Species at Risk Act
Recovery Strategy Series

Recovery Strategy and Action Plan for the Pugnose Minnow (*Opsopoeodus emiliae*) in Canada

Pugnose Minnow

2022

Canada

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For copies of the recovery strategy and action plan, or for additional information on species at risk, including Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry.

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Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of a recovery strategy and action plan for listed extirpated, endangered, and threatened species and are required to report on progress five years after the publication of the final documents on the Species at Risk Public Registry.

This document has been prepared to meet the requirements under SARA of both a recovery strategy and an action plan. As such, it provides both the strategic direction for the recovery of the species, including the population and distribution objectives for the species, as well as the more detailed recovery measures to support this strategic direction, outlining what is required to achieve the objectives. SARA requires that an action plan also include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation. It is important to note that the setting of population and distribution objectives and the identification of critical habitat are science-based exercises and socio-economic factors were not considered in their development. The socio-economic evaluation only applies to the more detailed recovery measures (that is, the action plan portion).

The Minister of Fisheries and Oceans is the competent minister under SARA for the Pugnose Minnow and has prepared this recovery strategy and action plan, as per sections 37 and 47 of SARA. In preparing this recovery strategy and action plan, the competent minister has considered, as per section 38 of SARA, the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty. To the extent possible, this recovery strategy and action plan has been prepared in cooperation with the Province of Ontario as per subsections 39(1) and 48(1) of SARA.

As stated in the preamble to SARA, success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this recovery strategy and action plan and will not be achieved by Fisheries and Oceans Canada (DFO), or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing this recovery strategy and action plan for the benefit of the Pugnose Minnow and Canadian society as a whole.

Implementation of this recovery strategy and action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

This recovery strategy and action plan was prepared by Peter L. Jarvis, Amy Boyko and Jessica Epp-Martindale on behalf of Fisheries and Oceans Canada (DFO). DFO would like to thank the following organizations for their support in the development of this recovery strategy and action plan: Ontario Freshwater Fish Recovery Team, Ontario Ministry of Natural Resources and Forestry. Mapping was produced by Andrew Geraghty, Lauren Slaunwhite, Amber Ballantyne, and Carolyn Bakelaar (DFO).

Executive summary

The Pugnose Minnow was listed as a species of special concern under the *Species at Risk Act* (SARA) in 2003. In 2012, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) re-assessed the species as threatened. The Pugnose Minnow was reclassified as threatened on Schedule 1 SARA in 2019. This recovery strategy and action plan is considered one in a series of documents for this species that are linked and should be taken into consideration together, including the COSEWIC status report (COSEWIC 2012) and the recovery potential assessment (DFO 2012). Recovery has been determined to be biologically and technically feasible.

The Pugnose Minnow reaches a maximum length of about 6 cm and is distinguished by a bluntly rounded snout with a very small upturned mouth. It has nine principal dorsal rays compared to eight for other minnows found in Canada. It is silvery with a distinct thin black line running the full length of each side of the body and a criss-cross pattern of scaling on the upper body.

The Canadian range of the Pugnose Minnow is limited to the Detroit River and its tributary, the Canard River, Lake St. Clair, and six locales within the Lake St. Clair drainage. The preferred habitat of the species is thought to be clear, vegetated waters, possibly making the Pugnose Minnow a useful indicator of aquatic ecosystem health. Furthermore, as the species represents a monotypic genus, scientific study of the Pugnose Minnow may result in important contributions to the evolutionary knowledge of North American Leuciscidae.

The main threats facing the species described in section 5 include: turbidity and sediment loading; nutrient loading; habitat alteration; contaminants and toxic substances; invasive species; and incidental harvest.

Population and distribution objectives establish, to the extent possible, the number of individuals and/or populations, and their geographic distribution, that is necessary for the recovery of the species. The population and distribution objectives for the Pugnose Minnow are:

- Long-term population objective: to ensure all sub-populations/populations (both extant and historical) demonstrate signs of reproduction and recruitment, and are stable or increasing, with low risk of known threats
    - Note that the inclusion of historical populations within this objective is limited only to locations where feasible and warranted
- Short-term population objective: to ensure the persistence of extant sub-populations/populations in 10 years
- Long-term distribution objective: to ensure the survival of self-sustaining sub-populations/populations at the following locations within currently, and where feasible and warranted, historically occupied reaches:
    - currently occupied: Detroit/Canard rivers, Lake St. Clair/Chenail Ecarté, Lake St. Clair tributaries (North Sydenham River, East Sydenham River, East Otter Creek, Little Bear Creek, Maxwell Creek, Whitebread Drain/Grape Run)
    - historically occupied: McDougall Drain, Thames River

A description of the broad strategies to be taken to address threats to the species' survival and recovery, as well as research and management approaches needed to meet the population and distribution objectives, are included in section 7.

For the Pugnose Minnow, critical habitat (section 8) is identified to the extent possible, using the best available information, and provides the functions and features necessary to support the species' life-cycle processes and to achieve the species' population and distribution objectives. This recovery strategy and action plan identifies critical habitat for the Pugnose Minnow in the following locations: Detroit/Canard rivers, East Sydenham River, North Sydenham River, Little Bear and Maxwell creeks, and Whitebread Drain/Grape Run.

The action plan portion of this document provides the detailed recovery planning in support of the strategic direction set out in the recovery strategy section of the document. The action plan outlines what needs to be done to achieve the population and distribution objectives, including the measures to be taken to address threats and monitor recovery of the species, as well as the required measures to protect critical habitat. An evaluation of the socio-economic costs of implementing the action plan and the benefits to be derived from its implementation is provided in section 9.

Recovery feasibility summary

The recovery of the Pugnose Minnow is believed to be biologically and technically feasible. Recovery feasibility is determined according to four criteria outlined by the Government of Canada (2009)[1]:

1. Are individuals of the wildlife species that are capable of reproduction available now or in the foreseeable future to sustain the population or improve its abundance?

Yes. Although spawning has not been directly observed, the species' continued presence indicates that reproducing populations exist (for example, in the Canard River). These sub-populations could provide a basis for natural expansions and potential translocations or artificial propagation if necessary.

2. Is sufficient suitable habitat available to support the species or could it be made available through habitat management or restoration?

Yes. Considerable uncertainty exists regarding the identification of suitable habitat for the species. It has been postulated that the species prefers clear, slow-moving waters with abundant vegetation; this habitat may be made available through current and proposed restoration efforts.

3. Can significant threats to the species or its habitat be avoided or mitigated?

Yes. Significant threats, such as sedimentation, nutrient and contaminant loading, can be mitigated through proposed recovery techniques. Throughout much of the range of the Pugnose Minnow, restoration and mitigation efforts are already underway. For example, improved water quality and habitat management (through stewardship and Best Management Practices [BMPs]) could improve and expand the extent of suitable habitat.

4. Do recovery techniques exist to achieve the population and distribution objectives or can they be developed within a reasonable timeframe?

Yes. Techniques to reduce identified threats (for example, BMPs to reduce sedimentation) and restore habitats are well known and proven to be effective. The effort expended to achieve recovery will not be uniform across all populations with much greater effort required to improve habitat at locations with reduced populations.

[1] Government of Canada. 2009. *Species at Risk Act* Policies [Draft]. *Species at Risk Act*, Policies and Guidelines Series. Ottawa, Ontario. Environment Canada. 48 pp.

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Background

1 Introduction

The Pugnose Minnow (*Opsopoeodus emiliae*) was listed as threatened under the *Species at Risk Act* (SARA) in 2019. This recovery strategy and action plan is part of a series of documents regarding the Pugnose Minnow that should be taken into consideration together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (COSEWIC 2012) and the science advisory report from the recovery potential assessment (RPA) (Fisheries and Oceans Canada [DFO] 2012), and possibly further action plans.

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets objectives and identifies the main areas of activities to be undertaken, while the action plan portion provides the detailed recovery planning that supports the strategic direction set out in the recovery strategy portion. Action planning for species at risk recovery is an iterative process. The implementation schedule (tables 4 to 6) in this recovery strategy and action plan may be modified in the future depending on the progression towards recovery.

The RPA is a process developed by DFO Science to provide the information and scientific advice required to implement SARA, relying on the best available scientific information, data analyses and modelling, and expert opinions. The outcome of this process informs many sections of the recovery strategy and action plan. For more detailed information beyond what is presented in this recovery strategy and action plan, refer to the COSEWIC status report and the RPA science advisory report.

2 COSEWIC species assessment information

Date of assessment: May 2012
Species' common name: Pugnose Minnow
Scientific name: *Opsopoeodus emiliae* (Hay, 1881)
Status: Threatened
Reason(s) for designation: This fish is a small-bodied species with a restricted and declining distribution that inhabits river, stream and lake habitats. The species is threatened by habitat loss, habitat degradation from nutrient and sediment loading, climate change and several exotic species. The overall level of threat has been assessed as high.
Canadian occurrence: Ontario
Status history: Designated special concern in April 1985. Status re-examined and confirmed in May 2000. Status re-examined and designated threatened in May 2012.

3 Species status information

Table 1. Summary of existing protection or other status designations assigned to the Pugnose Minnow

Jurisdiction	Authority/organization	Year(s) assessed and/or listed	Status/description	Designation level
Ontario	Committee on the Status of Species at Risk in Ontario (COSSARO)	2012	Threatened	Population
Ontario	*Endangered Species Act*, 2007	2013	Threatened	Population
Ontario	NatureServe	2011	Imperilled (S2[2])	Population
Canada	Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	2012	Threatened	Population
Canada	*Species at Risk Act* (SARA)	2019	Threatened	Population
Canada	NatureServe	2017	Imperilled (N2)	Population
United States[3]	NatureServe	1996	Secure (N5)	Population
International	NatureServe	1996	Secure (G5)	Species
International	International Union for Conservation of Nature (IUCN)	2012	Least concern	Species

Upon listing as a threatened species, the Pugnose Minnow became protected wherever it is found in Canada by section 32 of SARA:

> "No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species." [subsection 32(1)]
>
> "No person shall possess, collect, buy, sell or trade an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species, or any part or derivative of such an individual." [subsection 32(2)]

Under section 73 of SARA, the competent minister may enter into an agreement or issue a permit authorizing a person to engage in an activity affecting a listed wildlife species, any part of its critical habitat or its residences.

[2] Refer to NatureServe 2019 for full definitions of NatureServe conservation status ranks
[3] Refer to NatureServe 2019 for state-specific designations

4 Species information

4.1 Description

The following description is derived from Holm et al. (2009). The Pugnose Minnow (figure 1) is a small leuciscid with a maximum recorded total length (TL) of 64 mm, while individuals from Canadian populations reach approximately 50 mm TL. Distinguishing features include a rounded snout, a very small steeply upturned mouth and a pale lower lip and, unlike any other Canadian minnow, nine principal dorsal rays. Colouration includes a white belly, a pale yellow to olive green back, a prominent black lateral stripe that extends from the tail to the snout and darkly outlined scales that give the appearance of a cross-hatched pattern particularly evident on the upper body. Adult males have a dusky or black dorsal fin with a white bar in the middle that intensifies during the spawning season. Spawning males may also develop patches of small tubercles on their snout, lips, and chin.

The Pugnose Minnow may be confused with other minnows that have small, sharply upturned mouths, such as the Golden Shiner (*Notemigonus crysoleucas*) and the Pugnose Shiner (*Notropis anogenus*). Key features that distinguish the Pugnose Shiner from the Pugnose Minnow include a dark lower lip, non-outlined scales that do not form a cross-hatched pattern and eight principal dorsal rays, while the Golden Shiner has a body that is deeper and thinner from side to side as compared to the Pugnose Minnow, a strongly decurved lateral line, and a large anal fin with more than 11 rays.

As the Pugnose Minnow represents a monotypic (single species) genus, study of the species may result in important contributions to the evolutionary knowledge of North American Leuciscidae. Additionally, as the preferred habitat of the Pugnose Minnow is thought to be clear, vegetated waters, the species may be a useful indicator of aquatic ecosystem health.

Figure 1. Adult Pugnose Minnow. Illustration used with permission of Joe Tomelleri

4.2 Population abundance and distribution

4.2.1 Global distribution and population abundance

The Pugnose Minnow is widespread in the east-central United States, with a small portion of its range reaching into southwestern Ontario (figure 2). This species is more common and widespread in the southern United States where it is found from South Carolina and Florida west to Texas. Moving north, it is found in the Mississippi River system, northwest to southeastern Wisconsin into the Laurentian Great Lakes system, and northeast to southwestern Ontario. Globally, the Pugnose Minnow is considered secure (table 1) but reliable population estimates are rare.

