COSEWIC
Assessment and Status Report

on the

Bridle Shiner
Notropis bifrenatus

in Canada

SPECIAL CONCERN
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2013. COSEWIC assessment and status report on the Bridle Shiner *Notropis bifrenatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 30 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Previous report(s):

COSEWIC. 2001. COSEWIC assessment and status report on the bridle shiner *Notropis bifrenatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 19 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Holm, E., P. Dumont, J. Leclerc, G. Roy and E.J. Crossman. 1999. COSEWIC status report on the bridle shiner *Notropis bifrenatus* in Canada, *in* COSEWIC assessment and status report on the bridle shiner *Notropis bifrenatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-19 pp.

Production note:
COSEWIC would like to acknowledge Nicholas E. Mandrak, Scott F. Gibson, Pierre Dumont, Mary Burridge and Erling Holm for writing the status report on Bridle Shiner, *Notropis bifrenatus,* in Canada, prepared under contract with Environment Canada. This report was overseen and edited by John Post, Co-chair of the COSEWIC Freshwater Fishes Specialist Subcommittee.

For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: 819-953-3215
Fax: 819-994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Méné d'herbe (*Notropis bifrenatus*) au Canada.

Cover illustration/photo:
Bridle Shiner — Copyright Ellen Edmonson/SAREP.

Catalogue No. CW69-14/671-2013E-PDF
ISBN 978-1-100-22429-9

Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – May 2013

Common name
Bridle Shiner

Scientific name
Notropis bifrenatus

Status
Special Concern

Reason for designation
This species comes close to meeting Threatened status with reductions in the abundance of adults inferred from declines in the species' range. Threats to habitat are most severe in the central part of its distribution in Quebec, where intensive agriculture results in substantial turbidity, sedimentation, eutrophication, and loss of aquatic vegetation. The species may become Threatened if factors suspected of negatively influencing its persistence are not reversed.

Occurrence
Ontario, Quebec

Status history
Designated Special Concern in April 1999. Status re-examined and confirmed in November 2001 and May 2013.

COSEWIC
Executive Summary

Bridle Shiner
Notropis bifrenatus

Wildlife Species Description and Significance

The Bridle Shiner is a small member of the minnow family that reaches a maximum size of 65 mm standard length. It is one of five species of *Notropis* in Canada with a prominent black lateral band that extends from the tail and continues onto the snout. The black band narrows toward the tip of the snout and, at its end, is restricted to the upper lip with the lower lip having little or no pigment. The band is prominent in preserved specimens but may be obscured by silvery scales in live individuals. There is often a bold caudal spot that is confluent with the lateral band. The back is straw coloured and there is a green blue iridescence on the sides. During breeding season, both sexes develop yellow fins with males having bright yellow or gold on the lower sides. Wherever it occurs in sufficient numbers, the Bridle Shiner is presumably a forage fish.

Distribution

The Bridle Shiner is restricted to eastern North America. It occurs in the Atlantic drainage from Wellers Bay in Lake Ontario east to Maine and south to South Carolina. In Canada, it is found from Wellers Bay, Lake Ontario, northeast to Orléans Island, downstream to Québec City and south to Lake Memphrémagog (Québec). It is found in lowland areas and does not occur far inland from the St. Lawrence River or the Richelieu River.

Habitat

The Bridle Shiner is a warmwater fish that is found in quiet areas of streams and, occasionally, in lakes. It prefers colourless or moderately stained water and avoids turbid areas. The Bridle Shiner is usually associated with submerged, floating, or emergent aquatic macrophytes having little affinity for particular substrates, as it utilizes organic detritus, clay, silt, gravel, rubble, and rock habitats.

Biology

The Bridle Shiner spawns in its first year and limited studies reveal that no individuals older than two years of age were found on the spawning grounds. The breeding season ranges from May to mid-July. Spawning usually occurs between 17°C and 22°C. Eggs are broadcast on vegetation and no parental care is provided. The Bridle Shiner is a sight feeder and feeds during daylight hours on microcrustaceans, aquatic insects, detritus, and living plant material. Food is taken from submerged aquatic plants or the bottom when vegetation is sparse or lacking.

Population Sizes and Trends

Population sizes for the Bridle Shiner have not been estimated in Canada. In Québec, it is still established in Saint-Pierre Lake and Saint-Pierre Lake Archipelago, Lake St. Francis, Lake Saint-Louis, and Richelieu River watershed. Since 1995, despite an intensive sampling effort in the littoral zone, reported captures were scarce or null. In the Yamaska River basin, this species occurred only in the lower part where it was found from 1963 – 1971 and in 1989. It appears to have a reduced range in the Châteauguay River system as it was found in the lower part of the basin in 1968; however, in 1993 it was not recorded at any site. The species occurred in the Saint-François River in the 1940s, but has not been reported there since.

In Ontario, the species was historically present in the St. Lawrence River. Recent sampling throughout, and adjacent to, its historical range captured the species in the westernmost portion of the St. Lawrence River, but failed to capture any in the easternmost portion. Since the last Committee on the Status of Endangered Wildlife in Canada (COSEWIC) report, it has been found at many new locations in Prince Edward County and the Rideau River system. This is likely the result of increased identification of the species rather than actual increase in range.

Threats and Limiting Factors

Increased turbidity, loss of suitable aquatic vegetation, urbanization, agricultural development, channelization, pesticides, high nutrient loads, severe sedimentation and eutrophication, exotic species, baitfish harvesting, and climate change all threaten the Bridle Shiner.

Protection, Status, and Ranks

The Bridle Shiner is listed as Special Concern under the province of Ontario's *Endangered Species Act, 2007* and Canada's *Species at Risk Act* (Schedule 1). Several Canadian and provincial acts protect aquatic species and habitats in general. The following ranks apply to Bridle Shiner: Globally Vulnerable (G3); nationally in Canada Vulnerable (N3); in Québec, it is Vulnerable (S3); and in Ontario it is Imperilled (S2). It is considered a species of Special Concern by the Committee on the Status of Species at Risk in Ontario and COSEWIC. In Québec, the Bridle Shiner is identified as a vulnerable species according to the "*Loi sur les espèces menacées ou vulnérables"* (Act respecting threatened or vulnerable species).

TECHNICAL SUMMARY

Notropis bifrenatus
Bridle Shiner Méné d'herbe
Range of occurrence in Canada: ON, QC

Demographic Information

Generation time	1.3 yr
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, inferred from historical and recent declines in some waterbodies
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence 53364 km² (pre-2001 records) 38293 km² (2001-2010 records)	38293 km²
Index of area of occupancy (IAO) 2x2 grid value 964km² (pre-2001 records) 640km² (2001-2010 records)	640km²
Is the total population severely fragmented?	No
Number of extant locations∗ Ontario: Wellers Bay/Big Bay West Lake East Lake Bay of Quinte (Hay Bay, Black River) Big Rideau Lake Cranberry Lake Lake Opinicon Little Cranberry Lake Newboro Lake Lower Rideau Lake Sand Lake	25+

∗ See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Upper Rideau Lake Upper Rideau River Whitefish Lake Finney Creek Jones Creek Morton Creek Kingsford Lake? Upper St. Lawrence River Québec: Lower St. Lawrence River (downstream Montréal) Saint-Pierre Lake Saint-Pierre Lake Archipelago Magog Lake Lake St. Francis Lake St. Louis Richelieu River	
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Yes, observed
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No. Decline in Quebec populations offset by increase in Ontario populations.
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	No. Decline in Québec locations offset by increase in Ontario locations.
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes, inferred
Are there extreme fluctuations in number of populations?	Unknown
Are there extreme fluctuations in number of locations∗?	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each population)

Population	N Mature Individuals
All	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown

Threats (actual or imminent, to populations or habitats)

Increased turbidity, loss of suitable aquatic vegetation, urbanization, agricultural development, channelization, pesticides, high nutrient loads, severe sedimentation and eutrophication, exotic species, baitfish harvesting, and climate change

Rescue Effect (immigration from outside Canada)

∗ See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Status of outside population(s)? NY (S5); VT (S1?)	
Is immigration known or possible?	Possible from NY; unlikely from VT
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Possible from New York populations in the St. Lawrence River but likely limited by small size of species. Very unlikely from Vermont.

Status History

COSEWIC: Designated Special Concern in April 1999. Status re-examined and confirmed in November 2001 and May 2013.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	Not Applicable
Reasons for designation: This species comes close to meeting Threatened status with reductions in the abundance of adults inferred from declines in the species' range. Threats to habitat are most severe in the central part of its distribution in Québec, where intensive agriculture results in substantial turbidity, sedimentation, eutrophication, and loss of aquatic vegetation. The species may become Threatened if factors suspected of negatively influencing its persistence are not reversed.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Close to meeting Threatened A2(c).
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Close to meeting Threatened B2 with small IAO, but is not severely fragmented, number of locations exceed thresholds, and there is no evidence to support extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is not small or declining.
Criterion D (Very Small or Restricted Total Population): Not applicable. Population is not small or restricted spatially.
Criterion E (Quantitative Analysis): Not completed.

PREFACE

The Bridle Shiner remains a poorly studied and monitored species – very little has been published on its biology since the last the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) report in 2001. All sites where it had been found in southeastern Ontario, and many adjacent sites, have been sampled since the last report and it is still present at most historical sites, except for some sites primarily on the St. Lawrence River. Since the last report, it has been found widely distributed through the Rideau River system and Prince Edward County in Ontario, representing a major range extension, likely a result of previous low numbers or misidentification rather than dispersal. Many sites where the Bridle Shiner was historically found in Québec have been resampled. The species appears to be doing well in the eastern part of its Canadian range, Saint-Pierre Lake and its archipelago; however, it has not been found at many historical sites recently sampled (i.e. in the last 10 years). Extent of occurrence is largely unchanged and the index of area of occupancy as calculated here has declined by 33.6%. But unfortunately, data from recent resampling of many of the historical sites in Québec is unavailable so this decline is likely exaggerated. We therefore can't conclude that the real decline is greater than the 30% threshold for Threatened Status. Although threats specific to Bridle Shiner are unknown, they are believed to be degradation of habitat and water quality, and exotic species – all ongoing threats within Bridle Shiner habitat in Canada.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2013)

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

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

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

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

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

COSEWIC Status Report

on the

Bridle Shiner

Notropis bifrenatus

in Canada

2013

TABLE OF CONTENTS

List of Figures

List of Tables

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class	Actinopterygii
Order	Cypriniformes
Family	Cyprinidae (Carps, Minnows)
Scientific Name	*Notropis bifrenatus* (Cope, 1867)
English Common Name	Bridle Shiner
French Common Name	méné d'herbe

Gilbert (1980) suggested that the closest relative of *Notropis bifrenatus* is the Blackchin Shiner (*N. heterodon*). Coburn and Cavender (1992) retained the species in the genus *Notropis. Notropis cayuga*, described from Cayuga Lake and Falls Creek, Ithaca, New York in 1889 is recognized as a junior synonym of *N. bifrenatus* (Eschmeyer 2010).

