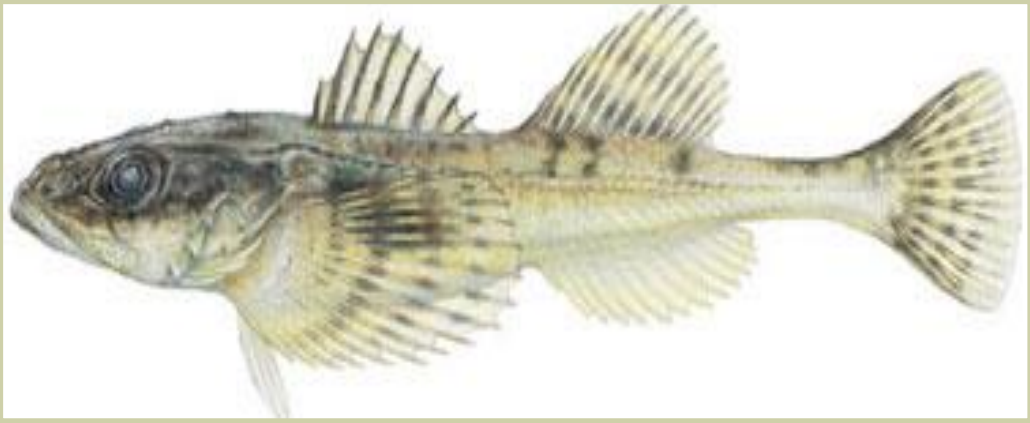
PROPOSED

Species at Risk Act
Management Plan Series

Management Plan for the Deepwater Sculpin (*Myoxocephalus thompsonii*) in Canada (Great Lakes-Western St. Lawrence populations)

Deepwater Sculpin



2016

Fisheries and Oceans Canada
Pêches et Océans Canada
Canada

About the *Species at Risk Act* Management Plan Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is "*to manage species of special concern to prevent them from becoming endangered or threatened*."

What is a species of special concern?

Under SARA, a species of special concern is a wildlife species that could become threatened or endangered because of a combination of biological characteristics and identified threats. Species of special concern are included in the SARA List of Wildlife Species at Risk.

What is a management plan?

Under SARA, a management plan is an action-oriented planning document that identifies the conservation activities and land use measures needed to ensure, at a minimum, that a species of special concern does not become threatened or endangered. For many species, the ultimate aim of the management plan will be to alleviate human threats and remove the species from the List of Wildlife Species at Risk. The plan sets goals and objectives, identifies threats, and indicates the main areas of activities to be undertaken to address those threats.

Management plan development is mandated under Sections 65–72 of SARA.

A management plan has to be developed within three years after the species is added to the List of Wildlife Species at Risk. Five years is allowed for those species that were initially listed when SARA came into force.

What's next?

Directions set in the management plan will enable jurisdictions, communities, land users, and conservationists to implement conservation activities that will have preventative or restorative benefits. Cost-effective measures to prevent the species from becoming further at risk should not be postponed for lack of full scientific certainty and may, in fact, result in significant cost savings in the future.

The series

This series presents the management plans prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as plans are updated.

To learn more

To learn more about the *Species at Risk Act* and conservation initiatives, please consult the SAR Public Registry.

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2016

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PREFACE

The Deepwater Sculpin is a freshwater fish and is under the responsibility of the federal government. The Minister of Fisheries and Oceans is a "competent minister" for aquatic species under the *Species at Risk Act* (SARA)[1]. The Deepwater Sculpin (Great Lakes-Western St. Lawrence populations) was listed as a species of Special Concern under SARA in December 2007. Western populations were assessed as Not at Risk and hence, are not included in this document. SARA (Sections 65 and 66) requires the competent minister(s) to prepare management plans for species listed as Special Concern. The development of this management plan was led by Fisheries and Oceans Canada, Central and Arctic Region and Quebec Region, in cooperation and consultation with many individuals, organizations and government agencies, including the provinces of Ontario and Quebec (see Appendix 1). The plan meets SARA requirements in terms of content and process (SARA sections 65-68).

Success in the conservation 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 plan and will not be achieved by Fisheries and Oceans Canada and Parks Canada Agency or any other party alone. This plan provides advice to jurisdictions and organizations that may be involved or wish to become involved in activities to conserve this species. In the spirit of the Accord for the Protection of Species at Risk, the Ministers of Fisheries and Oceans and of the Minister responsible for Parks Canada Agency invite all responsible jurisdictions and Canadians to join Fisheries and Oceans Canada in supporting and implementing this plan for the benefit of the Deepwater Sculpin and Canadian society as a whole. The Minister will report on progress within five years of the posting of the final version of the plan on the Species at Risk Public Registry.

AUTHORS

The management plan was prepared by Peter L. Jarvis (contractor), Amy Boyko (Fisheries and Oceans Canada [DFO] Central and Arctic Region), Daniel Hardy (DFO Quebec Region), and Andréanne Demers (DFO Quebec Region) on behalf of DFO.

ACKNOWLEDGMENTS

DFO would like to thank the following organizations for their support in the development of this management plan: Ontario Ministry of Natural Resources and Forestry (OMNRF), Ministère des Forêts, de la Faune et des Parcs du Québec (MFFP), and the Ontario Freshwater Fish Recovery Team. Additionally, DFO wishes to thank Maureen Walsh (USGS, Lake Ontario Biological Station) for information on recent Deepwater Sculpin dynamics in the U.S. portion of Lake Ontario, James Hoyle (OMNRF, Lake Ontario Management Unit) for information on Deepwater Sculpin in north-eastern Lake Ontario, Lloyd Mohr (OMNRF, Upper Great Lakes Management Unit) for information on Deepwater Sculpin in Lake Huron, Rick Salmon (OMNRF, Lake Nipigon Fisheries Assessment Unit) for the status of Deepwater Sculpin catches in Lake

[1] Deepwater Sculpin (Great Lakes-Western St. Lawrence populations) are also located in the Lake Superior National Marine Conservation Area (LS NMCA), an area administered by the Parks Canada Agency. In 2015, modifications to the *Canada National Marine Conservation Areas Act* ensure that the Lake Superior National Marine Conservation Area will be scheduled in the near future. Once the LS NMCA is scheduled under this Act, the Minister responsible for Parks Canada Agency will become an additional competent minister under SARA within the NMCA. Until such time, the Minister of Fisheries and Oceans remains the competent minister under SARA for this area.

Nipigon, Owen Gorman (USGS, Lake Superior Biological Station) for catch information by USGS in the Canadian waters of Lake Superior, Julie Deschênes (MFFP, Direction de l'expertise Faune – Forêts de l'Outaouais) for the status of Deepwater Sculpin in Quebec, Edward Roseman (USGS, Great Lakes Science Center) for catch information by USGS in the Canadian waters of Lake Huron, Gary Whelan (Michigan DNR, Fisheries Division) for information on viral hemorrhagic septicaemia testing, Brian Weidel (USGS, Great Lakes Science Center) for information on recent USGS survey efforts in Lake Ontario. The following individuals reviewed and greatly improved the document: David Bunnell (USGS, Great Lakes Science Center), Alan Dextrase (OMNRF, Biodiversity Policy Section), Henri Fournier (MRN), Scott Gibson (OMNRF, Species at Risk Branch), Chuck Madenjian (USGS, Great Lakes Science Center), Nick Mandrak (DFO, Great Lakes Laboratory for Fisheries and Aquatic Sciences), and Steve Pothoven (NOAA, Lake Michigan Field Station).

STRATEGIC ENVIRONMENTAL ASSESSMENT

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. 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.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that plans 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 on non-target species or habitats. The results of the SEA are incorporated directly into the plan itself, but are also summarized below.

This management plan will clearly benefit the environment by promoting the conservation of the Deepwater Sculpin. The potential for the plan to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this plan will clearly benefit the environment and will not entail any significant adverse effects. The reader should refer to the following sections of the document in particular: Description of the species' habitat and biological needs (Section 1.4.1.), Ecological role (Section 1.4.2.); Limiting factors (Section 1.4.3.); Description of threats (Section 1.5.2.); Management actions (Section 2.3.); and, Effects on other species (Section 2.4.).

EXECUTIVE SUMMARY

In 2006, the Deepwater Sculpin (Great Lakes-Western St. Lawrence populations) was designated a species of Special Concern in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and was listed on Schedule 1 of the *Species at Risk Act* (SARA) in 2007. The COSEWIC designation was based on the species' restricted distribution and the loss of two populations in addition to the possibility of a decline in one further population. Although the Deepwater Sculpin is also widely distributed in western Canada (Western populations), these populations were assessed as Not at Risk and, hence, are not included in this management plan.

The Deepwater Sculpin is a freshwater sculpin in the family Cottidae; it has an elongate body that lacks scales and has only been recorded with total lengths less than 200 mm. This species is a benthic dweller, most often found in deep, cold, highly-oxygenated water. Populations are found in postglacial lakes of North America, with the majority of its range located in Canada. It feeds predominately on crustaceans such as *Mysis relicta*, *Diporeia* spp. and chironimid larvae, while main predator species include Lake Trout and Burbot (on juveniles and adults) and Alewife (on larvae). In the Great Lakes, Deepwater Sculpin abundance appears to be heavily influenced by the arrival of the Alewife and subsequent dynamics of this invasive species.