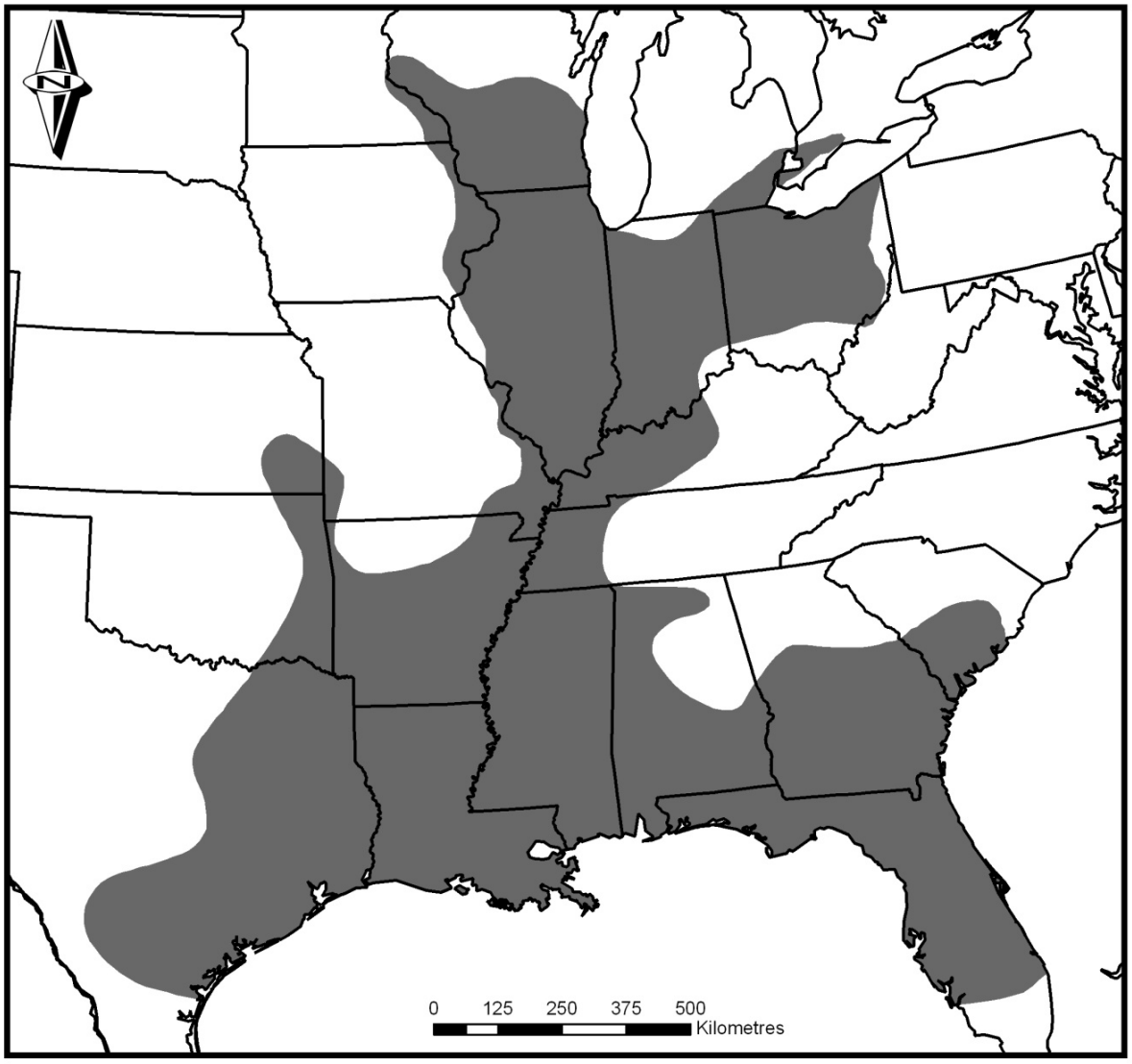

Figure 2. Global distribution of the Pugnose Minnow (from COSEWIC [2012])

4.2.2 Canadian distribution and population abundance

The Canadian range of the Pugnose Minnow is restricted to a small area in southwestern Ontario (figure 3). The species' current distribution includes the Detroit/Canard rivers and Lake St. Clair and some of its tributaries (COSEWIC 2012; Bouvier and Mandrak 2013). Tributaries of Lake St. Clair include Sydenham River (north and east branches), Bear Creek (a tributary of the North Sydenham River), East Otter Creek (a tributary of the Sydenham River), Chenail Ecarté (a man-made connecting channel between St. Clair River and Lake St. Clair), Little Bear and Maxwell creeks, and Whitebread Drain/Grape Run.

A contraction of the species' distribution is thought to have occurred as more recent surveys have failed to detect the Pugnose Minnow in two locations: Thames River (presumed extirpated) and McDougall Drain (possibly extirpated). Undetected populations may remain to be discovered. No population estimates are available for the Pugnose Minnow in Canada. The Canard River appears to support the largest abundance of the Pugnose Minnow. In 2018, targeted sampling for the Pugnose Minnow occurred in the Canard River, which resulted in 294 records from 26 sites (Gaspardy et al. 2020). Outside of the Canard River, capture of the species is rare and when successful few are actually captured (rarely exceeding 10 indviduals), suggesting that numbers are relatively low (COSEWIC 2012; Bouvier and Mandrak 2013). For further information on survey effort refer to COSEWIC (2012) and Bouvier and Mandrak (2013).

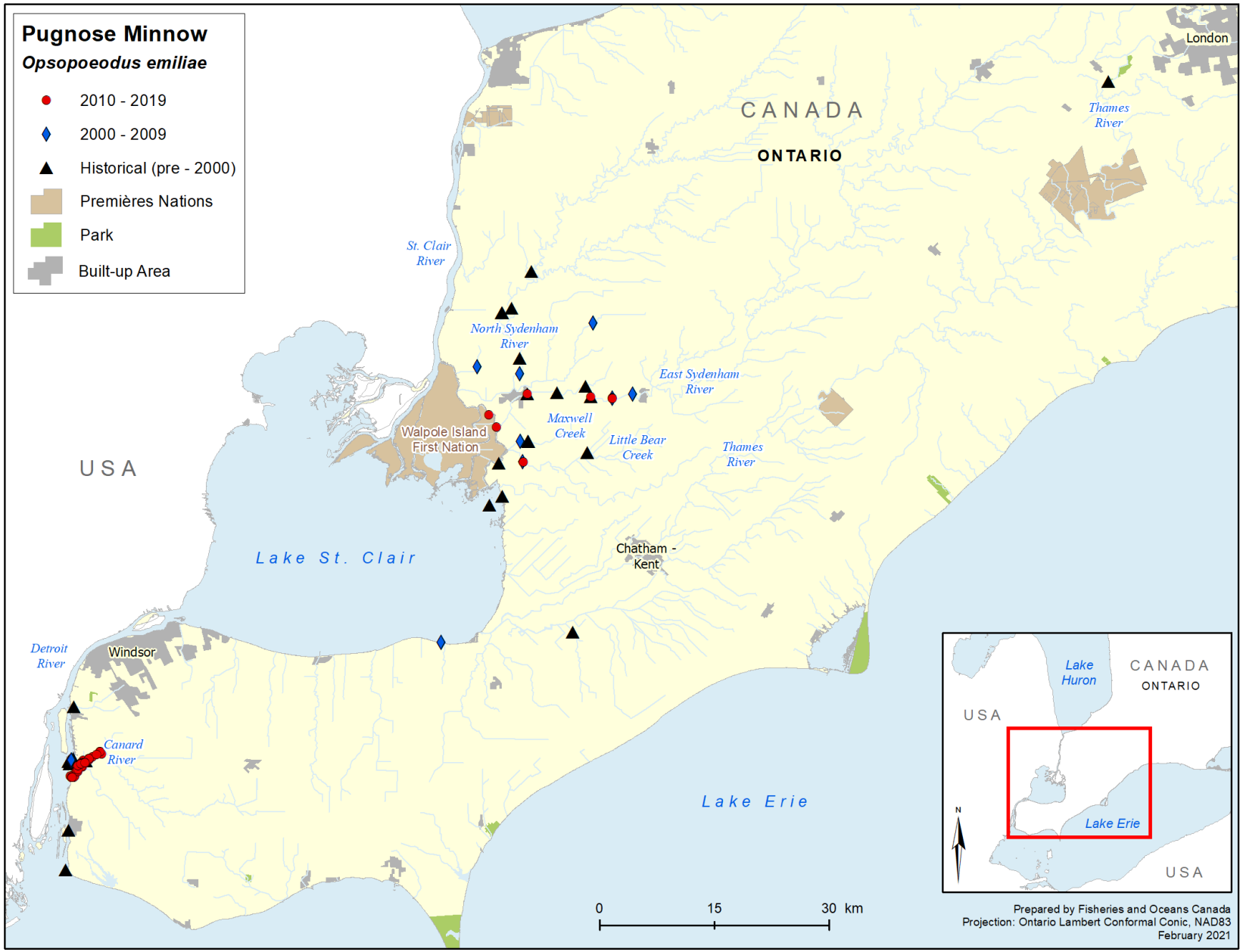

Figure 3. Distribution of the Pugnose Minnow in Canada

4.2.3 Population assessment

The status of Pugnose Minnow populations in Canada was assessed by Bouvier and Mandrak (2013) (table 2). Populations were ranked with respect to abundance and trajectory and then combined to determine the population status. A certainty level was also assigned to the population status, which reflected the lowest level of certainty associated with either abundance or trajectory. For the purposes of the RPA, Lake St. Clair and its tributaries are considered a single population as the species could conceivably move from one location to another within this area. Refer to Bouvier and Mandrak (2013) for further details on methods and sampling efforts.

Table 2. Population status and associated certainty of individual Pugnose Minnow populations (table adapted from DFO 2013b)

Population	Population status	Certainty
Detroit River/Canard River	Poor	Expert opinion
Lake St. Clair and tributaries	Poor	Expert opinion
McDougall Drain	Likely extirpated	Catch per Unit Effort (CPUE) or standardized sampling
Thames River	Extirpated	CPUE or standardized sampling

4.3 Needs of the Pugnose Minnow

Studies specific to the biological requirements of the Pugnose Minnow are rare, hence, defining the needs of the species relies largely on surveys that have recorded the Pugnose Minnow and habitat characteristics at point of capture. For further information refer to COSEWIC (2012) and Bouvier and Mandrak (2013).

Spawn to hatch: spawning requirements are largely undefined and only some detail has been inferred from laboratory experiments (Page and Johnston 1990) and the needs of similar species. Spawning is believed to occur in the spring, from May to June (Holm et al. 2009). Based on behaviour in a laboratory setting, the Pugnose Minnow lays eggs on the underside of flat surfaces such as rocks, while males have an elaborate courtship display (Page and Johnston 1990). The likely temperature range for egg hatching is 21 to 27°C (Page and Johnston 1990).

Larval stage and young-of-the-year (YOY): there is no information available on the habitat needs of the larval stages of the Pugnose Minnow; however, it is likely that there is some overlap with adult habitat for which some information is available.

Adult: the Pugnose Minnow has historically been described as preferring slow-moving, clear, heavily vegetated water (for example, Scott and Crossman 1973; Trautman 1981); however, populations in Canada are most often found in slow-moving turbid streams with little to no aquatic vegetation (Bouvier and Mandrak 2013). The limited understanding of adult requirements results primarily from the cataloguing of habitat characteristics at point of capture. Parker and Mckee (1980) described habitat as pond-like, weedy embayments along the edge of the North Sydenham River. More recent captures (collections by DFO in 2003, 2010, and 2018) indicate that the Pugnose Minnow is most often found in warm, slow-moving areas of turbid streams with little to no aquatic vegetation, over silt/clay substrates or slow-moving side channels of larger rivers with abundant vegetation (COSEWIC 2012; Gaspardy et al. 2020). The

more recent detection of this species in turbid environments has led to uncertainty concerning its tolerance to turbidity. More specifically, it is unclear if the more frequent collection of the Pugnose Minnow from more turbid environments means that it is well suited to this type of environment or it is merely persisting in suboptimal habitat. In Ohio, where relict Pugnose Minnow populations persisted for several years after turbidity increased and aquatic vegetation mostly disappeared, Trautman (1981) believed that populations may persist in submarginal conditions when preferred habitat is no longer available.

Limiting factors: It is probable that the species has fairly specific habitat requirements. For example, it may be incompatible with environments that are highly turbid or lacking aquatic vegetation (Trautman 1981). Due to limited understanding of the species, further key limiting factors may exist but are currently unknown.

5 Threats

5.1 Threat assessment

Bouvier and Mandrak (2013) assessed threats to extant Pugnose Minnow populations in Canada. Known and suspected threats were ranked with respect to threat likelihood and threat impact for each population, after which the rankings were combined to produce an overall threat status (table 3). The threat status levels were classified based on expert opinion. See Bouvier and Mandrak (2013) and DFO (2013b) for further details. Additional information is provided in the subsequent threat summaries.