Morphological Description

The Bridle Shiner (Figure 1) is a small member of the minnow family (Cyprinidae) that reaches a maximum size of 65 mm standard length (SL) (Holm *et al*. 2010). It is one of five species of *Notropis* in Canada with a prominent black lateral band that extends from the tail and continues on to the snout (Scott and Crossman 1973; Bernatchez and Giroux 2000; Holm *et al.* 2010), the others being Blacknose Shiner (*N. heterolepis*). Blackchin Shiner, Pugnose Shiner (*N. anogenus*), and Weed Shiner (*N. texanus*). There is often a bold caudal spot that is confluent with the lateral band. The black band is particularly obvious in most preserved specimens but may be obscured in living specimens by the silvery scales. The Bridle Shiner gets its scientific name and English common name from the bridle-like appearance of the black pigment on the snout and upper lip, and its French common name from its preference for areas with dense aquatic vegetation. The black band narrows toward the tip of the snout and, at its end, is restricted to the upper lip. The lower lip and chin are usually pale (Holm *et al*. 2010). The eye is one of the largest in Canadian cyprinids, its diameter ranging from 31.2 to 38.8% of head length (Scott and Crossman 1973). The mouth is large, terminal to subterminal, and extends backwards to below the posterior half of the nostril (Holm *et al*. 2010). The snout is short and does not usually overhang the mouth. Principal anal rays are usually seven (Werner 2004), although Scott and Crossman (1973) recorded 32% of specimens with eight. Male Bridle Shiner develop minute nuptial tubercles on the pectoral fins, head, and back in front of the dorsal fins (Jenkins and Burkhead 1993; Holm *et al*. 2010). The incomplete lateral line and insertion of the dorsal fin above, or in front of, the origin of the pelvic fins can help distinguish the Bridle Shiner from other blackline shiners (Robitaille 2005; Holm *et al*. 2010).

Figure 1. Bridle Shiner, *Notropis bifrenatus.* Copyright Ellen Edmonson/SAREP.

Life colours of *N. bifrenatus* have been described by Scott and Crossman (1973), Jenkins and Burkhead (1993) and Holm *et al*. (2010). In life, the back is straw-coloured with large scales that are darkly outlined (Holm *et al*. 2010) and there is a greenish-blue iridescence on the sides giving rise to the name “bluesides” used by a bait fisherman in the Lake St. Francis area (Scott and Crossman 1973). The black lateral stripe has crescent-shaped markings (Holm *et al*. 2010). During the breeding season, there is sexual dimorphism. Males are bright yellow or golden on the lower sides, and the first 5 or 6 pectoral rays are margined with brown (Robitaille 2005); the back is darker than in spawning females and non-breeding males. When breeding, both sexes develop yellow fins (Harrington 1947).

Population Spatial Structure and Variability

The spatial population genetic structure of Bridle Shiner populations in Canada is unknown.

Designatable Units

Based on the Canadian Freshwater Biogeographic Zone classification adopted by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the Canadian populations are found within the Great Lakes-Upper St. Lawrence Biogeographic Zone. The population structure within this zone is unknown. Therefore, a single designatable unit is recognized.

Special Significance

Wherever it occurs in sufficient numbers, the Bridle Shiner is presumably a forage fish. Predators would likely find the Bridle Shiner an easy target. It has limited use as a bait species because of its small size.

The Bridle Shiner is one of several “blackline” shiners (e.g. Blacknose, Blackchin, Pugnose shiners) that are superficially very similar and have a prominent black lateral band that extends from the tail and continues onto the snout. These species are sensitive to environmental change, are threatened by decreases in water clarity and aquatic vegetation and excessive loading of nutrients and pesticides (Boucher *et al*. 2011) and, thus, are indicators of environmental health.

DISTRIBUTION

Global Range

The Bridle Shiner is restricted to eastern North America in the Atlantic drainage, from eastern Lake Ontario east to Maine and south to South Carolina (Figure 2) (Gilbert 1980; Jenkins and Burkhead 1993). The Bridle Shiner has undergone a reduction in area of occupancy across much of its North American range (NatureServe 2010).

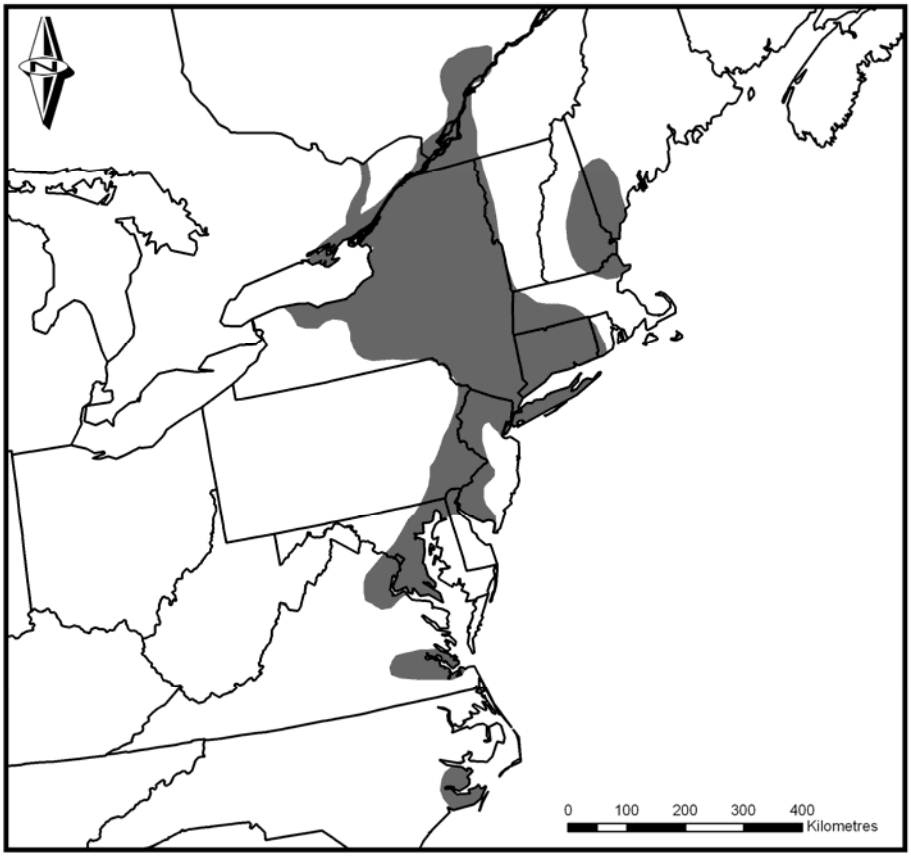

Figure 2. Global distribution of the Bridle Shiner (modified from Page and Burr 2011).

Canadian Range

Less than 5% of the Bridle Shiner's global range is in Canada. In Canada, the Bridle Shiner is at the northern limits of its range and is restricted to the eastern part of what is known as the Mixedwood Plains ecozone (Wiken 1986; Crossman and Holm 1997). It is found from Wellers Bay, Lake Ontario, northeast to Lake Saint Pierre, near Trois-Rivières, Québec and south to Lake Memphrémagog (Figures 3 and 4). In Québec, the Bridle Shiner has been recorded in the main course of the St. Lawrence River, in the Lake des Deux Montagnes and in the watershed of seven large tributaries (Châteauguay, Des Prairies, des Mille Iles, L'Assomption, Yamaska, Richelieu and Saint-François) and of 12 small tributaries (from the western to the eastern section: Brunson, Beaudette, À la Guerre, Saint-Louis, Chamberry, Saint-Jean, Aux Pins, Bayonne, À la Chaloupe, du Pot-au-beurre, Yamachiche, and Godefroy). In Ontario, the Bridle Shiner is believed to be extant in Prince Edward County, Rideau River system, and upper St. Lawrence River (Figure 3; Boucher *et al*. 2011).

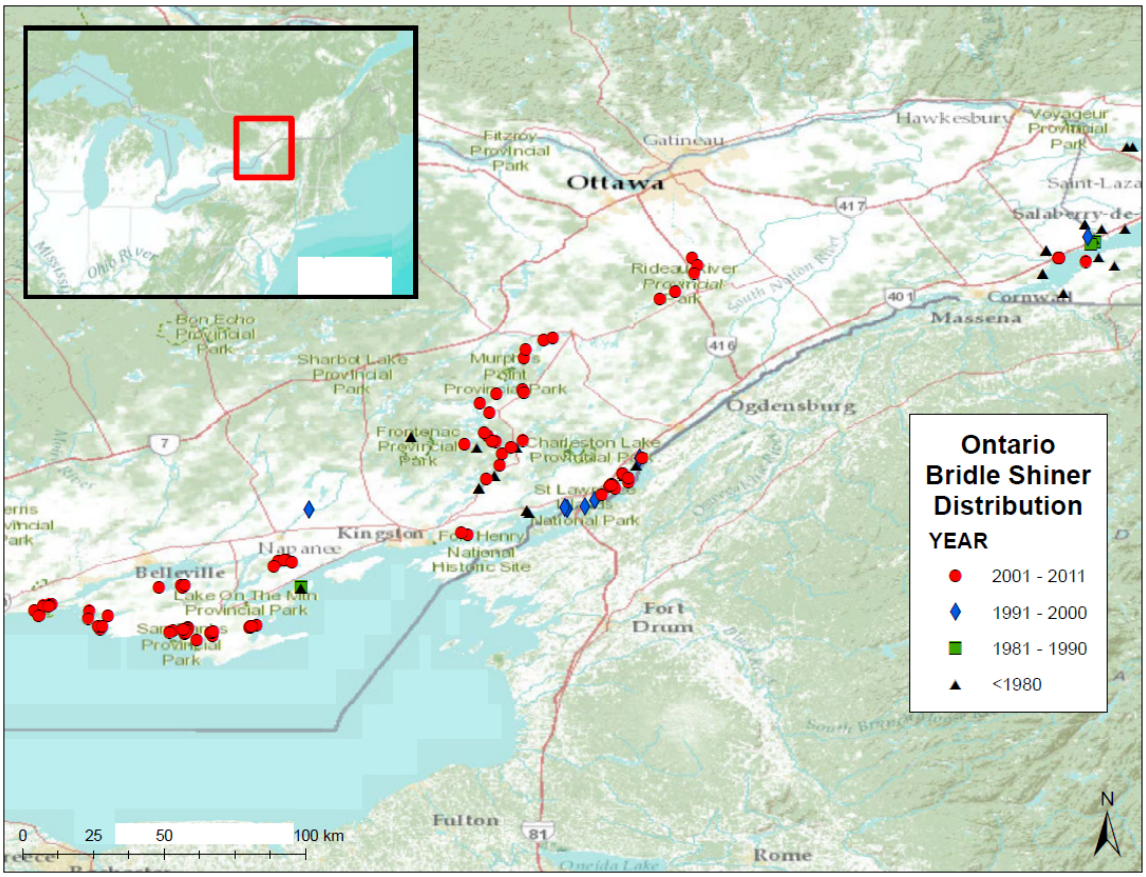

Figure 3. The distribution of Bridle Shiner in Ontario.