Across Canada, Deepwater Sculpin are known to occur in more than 60 different lakes; however, only ten lakes are known within the Great Lakes-Western St. Lawrence designatable unit (DU). In the Laurentian Great Lakes, Deepwater Sculpin are found in lakes Superior, Huron, and Michigan, and, sparsely, in Lake Ontario. Although young-of-the-year have been found in Lake Erie, there is no reproducing population in this lake. Additional populations within the Great Lakes-Western St. Lawrence DU include Lac des Iles, Thirty-One Mile, Heney and Grand Lac Rond (Roddick) lakes in Quebec, as well as Fairbank Lake and Lake Nipigon in Ontario.

The long-term (> 20 years) goal of this management plan is to ensure the long-term persistence of Deepwater Sculpin throughout its current and historic distribution in the Great Lakes – Western St. Lawrence DU. Management should be directed towards ensuring the conservation and restoration of habitat for known populations. More quantifiable objectives relating to individual populations will be developed once the necessary sampling and analysis have been completed.

The following short-term (5-10 years) management objectives have been identified to assist in meeting the long-term goal:

i. To understand the health and extent of existing populations and to determine population and habitat trends;
ii. To improve knowledge of the species' biology, ecology, and habitat requirements;
iii. To evaluate and mitigate threats to the species and its habitat;
iv. To maintain and, where applicable, expand existing populations, and to repatriate healthy self-sustaining populations in locations where the species has been extirpated or reduced, where feasible;
v. To ensure the efficient use of resources in the management of this species; and,
vi. To improve awareness and engage the public in the conservation of the Deepwater Sculpin and cold-water ecosystems as a whole.

As the mechanisms that determine the distribution and abundance of Deepwater Sculpin may be very different between the Great Lakes and smaller systems, a degree of separation in management actions is anticipated. Management approaches to assist in meeting the objectives listed above have been organized into the following categories: Surveys and Monitoring; Management and Coordination; Research; Stewardship, Habitat Protection and Improvement, and Threat Mitigation; and, Outreach and Communication. Each approach has several key actions that will be undertaken to obtain the desired outcome.

The development and implementation of management actions is being coordinated with other species at risk recovery teams throughout southern Ontario and Quebec as well as ecosystem-based recovery initiatives, to ensure the proposed management actions do not adversely affect other species at risk within the range of Deepwater Sculpin.

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1. SPECIES INFORMATION

1.1. Species assessment information from COSEWIC[2]

Date of assessment: April 2006
Common name (population): Deepwater Sculpin (Great Lakes – Western St. Lawrence populations)
Scientific name: *Myoxocephalus thompsonii*
COSEWIC status: Special Concern
Reason for designation: This species occurs in the deeper parts of 10 coldwater lakes, including lakes Superior, Huron and Ontario, in Ontario and Quebec. Previously thought to be exterminated[3] in Lake Ontario, it now appears to be reestablished in that lake, albeit in small numbers. Populations have been exterminated[4] in 2 lakes in Quebec due to eutrophication of these lakes, and may be in decline in Lake Huron, possibly in relation to the introduction of zebra mussel[5].
Canadian occurrence: Ontario and Quebec
COSEWIC status history: The "Great Lakes – Western St. Lawrence populations" unit (which includes the former "Great Lakes populations" unit designated Threatened in April 1987) was designated Special Concern in April 2006. Last assessment based on an update status report.

1.2. Description

The Deepwater Sculpin (*Myoxocephalus thompsonii* Girard, 1851) (Figure 1) is a lake-dwelling sculpin in the family Cottidae. Defining morphological characteristics include an elongate body lacking true scales with eyes on top of the head and a large mouth with small teeth on jaws, tongue, and the roof of the mouth. Body colouration is generally dark grey to brown with several dark saddles marking the back in addition to light speckling on the sides and a pale underside (Scott and Crossman 1973). Although closely related taxa include the freshwater and marine forms of Fourhorn Sculpin (*M. quadricornis*), the Deepwater Sculpin can be distinguished based on the absence of cephalic horns (Stewart and Watkinson 2004). Additionally, it can be distinguished from species in the genus *Cottus* based on the presence of disk-like tubercles on the upper sides along the body length, a gill membrane that is free from the isthmus, and distinct separation between the two dorsal fins (McPhail and Lindsey 1970).

Sheldon (2006) collected Deepwater Sculpin from 20 lakes across its Canadian range and recorded a range of 47.2 to 110.5 mm total length (TL), with a mean of 76.7 mm TL (from a total of 155 specimens captured across the 20 lakes). The maximum age of Deepwater Sculpin collected in this survey was 24 years, although most were between 5 and 10 years old. A maximum of 184 mm TL has been recorded (Holm et al. 2009) and the species appears to reach greater lengths in the Laurentian Great Lakes compared to inland lakes. Additionally, the

[2] Committee on the Status of Endangered Wildlife in Canada.
[3] While the wording presented is derived directly from the COSEWIC report on the species, the appropriate term is "extirpated".
[4] While the wording presented is derived directly from the COSEWIC report on the species, the appropriate term is "extirpated".
[5] Quagga Mussel (*Dreissena bugensis*) dominates the dreissenid assemblage in Lake Huron; Zebra Mussel (*D. polymorpha*) is rare in Lake Huron and would be lacking in deepwater habitats inhabited by Deepwater Sculpin.

body mass of the 155 individuals collected reached a maximum of 13.49 g and was typically between 1 and 7 g.

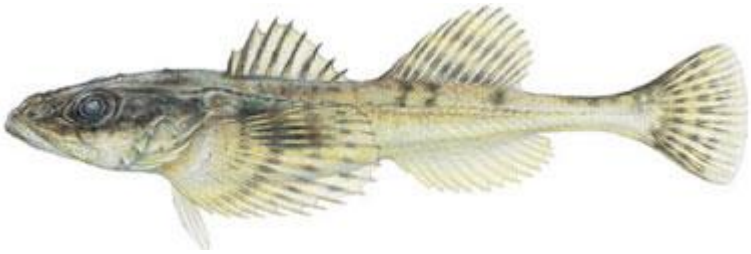

Figure 1. Deepwater Sculpin (*Myoxocephalus thompsonii*). Copyright Joseph Tomelleri.

1.3. Populations and distribution

Distribution

Global range: Deepwater Sculpin is restricted to North America, with most populations residing in Canada. The present-day distribution of the species was mediated by dispersal through glacial lakes and the Champlain Sea (Dadswell 1974; Sheldon et al. 2008) and extends from the Mont-Laurier region of Quebec through the Laurentian Great Lakes, continuing through Manitoba, Saskatchewan, and Alberta, and northwest to Great Slave and Great Bear lakes in the Northwest Territories. In the United States, the Deepwater Sculpin is found in a few inland lakes in Michigan and Minnesota in addition to the Great Lakes populations.

Canadian range: The Canadian range of the Deepwater Sculpin is thought to encompass more than 60 populations. The Deepwater Sculpin in Canada has been subdivided into two designatable units (DUs), one that encompasses the Western populations and one that includes the Great Lakes – Western St. Lawrence populations (see COSEWIC 2006). The separation into two DUs is based on the species' distribution within different Freshwater Ecozones (COSEWIC 2011). Although populations outside the Great Lakes – Western St. Lawrence DU encompass multiple Freshwater Ecozones, they have been combined into one DU as there is insufficient population demographic information to assess them separately and they appear to be free of immediate threat (COSEWIC designation: Not at Risk). The content of this management plan is restricted to the Great Lakes – Western St. Lawrence populations (COSEWIC designation: Special Concern), which encompasses, but is not limited to, the ten lakes in Ontario and Quebec.

Ontario – In Ontario, the Deepwater Sculpin occurs in Fairbank Lake, and lakes Huron, Nipigon, Ontario, and Superior (Figure 2). Young-of-the-year (YOY) have been found in Lake Erie; however, these are believed to have originated in Lake Huron and there is no reproducing population in Lake Erie. Although Cedar Lake in Algonquin Provincial Park was thought to contain Deepwater Sculpin, a survey in 2004 (Sheldon 2006) failed to capture any and it is thought that the original record was a misidentification of a single specimen (most likely a Spoonhead Sculpin [*Cottus ricei*], which are relatively common in this lake) taken from the stomach of a Lake Trout (*Salvelinus namaycush*) in the 1960s (Martin and Chapman 1965).