Table 3. Summary of threats and threat risks to extant Pugnose Minnow populations in Canada (the number in brackets refers to the level of certainty associated with each threat: 1=causative studies; 2=correlative studies; and, 3=expert opinion; table adapted from DFO 2013b)

Threat	Threat risk in Lake St. Clair and tributaries	Threat risk in Detroit River/Canard River
Turbidity and sediment loading	High (3)	Medium (3)
Nutrient loading	High (3)	Medium (3)
Habitat alteration	High (3)	High (3)
Contaminants and toxic substances	High (3)	High (3)
Invasive species	Low (3)	Low (3)
Incidental harvest	Low (1)	Low (1)

5.2 Description of threats

For further details on threats to the Pugnose Minnow refer to COSEWIC (2012) and Bouvier and Mandrak (2013).

Turbidity and sediment loading

Diminished populations of aquatic organisms from high sedimentation and turbidity results from a variety and cascade of factors (see Henley et al. 2000; Donohue and Garcia Molinos 2009). In a review of the impacts of fine sediment (inorganic and organic particles finer than 1 mm diameter) on riverine fishes, Kemp et al. (2011) concluded that fine sediments generally impact all fish species across all of their life stages within freshwater. Gray et al. (2014) tested the

behavioural response and critical swimming speed in a variety of *Notropis* spp. (including the sympatric Pugnose Shiner). Changes were recorded in critical swimming speed and schooling behaviour in relation to turbidity; responses were species-specific, highlighting the need for studies specific to the Pugnose Minnow. How turbidity impacts the Pugnose Minnow is unknown, but it may be related to turbid water reducing the effectiveness of the male mating display and, indirectly, to the negative effects of turbidity on submerged macrophyte communities.

The Canadian distribution of the species overlaps turbid environments with little submerged vegetation. High levels of turbidity have been recorded within the Sydenham River (Dextrase et al. 2003) and are often associated with agricultural activities and the loss of riparian vegetation. The loss of riparian buffer zones may be of particular concern as they are thought to play an important role in the mitigation of anthropogenic disturbances (for example, nutrient and sediment inputs from agricultural activities); the health of riparian zones has been positively correlated with that of freshwater fish communities (for example, Stauffer et al. 2000). The possibility has been raised that the Pugnose Minnow is currently found in these environments (that is, in turbid environments with little vegetation) because its preferred habitat has become rare and it is surviving in marginal habitats (Trautman 1981; Parker et al. 1987).

Nutrient loading

Elevated nutrient levels may act indirectly on fish communities by causing algal blooms, which can result in dissolved oxygen (DO) declining to critical levels by way of eutrophication. With the preponderance of agricultural and urban activities operating within watersheds containing the Pugnose Minnow, the species may be exposed to elevated nutrient levels. Improper agricultural practices and substandard septic and sewage treatment systems have been identified as key contributors to pollution loads (including nutrients) in the watershed containing the Pugnose Minnow (St. Clair Region Conservation Authority [SCRCA] 2009). High nutrient levels, with total phosphorus levels often exceeding provincial water quality objectives, have been recorded in the Thames and Sydenham rivers (Lower Thames Valley Conservation Authority 2012; Upper Thames River Conservation Authority 2012; SCRCA 2013).

Habitat alteration

The growth of agricultural and urban activities throughout the range of the Pugnose Minnow in southwestern Ontario has multifaceted effects on aquatic ecosystems, many of which are strongly linked to terrestrial alteration. The physical alteration of Pugnose Minnow-bearing river systems can take many forms (for example, dock and marina construction, dredging, construction and operation of impoundments); beyond the waterways themselves, adjacent wetlands and riparian forest habitats have been lost.

Agriculture is the predominant land use in the Lake St. Clair watershed (SCRCA 2009). The conversion to agricultural land has resulted in a loss or degradation of riparian vegetation, altered hydrological regimes, channelization, and the loss of much of the wetlands within the watershed. The Pugnose Minnow is found in waters classified as municipal drains, which are subject to periodic maintenance. Drain maintenance practices can alter flow characteristics, which results in reduced in-stream habitat complexity, reduced pool and wetland habitat, increased drainage rates (thereby leaving intermittent streams dry and inaccessible), reduced and/or eliminated riparian vegetation, and increased turbidity and sedimentation (Beauchamp et al. 2012). Fluctuating water levels (for example, through climate change or water level regulation) may have a negative effect on habitat availability for the Pugnose Minnow as the

tributaries where it is found are highly affected by water levels in Lake St. Clair. Lake St. Clair and the Detroit River have been particularly altered, with the creation of shipping lanes that resulted in shoreline hardening to protect against ship wave erosion, and dredging to maintain the shipping lanes (SCRCA 2009). Urbanization has resulted in alteration of the Lake St. Clair shoreline with the construction of marinas and dredging for marina purposes. The relative contribution of these factors on the Pugnose Minnow is unknown, but the degradation of aquatic macrophytes and littoral vegetation may be significant. The extirpation of the Pugnose Shiner (a closely related leuciscid with similar habitat requirements) from two Wisconsin lakes was associated with shoreline development and the removal of littoral zone macrophytes (Holm and Mandrak 2002).

Contaminants and toxic substances

Southwestern Ontario experiences frequent toxic spill events (for example, manure, chemicals, petroleum products). Agricultural growth has contributed to an increased risk of manure spills; during the period from 1988 to 1998, 214 manure spills were reported in southwestern Ontario, resulting in 42 known fish kills (Environmental Commissioner of Ontario 2002). Urban development has contributed to increased discharge of a variety of contaminants, including salt, pesticides, and fertilizers, all of which can enter the watercourse with runoff.

The severity of impacts from toxic compounds is likely linked to duration and intensity of exposure. Contaminants can directly kill the individual or its food and can slowly degrade the watercourse, affecting all life stages and life-history parameters. Contamination can be chronic or episodic and may also be cumulative (Thames River Recovery Team 2005). Specific toxicity of these compounds in relation to the Pugnose Minnow is currently unknown. Of increasing concern are substances such as flame-retardants, plasticizers and pharmaceuticals, as the long-term effects of these substances are unknown.

Invasive species

Invasive species may affect native fishes through several different pathways, including: direct competition for food, space and habitat; through trophic disruption; by the potential introduction of new parasites; and, disease transmission (Taylor et al. 1984, cited by Dextrase and Mandrak 2006). Invasive species that overlap with the Pugnose Minnow include the Common Carp (*Cyprinus carpio*), dreissenid mussels (Zebra Mussel [*Dreissena polymorpha*] and the Quagga Mussel [*D. bugensis*]), the Round Goby (*Neogobius melanostomus*), and the Tubenose Goby (*Proterorhinus semilunaris*). These species may negatively affect Pugnose Minnow populations by disrupting habitat, predating on its eggs and competing for resources or nest space.

Incidental harvest

Incidental harvest of the Pugnose Minnow as bait appears to be a low risk threat (DFO 2013b). Legislation exists to prevent the harvest of the Pugnose Minnow as bait, but the possibility remains that it may be inadvertently taken as it looks similar to other leuciscids. A portion of Ontario’s commercial baitfish harvest occurs in areas where the Pugnose Minnow may be found (see Drake and Mandrak 2014b); yet, due to the rarity of the species, the potential for incidental harvest of the Pugnose Minnow is expected to be low. Although the ability of harvesters to sort and remove the Pugnose Minnow from target catches is unknown, a study of the Ontario baitfish pathway did not document any Pugnose Minnow during sampling of baitfish purchases (Drake 2011; Drake and Mandrak 2014a).

Climate change

The capacity for climate change to alter water levels, temperature regimes and the frequency of extreme weather events is a further threat to the Pugnose Minnow. It is anticipated that the effects of climate change will be widespread and should be considered a contributing impact to species at risk and all habitats. Not all of the effects of climate change will negatively affect species at risk; those species that are limited in their range by cool water temperature may expand their distribution northward provided that dispersal corridors of suitable habitat are available (Chu et al. 2005). However, a suite of reactions related to changes in evaporation patterns and vegetation communities, lower lake levels, increased intensity and frequency of storms, and decreases in summer stream water levels may offset the direct benefits of increased temperatures. In addition to physical changes to the environment, warming trends, as a result of climate change, may favour the establishment of potentially harmful invasive species that may currently be limited by cooler water temperatures.

Doka et al. (2006) completed an assessment on the projected impacts of climate change on lower Great Lakes wetland fish assemblages by ranking fish species' vulnerability to climate change. Results indicated that the Pugnose Minnow was the most sensitive species to the predicted impacts of climate change of the 99 fish species assessed. Conversely, Chu et al. (2005) predicted a potential spread in the distribution of several cool and warm water species (including the related Pugnose Shiner) into more northern watersheds under climate change scenarios. However, the Pugnose Minnow's high vulnerability to specific environmental conditions may limit its distribution. Alofs et al. (2014) used survey data to examine the relationships between species occurrences and climate, and to measure the magnitude and direction of northern range-boundary shifts in 13 warm- and cool-water freshwater fishes in Ontario. Their analysis indicated that the northern range boundaries of sport fishes have shifted north, while those of baitfishes (a variety of leuciscids) have not.

As the effects of climate change on the Pugnose Minnow are highly speculative, it is difficult to determine the impact that this will have on the populations and, as such, it was not included in the threats table (table 3). Current and anticipated implications of climate change on the Pugnose Minnow require further assessment.

Recovery

6 Population and distribution objectives

Population and distribution objectives establish, to the extent possible, the number of individuals and/or populations, and their geographic distribution, that is necessary for the recovery of the species. The population and distribution objectives for the Pugnose Minnow are:

- Long-term population objective: to ensure all sub-populations/populations (both extant and historical) demonstrate signs of reproduction and recruitment, and are stable or increasing, with low risk of known threats

    - Note that the inclusion of historical populations within this objective is limited only to locations where feasible and warranted[4]

- Short-term population objective: to ensure the persistence of extant sub-populations/populations in 10 years

- Distribution objective: to ensure the survival of self-sustaining sub-populations/populations at the following locations[5] within currently and, where feasible and warranted, historically occupied reaches:

    - currently occupied: Detroit/Canard rivers, Lake St. Clair/Chenail Ecarté, Lake St. Clair tributaries (North Sydenham River, East Sydenham River, East Otter Creek, Little Bear Creek, Maxwell Creek, Whitebread Drain/Grape Run)
    - historically occupied: McDougall Drain, Thames River

The sub-populations/populations at these locations could be considered recovered when they demonstrate signs of reproduction and recruitment throughout their distribution. More quantifiable objectives will be developed once necessary surveys and studies have been completed (refer to section 8.2 schedule of studies to identify critical habitat).

Rationale: very little is known about the Pugnose Minnow and much information is required before the population and distribution objectives can be refined. Knowledge of population demographics (extent, abundance, trajectories and targets) is currently limited and remaining populations are small. There is some uncertainty about the ability to re-establish the species, (for example, through reintroduction, population augmentation, or natural expansion) at historical locations (that is, McDougall Drain and the Thames River) and further information is needed regarding current habitat conditions at these locations as well as the threats currently impacting them.

Recent modelling conducted by Young and Koops (2013) estimated that the minimum viable population size (MVP) for the Pugnose Minnow is 6,448,000 adults, given a 10% chance of a catastrophic event occurring per generation. However, the implementation of such a target is difficult without also having information on population demographics, spatial distribution and habitat quality, and a more complete understanding of the life history of the species. More confident objectives relating to MVP can be developed and further validation of model results obtained as the collective understanding of this species is improved.

COSEWIC assessed the Pugnose Minnow as threatened in 2012 because of its limited distribution. At the time of the report's publication, the Pugnose Minnow was considered extant at nine or ten locations in Canada, possibly extirpated from one location and extirpated from another (COSEWIC 2012). Currently, the total number of confirmed Pugnose Minnow locations as defined by COSEWIC, both extant and extirpated, is 11. To recover the species to a level

[4] Further surveys may determine that the species is still extant (that is, present) at sites that are believed to be extirpated (that is, historical). In addition, as research related to refining population and distribution objectives is completed, populations at some historical locations may be excluded and/or deemed not feasible to recover.

[5] In this context, location does not refer to the locality of the discrete population, but rather a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of this species present (COSEWIC 2017).

lower than threatened under COSEWIC criteria, a minimum of 11 extant locations with at least one self-sustaining population at each location are required. Where present, multiple populations at a single location should be maintained. Currently, the actual number of populations present at each Pugnose Minnow location in Canada is unknown.