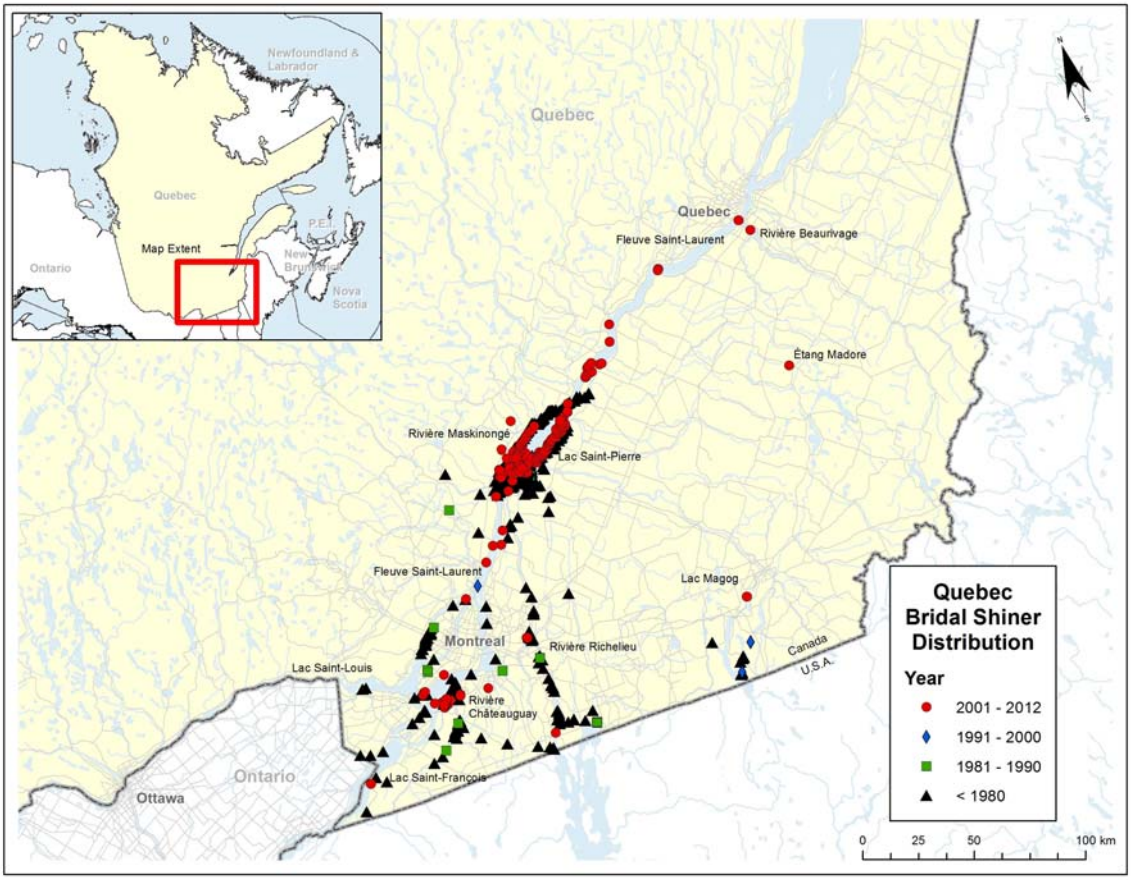

Figure 4. The distribution of Bridle Shiner in Québec.

The species was first documented in Québec by Cuerrier *et al*. (1946) from the Montréal and Saint-Pierre Lake regions. In Ontario, it was first captured in 1928 in the Bay of Quinte at the east end of Lake Ontario (Hubbs and Brown 1929). By 1938, collections by G.C. Toner (Royal Ontario Museum (ROM), unpubl. data) had extended the range northeastward into an unnamed tributary of the Rideau Canal near Brewer's Mill, and eastward into the Gananoque River, the St. Lawrence River near Gananoque, and in a tributary of Lake St. Francis. Radforth (1944) favoured the idea that *Notropis bifrenatus* had dispersed into Ontario from the Atlantic refugium either through the Mohawk-Hudson outlet or through the Champlain outlet. Its common occurrence in the upper Richelieu suggests that it used the latter as a means of postglacial dispersal. Radforth (1944) suggested that it had arrived in Ontario only recently and had possibly not reached its limit owing to insufficient time for dispersal. However, Scott and Crossman (1973) predicted that the expansion of the range of the Bridle Shiner in Canada would be prevented by sewage disposal problems caused by high population pressures and industrialization. In 2010, sampling by DFO in the Rideau Canal system and waterbodies in Prince Edward County in Ontario, substantially increased the known range of this species (Mandrak, unpubl. data; Figure 3).

The extent of occurrence (EO) for the most recent decade is 38,293 km^2 (2001-2010 records) representing a 28% decline from the previous records (pre-2001 records). The index of area of occupancy (IAO) is 640 km^2 (2001-2010 records) representing a 33.6% decline from prior records (pre-2001 records). Unfortunately, data from recent resampling of many of the historical sites in Québec is unavailable, so these estimated declines are likely exaggerated. We therefore can't reasonably conclude that the real decline in IAO is greater than the 30% threshold for Threatened Status.

Search Effort

In the last 10 years, targeted sampling for Bridle Shiner using appropriate gears has taken place at all historical locations in Ontario and many historical locations in Québec. Additional sampling has also found it at many new sites in Ontario. See **Sampling Effort and Methods** for further details.

HABITAT

Habitat Requirements

The Bridle Shiner is a warm water fish that is found in quiet areas of streams and, occasionally, in lakes. It is found over a soft bottom of sand, silt, and detritus. It prefers colourless or moderately stained water and avoids turbid areas (Scott and Crossman 1973; Smith 1985; Jenkins and Burkhead 1993). It is tolerant of brackish water but is not acid tolerant, which would likely prevent its spread in acid-sensitive areas on the Canadian Shield (Holm *et al*. 2001).

In Québec, this minnow is found in relatively high frequency in habitats characterized by slow current, dense aquatic vegetation, and highly developed shoreline perimeter along the numerous islands of the St. Lawrence River, the upper part of the Richelieu River, and Des Mille Iles River. In the past, it has also been reported in small creeks of the St. Lawrence lowlands and in a few small lakes on the Precambrian Shield.

In Ontario, the Bridle Shiner is primarily restricted to quiet areas of creeks and the St. Lawrence River, but has also been found in lakes. It is usually associated with slow current and submerged, floating, or emergent aquatic macrophytes. The substrate does not seem to be critical as it occurs over a variety of bottom types including organic detritus, clay, silt, gravel, rubble, and rocks. Bridle Shiner is a sight feeder and, therefore, requires habitats with relatively low turbidity. DFO collected Bridle Shiner in 95 sampling events in the St. Lawrence River in Ontario between 2009 and 2011. The habitat during these events was characterized as: mean; conductivity of 259 µS/m; mean dissolved oxygen of 9.6 mg/l; mean Secchi depth of 1.73 m; dominant substrate types of sand (38% of events), organic (27%), and silt (22%); and submerged vegetation (85%) was the dominant vegetation type with the dominant species being *Chara* spp. (43%) and *Vallisneria americana* (29%) (Mandrak, unpubl. data).

Harrington (1947) reported that the Bridle Shiner spawned among submerged aquatic plants (primarily native *Myriophyllum* and *Chara* adjacent to other types of submerged and floating vegetation) where there is 15-46 cm of free water above the vegetation. Some spawning occurred in relatively barren (i.e. absence of vegetation) areas later in the spawning season. Aquatic macrophytes are probably essential for nursery areas, as Smith (1985) noted newly hatched young (5 mm) remained within the vegetation prior to congregating into small schools. Harrington (1947) found that the young of the Bridle Shiner were restricted to areas where spawning had occurred and were found among strands of *Myriophyllum*. Adhesive eggs are broadcast on vegetation (Smith 1985). Larvae have cement glands that allow adhesion to plants (Jenkins and Burkhead 1993).

Potential spawning habitat was considered for Saint-Louis Lake and Saint-Pierre Lake (Québec) to have a water depth of 45 – 120 cm, fine substrate of clay, silt or sand, current velocity of 0 – 15 cm/sec, and a high density of submerged vegetation (Giguère *et al*. 2005). Physical habitat at capture sites has been described as having slow-moving current, dense aquatic vegetation, and substrates of organic detritus, clay, silt, gravel, rubble and rocks (Holm *et al*. 2001).

Habitat Trends

In Québec, agricultural activities have intensified over the past 50 years, resulting in increased stress on aquatic environments (Boucher *et al*. 2011). The St. Lawrence lowlands have a significant proportion of agricultural land, and include the vast majority of the Bridle Shiner's distribution. The Bridle Shiner has also been found in watersheds which are among the most polluted rivers in the province (i.e. Assomption, Richelieu, Saint-François, and Yamaska rivers). Water quality in these rivers is poor and, in the case of the Yamaska River, very poor, with high concentrations of nutrients (nitrogen, phosphorus), pesticides, suspended matter, and organic matter (Simard 2004; Hudon and Carignan 2008). The Richelieu, Yamaska and Saint-François rivers discharge directly into the upstream part of Saint-Pierre Lake, an area where Bridle Shiner is abundant. It is estimated that nearly 800 000 t of suspended matter from agricultural lands enter annually via Saint-Pierre Lake (Hudon and Carignan 2008). These habitats are also impacted by pollutants from the Montréal industrialized areas. The closure of some facilities and other efforts (improved domestic and industrial effluents treatment) made over the last 25 years have resulted in a reduction of contaminated waste and an overall improvement in the health of the St. Lawrence River (SLV 2008), but excessive nutrient loadings from most St. Lawrence River tributaries remain a major concern to aquatic life protection (Gangbazo *et al*. 2005; Hudon *et al*. 2012).

In Ontario, recent improvements in water clarity due to phosphorus control and Zebra Mussel (*Dreissena polymorpha*) resulting in increased submerged aquatic vegetation have occurred in the Bay of Quinte (Leisti *et al*. 2006). It is likely that similar improvements are occurring in the St. Lawrence River. It would be expected that aquatic vegetation would increase with increased clarity of the water, as it has in many other areas invaded by Zebra Mussel.

Habitat loss is likely occurring in the streams in the Lake St. Francis watershed (e.g. Wood, Gunn and Finney creeks) and in many other small tributaries in the St. Lawrence lowlands due to intensive agriculture associated with feed-lot and dairy cattle, mixed pasture and corn and soya crops. The streams in these areas have been channelized for field drainage and have high loadings of pesticides, nutrients, and suspended sediment (M. Eckersley, OMNR, Kemptville, pers. comm., cited in Holm *et al*. 2001; Simard 2004; Gangbazo *et al*. 2005).