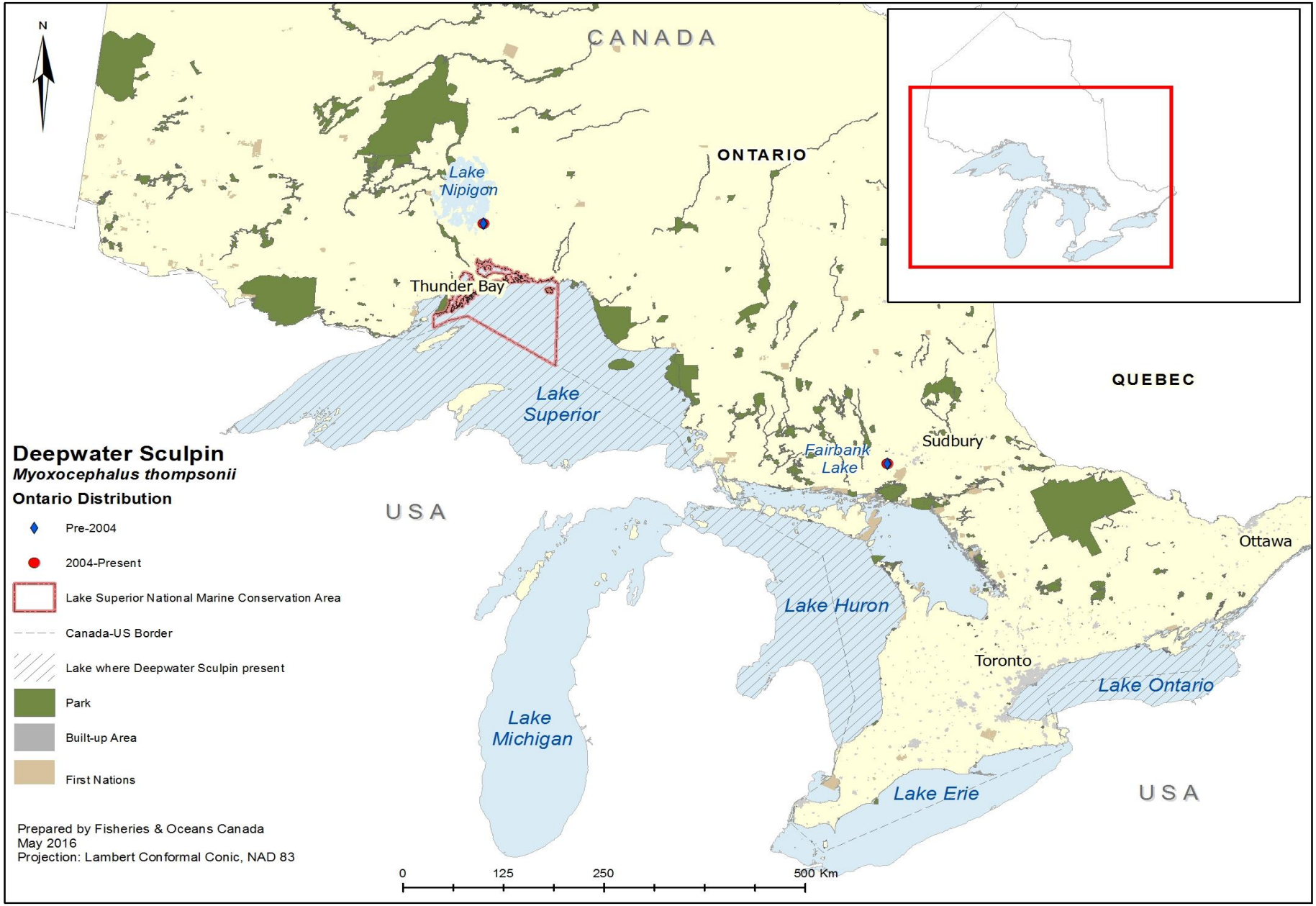

Figure 2. Distribution of Deepwater Sculpin (Great Lakes – Western St. Lawrence population) in Ontario.

Quebec – In Quebec, the species occurs in Grand Lac Rond (Roddick), Lac des Iles, as well as Heney and Thirty-One Mile lakes (Figure 3). Populations in Heney Lake and Lac des Iles may be extirpated (Sheldon 2006). Lake Simoneau, near Mont Orford, Quebec, and Lake Memphremagog, also in the Eastern Townships, were thought to contain Deepwater Sculpin but these records were likely misidentifications of the Slimy Sculpin (*C. cognatus*) (COSEWIC 2006).

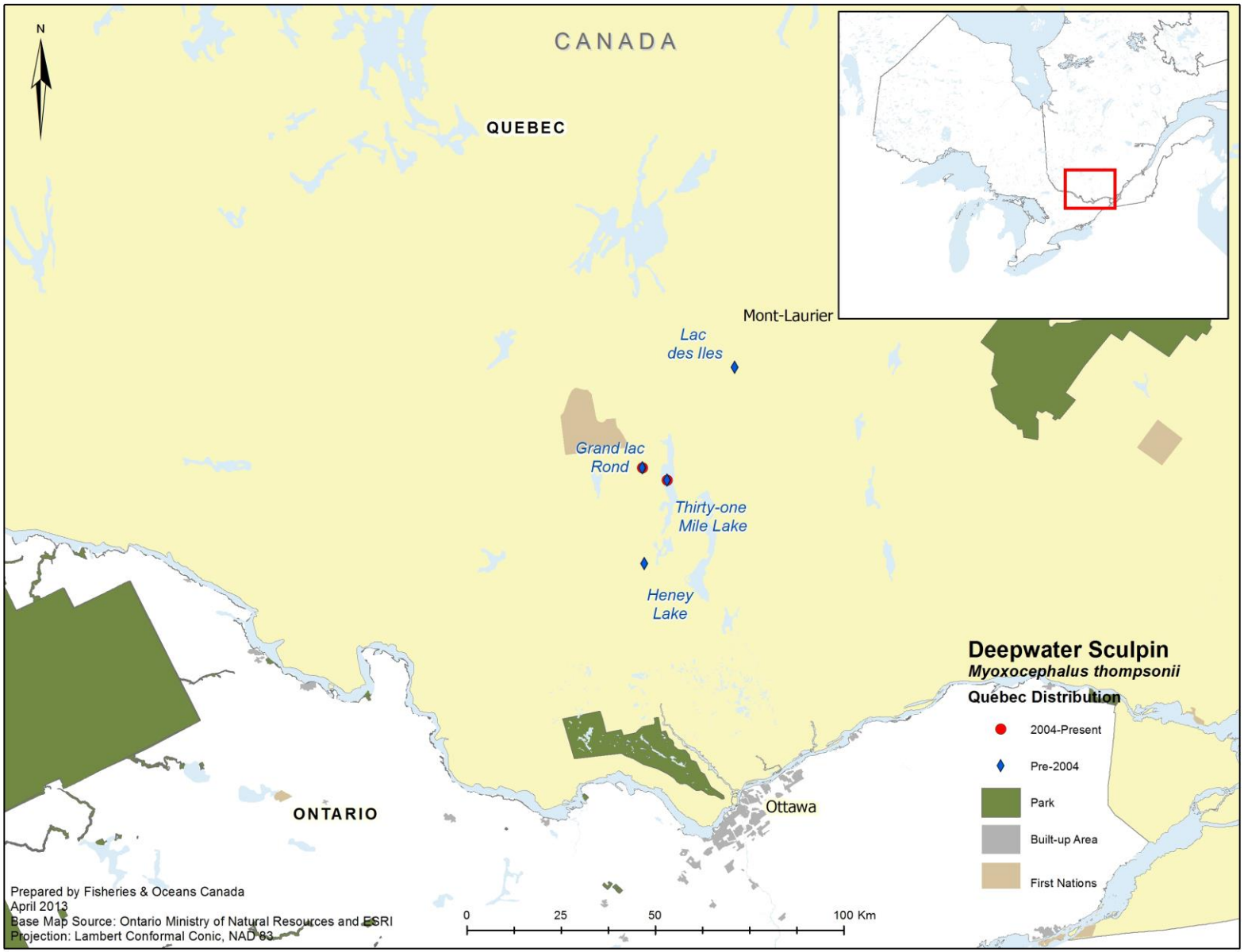

Figure 3. Distribution of Deepwater Sculpin (Great Lakes – Western St. Lawrence population) in Quebec.

Population size, status and trends

Global population size, status and trends: Globally, the Deepwater Sculpin is considered secure with a G5 status[6], while critically imperilled in Alberta, critically imperilled/imperilled in Quebec, imperilled in Manitoba, apparently secure in Ontario, secure in Saskatchewan, and not ranked in Northwest Territories (NatureServe 2015) (Table 1).

Table 1. Global, national and sub-national status for the Deepwater Sculpin.

Canada and U.S. national status (NX) and provincial/state status (SX)	
Global (G)	**G5** (last reviewed 06 September 1996)
National (N)	
Canada	**N4N5**
United States	**N5**
Sub-national (S)	
Canada	Alberta (**SU**), Manitoba (**S2S3**), Northwest Territories (**S3**), Ontario (**S3?**), Quebec (**S1S2**), Saskatchewan (**S5**)
United States	Indiana (**S1S2**), Michigan (**S5**), Minnesota (**SNR**), New York (**S1**), Pennsylvania (**SX**), Wisconsin (**S5**)

Source: NatureServe (2015) (Accessed: March 2013).