7 Broad strategies and general approaches to meet objectives

7.1 Actions already completed or currently underway

Single- and multi-species recovery strategies have been drafted previously for several freshwater fish species at risk, the distributions of which partly overlap with the Pugnose Minnow. Recovery actions within the following recovery strategies are currently being implemented and may benefit the Pugnose Minnow:

- Recovery Strategy for the Pugnose Shiner (*Notropis anogenus*) in Canada (DFO 2012b)
- Recovery Strategy for the Eastern Sand Darter (*Ammocrypta pellucida*) in Canada: Ontario Populations (DFO 2012a)

A variety of imperilled freshwater mussels (Unionidae) overlap with the range of the Pugnose Minnow and recovery teams are implementing actions outlined in the following recovery strategies that should also benefit the Pugnose Minnow:

- Recovery Strategy for the Round Hickorynut (*Obovaria subrotunda*) and Kidneyshell (*Ptychobranchus fasciolaris*) in Canada (DFO 2013c)
- Recovery Strategy for the Northern Riffleshell, Snuffbox, Round Pigtoe, Salamander Mussel, and Rayed Bean in Canada (DFO 2017)

Ecosystem-based recovery strategies that overlap and include provisions for the Pugnose Minnow include:

- Sydenham River Action Plan (DFO 2013a)
- The Essex-Erie Region Ecosystem-based Recovery Strategy (Essex-Erie Recovery Team 2008)
- Thames River Ecosystem Recovery Strategy (Thames River Recovery Team 2005)

Conservation authorities (Essex Region, Lower Thames Valley, Upper Thames River, and St. Clair Region) continue to play a vital role in stewardship and public education programs, which have resulted in increased awareness of species at risk and improvements to habitat and water quality throughout the range of the Pugnose Minnow in Ontario. For example, the SCRCA offers grants to landowners to improve agricultural practices, tree planting and other general stewardship activities that provide direct benefits to species at risk in the Sydenham River watershed.

DFO has developed guidance on mitigation measures for the protection of aquatic species at risk within the range of the Pugnose Minnow in Ontario (Coker et al. 2010).

Further to the guidelines on baitfish harvesting supplementing Ontario's recreational fishing regulations (OMNRF 2014), a baitfish primer (Cudmore and Mandrak 2018) has been developed that identifies the baitfish species of Ontario. The purpose of the baitfish primer is to reduce the chances of misidentification of baitfish and, hence, the removal of non-target species as by-catch, such as the Pugnose Minnow. The primer has been made available to commercial bait harvesters, anglers and the general public via Ontario Ministry of Natural Resources and Forestry (OMNRF) offices, ServiceOntario offices, and is currently available here.

7.2 Measures to be taken to implement the recovery strategy and action plan

Successful recovery of this species is dependent on the actions of many different jurisdictions. It requires the commitment and cooperation of the constituencies that will be involved in implementing the directions and measures set out in this recovery strategy and action plan.

This recovery strategy and action plan provides a description of the measures that provide the best chance of achieving the population and distribution objectives for the Pugnose Minnow, including measures to be taken to address threats to the species and monitor its recovery, to guide not only activities to be undertaken by DFO, but those for which other jurisdictions, organizations and individuals have a role to play. As new information becomes available, these measures and the priority of these measures may change. DFO strongly encourages all Canadians to participate in the conservation of the Pugnose Minnow by undertaking measures outlined in this recovery strategy and action plan.

Table 4 identifies the measures to be undertaken by DFO to support the recovery of the Pugnose Minnow. Table 5 identifies the measures to be undertaken collaboratively between DFO and its partners, other agencies, organizations or individuals. Implementation of these measures will be dependent on a collaborative approach, in which DFO is a partner in recovery efforts, but cannot implement the measures alone. As all Canadians are invited to join in supporting and implementing this recovery strategy and action plan, table 6 identifies the remaining measures that represent opportunities for other jurisdictions, organizations or individuals to lead for the recovery of the species. If your organization is interested in participating in one of these measures, please contact the Species at Risk Ontario and Prairie office.

Federal funding programs for species at risk that may provide opportunities to obtain funding to carry out some of the outlined activities include the Habitat Stewardship Program for Species at Risk and the Aboriginal Fund for Species at Risk.

The measures included in this recovery strategy and action plan to be implemented by DFO will be subject to the availability of funding and other required resources. As indicated in the tables below, partnerships with specific organizations will provide expertise and capacity to carry out some of the listed recovery measures. However, the identification of partners is intended to be advice to other jurisdictions and organizations and carrying out these actions will be subject to each group's priorities and budgetary constraints.

Table 4. Measures to be undertaken by Fisheries and Oceans Canada (DFO)

#	Recovery measure	Broad strategy	Approach	Priority[6]	Threat(s) or concern(s) addressed	Status/ timeline[7]
1	Implement a standardized index population and habitat-monitoring program with a specific sampling protocol (upon completion of recovery measure #5).	Inventory and monitoring	Population and habitat assessment	High	Knowledge gaps	New/4 to 5 years
2	Conduct targeted surveys of extant populations using sampling techniques proven effective at detecting the Pugnose Minnow to quantify distribution and abundance of extant populations.	Inventory and monitoring	Population and habitat assessment	High	Knowledge gaps	New/1 to 2 years
3	Conduct targeted surveys within the historical range of the Pugnose Minnow where the species is thought to be extirpated. Determine extent and abundance of any new populations detected.	Inventory and monitoring	Population and habitat assessment	High	Knowledge gaps	New/2 to 3 years
4	Conduct targeted surveys in non-historical areas for undetected populations in areas with suitable habitat characteristics.	Inventory and monitoring	Population and habitat assessment	High	Knowledge gaps	New/3 to 4 years
5	Develop a standardized index population and habitat monitoring program with a specific sampling protocol.	Research	Standardized population and habitat monitoring	High	All	New/2 to 3 years

[6] Priority" reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species:

- "high" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species
- "medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species
- "low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats

[7] Timeline reflects the amount of time required for the measure to be completed from the time the recovery strategy and action plan is published as final on the Species at Risk Public Registry.

Table 5. Measures to be undertaken collaboratively between Fisheries and Oceans Canada (DFO) and its partners.

#	Recovery measure	Broad strategy	Approach	Priority[8]	Threat(s) or concern(s) addressed	Status/ timeline[9]	Partner(s)[10]
6	Determine the life history of the Pugnose Minnow to inform critical habitat identification and improve modelling efforts designed to determine quantifiable recovery targets.	Research	Life-history characteristics	High	Knowledge gaps	New/4 to 5 years	Academia, CAs, DFO, OMNRF
7	Investigate potential threats such as sources of contamination and toxic substances (for example, manure spills).	Research	Threat evaluation	High	All	New/4 to 5 years	Academia, CAs, DFO, OMNRF
8	Identify thresholds of tolerance to habitat modifications (for example, loss of aquatic macrophytes and riparian vegetation).	Research	Threat evaluation	High	Habitat alteration; turbidity and sediment loading	New/4 to 5 years	Academia, CAs, DFO, OMNRF
9	Determine the feasibility of augmenting existing populations of the Pugnose Minnow where needed, and investigate the feasibility of re-establishing the Pugnose Minnow in historical habitat where appropriate.	Research	Population augmentation/ repatriation	Medium	Knowledge gaps	New/2 to 3 years	Academia, CAs, DFO, OMNRF

[8] Priority" reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species:

- "high" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species
- "medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species
- "low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats

[9] Timeline reflects the amount of time required for the measure to be completed from the time the recovery strategy and action plan is published as final on the Species at Risk Public Registry.

[10] CAs: conservation authorities; DFO: Fisheries and Oceans Canada; OMNRF: Ontario Ministry of Natural Resources and Forestry

#	Recovery measure	Broad strategy	Approach	Priority[8]	Threat(s) or concern(s) addressed	Status/ timeline[9]	Partner(s)[10]
10	Work with municipal planning authorities so that they consider the protection of critical habitat for the Pugnose Minnow within official plans.	Management and coordination	Coordination of activities	High	All	Ongoing	DFO, municipalities
11	Work with relevant organizations (for example, conservation authorities, OMNRF, First Nations) to share knowledge, combine resources, implement recovery actions and ensure a coordinated approach to recovery.	Management and coordination	Coordination of activities	Low	All	Ongoing	CAs, DFO, First Nations, OMNRF
12	Promote stewardship Best Management Practices (BMPs) among landowners and First Nations abutting aquatic habitats of the Pugnose Minnow, and other local landowners with potential to have direct or indirect effects on the habitat of the Pugnose Minnow.	Management and coordination	Coordination of activities	Low	All	Ongoing	CAs, DFO, First Nations, OMNRF
13	Support invasive species awareness initiatives for the public.	Stewardship and outreach	Awareness	Medium	Invasive species	Ongoing	CAs, DFO, OMNRF

Table 6. Measures that represent opportunities for other jurisdictions, organizations or individuals to lead.

#	Recovery measure	Broad strategy	Approach	Priority[11]	Threat(s) or concern(s) addressed	Potential jurisdictions or organizations[12]
14	Implement local stewardship programs to improve habitat conditions and reduce threats within critical habitat and historical habitats. Priorities and mitigation approaches to be informed through threat evaluation research.	Stewardship and outreach	Habitat improvement	High	All	CAs
15	Address watershed-scale stressors to Pugnose Minnow populations and their habitat in cooperation with existing relevant aquatic ecosystem recovery teams.	Stewardship and outreach	Habitat improvement	Medium	All threats	CAs
16	Increase public awareness about potential impacts of invasive species on the ecosystem as well as the ways in which these species get introduced (for example, through ballast water, release of food fishes, emptying of bait buckets).	Stewardship and outreach	Habitat improvement	Medium	Invasive species	CAs, OFAH, OMNRF
17	Encourage public support and participation by developing awareness materials and programs.	Stewardship and outreach	Awareness	Low	All	CAs, OFAH, OMNRF

[11] Priority" reflects the degree to which the measure contributes directly to the recovery of the species or is an essential precursor to a measure that contributes to the recovery of the species:

- "high" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species
- "medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species
- "low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats

[12] CAs: conservation authorities; OFAH: Ontario Federation of Anglers and Hunters; OMNRF: Ontario Ministry of Natural Resources and Forestry

7.3 Narrative to support the recovery planning and implementation tables

Recovery measures 1 to 5: further surveys are required to confirm the current distribution and to estimate population sizes, trajectory and trends over time of the Pugnose Minnow in Canada. Secondarily, surveys conducted outside the species' known distribution have the potential to detect new populations in areas with habitat characteristics similar to those where the species is known to occur (for example, tributaries on the southern shore of Lake St. Clair). Conventional sampling methods (that is, seining) may not be appropriate for the Pugnose Minnow, and may help explain low capture numbers despite targeted efforts. There is a need to explore novel sampling methods for the efficient capture of this species (Bouvier and Mandrak 2013). Novel methods for capturing the Pugnose Minnow should be used in concert with traditional seine netting to facilitate: 1) assessing changes in capture over time using similar methods; and, 2) the evaluation of capture probabilities among gear types at the same location/time.

The results of the monitoring program (that is, index netting) will allow for the assessment of progress made towards achieving population and distribution objectives. Monitoring populations and habitat will assist with refining critical habitat identification and implementing strategies to protect known currently and historically occupied habitats. The monitoring program should be designed to allow for quantitative tracking of changes in population demographics, analyses of habitat availability and use, and changes in these parameters over time (relative to known threats). When combined with population monitoring, habitat tracking can help determine threshold levels for certain measurable habitat parameters (for example, turbidity and contaminant levels). This approach can also assist in identifying specific areas in need of habitat restoration or mitigation of stressors.

In addition to abundance estimates and trends, defining population size structure and sex ratios is desirable to attain a more complete understanding of Pugnose Minnow populations. A thorough understanding of extant populations is necessary to refine the definition of critical habitat and to inform effective recovery actions.

Recovery measure 6: determination of the life history of the Pugnose Minnow is required to inform critical habitat identification and improve modelling efforts designed to ascertain quantifiable recovery targets. Of particular importance is the determination of fecundity, age of maturity and longevity of the Pugnose Minnow in Canada.

Recovery measures 7 and 8: many of the threats (table 3) facing the Pugnose Minnow can be classified as widespread and chronic, and represent general ecosystem threats affecting myriad other aquatic species. Efforts to remediate threats facing the Pugnose Minnow will benefit many species. In particular, the distribution of a variety of imperilled mussel species (Unionidae) overlaps with the Pugnose Minnow and they share many common threats. Specific needs include defining physiological thresholds for water-quality parameters (for example, chloride and pesticides) and tolerances to physical alterations (for example, susceptibility to changes in turbidity and sedimentation rates). A variety of potential threats to the Pugnose Minnow populations were identified in the COSEWIC status report (COSEWIC 2012) and through the RPA process (Bouvier and Mandrak 2013; DFO 2013b). The status, certainty and cumulative effects of these threats should be confirmed throughout the species' distribution to ensure that appropriate and defensible recovery actions are undertaken. Continued appraisal of contaminant impacts on the Pugnose Minnow is necessary as the establishment of causal links between population decline and specific contaminants has not yet been achieved.