BIOLOGY

Life Cycle and Reproduction

The spawning behaviour of the Bridle Shiner in New Hampshire and New York was described in detail in several papers by Harrington (1947, 1948a, 1950, 1951) and Smith (1985). No individuals older than two years of age were found on the spawning grounds and males normally spawned in their first year. Females spawned in their first year if they reached 30 mm SL, but the majority spawned in their second year. Spawning occurs in spring and summer in quiet pools and shorelines with dense aquatic vegetation. In New York, spawning was initiated prior to daylight with most activity occurring between 0700 and 1400 (Smith 1985). One or two males chase and swim alongside a female, often bumping his snout along her sides and snout prior to the release of eggs and sperm. Spawning occurs several times a day throughout the breeding season when water temperatures are between 14° and 26°C (Smith 1985; Holm *et al.* 2010). In New Hampshire, the spawning season ranged from the last week of May to mid-July. In New York, spawning activity began the beginning of May and lasted until August, but the height of activity occurred in mid-June. Generation time is estimated to be 1.3 years (Froese and Pauly 2012).

The number of eggs ranged from 1,062 for a 34 mm SL female to 2,110 for a 44 mm SL female but many of these eggs, with diameters ranging from 0.2 to 0.8 mm, may not have matured in time to be spawned. This size difference in the eggs was thought to indicate an extended spawning season. Smith (1985) noted that hardened eggs were approximately 1.5 mm in diameter and hatched in 57 hours at approximately 21°C. Eggs were broadcast on vegetation and no parental care was provided. The eggs are adhesive but it is not known if they attach to plants (Jenkins and Burkhead 1993). Young remain in the shelter of vegetation until late summer when they form schools (Smith 1985; Werner 2004).

Physiology and Adaptability

Very little is known regarding the physiology and tolerances of the Bridle Shiner. Accounts by Scott and Crossman (1973), Smith (1985), and Jenkins and Burkhead (1993) suggested that the species is sensitive to high levels of turbidity. The Bridle Shiner is sensitive to low pH, which may limit distribution onto watersheds on the Canadian Shield (Holm *et al*. 2001). In Connecticut, Bridle Shiner were collected at sites with moderate alkalinity (range 6-177 mEq/l, mean = 29 mEq/l; n= 32) and hardness (range 13-152 mg/l, mean = 74 mg/l; n= 14) (Whitworth *et al*. 1968). The species is tolerant of brackish habitats (Jenkins and Burkhead 1993).

Dispersal and Migration

No information on movement or migrations of the Bridle Shiner is available. It is not likely that this small, slow-swimming fish has a large home range.

Interspecific Interactions

Given its small size and weak swimming ability, it is presumed that, where locally abundant, the Bridle Shiner is subject to heavy predation by predators such as Northern Pike (*Esox lucius*), Grass and Redfin pickerels (*Esox americanus*), Muskellunge (*Esox masquinongy*), White Perch (*Morone americana*), Smallmouth Bass (*Micropterus dolomieu*), Largemouth Bass (*M. salmoides*), Black Crappie (*Pomoxis nigromaculatus*), and Yellow Perch (*Perca flavescens*) (Scott and Crossman 1973). Its extirpation in Maryland was thought to be due, in part, to predation by introduced Largemouth Bass, Channel Catfish (*Ictalurus punctatus),* and Blue Catfish (*I. furcatus*) (Kilian *et al*. 2011)

In the United States, the Bridle Shiner is thought to be a primary food source for Chain Pickerel (*Esox niger*; Scott and Crossman 1973), a species found within the range of this species in Canada. Harrington (1951) noted that in aquaria, Bridle Shiner ate most or all of their own eggs before they reached the bottom; however, it is not known if a significant number of eggs are eaten in nature.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Targeted and non-targeted sampling for Bridle Shiner has been undertaken using seining and electrofishing – both methods have been identified as suitable for sampling this species (Portt *et al*. 2008). However, the effort required and the detectability using these methods has not been compared for Bridle Shiner.

In Québec, Bridle shiner was most abundant in the channels of Sorel and Berthier Islands (Saint-Pierre Lake Archipelago) where 5,387 specimens were captured in 143 of 294 stations evenly distributed in the littoral zone and sampled between 1970 and 1971 (Massé and Mongeau 1974). In 1982, sampling efforts at 27 sites on 12 tributaries of the south shore of Saint-Pierre Lake failed to document the presence of Bridle Shiner, although the Blacknose Shiner, which is easily confused with the Bridle Shiner was recorded from two of the sites (MacFarlane and Durocher 1984). Sampling efforts in the same general vicinity in Saint-Pierre Lake (1995, 2002, 2007) and its archipelago (1995, 2003, 2010), also produced large numbers of Bridle Shiner with more than 6650 specimens being caught during the surveys of the *Réseau de Suivi Ichtyologique* (RSI), a fish monitoring network implemented in 1995 in these localities (Robitaille 2005; Ministère des Ressources naturelles et de la Faune (MRNF), unpubl.data). These periodic surveys cover around 115 seine littoral stations systematically located every 1 km along the shore (see La Violette *et al*. 2003 for a description of the sampling strategy and methods). The Bridle Shiner was caught in 40% of the stations. During this 15-year period, there was no temporal trend in the average catch or the frequency of occurrence of the species in these two areas. These results indicate that the Bridle Shiner is still well-established in Saint-Pierre Lake and its archipelago, and in the Maskinonge River. Bridle Shiner were also reported for the first time at several sites on the St. Lawrence River between Saint-Pierre Lake and Québec City since 2001 (Boucher *et al*. 2011). For example, 24 Bridle Shiner were caught in 8 of the 45 RSI stations sampled in 2008.

This is not the case in the other reaches of the Québec part of the St. Lawrence River. In Lake St. Francis, the species was reported at the mouth of Brunson Creek and À la Guerre and Beaudette rivers between 1941 and 1946 and in the northeastern part of the lake in 1968 (Mongeau 1979a). No Bridle Shiner were captured during the fall of 1996 and 2004 at 40 and 65 seine stations evenly distributed along the Québec shore of the lake (MRNF, RSI data); however, a total of 30 Bridle Shiner were captured in one of the 62 seine stations sampled in 2009 (D. Deschamps, MRNF, RSI data). In Lake Saint-Louis and some of its small tributaries (Saint-Louis River and Chamberry and Saint-Jean creeks), small numbers of Bridle Shiner were collected in 1941, 1942 1965 and between 1968 and 1974. Only one specimen was caught during the surveys of the *RSI* in 1997*.* None were caught at 46 seine stations sampled in 1997 and 100 sampled in 2005 (Robitaille 2005) but a total of 130 were reported in 18 of the 99 stations sampled in 2011.

The occurrence and abundance of the Bridle Shiner is also likely declining in the watersheds of most large tributaries of the St. Lawrence River in Québec where it was reported in the past. In the Yamaska River basin, this species occurred only in the lower part of the system where it was found in 12 of 210 seine hauls made between 1963 and 1971 (Mongeau 1979b). A 1995 electrofishing survey of 39 sites within the basin failed to capture any Bridle Shiner (including four sites with historical records) (La Violette 1997). However, 16 individuals were captured on 22 August 1989 in the Yamaska River near its confluence with Lake Saint-Pierre (ROM 57019). Reported for the first time in 1941 in the Pot-au-Beurre River, a small tributary of the Yamaska River near its outlet into Saint-Pierre Lake, its presence was also confirmed in 1987 (13 specimens in one seine station), 1995 (1966 specimens in 116 seine stations) and 1997 (156 specimens in 52 stations) (Holm *et al*. 2001).

Bridle Shiner populations appear to have been reduced in the Châteauguay River system, where it was first observed in 1941. It was found mainly in the lower part of the basin in 1968 and sampling efforts between 1975 and 1976 documented its presence in 21 of 217 seine hauls in that system. However, in 1993 and 2006, it was not recorded at any of the 21 sites electrofished by the Ministère de l'Environnement et de la Faune (La Violette and Richard 1996; Boucher *et al*. 2011).

The species was caught during the 1940s in the Saint-François River, but was not reported by Mongeau and his colleagues in the 1960s and 1970s (Mongeau and Legendre 1976). Similarly, extensive sampling in the river in 1991 (26 sites; Richard 1996), 1998 (13 sites; Kovacs *et al*. 2002), and 2002 (17 sites; Yvon Richard, Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP), unpubl. data) failed to capture any Bridle Shiner.

The Bridle Shiner was frequently encountered between 1965 and 1970 in the Richelieu River watershed, where it was found at 98 of 623 stations (Mongeau 1979c). It was first reported in this watershed in 1941 (Lacolle River), in its upper part near the Canada-United States border. The same year, it was also reported in Aux Brochets River, near the outlet to Missisquoi Bay (Lake Champlain). Systematic surveys completed in this river in the 1970s did not capture any individuals (Mongeau 1979c), but during the spring of 1990 six Bridle Shiner were captured in Missisquoi Bay near its mouth (Holm *et al*. 2001). None were reported in the 27 seine stations sampled in 2003 (Bilodeau *et al*. 2004) and in the 26 seine stations sampled in 2012 in Missisquoi Bay. In 1989, six specimens were captured by the ROM in the upper part of the Richelieu River near the Canada-United States border (ROM Accession 5518). In the same area, in 1995, one specimen was caught in one of 21 electrofishing stations (Saint-Jacques and Richard 1997) and two were caught in 2012 in one of 36 seine stations sampled (RSI data).

In the lower Richelieu, between Chambly and Saint-Marc, 27 specimens were collected in August 1970 (in 49 seine hauls). In 1993 no Bridle Shiner were caught during an August-September survey involving 129 seine hauls (Jean Leclerc, unpubl. data in Holm *et al*. 2001). A seine survey, systematically repeated in 1997 to 1999, 2001, 2003, 2004 and 2006 to 2012 in the lower reach of the river (near Saint-Marc sur le Richelieu, upstream of Saint-Ours dam), based on at least 40 seine stations, failed to capture any Bridle Shiner (Nathalie Vachon, MRNF, unpubl. data; see Vachon 2007 for a description of the sampling methodology). In 2012, two Bridle Shiner were caught in the lower reach of the Richelieu River, downstream of Saint-Ours dam and near its confluence with Lake Saint-Pierre (Nathalie Vachon, MRNF, unpubl. data).

The capture of the Bridle Shiner in the Lake Memphremagog basin, first reported in 1964, was confirmed in 1999 by Desroches *et al*. (2008). During the same year, these authors also observed the presence of the species in Lake Magog, also in the upper part of the Saint-François River watershed.

The presence of the Bridle Shiner in Lake St. Paul (Godefroy River watershed), near the outlet of Lake Saint-Pierre into the St. Lawrence River was reported in 1964 (Holm *et al*. 2001).

In Ontario, all historical sites for Bridle Shiner have been resampled since 1999, and it has also been found at new sites since 2001.

In 1994, a ROM survey sampled 13 sites in the Ontario range of the species, of which Bridle Shiner were known to occur at seven of those sites. It was captured at only three of the 13 sites and constituted approximately 4-24% (mean=6.6%) of the catch at those three sites.

In 1999, OMNR sampled three historical Bridle Shiner sites (Brewer's Mills, Leo Lake, Morton Creek) and two sites with suitable habitat (Gananoque Lake, St. Lawrence River at Halstead's Bay) using seines and did not capture any Bridle Shiner; however, Bridle Shiner were caught at the International Rift on the St. Lawrence River near a known location (Hill's Island) (Dextrase 1999).