Deepwater Sculpin is widely distributed in lakes Superior, Michigan, and Huron and can account for a substantial proportion of the offshore fish biomass. Extensive fish community surveys have been conducted in lakes Huron and Michigan since 1973 (see Madenjian et al. 2010; Riley and Adams 2010). A recent decline in Deepwater Sculpin abundance has been recorded in the American waters of Lake Huron, a trend observed for the majority of deepwater demersal fish species captured in this sampling program (Riley et al. 2008; Riley et al. 2010). Deepwater Sculpin is abundant in Lake Michigan but has recently (since 2007) experienced a decline in abundance after a period of stability (1990 to 2006; Madenjian et al. 2010). It is unknown if this recorded decline reflects an absolute decline in lake-wide Deepwater Sculpin densities or the species is merely occupying deeper waters. Madenjian and Bunnell (2008) have recorded the capture of Deepwater Sculpin at increasingly greater depths since the 1980s and, hence, an increasing proportion of the population may be occupying depths deeper than sampled in the annual fish community surveys. In the American waters of Lake Ontario, Deepwater Sculpin has been consistently caught recently, after no records of capture between 1942 and 1998 (COSEWIC 2006). From 2006 to 2011, a numerical increase in Deepwater Sculpin catch and spatial expansion along the southern shore has been observed from standard assessment trawls, leading to speculation that conditions for the survival of young Deepwater Sculpin are favourable (M. Walsh, United States Geological Survey [USGS], pers. comm. 2011; B. Weidel, USGS, pers. comm. 2012). Based on a long-term indexing program (from 1978), Deepwater

[6]The conservation status of a species or community is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global, N = National, and S = Subnational). The numbers have the following meaning: 1 = critically imperilled; 2 = imperilled; 3 = vulnerable to extirpation or extinction; 4 = apparently secure 5 = demonstrably widespread, abundant, and secure. S#S#: Range rank – A numeric range rank (e.g., S2S3) is used to indicate the range of uncertainty in the status of a species or community. A S2S3 rank would indicate that there is a roughly equal chance of S2 or S3 and other ranks are much less likely; SX: Presumed extirpated; SNR: Unranked. NatureServe Explorer.

Sculpin is fairly widespread in Lake Superior, although a decline in abundance has been observed over this time period (Bronte et al. 2003; Gorman et al. 2010).

Canadian population size, status, and trends: Population estimates for Deepwater Sculpin in Canada are not available. Outside of efforts in the Great Lakes (predominately in American waters), Deepwater Sculpin has not been sampled extensively in a standardized manner and, hence, estimating population sizes and trends is not possible at this time. The number of extant populations is also unknown as many lakes have never been sampled properly or recently. Therefore, population data on Deepwater Sculpin are mostly limited to presence/absence data, while relatively intensive long-term index sampling programs in the Great Lakes provide measures of relative abundance.

The Deepwater Sculpin (Great Lakes – Western St. Lawrence populations) was designated as a species of Special Concern in 2006 by COSEWIC (COSEWIC 2006) and was listed on Schedule 1 of the *Species at Risk Act* (SARA) in 2007. The Deepwater Sculpin is considered Not at Risk in Ontario (Ontario Ministry of Natural Resources and Forestry [OMNRF] 2013) and is designated as a species likely to be threatened or vulnerable under the *Act respecting threatened or vulnerable species* (Chapter E-12.01) in Quebec.

A comprehensive list of sampling efforts is catalogued in the Deepwater Sculpin COSEWIC report and includes information on a recent (Sheldon 2006) survey that specifically targeted Deepwater Sculpin (COSEWIC 2006). Aside from this recent survey, Deepwater Sculpin outside the Laurentian Great Lakes has only been recorded as present, without quantification of abundance.

Ontario

Lake Erie: Mature individuals have not been recorded in Lake Erie; the occasional capture of larvae and juveniles in Lake Erie is thought to result from larval drift from Lake Huron (Roseman et al. 1998).

Fairbank Lake: Six Deepwater Sculpin were captured in a targeted 2004 survey (Sheldon 2006).

Lake Huron: Deepwater Sculpin is occasionally captured in OMNRFs' annual offshore gillnet index but has not been captured since 1998; the survey protocol does not target Deepwater Sculpin (L. Mohr, OMNRF, pers. comm. 2011). The USGS annual deepwater trawl survey includes a station in Canadian waters (only to a maximum trawl depth of 73 m), which has not encountered a Deepwater Sculpin since 2004 (Riley et al. 2010; E. Roseman, USGS, pers. comm. 2011). Based on USGS efforts, Deepwater Sculpin appears to be fairly widely distributed, although in low abundance, with some indication of a recent decline (COSEWIC 2006; Riley et al. 2010).

Lake Nipigon: Two Deepwater Sculpin were captured in a targeted 2004 survey (Sheldon 2006) and, while it is occasionally captured in a fish community index netting program, this survey does not occur in deepwater habitats where Deepwater Sculpin is likely to reside (R. Salmon, OMNRF, pers. comm. 2011).

Lake Ontario: Once considered abundant in the deep waters of the main basin (Dymond et al. 1929), Deepwater Sculpin was rarely recorded in Lake Ontario from the 1940s to the 1990s and, at times, was considered extirpated (e.g., Christie 1973; Scott and Crossman 1973). However, recent genetics research comparing the DNA of Lake Ontario populations (both

historical and current) to those in the upper Great Lakes suggests that Deepwater Sculpin was not actually extirpated from Lake Ontario (Welsh et al. 2012). The near disappearance of Deepwater Sculpin from Lake Ontario has been attributed to the negative effects of Alewife (*Alosa pseudoharengus*) on Deepwater Sculpin abundance (Smith 1970; Owens et al. 2003; Madenjian et al. 2005; Madenjian et al. 2008). The resurgence of Deepwater Sculpin in the mid-1990s was likely driven by a decrease in Alewife abundance in Lake Ontario during 1980-2000 (Owens et al. 2003; Lantry et al. 2007). The OMNRF routine fish community index bottom trawling program in northeastern Lake Ontario has captured 43 specimens since 2005 (30 in 2011), but this program does not target sculpins and only one station is in ideal Deepwater Sculpin habitat (J. Hoyle, OMNRF, pers. comm. 2011). The appearance of gravid females, juveniles, and the increased appearance of recent year-classes provides strong circumstantial evidence that abundance is increasing, successful reproduction is occurring, and conditions for the survival of young are becoming more favourable (COSEWIC 2006; Lantry et al. 2007; J. Hoyle, OMNRF, pers. comm. 2011).

Lake Superior: Deepwater Sculpin appears to be fairly widely distributed and is caught consistently at low densities in Lake Superior (Bronte et al. 2003; Gorman et al. 2010). The USGS Great Lakes Science Center conducts annual daytime bottom trawl surveys each spring, including stations in Canadian waters (see Gorman et al. 2010). These trawls only reach the shallow portion of the Deepwater Sculpins' preferred depth range (15 to 80 m), hence confident statements on the status of this species in Lake Superior are difficult to formulate.

Quebec

In 2004, six specimens were captured in Thirty-One Mile Lake and eight in Grand Lac Rond (Roddick) (Sheldon 2006). No Deepwater Sculpin were found in Lac des Iles or Heney Lake during this sampling exercise.

1.4. Needs of the Deepwater Sculpin

1.4.1. Habitat and biological needs

Spawn to hatch: Little knowledge exists with respect to the generalized requirements for spawning but it appears that Deepwater Sculpin may have an extended spawning period. As such, typical spawning initiation cues, such as changing temperature and photoperiod, may not be appropriate for this species (Parker 1988). In the Great Lakes, Deepwater Sculpin spawning appears to occur during winter (Wells and McLain 1973) with peak hatching in March (Nash and Geffen 1991; E. Roseman, USGS, pers. comm. 2012); it is unknown if similar timing occurs in smaller inland lakes. Spawning migrations and habitat requirements for spawning are largely unknown.

Young-of-the-Year and Juveniles: Juveniles are bottom dwelling, whereas, the larvae use pelagic habitats. Lake Trout and Burbot (*Lota lota*) are major predators of juvenile sculpin, while Alewife target the larval forms (e.g., Madenjian et al. 2002; Gamble et al. 2011).

Adults: Deepwater Sculpin may be restricted to oligotrophic lakes with cold (typically < 7ºC), highly oxygenated water in its deepest regions (Sheldon et al. 2008). An extensive survey by Sheldon (2006) documented Deepwater Sculpin in 20 lakes across Canada, all of which had relatively low nutrient concentrations and low biological production rates. A possible extirpation

of this species in two lakes where it had previously been recorded (Lac des Iles and Heney Lake in the Mont-Laurier region of Quebec) has been hypothesized to be the result of the lakes becoming more eutrophied (Sheldon 2006). Adult Deepwater Sculpin are typically encountered in the deepest parts of resident lakes; in the Great Lakes, adults are most often encountered between 60 and 150 m (COSEWIC 2006). While this species is most often found in relatively deep lakes, it is also encountered in a few lakes that do not exceed 25 m in depth (Sheldon 2006; Steinhilber and Neely 2006).