Recovery measure 9: additional surveys may show that without direct intervention, some populations of the Pugnose Minnow are unlikely to persist. One intervention may be to augment existing populations with individuals from a nearby stable population or by stocking with artificially reared individuals. Re-establishment or augmentation efforts need to identify the location of potential source populations and the number of individuals required to re-establish self-sustaining populations. Feasibility (for example, biological, technical, economic) studies will need to be completed before any population augmentation or repatriations occur. For example, the success of these actions will depend on an understanding of the species' habitat needs, and on a sufficient quantity of suitable habitat being available. Further work would be needed to gather this information.

Recovery measure 10: major threats impacting Pugnose Minnow populations include contaminants and toxic substances and habitat removal and alteration. Working with municipal planning authorities allows planning and management agencies to be aware of habitats that are important to the Pugnose Minnow. Communicating and coordinating with municipal planning boards will increase the likelihood that further negative impacts on Pugnose Minnow habitat are avoided.

Recovery measures 11, 12, 14 and 15: it appears that the distribution of the Pugnose Minnow has declined as increased sampling using the same sampling methods at several previously known locations has consistently failed to identify the species. Threats and habitat degradation present at extant sites should be evaluated to determine if they pose immediate or long-term risks of extirpation. Where specific habitat restoration activities or threat-mitigation options are available, they should be pursued and monitored for success. In all likelihood, the Pugnose Minnow is sensitive to poor water quality and the loss of riparian vegetation. Supporting stewardship activities, such as planting, leaving riparian buffer strips, restricting livestock access to streams, preventing untreated or under-treated sewage or manure run-off into waterways, and minimizing chemical and fertilizer applications to lands adjacent to waterways, would maintain or improve water quality in Pugnose Minnow habitats.

Many of the threats affecting Pugnose Minnow populations are similar to those impacting other aquatic species. Therefore, efforts to remediate these threats should be done in close connection with other recovery teams and relevant groups. A number of ecosystem-based recovery strategies (that is, recovery strategies for the Essex-Erie region, Thames, and Sydenham rivers) encapsulate Pugnose Minnow populations; hence, a coordinated, cohesive approach between these and other relevant management teams that maximizes opportunities to share resources and information is necessary. In addition, the implementation of Pugnose Minnow recovery actions will be coordinated with recovery approaches for other listed endangered and threatened species with distributions that overlap that of the Pugnose Minnow (see section 7.1).

Best management practices (BMPs) represent a good tool to provide clear direction for improved methods of operation for industries such as agriculture or forestry. To be effective, BMPs should target primary threats affecting both currently and historically occupied habitat and, in particular, critical habitat. Once threats have been evaluated, the results will inform local stewardship programs for threat mitigation. As with other fish species, measures to improve habitat for the Pugnose Minnow may include stewardship actions involving BMPs for agricultural properties (Agriculture Canada and OMAFRA 1992 to 2011) and residential properties (School of Environmental Design and Rural Development 2007) within the catchment areas of the critical habitat identified.

Recovery measures 13, 16 and 17: public participation in the recovery process for the Pugnose Minnow is essential, as the primary threats to its populations result from diffuse non-point source inputs relating to the general agricultural and urban activities within these watersheds. Recovery cannot occur without the full participation of local citizens and landowners, highlighting the need for an effective public awareness program. Additionally, the Pugnose Minnow should be considered in existing communication and outreach programs both for ecosystem-based recovery and for other endangered and threatened aquatic species to instil the awareness of the needs to protect freshwater fishes and ensure the health of aquatic freshwater ecosystems.

Various organizations have already undertaken public education efforts to prevent the further spread of invasive species. Duplicating efforts or competing for funding are counterproductive; instead, DFO will support and encourage the continuation of these education efforts as they also support Pugnose Minnow recovery.

8 Critical habitat

8.1 Identification of Pugnose Minnow critical habitat

8.1.1 General description of Pugnose Minnow critical habitat

Critical habitat is defined in SARA as "…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species". [subsection 2(1)]

Also, SARA defines habitat for aquatic species as "… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." [subsection 2(1)]

For the Pugnose Minnow, critical habitat is identified to the extent possible, using the best available information, and provides the functions and features necessary to support the species' life-cycle processes and to achieve the species' population and distribution objectives.

This recovery strategy and action plan identifies critical habitat for the Pugnose Minnow as vegetated slow-moving areas of streams or side channels within the Detroit/Canard rivers, East Sydenham River, Little Bear Creek, Maxwell Creek, North Sydenham River, and Whitebread Drain/Grape Run.

The critical habitat identified in this recovery strategy and action plan is insufficient to achieve the species' population and distribution objectives. The schedule of studies outlines research required to identify additional critical habitat and acquire more detailed information about the critical habitat identified to achieve the species' population and distribution objectives.

8.1.2 Information and methods used to identify critical habitat

Using the best available information, critical habitat has been identified using the 'bounding box' approach for extant populations of the Pugnose Minnow in the Detroit/Canard rivers, East

Sydenham River, Little Bear Creek, Maxwell Creek, North Sydenham River, and Whitebread Drain/Grape Run.

This approach requires the use of essential functions, features and attributes for each life stage of this species to identify patches of critical habitat within the 'bounding box', which is defined by occupancy data for the species. Life-stage habitat information was summarized in table 8 using available data and studies referred to in section 4.3 (needs of the Pugnose Minnow). The 'bounding box' approach was the most appropriate, given the limited information available for this species and the lack of detailed habitat mapping for these areas.

Although critical habitat for the Pugnose Minnow has not been identified at this time in East Otter Creek, Lake St. Clair/Chenail Ecarté, McDougall Drain, and the Thames River, it may be identified at a future date. The Pugnose Minnow is thought to be extirpated from the Thames River and likely extirpated from McDougall Drain; further detailed information on current habitat conditions at these locations is required. Only a single Pugnose Minnow record exists in East Otter Creek (Bouvier and Mandrak 2013) and further sampling to confirm its ongoing presence is needed. Additional areas of critical habitat within Lake St. Clair/Chenail Ecarté will be considered in collaboration with Walpole Island First Nation.

Within the East Sydenham River, Little Bear Creek, Maxwell Creek, North Sydenham River, and Whitebread Drain/Grape Run, an ecological classification system was used in the identification of critical habitat. The OMNRF's Aquatic Landscape Inventory System (ALIS version 1) (Stanfield and Kuyvenhoven 2005) was used as the base unit for defining reaches within riverine systems. The ALIS system employs a valley segment classification approach to define river segments with similar habitat and continuity on the basis of hydrography, surficial geology, slope, position, upstream drainage area, climate, land cover and the presence of instream barriers, all of which are believed to have a controlling effect on the biotic and physical processes within the catchment. Therefore, if the species has been found in one part of a valley segment, it would be reasonable to expect that it would be present in other spatially contiguous areas of the same valley segment. Within all identified river segments (that is, valley segments), the width of the habitat zone is defined as the area from the mid-channel point to bankfull width on both the left and right banks. The critical habitat description includes the entire bankfull channel, which plays an essential role in maintaining channel forming flows. Critical habitat for the Pugnose Minnow was, therefore, identified as the reach of river that includes all contiguous ALIS segments from the uppermost stream segment with the species present to the lowermost stream segment with the species present; segments or reaches were excluded only when supported by robust data indicating the species absence and/or unsuitable habitat conditions. Unoccupied ALIS segments with suitable habitats located adjacent to or between occupied segments were also included when limited sampling had occurred (that is, the species was assumed to be present).

Within the Detroit/Canard rivers, critical habitat was identified based on the 'bounding box' approach and further refined using ALIS (Canard River) and a population-range envelope (Detroit River). The population-range envelope is a projected rectangle around the occurrence points based on the minimum and maximum latitude and longitude values. This rectangle is then buffered by a value of 10% to the minimum and maximum latitude and longitude values of all occurrence points for the population.

8.1.3 Identification of critical habitat

Geographic information:

For the Pugnose Minnow, critical habitat is identified in the Detroit/Canard rivers, East Sydenham River, Little Bear Creek, Maxwell Creek, North Sydenham River, and Whitebread Drain/Grape Run (figures 4 to 8).

Using the best available information, the locations of the critical habitat's functions, features, and attributes have been identified using the 'bounding box' approach. This means that critical habitat is not comprised of the entire area within the identified boundaries but only those areas within the identified geographical boundaries where the described biophysical feature and function it supports occur, as described in table 8. Brief explanations for the areas within which critical habitat is found are provided for each of the waterbodies below. Table 7 provides the geographic coordinates for the areas within which critical habitat is found for the Pugnose Minnow; these points are indicated on figures 4 to 8.

Note that existing permanent anthropogenic structures that may be present within the delineated areas (for example, marinas, navigation channels) are specifically excluded (unless said structures are maintaining critical habitat); it is understood that maintenance or replacement of these features may be required at times[13].

Areas of critical habitat identified may overlap with critical habitat identified for other co-occurring species at risk (for example, the Pugnose Shiner, the Eastern Sand Darter, the Lilliput [*Toxolasma parvum*], the Mapleleaf [*Quadrula quadrula*], the Northern Riffleshell [*Epioblasma rangiana*], the Snuffbox [*Epioblasma triquetra*], the Rayed Bean [*Villosa fabalis*], the Salamander Mussel [*Simpsonaias ambigua*], and the Round Pigtoe [*Pleurobema sintoxia*]); however, the specific habitat requirements within these areas may vary by species.

Table 7. Coordinates for the areas within which critical habitat is found for the Pugnose Minnow*†

Location	Point 1	Point 2	Point 3	Point 4
Detroit/Canard Rivers	42.182495 -83.127502	42.205688 -83.039001	42.170471 -83.029785	42.147278 -83.118286
East Sydenham River	42.561103 -82.410785	42.585768 -82.190521	-	-
Little Bear Creek	42.531349 -82.402000	42.540901 -82.200233	-	-
Maxwell Creek	42.531487 -82.401867	42.549084 -82.334309	42.550183 -82.303644	-
North Sydenham River	42.728387 -82.351574	42.594227 -82.381344	-	-
Whitebread Drain/Grape Run	42.623509 -82.479985	42.631158 -82.455922	42.643029 -82.443524	42.630738 -82.430996

* Riverine habitats are delineated to the midpoint of channel of the uppermost stream segment(s) and lowermost stream segment.
† All coordinates obtained using map datum NAD 83

Detroit/Canard rivers: the area within which critical habitat is found in the Detroit/Canard rivers is currently identified based on a population-range envelope and refined using National Oceanic

[13] Depending on the type of maintenance or replacement, permits may be required to conduct the work.

and Atmospheric Administration (NOAA) bathymetry data (Detroit River) and ALIS segments (Canard River) (figure 4). This represents an area of approximately 4.45 km^2 and is described as follows:

- Canard River: beginning approximately 1 km upstream of Concession Road 5 North and continuing downstream to the confluence with the Detroit River; in an unnamed tributary, beginning approximately 0.4 km south of Kelly Road and approximately 1.2 km west of Disputed Road, continuing downstream to the confluence with the Canard River; in an unnamed tributary, beginning approximately 0.5 km upstream of North Side Road and continuing to the confluence with the Canard River; in an unnamed tributary, beginning 0.65 km upstream of Malden Road and continuing downstream to the confluence with the Canard River; and, in an unnamed tributary, beginning where the watercourse intersects Front Road North, and continuing to the confluence with the Canard River

- Detroit River: the area within which critical habitat is found in the Detroit River is currently identified as the wetted areas from the shore down to the 2 m bathymetry contour beginning at the mouth of the Canard River and extending approximately 1 km downstream and approximately 2.54 km upstream, excluding the diked wetlands (figure 4) (two records fall outside of this definition as they were collected in waters ~9 m deep, which is considered atypical for the Pugnose Minnow)

Little Bear Creek: the area within which critical habitat is found in Little Bear Creek is currently identified as the ALIS segments with the species present (figure 6). This represents a total river reach of approximately 23 km in length and is described as follows:

- beginning approximately 0.75 km upstream of Centre Side Road, continuing downstream to the confluence with the Chenail Ecarté

Maxwell Creek: the area within which critical habitat in Maxwell Creek is found is currently identified as the ALIS segments with the species present (figure 6). This represents a total river reach of approximately 13 km in length and is described as follows:

- beginning where Maxwell Creek crosses Prince Albert Road, continuing downstream to the confluence with the Chenail Ecarté; and, in a tributary to Maxwell Creek, beginning at Fraser Road and continuing downstream to the confluence with Maxwell Creek

Sydenham River

East Sydenham River: the area within which critical habitat is found in the East Sydenham River is currently identified as the reach of river represented by a single ALIS segment with the species present (figure 5). In this case, the ALIS segment was cut at Dresden as the gradient of the river increases at this point, causing higher current velocities that no longer support the required habitat for the Pugnose Minnow. This represents a total river reach of approximately 33 km in length and is described as follows:

- beginning approximately 1 km downstream of County Road 21 in Dresden, continuing downstream to the confluence with the Chenail Ecarté

North Sydenham River: the area within which critical habitat is found in the North Sydenham River is currently identified as the ALIS segments with the species present (figure 7). This represents a total river reach of approximately 34 km in length. The area within which critical habitat is found is described as follows:

- beginning at the confluence of Bear and Black creeks, near Wilkesport, and continuing downstream to the confluence with East Sydenham River in Wallaceburg

Whitebread Drain/Grape Run: the area within which critical habitat is found in Whitebread Drain/Grape Run is currently identified as the ALIS segments with the species present (figure 7). This represents a total river reach of approximately 10 km in length. The area within which critical habitat is found is described as follows:

- beginning from a point where the watercourse intersects Pointe Line and continuing downstream until the confluence with the Chenail Ecarté; and, beginning approximately 1.5 km east of Baseline Road and continuing eastward along Whitebread Line to the intersection of Hwy 40

The following critical habitat maps (figures 4 to 7) depict the areas within which critical habitat is found for the Pugnose Minnow. For the most up-to-date maps, please visit DFO's aquatic species at risk map webpage.