Between 2004 and 2010, DFO conducted many surveys within the range of the Bridle Shiner in eastern Ontario using a variety of gears (fine-mesh seines, boat seines, backpack electrofisher, boat electrofisher, fine-mesh trawls) and efforts (Figure 3) (Mandrak *et al*. 2006; Mandrak, unpubl. data).

In 2004, DFO caught 34 species, including many minnow species at 16 sites sampled in Lake St. Francis, 31 species at eight sites on the St. Lawrence River at Cornwall, 30 species at four sites on the St. Lawrence River at Maitland in August and November using boat electrofishing (350 minutes, 260 minutes, 85 minutes, respectively). Although many minnow species were captured at these sites, no Bridle Shiner were caught (Mandrak, unpubl. data).

In 2005, DFO caught a single Bridle Shiner at one of five sites sampled on Big Rideau Lake, a new location, and eight specimens at two of 14 sites sampled within its known range in the St. Lawrence River (Figure 3; Mandrak *et al*. 2006).

In 2009, DFO seined Bridle Shiner at Thompson's Bay (60 specimens), Eastview (19), and the mouths of Jones (2) and Morton (2) creeks within its known range on the St. Lawrence River. More significantly, 28 Bridle Shiner were caught in West Lake, Prince Edward County, ON – extending its known range substantially westward into the Lake Ontario drainage (Figure 3; Mandrak, unpubl. data).

In 2010, DFO caught 66 Bridle Shiner in West Lake, and also caught it at several other new locations in Prince Edward County including Black River (22 specimens), East Lake (84), and Hay Bay (520). More significantly, Bridle Shiner were caught in two bays in Lake Ontario northwest of West Lake – Big Bay (27 specimens) and Wellers Bay (72) – extending its known range further westward (Figure 3; Mandrak, unpubl. data).

In 2010, DFO also caught Bridle Shiner by seining in the Rideau River system including Big Rideau Lake (19 at five sites), Cranberry Lake (19 at one site), Lake Opinicon (14 at two sites), Little Cranberry Lake (31 at one site), Newboro Lake (one at one site), Lower Rideau Lake (13 at two sites), Sand Lake (nine at three sites), Upper Rideau Lake (eight at one site), and Whitefish Lake (10 at two sites). Twenty-three Bridle Shiner were also caught at four sites on the Rideau River from the outlet of Murphy Drain north to the mouth of Cranberry Creek (Figure 3; Mandrak, unpubl. data).

In 2007, a survey targeted fish species at risk at 30 sites in the Rideau River system from Lake Opinicon in the south to Dows Lake in Ottawa to the north (Mapleston *et al*. 2007). Four different gear types were used (seine nets, backpack electrofisher, hoop net, trap net) and 28 fish species were collected; however, no Bridle Shiner were identified. In 2008, the survey was repeated at 41 sites, including some of the 2007 sites and additional sites between Smiths Falls and Kingston (Hair and Cooke 2009). Twenty-eight fish species were collected; however, no Bridle Shiner were identified. In 2009, the survey was repeated at 67 sites between Smiths Falls and Kingston and 37 fish species were collected; however, no Bridle Shiner were identified (Colotelo and Cooke 2010).

In 2008 and 2009, the Raisin Region Conservation Authority (RRCA) sampled 24 historical Bridle Shiner sites in six streams (Raisin River; Finney, Fraser, Gunn, Sutherland, and Wood creeks) within their jurisdiction using a variety of gears (seines, Windermere traps, backpack electrofisher, boat electrofisher) and failed to capture any Bridle Shiner (Jacobs 2009, 2010). In 2010, RRCA caught five Bridle Shiner at one site on Finney Creek (Jacobs 2011).

Abundance

Population sizes for the Bridle Shiner have not been estimated in Canada. In 2010, DFO conducted targeted sampling of many historical localities of Bridle Shiner in Ontario and throughout the Rideau River system using fine mesh seine nets and a minimum of three seine hauls. Where the species was detected, a minimum of five seine hauls were undertaken to estimate population sizes using a depletion method. Unfortunately, sufficient depletion was not observed to estimate population size at any location where it was captured (Mandrak, unpubl. data).

Fluctuations and Trends

The lack of sampling in recent years in certain rivers with historical records has made it difficult to evaluate trends in distribution. The Bridle Shiner is confused with the Blacknose Shiner (*N. heterolepis*) and other blackline shiners with which it commonly co-occurs, and errors in species identification have often been made, resulting in inaccurate estimates of Bridle Shiner abundance. Population trends of Bridle Shiner in Canada are difficult to determine due, in part, to difficulties in species identification (Boucher *et al*. 2011).

In Canada, evidence suggests that populations have declined in several river systems such as the Yamaska, St-François, Richelieu, Châteauguay, St. Lawrence (Lac St-Louis and St. Francis Lake). There is no evidence of decline in recently surveyed waters in the St. Lawrence River in Saint-Pierre Lake and around the Thousand Islands. Only recently has the species been extensively found across Prince Edward County and the Rideau River system in Ontario. It is not known if these newly found populations represent recent range extensions, or existing populations that increased to detectable levels or had not been previously identified.

Page and Burr (2011) indicated that the Bridle Shiner was fairly common but decreasing in some areas of its American range. Jenkins and Burkhead (1993) documented several areas in the United States where the Bridle Shiner has declined or been extirpated. They consider that the Neuse River population in North Carolina is probably extirpated. In Virginia, some populations are extirpated or nearly so and the range of the species has receded sharply in Massachusetts, New Jersey, Pennsylvania and Maryland. Kilian *et al*. (2011) considered the Bridle Shiner to be extirpated in Maryland based on the lack of specimens collected since 1984 despite intensive targeted sampling using seining and electrofishing. Cooper (1983) indicated that the Bridle Shiner was once abundant in eastern Pennsylvania but is now taken only rarely, and only in the Delaware River drainage. In addition, it has been found recently in only one of 31 historical localities in Pennsylvania and in a small percentage of several dozen historical localities in Massachusetts (NatureServe 2010).

Rescue Effect

Bridle Shiner populations in New York are ranked as S5 (Secure) where it is known from the southern shores of eastern Lake Ontario and the St. Lawrence River (Smith 1985). Natural dispersal across the St. Lawrence River into the Ontario range of the species is possible but likely limited by the small size of the species. Bridle Shiner is ranked as S1 in Vermont (NatureServe 2013); therefore, natural dispersal from the United States into the Québec range is highly unlikely.

THREATS AND LIMITING FACTORS

The Bridle Shiner is sensitive to habitat degradation and poor water quality that typically occur as a result of infilling of wetlands, channelization, eutrophication, sediment inputs, and increased turbidity, all of which are likely responsible for the decline of the species throughout its range. Kilian *et al*. (2011) attributed, in part, the extirpation of this species in Maryland to declining water quality. Many of these threats are associated with intensive agricultural practices, and more particularly with corn and soya production, which has experienced a significant expansion in southern Québec since 1970. Excess fertilizers, the primary impact of corn and soya farming, particularly affect fish habitat through the eutrophication of waterbodies (Vachon 2003; MDDEP 2007). It is estimated that close to 800,000 t of suspended matter originating from agricultural lands enter Saint-Pierre Lake (Hudon and Carignan 2008). It was estimated that more than 40% of Saint-Pierre Lake exceeded provincial water quality objectives for phosphorus (>30 ug P/L) (Hudon and Carignan 2008). Recently, the replacement of aquatic macrophytes and filamentous chlorophytes by benthic mats of filamentous cyanobacteria in a large zone of the southern shore, associated with excessive nutrient loads from Saint-Pierre Lake tributaries, resulted in a less complex 3-D habitat structure and a low invertebrate availability for fishes (Hudon *et al*. 2012).

With the exception of the St. Lawrence River, Rideau River, and Lake Ontario, most of the areas where Bridle Shiner has been reported now suffer from severe sedimentation and eutrophication. Excessive sedimentation often suffocates deposited eggs, reduces oxygen availability in the substrate, and affects the abundance of food resources (Holm and Mandrak 1996). In Ontario, the streams affected by agricultural development are in the Lake St. Francis watershed where feed-lot and dairy cattle are raised and mixed pasture and corn crops are grown. Streams in this area (e.g. Wood, Gunn, and Finney creeks) have been channelized for drainage and have high loadings of pesticides, nutrients, and sediment (Jacobs 2010; M. Eckersley, OMNR Kemptville, pers. comm., cited in Holm *et al*. 2001).

Increased turbidity adversely affects the ability of this species to locate its food and hinders the growth of submerged aquatic plants essential for feeding, reproduction, and cover (Jenkins and Burkhead 1993). Infilling of wetlands and physical removal of aquatic vegetation would also be expected to have negative impacts on Bridle Shiner populations. The composition of the aquatic macrophyte community is probably important for suitable spawning areas and food. This species prefers to spawn over aquatic vegetation such as watermilfoil (*Myriophyllum*) and *Chara* (Harrington 1947). The presence of a clear area above the submerged vegetation is probably important for spawning activities (Harrington 1947). Thus, any plant that has a tendency to grow to the surface before Bridle Shiner spawning occurs will have a negative effect on spawning success. The decline of the closely related Blackchin and Blacknose shiners has been associated with an explosion of the exotic Eurasian Watermilfoil (*M. spicatum)* in several Wisconsin lakes (Lyons 1989), and it may impair spawning of the Bridle Shiner (Sabo 2000). Kilian *et al*. (2011) suggested that Eurasian Watermilfoil and another invasive species Hydrilla (*Hydrilla verticillata*) decreased the native submerged aquatic vegetation required for spawning in Maryland, where Bridle Shiner is considered extirpated. Eurasian Watermilfoil has been recorded in Lake Ontario and the St. Lawrence River and is widespread in eastern Ontario (Keast 1984, Makkay *et al*. 2008), whereas, Hydrilla has not yet been found in Canada (www.invadingspecies.org, accessed October 22, 2012). Eurasian Watermilfoil and another invasive plant, European Frogbit (*Hydrocharis morsusranae*) have been found in Finney Creek (Jacobs 2010), where five Bridle Shiner were caught in 2011 (Jacobs 2011). European Frogbit forms dense mats at the surface and would eliminate the open water area above submerged aquatic vegetation that Bridle Shiner prefer for spawning (Jacobs 2010). In the New England states, invasive predators (e.g. *Micropterus* spp.) eliminated populations of Bridle Shiner in lakes and ponds where aquatic vegetation was removed (Sabo 2000).