The Deepwater Sculpin is known to primarily consume two glacial relic crustaceans, *Mysis relica* and *Diporeia* spp. (hereafter referred to as *Diporeia*), along with chironomid larvae (e.g., Hondorp et al. 2005, 2011). Secondary food items can include trichopteran larvae, sphaeriid clams, ostracods, leeches, fish eggs, and small fishes (e.g., Sheldon 2006; O'Brien et al. 2009); presumably the larvae feed on zooplankton.

1.4.2. Ecological role

The Deepwater Sculpin is an important component of deepwater predator-prey interactions. As it is a significant constituent in the diet of several deepwater piscivores (e.g., Lake Trout, Burbot), the Deepwater Sculpin plays a key role in coupling nutrients from energy-rich benthic invertebrates to top-level predators (O'Brien et al. 2009). For example, Gamble et al. (2011) stated that Deepwater Sculpin appears to be the main fish component of piscivorous predator-prey interactions in the offshore waters of Lake Superior. It has been proposed that the health of Deepwater Sculpin populations reflects the general condition of deepwater fish communities and habitat in the Great Lakes (Casselman and Scott 2003; Mills et al. 2003). Additionally, various helminth parasites recovered from Deepwater Sculpin captured across its Canadian range have been reported as adults in Lake Trout or Burbot, which suggests Deepwater Sculpin may play an important role in energetic transfer and parasitic transmission to higher trophic levels (Carney et al. 2009).

1.4.3. Limiting factors

The Deepwater Sculpin has very specific habitat requirements (see 1.4.1. Habitat and biological needs), which have confined it to oligotrophic lakes with low benthic water temperatures and relatively high dissolved oxygen levels (Sheldon 2006). Deepwater Sculpin appears to be highly sensitive to small environmental changes, which include such factors as benthic water temperatures, nutrient and dissolved oxygen levels, and changes in their main prey species (Sheldon 2006). Deepwater Sculpin population dynamics appear to be closely linked to the dynamics of other fish species. Alewife is believed to interfere with reproduction by Deepwater Sculpin through predation on larval sculpin and, therefore, sufficiently high abundances of Alewife is thought to lead to decreases in Deepwater Sculpin abundance in the Great Lakes (Smith 1970; Wells and McLain 1973; Madenjian et al. 2002; Owens et al. 2003; Madenjian et al. 2005; Madenjian et al. 2008).

Sheldon et al. (2008) encountered Deepwater Sculpin in 20 lakes and never found Deepwater Sculpin and Spoonhead Sculpin in the same lakes together, which seemed to suggest that competitive exclusion may occur between these species outside of the Great Lakes [they coexist in Lake Superior (Selgeby 1988) and lakes Huron and Ontario (Dadswell 1972)]. However, according to Dadswell (1972), they also coexist in Thirty-One Mile Lake, and Heney Lake. As the Deepwater Sculpin is relatively long-lived, it may experience low rates of population growth (Sheldon 2006). There has been no indication that the Deepwater Sculpin has expanded its range since the late stages of the Wisconsinan glacial lake phase (Sheldon et

al. 2008), hence it is expected that the species is unable to expand its range or exploit newly suitable habitat on its own.

1.5. Threats

1.5.1. Threat classification

Current and potential threats to the Deepwater Sculpin are listed in Table 2. They are ranked based on their relative impact, spatial extent, and expected severity and have been prioritized starting with the greatest perceived threat to the survival of the species based on the strongest evidence. There may be some variability in the severity and level of concern for some threats for individual populations. For example, changes in water quality, warming, and temperatures associated with climate change are of concern in smaller systems, while not of immediate threat in the Great Lakes. Threat assessment, particularly where evidence is limited, is an ongoing process linked to both species assessment and, where applicable, management. The threat classification parameters are defined as follows:

Extent – spatial extent of the threat in the species range/waterbody (widespread/localized);
Occurrence – current status of the threat (e.g., current, imminent, anticipated);
Frequency – frequency with which the threat occurs in the species range/waterbody (seasonal/continuous);
Causal certainty – level of certainty that it is a threat to the species (High – H, Medium – M, Low - L);
Severity – severity of the threat in the species range/waterbody (H/M/L); and,
Overall level of concern – composite level of concern regarding the threat to the species, taking into account the five parameters listed above (H/M/L).

Table 2. Threat classification table for Deepwater Sculpin (Great Lakes – Western St. Lawrence population).

Threat	Extent (widespread/localized)	Occurrence (current, imminent, anticipated)	Frequency (seasonal/continuous)	Causal certainty (high, medium, low)	Severity (high, medium, low)	Overall level of concern (high, medium, low)
Invasive species and disease	Widespread	Current/ Anticipated	Continuous	High	High	High
Water quality[7]						
Nutrient loading	Widespread	Current	Continuous	High	High	High
Contaminants and toxic substances	Widespread	Current	Continuous	Low	Medium	Medium
Climate change	Widespread	Current/ Anticipated	Continuous	Unknown	Unknown	Medium

1.5.2. Description of threats

The primary threats affecting Deepwater Sculpin appear to be degradation of water quality and invasive species invasions. Industrial, urban, and, agricultural developments have reduced the quality of habitat available to this species, posing a significant threat to its continued survival in inland lakes. Nutrient enrichment may have resulted in the extirpation of the species from two Quebec lakes, while the appearance and persistence of invasive species plays a fundamental role in the structure and function of Deepwater Sculpin populations. Increased abundance of Alewife may have led to the extirpation or near extirpation of Deepwater Sculpin from Lake Ontario during the second half of the 20th century (Smith 1970; Owens et al. 2003; Madenjian et al. 2008).

Invasive species and disease: Dextrase and Mandrak (2006) suggested that, while habitat loss and degradation is the predominant threat affecting aquatic species at risk, invasive species are the second most prevalent threat, affecting 26 of 41 federally listed species across Canada. Fundamental ecological modifications have been noted (e.g., Mills et al. 1993) as has ecological resilience (e.g., Schmidt et al. 2009) in relation to invasive species invasions. Invasive species may affect Deepwater Sculpin through several different pathways, including direct competition for space, habitat and food, predation, and the alteration of food web dynamics.

Riley et al. (2008) and Riley and Adams (2010) suggested the recent invasion of Lake Huron by multiple invasive species at several trophic levels is a major factor responsible for recent declines of the deepwater demersal fish community, including Deepwater Sculpin. It appears that the arrival of Alewife in the Great Lakes had a profound impact on Deepwater Sculpin

[7]Declining water quality from nutrient loading and contaminant inputs is a concern in the smaller systems in Quebec.

dynamics. Alewife has been suspected of interfering with Deepwater Sculpin reproduction by feeding on the pelagic larvae (Smith 1970; Wells and McLain 1973). In Lake Ontario, the near extirpation of Deepwater Sculpin as well as its reduced abundance in Lake Michigan (and likely Lake Huron as well) during the 1960s has been linked to the Alewife invasion. The subsequent decrease in Alewife abundance into the 1970s has been implicated as the main factor in the recovery of the Deepwater Sculpin populations in lakes Michigan and Huron (Madenjian et al. 2008). The continued decline of Alewife abundance in Lake Ontario during the 1990s and 2000s was likely a key factor in the recent signs of a Deepwater Sculpin recovery in Lake Ontario (Owens et al. 2003; Lantry et al. 2007).

An alteration of the Deepwater Sculpin prey assemblage may have occurred as significant declines in *Diporeia* (e.g., Nalepa et al. 2007; Watkins et al. 2007) have been linked to the invasion of dreissenid mussels (e.g., Dermott 2001). Furthermore, speculated interactions with invasive species include the displacement of Deepwater Sculpin by the Round Goby (*Neogobius melanostomus*) (Jude 1997) and egg and larval predation by Round Goby and Rainbow Smelt (*Osmerus mordax*). More recently, Londer (2011) demonstrated a lack of diet overlap between the Round Goby and Deepwater Sculpin and, given that the species are segregated much of the year, displacement appears unlikely.

In Quebec, an invasive aquatic plant species, the Eurasian Watermilfoil (*Myriophyllum spicatum*) is found in Heney and Thirty-One Mile lakes, as well as in Lac des Iles. The direct and indirect effects of this introduction on Deepwater Sculpin are unknown, but the presence of this plant can lead to changes in dissolved oxygen, water temperature, and nutrient levels (Auger 2006; Labelle et al. 2010) that could have deleterious effect on Deepwater Sculpin populations.

The introduction of alien pathogens can also constitute a threat for Deepwater Sculpin. For example, viral hemorrhagic septicaemia (VHS) is a contagious viral disease that affects a variety of fish species in the Great Lakes basin (Whelan 2009; Bain et al. 2010). First identified in the Great Lakes in 2005 (Canadian Cooperative Wildlife Health Centre 2005), this potentially fatal disease has been linked to mass mortalities in several fish species in the region; to date, no cases of VHS have been detected in Quebec. The Canadian Food Inspection Agency (CFIA) implemented a biennial plan to monitor the presence of the VHS virus in Canadian wild fishes in 2007 (CFIA 2011). Given the low population abundance of Deepwater Sculpin in Canada, mass mortalities associated with an alien pathogen, such as VHS, could be highly detrimental to the survival and conservation of the species.