To assist with identifying the boundaries of the areas within which critical habitat is found, geo-referenced location points (P1, P2, P3, etc.; Decimal Degrees [WGS 1984]) have been added to the figures in addition to the red areas. Coordinates for these points can be found in table 7. For more information, refer to the legend of each map or DFO's aquatic species at risk map webpage.

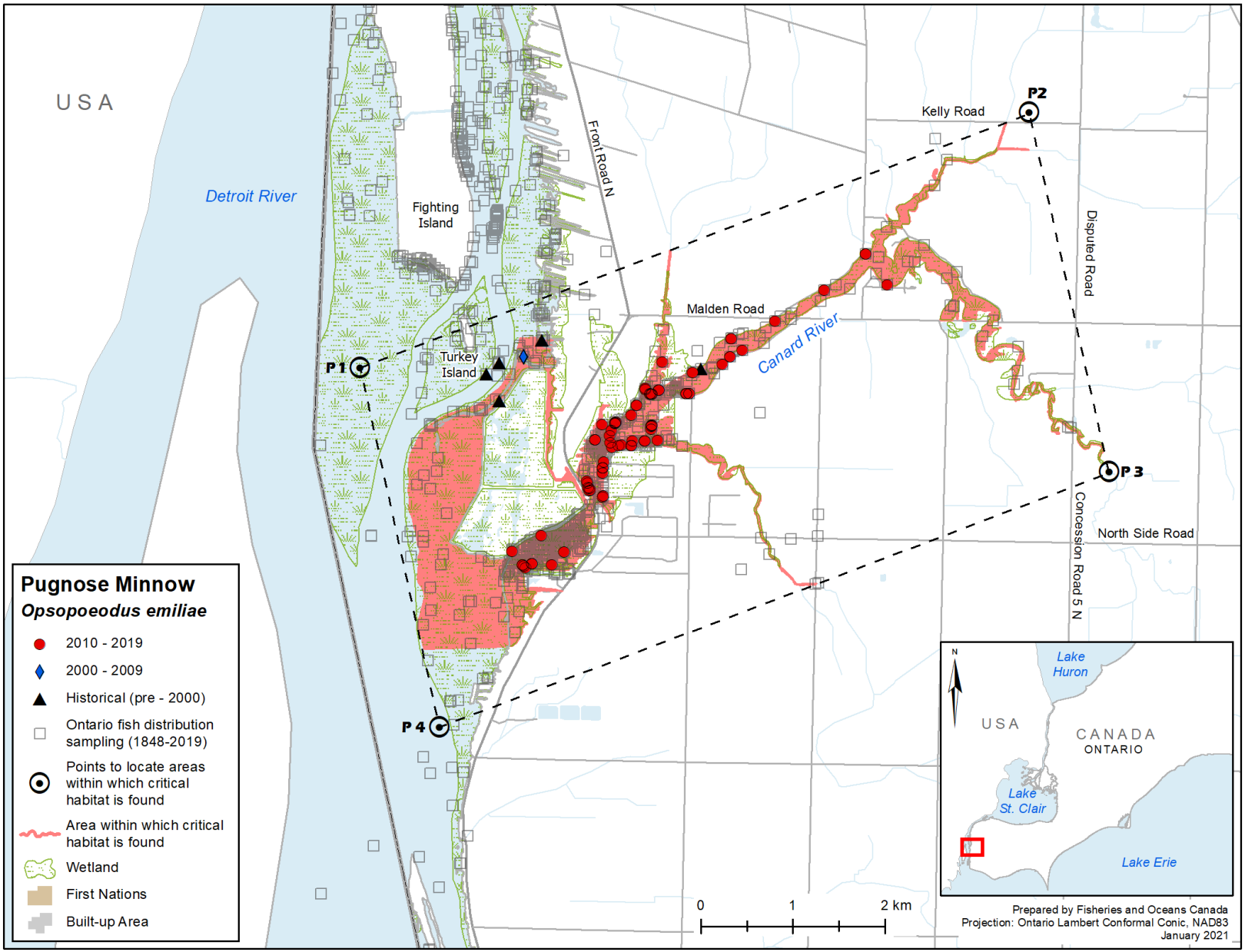

Figure 4. Area within which critical habitat is found for the Pugnose Minnow in the Detroit/Canard rivers

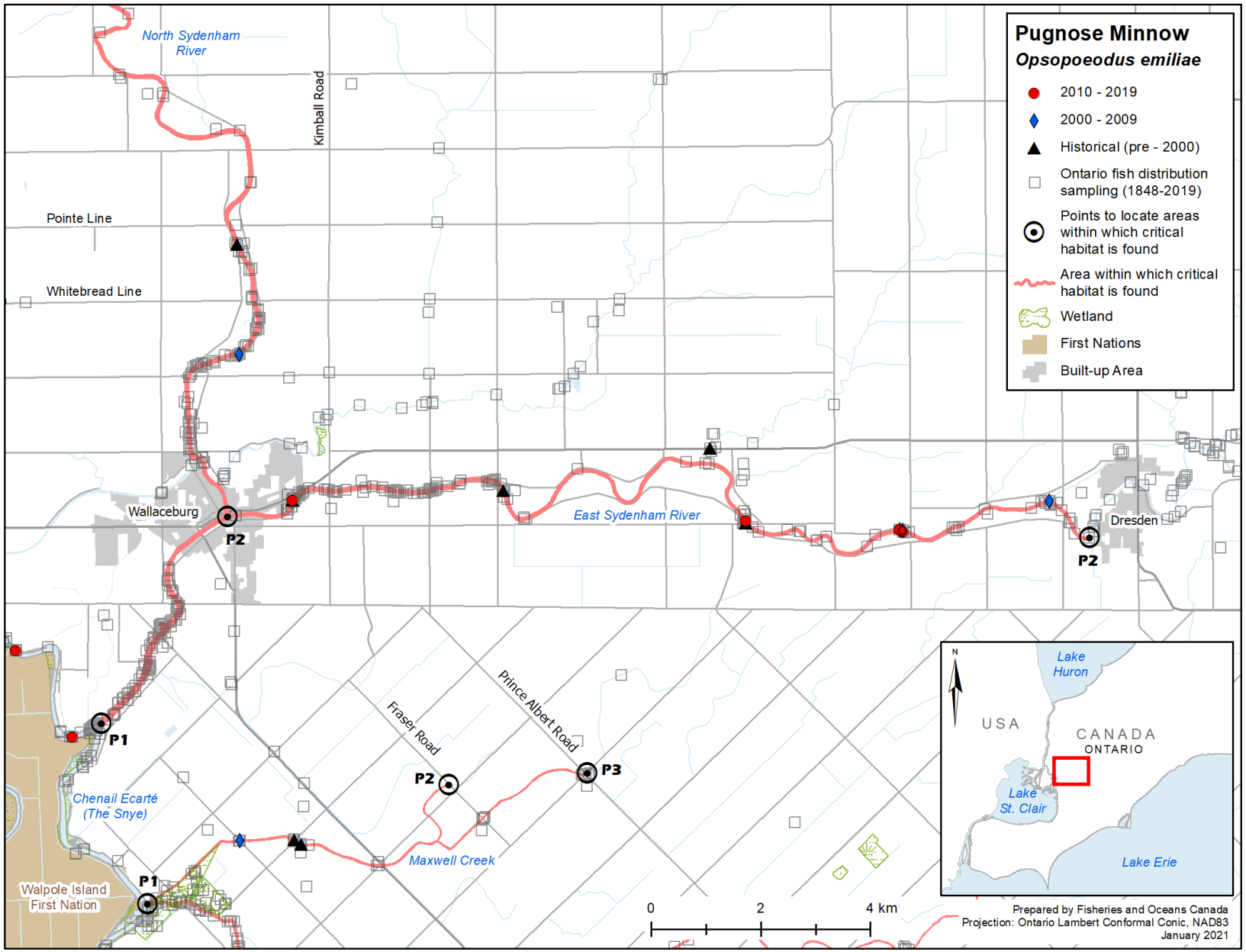

Figure 5. Area within which critical habitat is found for the Pugnose Minnow in the East Sydenham River

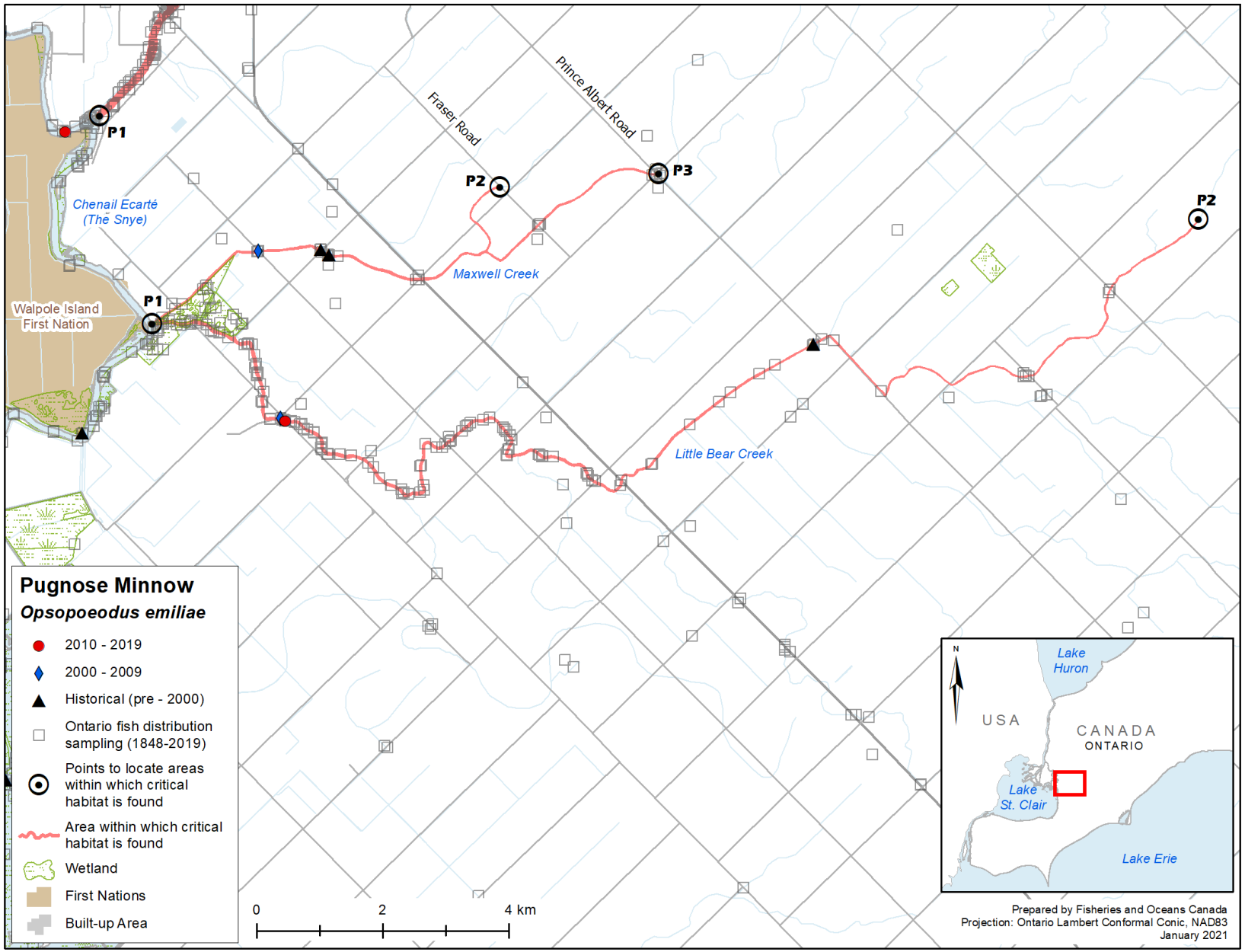

Figure 6. Area within which critical habitat is found for the Pugnose Minnow in Little Bear Creek and Maxwell Creek