Effects of exotic species, such as Common Carp (*Cyprinus carpio*), Zebra Mussel and Round Goby (*Neogobius melanostomus)*, on the Bridle Shiner are unknown. Common Carp, found throughout the range of Bridle Shiner in Canada, uproot essential aquatic macrophytes and increase turbidity that likely negatively impacts the Bridle Shiner. The filter feeding of Zebra Mussel, widespread in the Great Lakes and the main stem of the St. Lawrence River, may positively impact Bridle Shiner, as this increases water clarity, allows more light to penetrate, and increases aquatic macrophyte growth (Boucher *et al*. 2011). The Round Goby, introduced in 1990, is now widespread in the Great Lakes and the main stem of the St. Lawrence River and well integrated in the food chain (Reyjol *et al*. 2010; Taraborelli *et al*. 2010). It has been shown that Mottled Sculpin (*Cottus bairdii*), Johnny Darter (*Etheostoma nigrum*) and Logperch (*Percina caprodes*) populations declined drastically after the colonization of Round Goby in the Great Lakes. This is notably related to its aggressive behaviour for food or space, and to a series of biological traits that enhance colonization success, such as a broad diet, multiple spawning periods and parental care (Corkum *et al*. 2004). The Round Goby is also likely to feed on the eggs and fry of native species (Steinhart *et al*. 2004), causing recruitment failure in some cases. Important changes in the pathways of nutrient and contaminant transfer in the Great Lakes – St. Lawrence River system are likely (Vanderploeg *et al*. 2002). However, it is unclear how the Round Goby may impact the Bridle Shiner.

Climate change could be responsible for a reduction from 20% to 40% of the mean flow of the St. Lawrence River over the next 50 years and cause a drop of over 1 m from the current water level (SLV 2000, 2007). This dramatic reduction in water levels will reduce the shallow area occupied by aquatic macrophytes, limiting the open space between the top of the vegetation and the water's surface, which is required for spawning. These impacts could affect Bridle Shiner populations, particularly in Saint-Pierre Lake and its archipelago, where the species is found in abundance (Robitaille 2005).

A recent assessment of projected impacts of climate change on coastal wetland fish assemblages in the lower Great Lakes found that Pugnose Shiner (a similar species that occurs with the Bridle Shiner) was highly vulnerable to climate-induced changes in coastal wetlands and nearshore habitats due to loss of aquatic vegetation (Doka *et al*. 2006). Pugnose Shiner was ranked sixth most vulnerable out of 99 species assessed. Given the similarities between the two species, it is believed that Bridle Shiner would be equally sensitive to the impacts of climate change.

The effects of the baitfish industry are not well known in Québec and Ontario. Over 60 Bridle Shiner, out of a total 41,500 fishes, were collected during a baitfish study in fall 2005 in Québec (Boucher *et al*. 2006). Most Bridle Shiner were harvested from Saint-Pierre Lake, where it was considered abundant; however, Boucher *et al*. (2006) concluded that this level of harvesting would not jeopardize the Bridle Shiner population in the lake. Observations of the baitfish industry in spring and summer 2007 indicated that the fall fishery has the greatest potential for capturing the species (Garceau *et al*. in press). Furthermore, Québec is planning a summer ban on use of baitfish to limit the potential effect of harvesting. The Bridle Shiner is not a legal baitfish in Ontario (OMNR 2010); however, incidental harvest in the commercial bait fishery is a potential threat.

The threats assessment in the national management plan for Bridle Shiner indicated that the overall level of concern was high for the following threats: agricultural pollution; urban and industrial pollution; removal/destruction of riparian vegetation; large-scale fluctuation of water levels; and climate change (Boucher *et al*. 2011; Table 1).!

Table 1. Threats to Bridle Shiner populations in Canada, listed in order of their overall level of concern, from highest to lowest (some variability may occur in the severity and level of concern at specific locations). From Boucher *et al*. (2011).

Specific Threat	Extent (widespread/localized)	Occurrence (current/imminent)	Frequency (seasonal/continuous)	Causal Certainty (high, medium, low)	Severity (high, medium, low)	Overall Level of Concern (high, medium, low)	Stress
Agricultural Pollution	Widespread	Current	Continuous	Medium	High	High	▪ Increased mortality ▪ Decreased production ▪ Reduction in available resources ▪ Modification or loss of habitat quality
Urban and Industrial Pollution	Widespread	Current	Continuous	Medium	High	High	▪ Increased mortality ▪ Decreased production ▪ Low reproductive success ▪ Physiological changes ▪ Behavioural changes
Removal/Destruction of Riparian Vegetation	Widespread	Current	Continuous	Medium	High	High	▪ Reduction in population abundance ▪ Reduction in available resources ▪ Increased sedimentation and turbidity
Large-Scale Fluctuation of Water Levels	Widespread	Current/ Imminent	Continuous	Medium	High	High	▪ Reduction in available resources ▪ Modification or loss of habitats
Climate Change	Widespread	Imminent	Continuous	Medium	High	High	▪ Decrease in abundance ▪ Modification or loss of habitat
Local Modification of Natural Flow Regimes	Widespread	Current	Continuous	Medium	Medium	Medium	▪ Reduction in available resources ▪ Modification or loss of habitats
Removal/Destruction of Aquatic Vegetation	Localized	Current	Continuous	Medium	High	Medium	▪ Low reproductive success ▪ Reduction in available resources
Exotic Species and Disease Spread	Widespread	Current	Continuous	Low	Medium/Not known	Medium	▪ Decrease in abundance ▪ Modification or loss of habitat
Baitfish Harvesting	Localized	Current	Seasonal	Medium	Medium/Low	Low	▪ Decrease in abundance

PROTECTION, STATUS, AND RANKS

The Bridle Shiner is listed as Special Concern under the federal *Species at Risk Act* (SARA) and has been protected under the SARA since June 2003. In Ontario, the Bridle Shiner is listed as Special Concern under the *Endangered Species Act, 2007* (ESA). SARA and ESA do not provide specific protection for Special Concern species. In Québec, the Bridle Shiner is identified as a vulnerable species according to the "*Loi sur les espèces menacées ou vulnérables*" (Act respecting threatened or vulnerable species).

Non-Legal Status and Ranks

The Bridle Shiner is considered Vulnerable (G3; last assessed in 2007) globally and nationally in Canada (N3) and the United States (N3) (NatureServe 2013). The American Fisheries Society considers the Bridle Shiner to be Vulnerable (Jelks *et al*. 2008). It is ranked as S2 in Ontario and S3 in Québec. It is considered a species of Special Concern by COSEWIC and by the Committee on the Status of Species at Risk in Ontario (NHIC 2010).

NatureServe (2013) ranks for American states: Connecticut (S3), Delaware (S1), District of Columbia (SH), Maine (S2), Maryland (SH), Massachusetts (S3), New Hampshire (S2), New Jersey (S4), New York (S5), North Carolina (S1), Pennsylvania (S1), Rhode Island (S5), South Carolina (SNR), Vermont (S1?), Virginia (S2).

Habitat Protection/Ownership

The federal *Fisheries Act* historically represented the single most important piece of legislation protecting the Bridle Shiner and its habitat in Canada. However, recent changes to the *Fisheries Act* have significantly altered protection for this species and it is unclear at this time if the *Fisheries Act* will continue to provide any protection for this species.

Habitat within the St. Lawrence Islands National Park is afforded protection under the *Canada National Parks Act* administered by Parks Canada Agency. Similarly, habitats within the Rideau River system are protected under *Historical Canal Regulations* under the *Department of Transport Act*. Habitat within Murphy's Point, Presqu'ile, Rideau River, and Sandbanks provincial parks is protected under the Ontario *Provincial Parks and Conservation Reserves Act*.

Bridle Shiner habitat is protected by three pieces of Québec legislation. The Wildlife Habitats Chapter IV.1 of the *Loi sur la conservation et la mise en valeur de la faune* protects fish habitat on public lands. Under articles 128.1 to 128.18, all activities that are likely to modify a biological, physical or chemical component of fish habitat are prohibited, aside from the exceptions mentioned in the regulations. In Québec, the Bridle Shiner is identified as a vulnerable species according to the *Loi sur les espèces menacées ou vulnérables* (Act respecting threatened or vulnerable species), which makes additional provision for the protection of the habitat of threatened or vulnerable species. Additionally, the *Loi sur la qualité de l'environnement* protects fish habitat by prohibiting the release or emission into the environment of any contaminant likely to be prejudicial to wildlife, beyond the quantity or concentration established by the regulations, whether on private or public lands. The *Loi sur la qualité de l'environnement* also regulates the development and implementation of the *Politique de protection des rives, du littoral et des plaines inondables* (Protection policy for lakeshores, riverbanks, littoral zones and floodplains) that aims to protect lakes and streams. This policy establishes minimum standards that must, under the *Loi sur l'aménagement et l'urbanisme* (*An Act respecting land use planning and development*), be adapted in development plans of regional municipalities. Additionally, under the terms of the *Règlement sur les exploitations agricoles* (Agricultural Operations Regulation) of the *Loi sur la qualité de l'environnement*, with the exception of fords, it is prohibited as of April 1, 2005, to allow livestock free access to water bodies and shorelines and land soil fertilization is regulated.

Ontario legislation that may protect habitat of Bridle Shiner includes the *Environmental Protection Act*, *Environmental Assessment Act*, *Fish and Wildlife Conservation Act*, *Planning Act*, and *Water Resources Act*. In Ontario, aquatic habitats that fall within regulated lands of a Conservation Authority are protected against wetland infilling, shoreline alterations and work occurring within the floodplain by the *Conservation Authorities Act*.

SARA and ESA do not provide specific protection for the habitat of Special Concern species. Where Bridle Shiner and Pugnose Shiner overlap, critical habitat identified for Pugnose Shiner may provide protection for Bridle Shiner habitat. Identified critical habitat for Pugnose Shiner overlaps with Bridle Shiner habitat in Wellers Bay, West Lake, East Lake, and the St. Lawrence River in the vicinity of the St. Lawrence Islands National Park (Edwards *et al*. 2012).

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

The following authorities were contacted and a response received: Canadian Museum of Nature; City of Ottawa; OMNR Natural Heritage Information Centre; OMNR Glenora; OMNR Kemptville; OMNR Peterborough; Ministère des Ressources naturelles et de la Faune du Québec (MRN); Isabelle Gauthier and Marc-Antoine Couillard, Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs du Québec; Parks Canada; Quinte Conservation Authority; Raisin Region Conservation Authority; Rideau Valley Conservation Authority; Trent Valley Conservation Authority.

The following authorities were contacted and a response was not received: Cataraqui Region Conservation Authority; Lower Trent Valley Conservation Authority; South Nations Conservation Authority.

INFORMATION SOURCES

Bernatchez, L., and M. Giroux. 2000. Les poissons d'eau douce du Québec et leur répartition dans l'Est du Canada. Broquet, Boucherville, Québec. 350 pp.

Bilodeau, P., Dumas, B., et H. Massé. 2004. Composition et état de santé de la communauté des poissons de la baie Missisquoi, lac Champlain, été 2003. Ministère des Ressources naturelles, de la faune et des parcs, Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie, Longueuil, Rapport technique 16-23, xii + 43 p. + annexes

Boucher, J., M. Berubé, A. Boyko, and M. Bourgeois. 2011. Management plan for the Bridle Shiner (*Notropis bifrenatus*) in Canada (Final version). *Species at Risk Act* Management Plan Series, Fisheries and Oceans Canada, Ottawa. v + 43 pp.