Water quality:
Nutrient loading - Nutrients (nitrogen and phosphorus) enter waterbodies through a variety of pathways, including manure and fertilizer applications to farmland, fish farms, manure spills, sewage treatment plant outfalls, and domestic septic systems. Nutrient enrichment of waterways can negatively influence aquatic health through algal blooms and an associated reduction in dissolved oxygen concentrations. The decline and/or loss of Deepwater Sculpin in two Quebec lakes has been linked to a change in the trophic status of the lakes suggesting that eutrophication of lakes could result in the extirpation of this species (Sheldon 2006). In 2007, Heney Lake had a total phosphorous concentration averaging 22 ug/l (Carignan 2009), which corresponds to a meso-eutrophic lake according to the Canadian Council of Ministers of the Environment (CCME) standards (Water Quality for the Protection of Aquatic Life). It was determined that more than 1200 kg of phosphorous were being released into the lake every year from a Brook Trout (*S. fontinalis*) in-lake farm established on the lake in 1996, while the lake could only absorb 231 kg. Eventually the fish plant had to stop its activity and was

condemned in 2004 to pay almost $5M in damages to restore the lake environment. Dr. Richard Carignan from Université de Montréal is conducting research on the lake recovery. Eutrophication effects that may be detrimental to Deepwater Sculpin include elevated benthic water temperatures, reduced dissolved oxygen, and the availability of prey items.

Contaminants and toxic substances - Scientists from the International Joint Commission have proposed that the extirpation or near extirpation of Deepwater Sculpin from Lake Ontario may have been due to contaminant effects on Deepwater Sculpin abundance (Scott and Crossman 1973). However, the evidence to support this contention is not strong. To the best of our knowledge, no study has demonstrated a negative effect of contaminants on survival of either adult or larval Deepwater Sculpin. The negative influence of dioxins on reproduction of Lake Trout, which is thought to be one of the species most sensitive to dioxin effects, was sufficiently low by 1980 as to not impede Lake Trout reproduction in Lake Ontario (Cook et al. 2003). Yet, to date, the Lake Trout population in Lake Ontario has not been rehabilitated. A relatively small degree of successful natural reproduction by Lake Trout in Lake Ontario was detected during the early 1990s, but this successful natural reproduction was attributed to a two-week delay in the timing of the spring onshore migration of Alewife (O'Gorman et al. 2000). This two-week delay enabled some of the Lake Trout fry to avoid predation by Alewife. Thus, the recovery of Lake Trout in Lake Ontario appeared to be influenced by Alewife abundance and behaviour rather than contaminant effects. Most likely, this was also true for the recovery of Deepwater Sculpin in Lake Ontario (see Madenjian et al. [2008] for a discussion on varying intensity of Alewife effects on populations of native fish species). Nonetheless, Deepwater Sculpin in smaller systems may be vulnerable to potential levels of contaminant loading that these systems can experience.

Climate change: While climate change-mediated shifts in the distribution of marine fishes have been observed (e.g., Perry et al. 2005), long-term analysis is lacking for freshwater systems. Climate change is expected to have significant effects on aquatic communities of the Great Lakes basin through several mechanisms, including increases in water and air temperatures, lowering of water levels, shortening of the duration of ice cover, increases in the frequency of extreme weather events, emergence of diseases and shifts in predator-prey dynamics (Lemmen and Warren 2004). Additionally, 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. The appearance of new invasive species may be expected to have a greater impact on Deepwater Sculpin than climate change as any alteration of water temperatures may be mitigated by the benthic nature of the fish and the fact that hypolimnetic temperatures may not be significantly affected by warming. Nonetheless, those Deepwater Sculpin inhabiting smaller lakes may be vulnerable to warming temperatures, particularly in locations where they are found at relatively shallow depths.

1.6. Actions already completed or underway

Ontario and Quebec
Recent surveys: Table 3 summarizes recent fish surveys conducted by various agencies within areas of known occurrence of the Deepwater Sculpin in Ontario and Quebec.

Table 3. Summary of recent fish surveys in areas of Deepwater Sculpin occurrence (further survey details are available in (COSEWIC [2006]).

Waterbody	Survey description
Ontario	
Lake Erie	• No targeted sampling occurs.
Fairbank Lake	• No targeted sampling occurs. The only recent survey of Fairbank Lake occurred during a study on the biogeography of Deepwater Sculpin across its Canadian range (Sheldon 2006).
Lake Huron	• USGS conducts annual trawl surveys to assess changes in the deepwater demersal fish community, which includes a station in Canadian waters off Goderich (sampled since 1998). • OMNRF collects Lake Trout diet data annually and no Deepwater Sculpin have been identified in the gut contents of Lake Trout since the program began in 2004 (L. Mohr, OMNRF, pers. comm. 2013).
Lake Ontario	• Although no targeted sampling is occurring, Deepwater Sculpin is caught in annual bottom trawling performed for the purpose of contaminant analysis. Environment and Climate Change Canada and OMNRF occasionally capture the species in a routine fish community index bottom trawling program.
Lake Nipigon	• No targeted sampling occurs. The only recent survey of Lake Nipigon occurred during a study on the biogeography of Deepwater Sculpin across its Canadian range (Sheldon 2006).
Lake Superior	• USGS conducts annual daytime bottom trawl surveys each spring, which includes stations in Canadian waters.
Quebec	
Grand Lac Rond (Roddick)	• No targeted sampling occurs. The only recent survey of Grand Lac Rond occurred during a study on the biogeography of Deepwater Sculpin across its Canadian range (Sheldon 2006).
Heney Lake	• No targeted sampling occurs. The only recent survey of Heney Lake occurred during a study on the biogeography of Deepwater Sculpin across its Canadian range (Sheldon 2006).
Lac des Iles	• No targeted sampling occurs. The only recent survey of Lac des Iles occurred during a study on the biogeography of Deepwater Sculpin across its Canadian range (Sheldon 2006).
Thirty-One Mile Lake	• No targeted sampling occurs. The only recent survey of Thirty-One Mile Lake occurred during a study on the biogeography of Deepwater Sculpin across its Canadian range (Sheldon 2006).

1.7. Knowledge gaps

A combination of factors (e.g., disparate and remote locations, depth of habitat, and lack of economic value) has resulted in a paucity of knowledge concerning Deepwater Sculpin. Therefore, efforts to study the basic biological and habitat needs of the Deepwater Sculpin are desirable. In particular, further understanding of the species' life history with a particular emphasis on spawning characteristics (e.g., timing, fecundity), early life history traits, and sensitivity to nutrient input (eutrophication) is needed. Further surveys are required to determine the current range, abundance, and status of populations in Ontario and Quebec. Lakes where recent sampling failed to detect Deepwater Sculpin within the Great Lakes – Western St. Lawrence DU should be re-sampled. Once there is a better understanding of the distribution and biology of Deepwater Sculpin, additional information will be needed on threats to the survival of the species. Further knowledge is required regarding the apparent disappearance of the Deepwater Sculpin from Lac des Îles. Changes in trophic status and periods of anoxia have been reported in Heney Lake, which could explain the disappearance of this species. Some rehabilitation work has been done on this lake and further monitoring is required. The four lakes in Quebec where the presence of the species has been confirmed are all susceptible to accelerated eutrophication and should be studied and monitored to promote the reestablishment and survival of Deepwater Sculpin.

1.8. Relevant federal and provincial fish habitat and fisheries habitat management legislation

Canada – In Canada, SARA and the *Canadian Environmental Assessment Act,* 2012 (CEAA 2012) directly and indirectly address Deepwater Sculpin management. Section 79 of SARA states that environmental assessments must identify the effects of a project on all species listed at risk in the area. When the CEAA 2012 applies and a species at risk has been identified as a valued ecosystem component within the scope of the review pursuant to that Act, the environmental assessment will take into account, any change that might be caused to aquatic species as defined in s.2(1) of SARA. Furthermore, under s.79 of SARA, during an environmental assessment of a project under CEAA 2012, the competent minister must be notified if the project will affect a listed wildlife species. The Lake Superior National Marine Conservation Area is subject to the *Canada National Conservation Areas Act*, administered by Parks Canada Agency. According to the Act, marine conservation areas shall be managed and used in a sustainable manner that meets the needs of present and future generations without compromising the structure and function of the ecosystems, including the submerged lands and water column, with which they are associated.

Quebec – Several pieces of Quebec's legislation are relevant to Deepwater Sculpin habitat protection. According to *An Act Respecting the Conservation and Development of Wildlife* (R.S.Q., c. C-61.1), no person may carry on an activity in wildlife habitat that might alter any biological, physical, or chemical component peculiar to the habitat of the animal or fish concerned. However, there are exceptions to this, including (but not limited to): activities exempted by regulation; activities carried on in accordance with standards or conditions of management prescribed by regulation; activities authorized by the Minister under the Act; and, activities required to repair damage caused by a catastrophe or to prevent such damage.