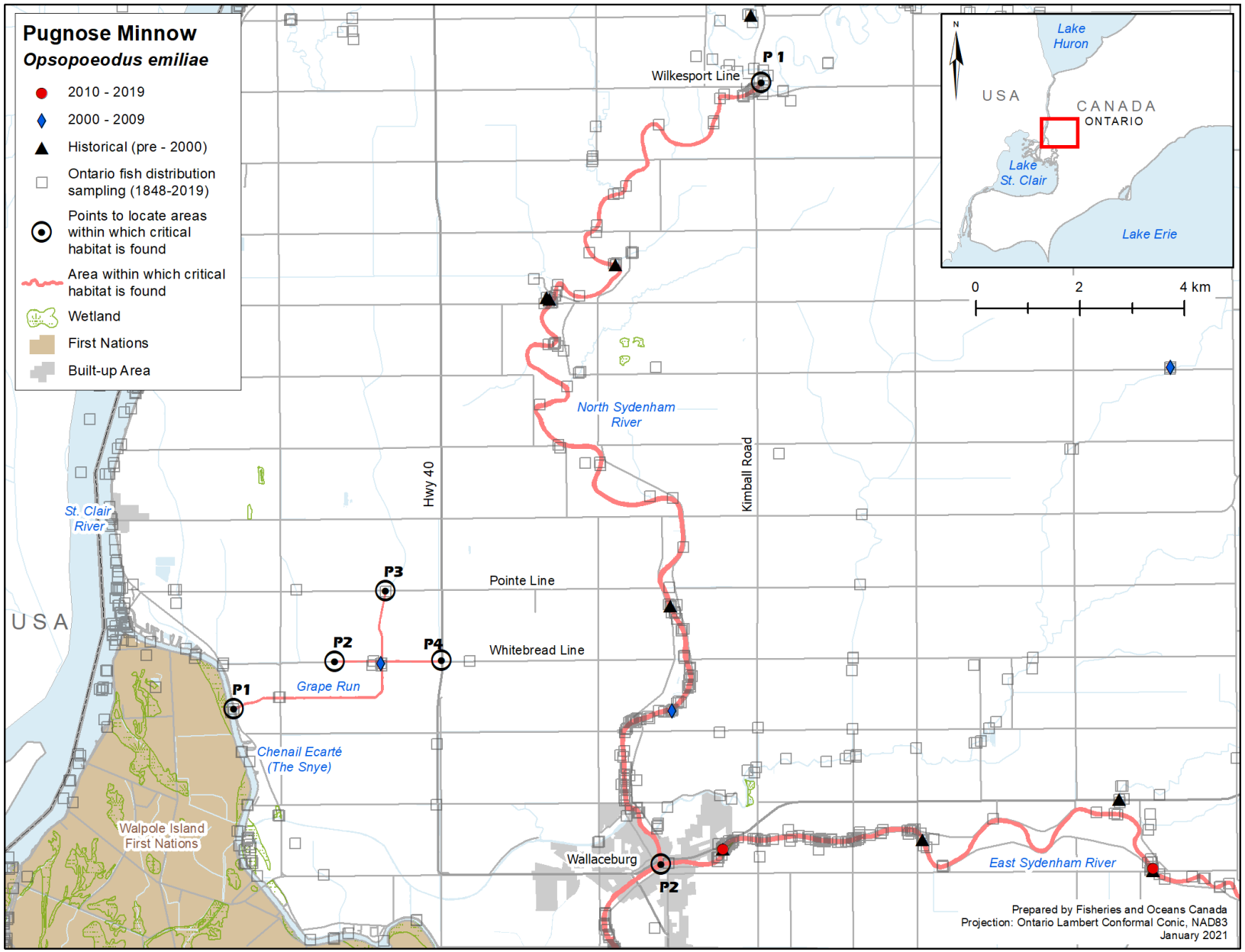

Figure 7. Area within which critical habitat is found for the Pugnose Minnow in the North Sydenham River and Whitebread Drain/Grape Run

Biophysical functions, features, and attributes:

Table 8 summarizes the best available knowledge of the functions, features, and attributes for each life stage of the Pugnose Minnow (refer to section 3.3 Needs of the Pugnose Minnow and Bouvier and Mandrak 2013 for full references). Note that not all attributes in table 8 must be present for a feature to be identified as critical habitat. If the features as described in table 8 are present and capable of supporting the associated function(s), the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table.

Table 8. General summary of the biophysical functions, features, and attributes of critical habitat necessary for the survival and recovery of the Pugnose Minnow.

Life stage	Function[14]	Feature(s)[15]	Attribute(s)[16]
Spawning	Reproduction (spawning likely occurs May to June), nursery	Slow-moving areas of streams or slow-moving side channels of larger rivers	• Attributes assumed to be same as for adults (see below) • Appropriate horizontal surfaces for egg deposition (for example, rocks, logs) • Water temperatures 21 to 27°C for egg hatching
Juvenile (hatch to age 1)	Feeding, cover	Slow-moving areas of streams or slow-moving side channels of larger rivers	• Attributes assumed to be same as for adults (see below)
Adult (from age 1: onset of sexual maturity)	Feeding, cover	Slow-moving areas of streams or slow-moving side channels of larger rivers	• Slow current • Areas of shallow water, ranging from 0.42 to 2 m • Low turbidity • Presence of aquatic vegetation • Sufficient DO levels [DO > 47% saturation at temperatures from 0 to 25°C (Ministry of the Environment and Energy 1994) for protection of warm water species]

[14] Function: a life-cycle process of the listed species taking place in critical habitat (for example, spawning, nursery, rearing, feeding, migration). The function informs the rationale for its protection. The identification of critical habitat must describe how the functions support a life process necessary for the survival or recovery of a species at risk.

[15] Feature: every function is the result of a single or multiple feature(s), which are the structural components of the critical habitat. Features describe the essential structural component that provides the requisite function(s) to meet the species' needs. Features may change over time and are usually comprised of more than one part, or attribute. A change or disruption to the feature or any of its attributes may affect the function and its ability to meet the biological needs of the species.

[16] Attribute: attributes are measurable properties or characteristics of a feature. Attributes describe how the identified features support the identified functions necessary for the species' life processes. Together, the attributes allow the feature to support the function. In essence, attributes provide the greatest level of information about a feature, the quality of the feature and how the feature is able to support the life-cycle requirements of the species.

Studies to further refine knowledge on the essential functions, features, and attributes for various life stages of the Pugnose Minnow are described in section 8.2 (schedule of studies to identify critical habitat).

Summary of critical habitat relative to population and distribution objectives:

Critical habitat are areas that, based on current best available information, the Minister of Fisheries and Oceans considers necessary to partially achieve the species' population and distribution objectives required for the survival and recovery of the species. Additional critical habitat may be identified in future updates to the recovery strategy and action plan.

8.2 Schedule of studies to identify critical habitat

Further research is required to refine the boundaries of the currently identified critical habitat in order to: refine the understanding of the functions, features, and attributes of the currently identified critical habitat necessary to support the species' population and distribution objectives; protect the critical habitat from destruction; and, identify additional areas of critical habitat. The activities listed in table 9 are not exhaustive, and it is likely that completing these studies will lead to the discovery of further knowledge gaps that need to be addressed.

Table 9. Schedule of Studies to refine critical habitat identification and refine the understanding of the functions, features, and attributes of the currently identified critical habitat

Description of study	Outcome/rationale	Timeline[17],[18]
Conduct studies to determine the habitat requirements of each life stage of the Pugnose Minnow	There is almost no information available regarding the habitat requirements of the juvenile Pugnose Minnow. Determining the habitat requirements of each life stage will ensure that all necessary features and attributes of critical habitat for this species will be identified.	5 years
Survey and map habitat quality and quantity within historical and extant sites, and sites adjacent to extant habitat	Strengthen confidence in data used to determine if sites meet the criteria to identify critical habitat; monitor current sites for changes in population data that may result in changes to critical habitat identification; survey adjacent habitat to ensure accuracy of areas of occurrence, by which critical habitat is being partly defined.	5 to 7 years

[17] Timeline reflects the amount of time required for the study to be completed from the time the recovery strategy and action plan is published as final on the Species at Risk Public Registry.
[18] Timelines are subject to change in response to demands on resources and/or personnel and as new priorities arise.

Description of study	Outcome/rationale	Timeline[17],[18]
Determine the physiological tolerance thresholds of the Pugnose Minnow with respect to various water-quality parameters (for example, turbidity, contaminants) and check against existing standards	Will help to refine functions, features, and attributes of critical habitat.	5 years
Conduct research to determine the need for riparian critical habitat, including amount, location, and configuration	The species is impacted by degraded water and habitat quality caused by overland runoff from agricultural areas. Identifying riparian areas as critical habitat would result in further habitat improvements and protections.	2 years
Based on collected information, review population and distribution objectives. Determine amount, configuration, and description of critical habitat required to achieve these objectives if adequate information exists.	Revision of recovery targets may be required to ensure that they are achievable and defensible; will allow further refinement of critical habitat description (spatial and biophysical attributes).	Ongoing

8.3 Examples of activities likely to result in the destruction of critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a final recovery strategy or action plan. For Pugnose Minnow critical habitat, it is anticipated that this will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

The following examples of activities likely to result in the destruction[19] of critical habitat (table 10) are based on known human activities that are likely to occur in and around critical habitat and would result in the destruction of critical habitat if unmitigated. The list of activities is neither exhaustive nor exclusive and has been guided by the threats described in section 5. The absence of a specific human activity from this table does not preclude or restrict the Department's ability to regulate that activity under SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition and does not mean the activity will inevitably result in the destruction of critical habitat. Every proposed activity must be assessed on a case-by-case basis and site-specific mitigation will be applied where it is available and reliable. Where information is available, thresholds and limits have been developed for critical habitat attributes to better inform management and regulatory decision making. However, in many cases, knowledge of a species and its critical habitat's thresholds of tolerance to disturbance from human activities is lacking and must be acquired.

[19] Destruction occurs when there is a temporary or permanent loss of a function of critical habitat at a time when it is required by the species.

Table 10. Examples of activities likely to result in the destruction of critical habitat for the Pugnose Minnow

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
Turbidity and sediment loading	• Altering flow regimes causing erosion and changing sediment transport (for example, tiling of agricultural drainage systems, removal of riparian zones) • Work in or around water with improper sediment and erosion control (for example, overland runoff from ploughed fields, use of industrial equipment, cleaning or maintenance of bridges or other structures)	Improper sediment and erosion control or mitigation can cause increased turbidity levels, changing preferred substrates and their oxygen levels, potentially reducing feeding success or prey availability, impacting the growth of aquatic vegetation and possibly excluding fishes from habitat due to physiological impacts of sediment in the water (for example, gill irritation).	• Reproduction • Nursery • Feeding • Cover	• Slow-moving areas of streams or slow-moving side channels of larger rivers.	• Low turbidity • Presence of aquatic vegetation • Water temperatures 21 to 27°C for egg hatching • Sufficient dissolved oxygen (DO) levels
Nutrient loading	• Over-application of fertilizer and improper nutrient management (for example, organic debris management, wastewater management, animal waste, septic systems and municipal sewage)	Improper nutrient management can cause nutrient loading of nearby waterbodies. Elevated nutrient levels can cause increased aquatic plant growth, changing water temperatures and slowly change preferred flows and substrates. DO levels can also be negatively affected.	Same as above	Same as above	• Slow current • Low turbidity • Presence of aquatic vegetation • Sufficient DO levels
Habitat alteration	• Dredging • Grading • Excavation	Changes in bathymetry and shoreline morphology caused by dredging and nearshore grading and excavation can	Same as above	Same as above	• Slow current • Areas of shallow

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
	• Placement of material or structures in water (for example, groynes, piers, infilling, partial infills, jetties) • Shoreline hardening	remove (or cover) preferred substrates, change water depths, cause erosion and alter turbidity levels, and change flow patterns, potentially affecting nutrient levels and water temperatures. Dredging can also remove the aquatic vegetation seed bank. Placing material or structures in water reduces habitat availability (for example, the footprint of the infill or structure is lost). Placing of fill can cover preferred substrates. Hardening of shorelines can reduce organic inputs into the water and alter water temperatures, potentially affecting the availability of prey for this species.			water, ranging from 0.42 to 2 m • Low turbidity • Presence of aquatic vegetation • Appropriate horizontal surfaces for egg deposition • Water temperatures 21 to 27°C for egg hatching • Sufficient DO levels
Habitat alteration	• Water extraction • Change in timing, duration and frequency of flow	Water extraction can affect surface water levels and flow and groundwater inputs into streams and rivers, affecting habitat availability, the oxygenation of substrates, and prey abundance. Altered flow patterns can affect sediment deposition (for example, changing preferred substrates), oxygenation of substrates, and prey abundance.	Same as above	Same as above	• Slow current • Low turbidity • Presence of aquatic vegetation • Sufficient DO levels • Water temperatures 21 to 27°C for egg hatching