Boucher, J., M. Letendre, M. Bérubé, H. Fournier, Y. Mailhot, C. Côté, L. Nadon, and P-Y. Collin. 2006. Évaluation de l'impact de la pêche commerciale automnale aux poissons appâts sur cinq espèces de poissons à situation précaire en vertu de la Loi sur les espèces en péril (chevalier cuivré, brochet vermiculé, méné d'herbe, dard de sable, fouille-roche gris). Fisheries and Oceans Canada, Ministère des Ressources naturelles et de la Faune, Société Provancher d'histoire naturelle du Canada. 81 pp.

Coburn, M. M., and T. M. Cavender, 1992. Interrelationships of North American cyprinid fishes. Pages 328-373 *in* R.L. Mayden, ed., Systematics, historical ecology, and North American freshwater fishes, Stanford Univ. Press, Stanford, CA.

Colotelo, A.H., and S.J. Cooke. 2010. Inventory of fish considered to be at risk in the Rideau Canal System including Pugnose Shiner (*Notropis anogenus*), Bridle Shiner (*Notropis bifrenatus*), River Redhorse (*Moxostoma carinatum*) and American Eel (*Anguilla rostrata*). Fish Ecology and Conservation Physiology Laboratry Research Report Series 10-01. Carleton University. Ottawa,Ontario.

Cooper, E. L. 1983. Fishes of Pennsylvania and the northeastern United States. The Pennsylvania State University Press, University Park, PA.

Corkum, L.D., M.R. Sapota, and K.E. Skora. 2004. The round goby, *Neogobius melanostomus*, a fish invader on both sides of the Atlantic Ocean. Biol. Invasions 6: 173–181.

Crossman, E. J. and E. Holm. 1997. Freshwater Fishes. *In:* Assessment of species diversity in the Mixedwood Plains ecozone. I. M. Smith (editor). http://www.cciw.ca/eman-temp/reports/publications/Mixedwood/fish/intro.htm#toc Accessed October 1997.

Cuerrier, J.-P., F. E. J. Fry, et G. Préfontaine. 1946. Liste préliminaire des poissons de la région de Montréal et du Lac Saint-Pierre. Le Naturaliste Canadien 73:17-32.

Desroches, J.F., D. Pouliot, I. Picard, and R. Laparé. 2008. Nouvelles mentions pour six espèces de poissons d'eau douce rares au Québec. Le Naturaliste Canadien 132(2): 62-66.

Dextrase, A. 1999. 1999 sampling for fishes at risk in the Rideau, Gananoque and St. Lawrence drainages. Unpubl. report. OMNR, Peterborough, ON.

Doka. S., C. Bakelaar, and L. Bouvier. 2006. Chapter 6. Coastal wetland fish community assessment of climate change in the lower Great Lakes. pp. 101-128. *In*. L. Mortsch, J. Ingram, A. Hebb, and S. Doka (eds.), Great Lakes Coastal Wetland Communities: Vulnerability to Climate Change and Response to Adaptation Strategies, Environment Canada and Fisheries and Oceans Canada, Toronto, ON.

Edwards, A.L., Matchett, S.P., Doherty, A., and Staton, S.K. 2012. Recovery strategy for the Pugnose Shiner (*Notropis anogenus*) in Canada (Proposed). Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa ON. x+72 p.

Eschmeyer, W. N. (ed.) 2010. Catalog of Fishes. Electronic Version. http://research.calacademy.org/ichthyology/catalog. [Accessed November 6, 2010].

FAPAQ (Société de la faune et des parcs du Québec). 2002. Rapport sur les impacts de la production porcine sur la faune et ses habitats. Vice-présidence au développement et à l'aménagement de la faune, Québec.

Froese, R., and D. Pauly (eds.). 2012. FishBase. World Wide Web Electronic Publication. www.fishbase.org. [Accessed January 2012].

Gangbazo, G., J. Roy, and A. Le Page. 2005. Capacité de support des activités agricoles par les rivières : le cas du phosphore total. Direction des politiques en milieu terrestre, Ministère du Développement durable, de l'Environnement et des Parc, Québec. http://www.mddep.gouv.qc.ca/eau/bassinversant/capacite-phosphore.pdf. Accessed March 22 2011.

Garceau, S., J. Boucher, B. Dumas, et M. Letendre. In press. Évaluation de l'impact de la pêche commerciale estivale aux poissons appâts sur cinq espèces de poissons à situation précaire en vertu de la Loi sur les espèces en péril (chevalier cuivré, brochet vermiculé, méné d'herbe, dard de sable, fouille-roche gris). Ministère des Ressources naturelles et de la Faune du Québec en collaboration avec le Comité de concertation et de valorisation du bassin de la rivière Richelieu et Pêches et Océans Canada, 36 p. + annexes.

Giguère, S., J. Morin, P. Laporte, and M. Mingelbier. 2005. Évaluation des impacts des fluctuations hydrologiques sur les espèces en péril, tronçon fluvial du Saint-Laurent (Cornwall à Trois-Rivières). Rapport final présenté à la Commission mixte internationale, dans le cadre de l'étude internationale sur le lac Ontario et le fleuve Saint-Laurent, par Environnement Canada, Service canadien de la faune et Service météorologique du Canada, et le ministère des Ressources naturelles et de la Faune du Québec. 71 pp.

Gilbert, C. 1980. *Notropis bifrenatus* (Cope), Bridle shiner. Page 238 *in* Atlas of North American Freshwater Fishes. *Edited by* D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer. North Carolina State Museum Natural History, Publication Number 1980-12.

Hair, K.P.E., and S.J. Cooke. 2009. Fall 2008 inventory of fish considered to be at risk in the Rideau River system with a focus on the middle reaches. Fish Ecology and Conservation Physiology Laboratory Research Report Series 09-01. Carleton University. Ottawa, Ontario.

Harrington, R. H. 1947. The breeding behavior of the bridled shiner, *Notropis bifrenatus*. Copeia 1947(3):186-192.

Harrington, R. H. 1948a. The life cycle and fertility of the bridled shiner, *Notropis bifrenatus* (Cope). The American Midland Naturalist 39(1):83-92.

Harrington, R. H. 1948b. The food of the bridled shiner, *Notropis bifrenatus* (Cope). The American Midland Naturalist 40(2):353-361.

Harrington, R. H. 1950. Preseasonal breeding by the bridled shiner, *Notropis bifrenatus*, induced under light-temperature control. Copeia 1950(4):304-311.

Harrington, R. H. 1951. Notes on spawning in an aquarium by the bridled shiner, *Notropis bifrenatus*, with counts of the eggs deposited. Copeia 1951(1):85-86.

Holm, E., and N.E. Mandrak. 1996. The status of the eastern sand darter, *Ammocrypta pellucida*, in Canada. Canadian Field-Naturalist 110(3):462-469.

Holm, E., P. Dumont, J. Leclerc, G. Roy, and E.J. Crossman. 2001. COSEWIC status report on the bridle shiner *Notropis bifrenatus* in Canada, in COSEWIC assessment and status report on the bridle shiner *Notropis bifrenatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. 19 pp.

Holm, E., N. E. Mandrak, and M. E. Burridge. 2010, The ROM field guide to freshwater fishes of Ontario. Royal Ontario Museum, Toronto, ON. 462 pp.

Hubbs, C. L., and D. E. Brown. 1929. Materials for a distributional study of Ontario fishes. Transactions Royal Canadian Institute. 17(1):1-56.

Hudon, C., and R. Carignan. 2008. Cumulative impacts of hydrology and human activities on water quality in the St. Lawrence River (Lake St. Pierre, Québec, Canada). Canadian Journal of Fisheries and Aquatic Sciences 65 (6): 1165-1180.

Hudon, C., A. Cattaneo, A.-M. Tourville Poirier, P. Brodeur, P. Dumont, Y. Mailhot, J.-P. Amyot, S.P. Despatie, and Y. de Lafontaine. 2012. Oligotrophication from wetland epuration alters the riverine trophic network and carrying capacity for fish. Aquatic Science 495-514.

Jacobs, B. 2009. Status of Bridle Shiner (*Notropis bifrenatus*) and Cutlip Minnow (*Exoglossum maxillingua*) in Cornwall Area of Concern. MNR – Species at Risk Stewardship Fund Final Report. Raisin Region Conservation Authority, Cornwall, ON.

Jacobs, B. 2010. Status of Bridle Shiner (*Notropis bifrenatus*),Cutlip Minnow (*Exoglossum maxillingua*), Grass Pickerel (*E. a. vermiculatus*), and River Redhorse (*M. carinatum*) in the Cornwall Area of Concern. MNR – Species at Risk Stewardship Fund Final Report. Raisin Region Conservation Authority, Cornwall, ON.

Jacobs, B. 2011. Status of Bridle Shiner (*Notropis bifrenatus*), Cutlip Minnow (*Exoglossum maxillingua*), Grass Pickerel (*E. a.vermiculatus*), River Redhorse (*M. carinatum*), and American Eel (*A. rostrata*) in the Cornwall AOC. MNR – SAR Fund Final Report. Raisin Region Conservation Authority, Cornwall, ON.

Jelks, H.L., S.J. Walsh, N.M. Burkhead, S. Contraras-Balderas, E. Diaz-Pardo, D.A. Hendrickson, J. Lyons, N.E. Mandrak, F. McCormick, J.S. Nelson, S.P. Platania, B.A. Porter, C.B. Renaud, J. J. Scmitter-Soto, E.B. Taylor, and M.L. Warren, Jr. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries 33 (8): 372-407.

Jenkins, R. E., and N.M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, MD.

Johnson, J. E. 1987. Protected fishes of the United States and Canada. American Fisheries Society, Bethesda, MD.

Keast, A. 1984. The introduced aquatic macrophyte, *Myriophyllum spicatum,* as habitat for fish and their invertebrate prey. Can. J. Zool. 62: 1289-1303.

Kilian, J.V., R.L. Raesly, S.A. Stranko, A.J. Becker, and E. Durell. 2011. Extirpation of the Bridle Shiner (*Notropis bifrenatus*) from Maryland. Northeastern Naturalist 18(2):236-242.

Kovacs T.G., P.H. Martel, and R.H. Voss. 2002. Assessing the biological status of fish in a river receiving pulp and paper mill effluents. Environmental Pollution 118: 123-140.

La Violette, N. 1997. Le bassin de la rivière Yamaska: les communautés ichtyologiques et l'intégrité biotique du milieu, Ministère de l'Environnement et de la Faune, Direction des écosystèmes aquatiques, Québec.

La Violette, N. and Y. Richard. 1996. Le bassin de la rivière Châteauguay: les communautés ichtyologiques et l'intégrité biotique du milieu, Ministère de l'Environnement et de la Faune, Direction des écosystèmes aquatiques, Québec, Envirodoq EN960454, rapport no EA-7, 64 pages + 9 annexes.

La Violette, N., D. Fournier, P. Dumont, and Y. Mailhot. 2003. Caractérisation des communautés de poissons et développement d'un indice d'intégrité biotique pour le fleuve Saint-Laurent, 1995-1997. Faune et Parcs Québec, Direction de la recherche sur la faune.

Leisti,K.E., E.S. Millard, and C.K. Minns, 2006. Assessment of submergent macrophytes in the Bay of Quinte, Lake Ontario, August 2004, including historical context. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2762: x+81pp.

