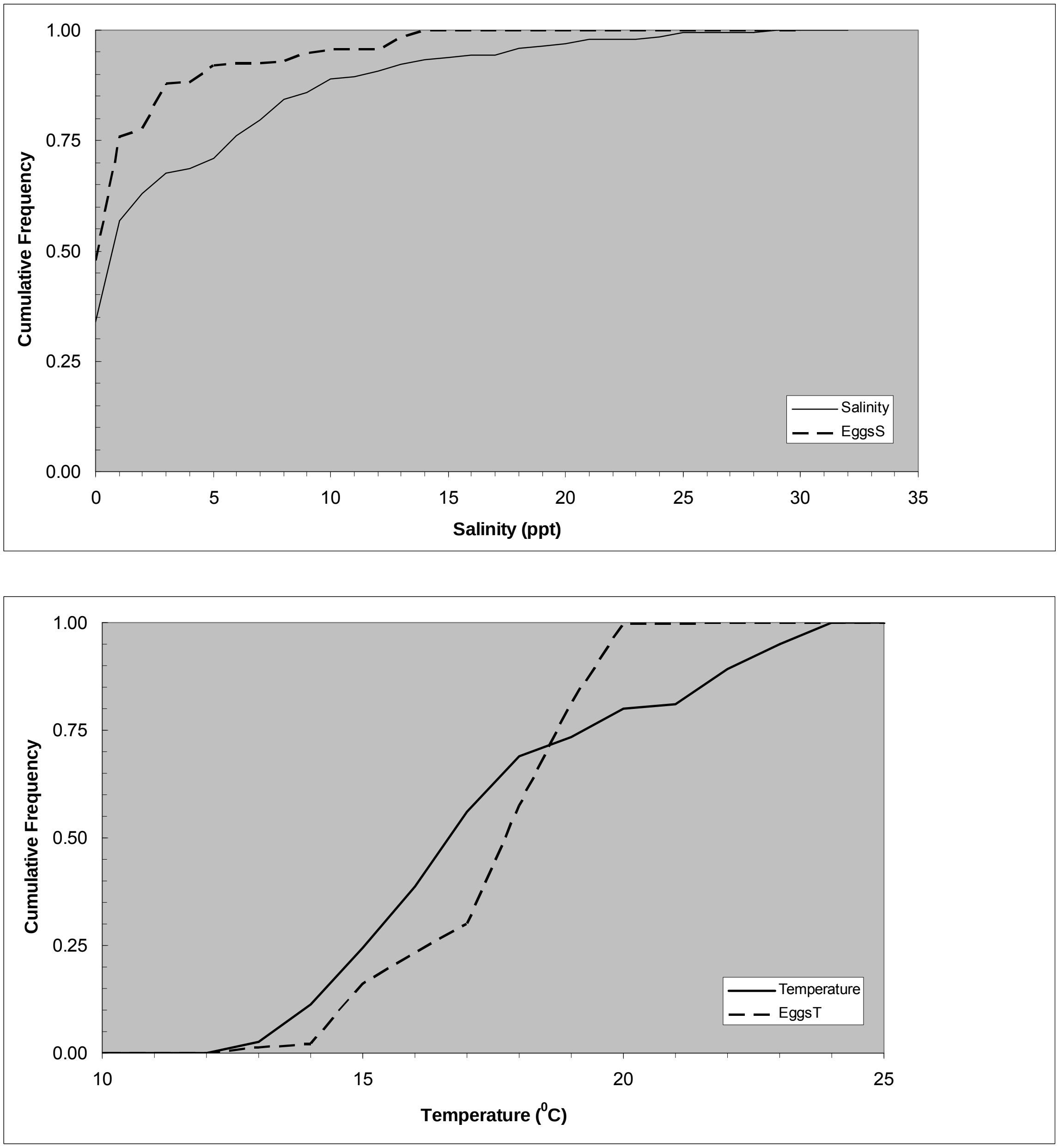

Figure 14. Cumulative frequency distributions of observed temperature and salinity during striped bass egg surveys conducted within the tidal Stewiacke River during 2000 and 2001. The cumulative frequency distributions of eggs collected (numbers per m3) during the surveys are shown.