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
Habitat alteration	• Unfettered livestock access to waterbodies • Grazing of livestock and ploughing to water's edge	Resulting damage to shorelines, banks and watercourse bottoms from unfettered access by livestock can cause increased erosion and sedimentation, affecting substrate oxygenation and water temperatures. Such access can also increase organic nutrient inputs into the water, causing nutrient loading and potentially promoting algal blooms and decreasing prey abundance.	Same as above	Same as above	• Low turbidity • Presence of aquatic vegetation • Sufficient DO levels • Water temperatures 21 to 27°C for egg hatching
Habitat Alteration	• Mechanical and chemical removal of aquatic and riparian vegetation	Removal of aquatic or riparian vegetation can cause erosion and increase turbidity, ultimately affecting preferred substrates and oxygenation of substrates. Water temperatures can also be negatively affected by removal of riparian vegetation, and water velocities can be increased during high water events.	Same as above	Same as above	• Slow current • Low turbidity • Presence of aquatic vegetation • Sufficient DO levels • Water temperatures 21 to 27°C for egg hatching
Contaminants and toxic substances	• Over application or misuse of herbicides and pesticides • Release of urban and industrial pollution into habitat	Introduction of toxic compounds into habitat used by this species can change water chemistry affecting habitat availability or use and cause increased aquatic plant growth affecting spawning and recruitment success.	Same as above	Same as above	• Low turbidity • Presence of aquatic vegetation • Sufficient DO levels

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
Invasive species	• Introduction of invasive species	Invasive species may affect Pugnose Minnow critical habitat by altering the nature of the habitat (for example, Common Carp uproot aquatic vegetation, resulting in increased turbidity).	Same as above	Same as above	• Low turbidity • Presence of aquatic vegetation • Sufficient DO levels

In future, threshold values for some stressors may be informed through further research. For some of the above activities, BMPs may be enough to mitigate threats to the species and its habitat; however, in some cases, it is not known if BMPs are adequate to protect critical habitat and further research is required.

9 Evaluation of socio-economic costs and benefits of the action plan

SARA requires that the action plan component of the recovery document[20] (action plan) include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation (SARA 49(1)(e), 2003). This evaluation addresses only the incremental socio-economic costs of implementing this action plan from a national perspective as well as the social and environmental benefits that would occur if the action plan were implemented in its entirety, recognizing that not all aspects of its implementation are under the jurisdiction of the federal government. It does not address cumulative costs of species recovery in general nor does it attempt a cost-benefit analysis. Its intent is to inform the public and to guide decision making on implementation of the action plan by partners.

The protection and recovery of species at risk can result in both benefits and costs. The Act recognizes that "wildlife, in all its forms, has value in and of itself and is valued by Canadians for aesthetic, cultural, spiritual, recreational, educational, historical, economic, medical, ecological and scientific reasons" (SARA 2003). Self-sustaining and healthy ecosystems with their various elements in place, including species at risk, contribute positively to the livelihoods and the quality of life of all Canadians. A review of the literature confirms that Canadians value the preservation and conservation of species in and of themselves. Actions taken to preserve a species, such as habitat protection and restoration, are also valued. In addition, the more an action contributes to the recovery of a species, the higher the value the public places on such actions (Loomis and White 1996; DFO 2008). Furthermore, the conservation of species at risk is an important component of the Government of Canada's commitment to conserving biological diversity under the International Convention on Biological Diversity. The Government of Canada has also made a commitment to protect and recover species at risk through the Accord for the Protection of Species at Risk. An estimate of the costs and benefits associated with this action plan are described below.

This evaluation does not address the socio-economic impacts of protecting critical habitat for the Pugnose Minnow. Under SARA, DFO must ensure that critical habitat identified in a recovery strategy or action plan is legally protected within 180 days of the final posting of the recovery document. Where an Order will be used for critical habitat protection, the development of the SARA Critical Habitat Order will follow a regulatory process in compliance with the Cabinet Directive on Regulatory Management, including an analysis of any potential incremental impacts of the Critical Habitat Order that will be included in the Regulatory Impact Analysis Statement. As a consequence, no additional analysis of the critical habitat protection has been undertaken for the assessment of costs and benefits of the action plan.

9.1 Policy baseline

The policy baseline consists of the protection under SARA for the Pugnose Minnow (the species was listed under SARA as threatened in 2019), along with continued protection under the federal *Fisheries Act* and Ontario's *Endangered Species Act*, 2007 (ESA 2007). Further

[20] That is, tables 4 to 6 and section 9

protections may be afforded to the Pugnose Minnow and its habitat under other provincial legislation[21].

The policy baseline also includes recovery measures that were implemented prior to and after the Pugnose Minnow was listed under SARA. These recovery measures include recovery strategies and action plans for other freshwater species as well as multispecies ecosystem-based recovery programs discussed in section 7.1 of this report.

9.2 Socio-economic profile and baseline

Most of the lands adjacent to known Pugnose Minnow locations are private. The species has a limited range comprising a small area in southwestern Ontario. This basin consists largely of land used for agricultural activities. There are also urban and industrial activities within the region.

The lead agency for the actions identified in this plan is DFO. Partners for specific initiatives include conservation authorities (Essex Region, Lower Thames Valley, Upper Thames River, and St. Clair Region), OMNRF, First Nations, the Ontario Federation of Anglers and Hunters, and universities.

9.3 Socio-economic costs of implementing this action plan

The recovery measures are grouped under four broad strategies: inventory and monitoring; research; management and coordination; and, stewardship and outreach. Some measures are ongoing, and the majority of the costs are expected to occur over the next two years.
Costs would be incurred by the federal government to implement the measures listed in the action plan. Costs would also be incurred by partners who choose to participate in the recovery measures. Costs include both financial contributions and/or in-kind costs such as time, expertise and/or equipment. Some measures could be funded from existing federal government resources or annual funding programs such as the Habitat Stewardship Program (HSP). Such programs typically require direct or in-kind support costs from applicants as matching funds[22].

The most costly recovery measures relate to research to determine the life history of the Pugnose Minnow and characterize and protect its habitat. The approaches related to these measures are estimated to cost approximately $75,000 per year for two years. The total costs (direct and in-kind) associated with the recovery measures outlined in this action plan are estimated to be low[23]. Expenditures beyond five years cannot be determined in great detail as it is expected these activities would be funded through existing annually funded government programs (for example, HSP) where support is determined on a priority basis and based on availability of resources. However, it is expected that long-term costs will continue to be low. Implementation of the recovery measures is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

[21] Examples of other provincial legislation that provide habitat protection include, but may not be limited to, considerations under section 3 of Ontario's *Planning Act* section 2.1.7 of the Provincial Policy Statement (2014) under the *Planning Act*, which prohibits development and site alteration in the habitat of endangered and threatened species, except in accordance with provincial and federal requirements, as well as protection under the *Lakes and Rivers Improvement Act* in Ontario.
[22] For example, matching funds for the HSP can come from landowners and/or provincial funding programs. This helps leverage additional support for recovery actions.
[23] Low costs are defined as less than $1 million annually.

9.4 Socio-economic benefits of implementing this action plan

The identified recovery measures contribute to protecting and maintaining self-sustaining populations of the Pugnose Minnow. The socio-economic benefits of these measures are not quantifiable but are expected to be low and would occur over the long term. In addition to the non-market benefits to Canadians that result from the preservation and conservation of species, the recovery measures may provide broader long-term benefits.

Research activities that contribute to the knowledge of the Pugnose Minnow and the quality of its habitat would assist in protecting and recovering the target species and would also contribute to the body of knowledge on all species in the ecosystem. Increased knowledge of the species and its habitat, particularly studies that refine critical habitat identification, would contribute to protecting and maintaining the species, and to protecting habitat for other species in the ecosystem. The Pugnose Minnow represents a monotypic genus (Nelson et al. 2004) and, as a result, the study of the unique morphology, behaviour, and genetics of this species contributes to our knowledge of the evolution of North American Leuciscidae.

Education and outreach activities help to develop public interest in species at risk and may lead to increased participation in recovery measures. Stewardship and communication recovery measures aimed at protecting against invasive species also provide ecological and economic benefits beyond the protection of the Pugnose Minnow. Promoting the development and implementation of stewardship and BMP activities outlined in this plan will also contribute to environmental quality in the region.

Some unquantifiable non-market benefits would be enjoyed by the Canadian public as a result of implementing the recovery actions contained in the action plan. Recent research (Rudd et al. 2016) found that Canadian households had positive and significant willingness to pay values for recovery actions that led to improvements for little known species at risk in southern Ontario. This research explicitly included the Pugnose Minnow. It is not possible to assess the incremental benefits directly attributable to this action plan.

9.5 Distributional impacts

The federal and provincial governments will incur the majority of costs of implementing the action plan. Partners who choose to participate in recovery measures will also incur costs[24].

The Canadian public will benefit from the implementation of the action plan through the protection and recovery of the Pugnose Minnow populations, through the protection of the ecosystem, through the maintenance of biodiversity in Canada, and through increased scientific knowledge.

10 Measuring progress

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. A successful recovery program will achieve the overall aim of recovering populations to a state where they are stable or increasing

[24] This section estimates costs associated with implementing the action plan only; costs to be compliant with prohibitions and requirements resulting from listing or orders to protect critical habitat are assessed in Regulatory Impact Analysis Statements that accompany Critical Habitat Orders.

and demonstrably secure with low risk from known threats. Progress towards meeting these objectives will be reported in the report on the progress of recovery strategy implementation.

Performance indicators:

1. The continued presence of the Pugnose Minnow within its current distribution by 2026
2. Population trajectories in the Detroit River and Lake St. Clair and its tributaries stable or increasing by 2031
3. Status of the Pugnose Minnow in McDougall Drain confirmed by 2023
4. Detections in formerly unoccupied sites within historical range by 2036 (that is, evidence of expansion)

Reporting on the ecological and socio-economic impacts of the recovery strategy and action plan (under section 55 of SARA) will be done by assessing the implementation of the recovery strategy and action plan after five years. Many measures in this recovery strategy and action plan will increase our understanding of the species, its status, and the threats it faces, and over time will contribute to monitoring of the Pugnose Minnow in Canada. This monitoring information will be used to report on the performance indicators and progress towards recovery in future reports on the progress towards recovery strategy Implementation.

The broader ecological impacts of the implementation of this recovery strategy and action plan have been considered in its development. To report on the ecological impacts of implementation (under section 55 of SARA), monitoring data for other ecological components have been identified, and include water quality and quantity monitoring data for the watersheds where the species is found, where it exists. Additionally, other sensitive species with ranges that overlap that of the Pugnose Minnow (for example, the Pugnose Shiner, the Lake Chubsucker [*Erimyzon sucetta*]) could be monitored to track their trajectories and to document changes to overall fish community composition and abundance.

Reporting on the socio-economic impacts of the recovery strategy and action plan (under section 55 of SARA) will be done by collecting data on the costs incurred to implement it.

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Appendix A: effects on the environment and other species

In accordance with the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals (2010), the *Species at Risk Act* (SARA) recovery planning documents incorporate Strategic Environmental Assessment (SEA) considerations throughout the document. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

Many of the stewardship and habitat improvement activities will be implemented through existing ecosystem-based recovery programs that have already taken into account the needs of other species at risk. Recovery actions related to research are specific to the Pugnose Minnow, and should have no impact on other species. No negative impacts on other species resulting from implementation of the Pugnose Minnow recovery actions are expected.

Appendix B: record of cooperation and consultation

Recovery strategies and action plans are to be prepared in cooperation and consultation with other jurisdictions, organizations, affected parties and others as outlined in the *Species at Risk Act* (SARA) sections 39 and 48. Fisheries and Oceans Canada has utilized a process of species expert/subject matter expert review to seek input to the development of this recovery strategy and action plan. Information on participation is included below.

Subject matter expert reviewers

Name	Affiliation
Rebecca Dolson	Ontario Ministry of Natural Resources and Forestry
Andrew Drake	Fisheries and Oceans Canada
Bill Glass	Fisheries and Oceans Canada
Scott Gibson	Ontario Ministry of Natural Resources and Forestry
Scott Reid	Ontario Ministry of Natural Resources and Forestry

In addition, consultation on the draft recovery strategy and action plan occurred through letters sent to potentially impacted Indigenous groups. DFO did not receive feedback from these groups. Additional stakeholder, Indigenous, and public input was sought through the publication of the proposed document on the Species at Risk Public Registry from January to March 2021. No comments were received during this period.