Additionally, the *Environment Quality Act* (EQA) (R.S.Q., c. Q-2) protects fish habitat by prohibiting the release or emission into the environment of any contaminant likely to be

prejudicial to wildlife, beyond the quantity or concentration established by the regulations, whether on private or public lands. The EQA also regulates the development and implementation of the Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains that aims to protect lakes and streams. This policy establishes minimum standards that must, under *An Act Respecting Land Use Planning and Development* (R.S.Q., c. A-19.1), be adapted in development plans of regional municipalities. However, in 2004, Sager (2004) observed that the protection provisions of this policy were only marginally applied throughout Quebec. This situation has changed little in recent years. Aside from initiatives by a few municipalities or enhancement projects, in general, there was deterioration in the quality of riparian strips, both in urban and agricultural areas (Boucher and Garceau 2010). Additionally, under the terms of the *Agricultural Operations Regulation* of the EQA, with the exception of fords, it is prohibited as of April 1st, 2005, to allow livestock free access to waterbodies and shorelines.

Ontario – Deepwater Sculpin habitat may also be directly or indirectly protected under the *Environmental Assessment Act* (R.S.O. 1990, c. E.18), *Environmental Protection Act* (R.S.O. 1990, c. E.19), the *Ontario Water Resources Act* (R.S.O. 1990, c. O.40) and the *Endangered Species Act, 2007* (S.O. 2007, c.6).

2. MANAGEMENT

The following management goals and objectives, and the actions required to achieve them, were developed in part through consideration of information presented in the COSEWIC assessment and status report on the Deepwater Sculpin (COSEWIC 2006) as well as recent Deepwater Sculpin survey and research efforts.

2.1. Goal

The long-term goal (> 20 years) of this management plan is to ensure the long-term persistence of Deepwater Sculpin throughout its current and historical distribution in the Great Lakes – Western St. Lawrence DU. Management should be directed towards ensuring the conservation and restoration of habitat for known populations; some separation in management action is expected between Deepwater Sculpin in the Great Lakes compared with smaller lake populations. More quantifiable objectives relating to individual populations will be developed once the necessary sampling and analysis have been completed.

2.2. Objectives

The following short-term objectives, to be considered over the next 5-10 years, have been identified to assist with meeting the long-term goal:

i. To understand the health and extent of existing populations and to determine population and habitat trends;
ii. To improve knowledge of the species' biology, ecology, and habitat requirements;
iii. To evaluate and mitigate threats to the species and its habitat;
iv. To maintain and, where applicable, expand existing populations, and to repatriate healthy self-sustaining populations in locations where the species has been extirpated or reduced, if feasible;
v. To ensure the efficient use of resources in the management of this species; and,

vi. To improve awareness and engage the public in the conservation of the Deepwater Sculpin and cold-water ecosystems as a whole.

2.3. Actions

In an effort to meet the goals and objectives of the management plan, five categories of actions have been identified. These actions comprise the strategies required to protect, maintain, and improve Deepwater Sculpin populations and habitat. Many of these actions can and should be performed in conjunction with other recovery and management teams dealing with individual species and ecosystem-based approaches. Ensuring that Deepwater Sculpin is considered where feasible in surveys, outreach, and educational efforts targeted at species at risk will result in more efficient and cost-effective conservation efforts.

Management priorities for the Deepwater Sculpin have been assigned five key categories as follows:

1. Surveys and monitoring
2. Management and coordination
3. Research
4. Stewardship, habitat protection and improvement, and threat mitigation
5. Outreach and communication

2.3.1. Surveys and monitoring

Surveys targeting Deepwater Sculpin should include the use of standardized sampling techniques (see Section 2.3.3. Research). Potential sites with suitable habitat, and covered by glacial lakes but lacking Deepwater Sculpin records, should be sampled in both provinces. Survey data will be added to existing distribution data and will establish baseline information upon which further management initiatives can be developed. A standardized index population and habitat monitoring program should be coordinated with existing monitoring programs where possible (e.g., OMNRF, surveys for Endangered/Threatened species). A long-term monitoring program will enable assessments of changes/trends in range, population distribution and abundance, key demographic characters, and changes/trends in habitat parameters (i.e., temperature, dissolved oxygen, and nutrient levels).

Actions:

1. Conduct background surveys to confirm current status/abundance at sites of known occurrence.
2. Conduct surveys in areas with suitable habitat and covered by glacial lakes but lacking Deepwater Sculpin records.
3. Integrate the long-term monitoring requirements of Deepwater Sculpin with existing fish community survey efforts, where possible.
4. Monitor the occurrence, abundance and potential arrival of invasive species in Deepwater Sculpin habitat. Where possible, this should be coordinated with relevant ecosystem-based programs.

2.3.2. Management and coordination

Management efforts targeting Deepwater Sculpin should be coordinated with existing relevant management (e.g., Watershed Committees [WC] and Lake Protection Associations [LPA] in Quebec) and recovery teams to facilitate resource and knowledge sharing and to avoid duplication of effort and potential conflicts. Management efforts benefiting Deepwater Sculpin should be included in integrated management plans where possible (e.g., Lake Nipigon Conservation Reserve Resource Management Plan, Lakewide Management Plans, Biodiversity Conservation Plans for the Great Lakes).

As Deepwater Sculpin are present in waterbodies shared by Canada and the U.S., conservation efforts underway in the U.S. may directly affect the health of populations assessed in Canada. Continued coordination with American officials on survey efforts and watershed protection is imperative.

Actions:

1. Collaborate with and share information between relevant groups, initiatives and recovery/management teams (e.g., WC, OMNRF, DFO, PCA, Great Lakes Fishery Commission) to address management actions of benefit to Deepwater Sculpin.
2. Collaborate with American researchers involved in management actions benefiting the Great Lakes, and those involved in regular surveys capturing Deepwater Sculpin (e.g., USGS).
3. Consolidate existing data into a central database, including habitat parameters, to facilitate Deepwater Sculpin data synthesis and transfer in Quebec (ongoing). A central database currently exists in Ontario.

2.3.3. Research

The development of standardized protocols for Deepwater Sculpin sampling is required. For inland lakes, the deployment of cyalume light-stick baited wire minnow traps may be more effective for sampling Deepwater Sculpin compared to the often utilized small-mesh gill nets or traditional basket minnow traps (see Sheldon 2006; Steinhilber and Neely 2006). Current knowledge regarding general biology and threats facing the species is limited. Protection of existing populations and their habitat is the principal foundation of this management plan. A useful starting point for determining the relative importance of habitat for different life stages of Deepwater Sculpin has been developed by way of an area-per-individual model by Minns (2003). To enact viable and targeted protection measures, the development of a comprehensive threat assessment to quantify the impacts of possible threats will be required. It is important to ensure that threats are differentiated by geographic area where necessary.

Actions:

1. Develop standardized protocols for surveying and monitoring Deepwater Sculpin populations.
2. Increase knowledge of Deepwater Sculpin biology, particularly knowledge in areas currently limiting conservation planning (e.g., spawning behaviour, reproductive life history).
3. Determine the quantity and quality of habitat required to ensure long-term conservation of Deepwater Sculpin and to support the long-term management goal.
4. Investigate the feasibility of population supplementation or repatriation for populations that may be extirpated or reduced. Develop a repatriation plan where appropriate.

5. Gather information on population dynamics of Deepwater Sculpin and the associated fish community, with particular emphasis on understanding the degree to which predator (Alewife, Lake Trout, Rainbow Smelt, etc.) and prey (*Diporeia*, *Mysis*, etc.) abundances impact population dynamics.
6. Conduct a threat assessment, to evaluate threat factors that may be impacting the Deepwater Sculpin (e.g., invasive species, eutrophication, diseases), which will be updated as new information becomes available.
7. Determine the mechanisms that have led to the loss/decline of Deepwater Sculpin in Lac des Iles.

2.3.4. Stewardship, habitat protection and improvement and threat mitigation

Active promotion of stewardship activities will raise community support and awareness of conservation issues regarding the Deepwater Sculpin as well as cold-water ecosystems, and increase awareness of opportunities to improve cold-water habitats and land management practices that affect these ecosystems. Habitat improvement activities should be coordinated with existing groups and initiatives (e.g., ecosystem-based recovery programs), and direction, technical expertise/contacts, and information on financial incentives (i.e., existing funding opportunities for private landowners) should be provided. Where possible, habitat improvement activities and Best Management Practices (BMPs) should be targeted at areas where there are identified threats to inland Deepwater Sculpin populations.

Actions:

1. Coordinate stewardship activities with existing groups and initiatives.
2. Promote stewardship initiatives (e.g., federal/provincial funding programs) related to Deepwater Sculpin conservation and ensure that information related to funding opportunities for interested parties is made available.
3. Encourage the implementation of BMPs relating to livestock management, the establishment of riparian buffers, nutrient and manure management and tile drainage as a means of reducing nutrient inputs into inland lakes in Quebec where Deepwater Sculpin are resident.