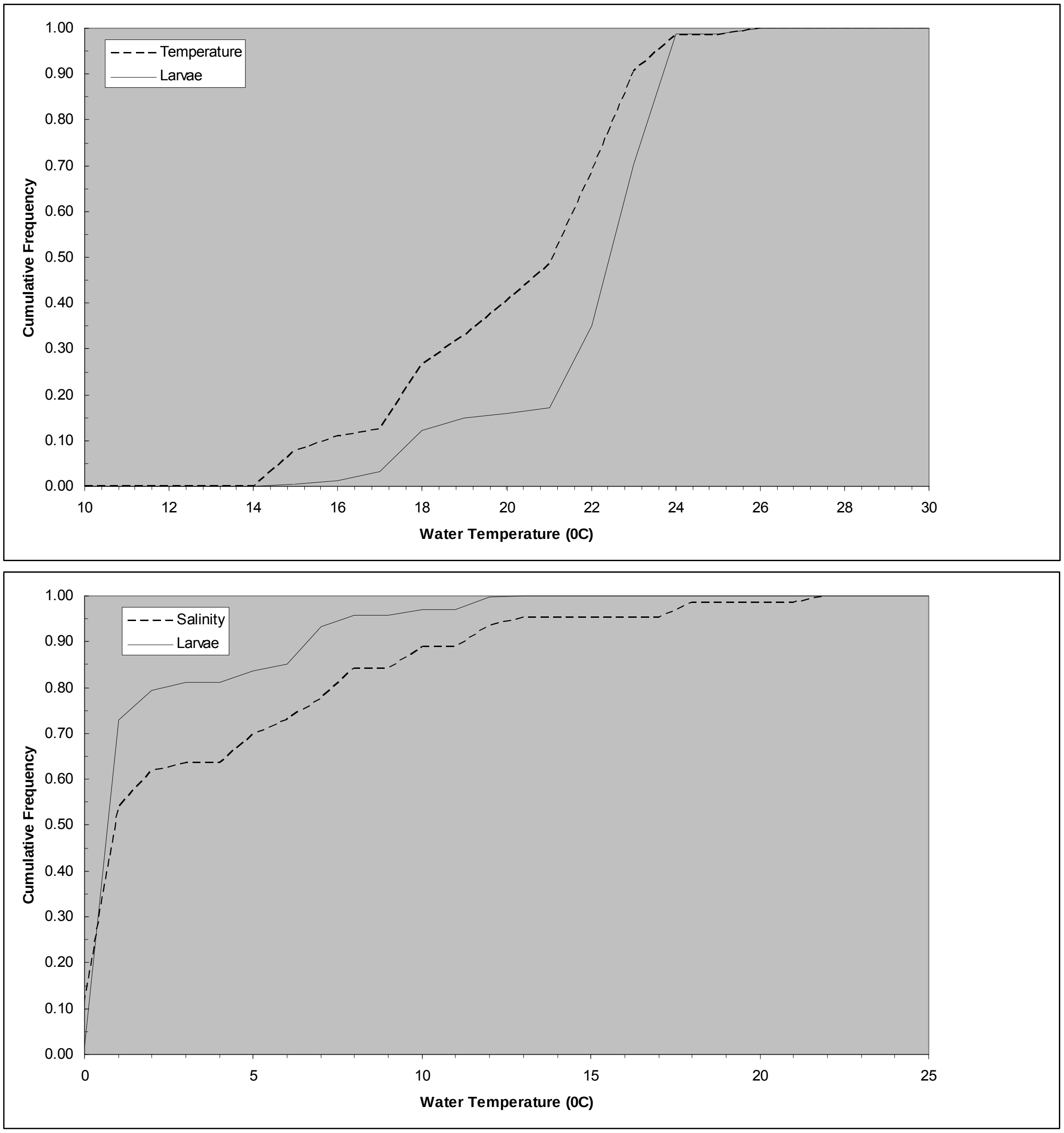

Figure 15. Cumulative frequency distributions of observed temperature and salinity during larval striped bass surveys conducted within the tidal Stewiacke River during 2000 and 2001. The cumulative frequency distributions of eggs collected (numbers per m3) during the surveys are shown.