Lyons, J. 1989. Changes in the abundance of small littoral zone fishes in Lake Mendota, Wisconsin. Canadian Journal of Zoology 67(12):2910-2916.

MacFarlane, A., and L. Durocher. 1984. Inventaire ichthyologique de plusieurs tributaires de la rive sud du lac Saint-Pierre et du fleuve Saint-Laurent (Région de Gentilly). Québec, Ministère du Loisir, de la Chasse et de la Pêche, Direction régionale des Trois-Rivières, Service de l'Aménagement et de l'exploitation de la Faune.

Makkay, K., F.R. Pick , and L. Gillespie. 2008. Predicting diversity versus community composition of aquatic plants at the river scale. Aquatic Botany 88: 338–346.

Mandrak, N.E., J. Barnucz, G.J. Velema, and D. Marson. 2006. Survey of the fish assemblages of St. Lawrence Islands National Park in 2005. Can. Manuscr. Rep. Fish. Aquat. Sci. 2777: v + 17 pp.

Mapleston, A., L.A. Thompson, and S.J. Cooke. 2007. Inventory of fish considered to be at risk in the Rideau Canal System including Pugnose Shiner (*Notropis anogenus*), Bridle Shiner (*Notropis bifrenatus*), River Redhorse (*Moxostoma carinatum*) and American Eel (*Anguilla rostrata*). Fish Ecology and Conservation Physiology Laboratory Research Report Series 07-02. Carleton University, Ottawa, ON.

Massé, G., et J.-R. Mongeau. 1974. Répartition géographique des poissons, leur abondance relative et bathymétrie de la région du lac Saint-Pierre. Québec, Ministère du Tourisme, de la Chasse et de la Pêche, Service de l'Aménagement de la Faune, Rapport technique 06-01.

MDDEP (Ministère du Développement durable, de l'Environnement et des Parcs). 2007. L'eau au Québec : une ressource à protéger. Available : http://www.mddep.gouv.qc.ca/eau/inter.htm [Accessed 23 juillet 2007].

Mongeau, J.-R. 1979a. Recensement des poissons du lac Saint-François comtés de Huntingdon et Vaudreuil-Soulanges, pêche sportive et commerciale, ensemencements de maskinongés, 1963-1977. Québec, Ministère du Loisir, de la Chasse et de la Pêche, Service de l'aménagement et de l'exploitation de la faune, Rapport technique 06-25.

Mongeau, J.-R. 1979b. Les poissons du bassin de drainage de la rivière Yamaska, 1963 à 1975. Québec, Ministère du Tourisme, de la Chasse et de la Pêche, Service de l'Aménagement de la Faune. Rapport technique 06-22.

Mongeau, J.-R. 1979c. Dossiers des poissons du bassin versant de la Baie Missisquoi et de la Rivière Richelieu, 1954 à 1977. Québec, Ministère du Tourisme, de la Chasse et de la Pêche, Service de l'Aménagement de la Faune. Rapport technique 06-24.

Mongeau, J.-R., et V. Legendre. 1976. Les resources fauniques du bassin inférieur de la Rivière Saint-François: évolution des populations en dix ans 1965-1974. Québec, Ministère du Tourisme, de la Chasse et de la Pêche, Service de l'Aménagement de la Faune, Rapport Technique 06-14.

NatureServe**.** 2010**.** NatureServe Explorer, an online encyclopedia of life website. The Association for Biodiversity Information. http://www.natureserve.org/explorer. Accessed October 2010.

NatureServe. 2013. NatureServe Explorer, an online encyclopedia of life website. The Association for Biodiversity Information. http://www.natureserve.org/explorer. Accessed February 2013.

Natual Heritage Information Centre. 2010. Data provided by the Natural Heritage Information Centre, Ontario Ministry of Natural Resources. http://nhic.mnr.gov.on.ca. Accessed October 2010

OMNR (Ontario Ministry of Natural Resources). 2010. Ontario Fishing Regulations. http://www.fishinontario.com/regs.html. [Accessed December 2010].

Page, L. M., and B. M. Burr. 2011. A field guide to freshwater fishes, second edition. Houghton Mifflin Company, Boston, MA.

Portt, C.B., G.A. Coker, N.E. Mandrak, and D.L. Ming. 2008. Protocol for the detection of fish Species At Risk in Ontario Great Lakes Area (OGLA). Canadian Science Advisory Secretariat Research Document 2008/026.

Radforth, I. 1944. Some considerations on the distribution of fishes in Ontario. Contributions of the Royal Ontario Museum of Zoology No. 25:1-116.

Reyjol, Y., P. Brodeur, Y. Mailhot, M. Mingelbier, and P. Dumont. 2010. Do native predators feed on exotic prey? The case of round goby in a fluvial piscivorous fish assemblage. Journal of Great Lakes Research 36:618-624.

Richard, Y. 1996. Le bassin versant de la rivière Saint-François: les communautés ichtyologiques et l'intégrité biotique du milieu, Ministère de l'Environnement et de la Faune, Direction des écosystèmes aquatiques, Québec, Envirodoq EN960254, rapport no EA-3, 70 pages + 10 annexes.

Robitaille, J. 2005. Rapport sur la situation du méné d'herbe (*Notropis bifrenatus*) au Québec. Ministère des Ressources naturelles et de la Faune. Direction du développement de la faune. 18 pp.

Sabo, M. 2000. Threatened fishes of the world: *Notropis bifrenatus* (Cope, 1867) (Cyprinidae). Environmental Biology of Fishes 59: 384.

Saint-Jacques, N., et Y. Richard. 1997. Le bassin de la rivière Richelieu: les communautés ichtyologiques et l'intégrité biotique du milieu. Ministère de l'Environnement et de la Faune, Direction des écosystemes aquatiques, Québec.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

SVL 2000 (Saint-Laurent Vision 2000). 2008. Portrait global de l'état du Saint-Laurent – 2008- eaux, sédiments, rives, ressources biologiques et usages. http://www.planstlaurent.qc.ca/sl_obs/sesl/publications/portrait/2008/Portrait_global_2008_f.pd [Accessed March 22 2011].

Simard, A., 2004. Portrait global de la qualité de l'eau des principales rivières du Québec. www.mddep.gouv.qc.ca/eau/bassinversant/global-2004/index.htm. Accessed March 22 2011.

Smith, C.-L. 1985. The inland fishes of New York State. New York State Department of Environmental Conservation. Albany, NY.

Steinhart, G.B., E.A. Marshall, and R.A. Stein. 2004. Round goby predation on smallmouth bass offspring in nests during simulated catch-and-release angling. Trans. Am. Fish. Soc.133, 121–131.

Taraborelli, A.C., M. G. Fox, T. B. Johnson, and T. Schaner. 2010. Round goby (*Neogobius melanostomus*) population structure, biomass, prey consumption and mortality from predation in the Bay of Quinte, Lake Ontario. Journal of Great Lakes Research 36(4):625-632.

Vachon, N. 2003. L'envasement des cours d'eau : processus, causes et effets sur les écosystèmes avec une attention particulière aux Castostomidés dont le chevalier cuivré (*Moxostoma hubbsi*). Société de la faune et des parcs du Québec, Direction de l'aménagement de la faune de Montréal, de Laval et de la Montérégie, Longueuil, Rapport technique 16-13. vi + 49 pp.

Vachon, N. 2007**.** Bilan sommaire du suivi du recrutement des chevaliers dans le secteur Saint-Marc de la rivière Richelieu de 2003 à 2006 avec une attention particulière portée au chevalier cuivré (*Moxostoma hubbsi*). Ministère des Ressources naturelles et de la Faune, Direction de l'aménagement de la faune de l'Estrie, de Montréal et de la Montérégie. Longueuil. Rapp. Tech. 16-34, vii + 31 pages + 1 annexe.

Vanderploeg, H.A., T.F. Nalepa, D.J. Jude, E.J. Mills, K.T. Holeck, J.R. Liebig, I.A. Grigorovich, and H. Ojaveer. 2002. Dispersal and emerging ecological impacts of Ponto-Caspian species in the Laurentian Great Lakes. Can. J. Fish. Aquat. Sci. 59: 1209–1228.

Werner, R. G. 2004. A field guide to freshwater fishes of the northeastern United States. Syracuse University Press, Syracuse, NY. xiv + 335 pp.

Whitworth, W.R., P.L. Berrien, and W.T. Keller. 1968. Freshwater fishes of Connecticut. State Geological and Natural History Survey of Connecticut, Department of Environmental Protection. Bulletin 101.

Wiken, E. 1986. Terrestrial ecozones of Canada. Ecological Land Classification Series #19, Canada Lands Directorate, Environment Canada.

BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Nicholas E. Mandrak is a Research Scientist with Fisheries and Oceans Canada in Burlington, Ontario. His research interests are the biodiversity, biogeography and conservation of Canadian freshwater fishes. Nick has co-authored 32 COSEWIC reports. He is the co-author of the ROM Field Guide to Freshwater Fishes of Ontario.

Scott Gibson was a Senior Fisheries Biologist with Azimuth Environmental Consulting during the initial preparation of this report, but has recently taken a position as the Aquatic Species at Risk Specialist with the Ontario Ministry of Natural Resources. Scott has completed fish surveys for various research and assessment projects across most regions of Ontario for more than 15 years.

Pierre Dumont is a senior fisheries biologist, working in Québec freshwater ecosystems since the beginning of the 1970s, when he was involved in the impact studies of the James Bay hydropower development. Now retired, he has worked for the Québec government since 1978, first in the Outaouais region and, after 1982, in the St. Lawrence River lowlands, in the most urbanized part of the province. He was mainly involved in scientific studies on the status and management of Lake Sturgeon, Yellow perch and American Eel, on the long-term monitoring of fish communities along the St. Lawrence River, on fish habitat improvement and on the restoration of the Copper Redhorse, an endangered species, endemic to southwestern Québec.

Mary Burridge is an Assistant Curator of Ichthyology in the Department of Natural History, Royal Ontario Museum. With more than 30 years of experience, she has written numerous scientific papers describing new fish species from Southeast Asia and the Indo-Pacific. She has also written popular articles on issues affecting Ontario's native species, and the ROM's exhibitions and collections. Mary is a team member of the ROM's Water Exhibition, the Life in Crisis-Schad Gallery of Biodiversity, and the Patrick and Barbara Keenan Family Gallery of Hands-on Biodiversity. She is also active in outreach programs, visiting schools and youth groups to advocate Ontario's native biodiversity. She is co-author of the ROM Field Guide to Freshwater Fishes of Ontario.

Erling Holm is Assistant Curator of fishes with the Royal Ontario Museum, Toronto. His interests include the taxonomy and ecology of Canadian freshwater fishes. Since 1986, he has focused on fishes at risk and has co-authored 11 status reports. He manages one of Canada's largest fish collections, conducts fieldwork in Ontario, and coordinates the ROM's annual fish identification workshops. He is co-author of the ROM Field Guide to Freshwater Fishes of Ontario.

COLLECTIONS EXAMINED

None.