2.3.5. Outreach and communication

Despite its listing under SARA, the Deepwater Sculpin is not widely known, and communication and education materials relating to Deepwater Sculpin are limited. Therefore, it is crucial to engage the cooperation of all appropriate landholders in nutrient and invasive species control efforts and raise awareness regarding the Deepwater Sculpin. The Deepwater Sculpin should be included in existing communication and outreach programs for both ecosystem-based recovery as well as Endangered and Threatened aquatic species recovery to ensure the efficient use of resources, and to instil awareness of the need to protect freshwater fishes and ensure the health of cold-water ecosystems.

Actions:

1. Include the Deepwater Sculpin in existing and future communication and outreach programs for both ecosystem-based recovery as well as Endangered and Threatened aquatic species recovery.

2. Promote awareness with municipal planning offices and planning officials to develop and adopt land management practices that minimize impacts on Deepwater Sculpin.
3. Develop and distribute educational materials to interested parties (e.g., conservation biologists) that provide the key characteristics that distinguish the cottid species.
4. Increase public awareness of the impacts of invasive species on the natural ecosystem and encourage the use of existing invasive species reporting systems.

2.4. Effect on other species

In addition to improving lake water quality, which supports Deepwater Sculpin, the proposed management actions are expected to have a net positive effect on other syntopic native species. While there is potential for conflicts with other species at risk (both aquatic and semi-aquatic) during implementation of management actions, this possibility will be minimized through strong coordination among the various recovery teams and groups/government agencies that may be working on species at risk and habitat management within the range of the Great Lakes-Western St. Lawrence populations of Deepwater Sculpin. Many of the stewardship and habitat improvement activities will be implemented through ecosystem-based recovery programs that have already taken into account the needs of other species at risk.

3. PROPOSED IMPLEMENTATION SCHEDULE

Fisheries and Oceans Canada (DFO) encourages other agencies and organizations to participate in the conservation of the Deepwater Sculpin through the implementation of this management plan. Table 4 summarizes those actions that are recommended to support the management goals and objectives. The activities implemented by DFO will be subject to the availability of funding and other required resources. Where appropriate, partnerships with specific organizations and sectors will provide the necessary expertise and capacity to carry out the listed action. However, this identification is intended to be advice to other agencies, and carrying out these actions will be subject to each agency's priorities and budgetary constraints. (Note that the list of participating agencies is not meant to be an exhaustive list.)

Table 4. Implementation schedule.

Action	Management Objectives[8]	Priority	Threats addressed[9]	Participating agencies[10]		Approximate timeframe[11]
				Ontario	Quebec	
2.3.1. Surveys and monitoring (populations and habitat)						
1. Conduct baseline surveys to confirm current status/abundance	i	Necessary	All	DFO, OMNRF	DFO, MFFP	2016-2021
2. Conduct surveys in areas with suitable habitat	i	Necessary	All	DFO, OMNRF	DFO, MFFP	2016-2021
3. Integrate long-term monitoring with existing efforts	i	Necessary	All	DFO, OMNRF	DFO, MFFP	2016-2021
4. Monitor occurrence of invasives	iii	Beneficial	Invasives	DFO, OMNRF	DFO, MFFP	2016-2021
2.3.2. Management and coordination						
1. Collaborate with and share information between relevant groups etc.	v	Necessary	All	DFO, OMNRF, PCA, USGS	DFO, MFFP	2017-2022
2. Collaborate with American researchers	i-v	Necessary	All	DFO, OMNRF, USGS	DFO, MFFP	2016-2021
3. Consolidate data into centralized databases	v	Beneficial	All	DFO, OMNRF	DFO, MFFP	2017-2022
2.3.3. Research						

[8] Refer to Section 2.2 Objectives.
[9] Refer to Section 1.5.2. Description of threats.
[10] Refer to Section 6. Acronyms.
[11] Timeframes are subject to change in response to demands for resources.

1. Develop standardized protocol for sampling Deepwater Sculpin	v	Necessary	All	DFO, OMNRF	DFO, MFFP	2016-2018
2. Increase knowledge of species' biology	ii	Necessary	All	DFO, OMNRF, AI	DFO, MFFP, AI	2016-2021
3. Determine habitat quantity and quality to ensure long-term conservation	i	Necessary	All	DFO, OMNRF, AI	DFO, MFFP, AI	2016-2021
4. Investigate feasibility of repatriations	iv	Beneficial	All	DFO, OMNRF, USGS, AI	DFO, MFFP, AI	2017-2022
5. Investigate population dynamics	i	Necessary	All	DFO, OMNRF, AI, USGS	DFO, MFFP, AI	2016-2021
6. Conduct threat assessment	iii	Necessary	All	DFO, OMNRF, AI	DFO, MFFP, AI	2016-2021
7. Determine mechanisms that have led to loss/decline in Lac des Iles	iii, iv	Necessary	All	DFO, OMNRF, AI	DFO, MFFP, AI	2017-2022

Table 4 (Cont'd). Implementation schedule.

Action	Management Objectives[8]	Priority	Threats addressed[9]	Participating agencies[10]		Approximate timeframe[11]
				Ontario	Quebec	
2.3.4. Stewardship, habitat protection and improvement, and threat mitigation						
1. Coordinate stewardship activities	v, vi	Necessary	All	DFO, OMNRF	DFO, MFFP, WC	2016-2021
2. Promote stewardship initiatives	iv, vi	Necessary	All	DFO, OMNRF	DFO, MFFP, WC, FFC	2016-2021
3. Encourage BMP implementation	iv, vi	Necessary	All	DFO, OMNRF	DFO, MFFP, WC	2016-2021
2.3.5. Outreach and communication						
1. Include Deepwater Sculpin in existing/future communication and outreach programs	vi	Necessary	All	DFO, OMNRF	DFO, MFFP, WC	2016-2021
2. Promote awareness with planning offices	vi	Beneficial	All	DFO, OMNRF	DFO, MFFP, WC	2016-2021
3. Develop educational materials for cottid species	vi	Beneficial	All	DFO, OMNRF	DFO, MFFP	2016-2021
4. Promote public awareness regarding impacts of invasive species	iii, vi	Beneficial	Invasive species	DFO, OMNRF, PCA	DFO, MFFP	2016-2021

4. ASSOCIATED PLANS

There are a few non-benthic species at risk with ranges overlapping those of the Deepwater Sculpin in Quebec and Ontario (e.g., Shortnose Cisco [*Coregonus reighardi*], Kiyi [*C. kiyi*]) that have single- or multi-species recovery strategies/management plans in development or completed. Recovery initiatives within these strategies/plans may also provide some benefit for Deepwater Sculpin. Additionally, there are also numerous watershed-based management plans and initiatives that could benefit the Deepwater Sculpin, including Great Lakes Lakewide Management Plans, Lake Nipigon Conservation Reserve Resource Management Plan, Fish and Fish Habitat Management Plans, and Source Water Protection Planning. In Quebec, several integrated resource and sustainable development management initiatives are currently underway within the range of the Deepwater Sculpin, most notably WC and LPA committees.

In Quebec, Heney and Thirty-One Mile lakes, as well as the Grand Lac Rond, are in the watershed under the responsibility of the “Agence de Bassin Versant des Sept”, while Lac des Iles is in the territory covered by the “Comité du Bassin Versant de la Rivière La Lièvre”. A LPA is present in each lake where Deepwater Sculpin actual or historic presence has been confirmed in Quebec: the “Association du Grand Lac Rond (lac Roddick)”, the “Association pour la Protection du Lac des Trente et Un Miles”, the “Association de Protection du Lac des Îles” and the “Association pour la Protection du Lac Heney”.

These organizations are involved in different activities to protect, conserve, and improve the quality of the watershed or lake under their responsibilities. Riparian vegetation protection and restoration, domestic septic installation inspections and improvement, land-use management, invasive species prevention and control, and education and public awareness, are some of the activities that help to maintain or improve the water quality, which will indirectly benefit Deepwater Sculpin. Many municipalities and regional county municipalities are also involved in the regulation and promotion of similar activities. One of the leading purposes for these actions is to address the repetitive occurrence of blue-green algal blooms in recent years in many lakes, which has a negative impact on their recreation potential.

An interesting example is the Heney Lake restoration project, which is attempting to reduce phosphorus enrichment of the lake, in part, caused by the operation of a commercial fish-farm between 1994 and 1999 (Carignan 2009).

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6. ACRONYMS

AI	Academic Institutions
BMP	Best Management Practices
CFIA	Canadian Food Inspection Agency
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
DNR	Department of Natural Resources
DU	Designatable Unit
FFC	Fédération de la Faune du Québec
LPA	Lake Protection Association
MFFP	Ministère des Forêts, de la Faune et des Parcs du Québec
OMNRF	Ontario Ministry of Natural Resources and Forestry
USGS	United States Geological Survey
SARA	*Species at Risk Act*
SEA	Strategic Environmental Assessment
TL	Total Length
VHS	Viral Hemorrhagic Septicemia
WC	Watershed Committee