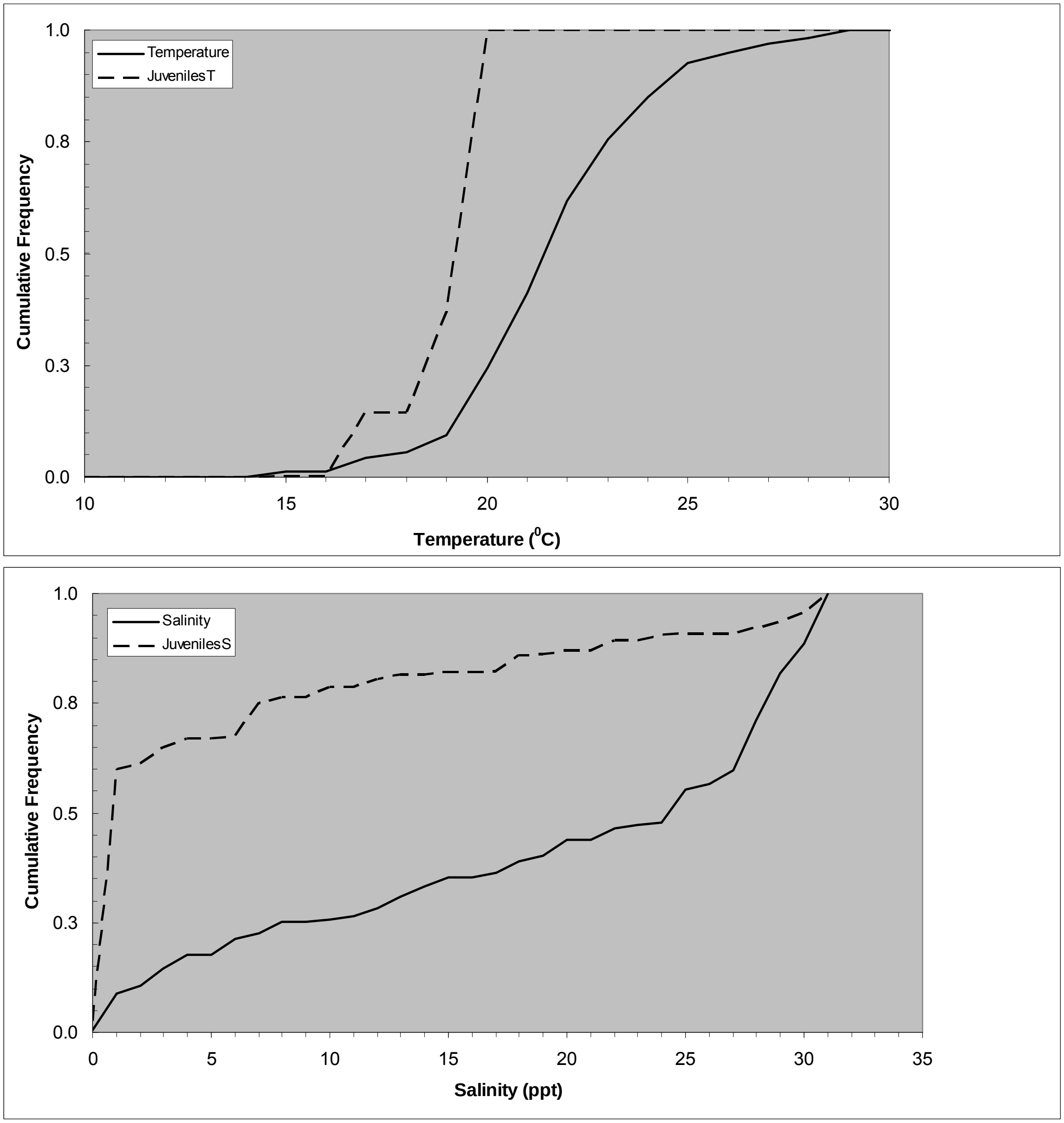

Figure 16. Cumulative frequency distributions of observed temperature and salinity during juvenile striped bass beach seine surveys conducted throughout the tidal portions of the Shubenacadie River and Minas Basin during 2000 and 2001. The cumulative frequency distributions of juveniles collected (numbers per 50m) during the surveys are shown.