Species at Risk Act
Recovery Strategy Report Series

Report on the Progress of Management Plan Implementation for the Deepwater Sculpin, (*Myoxocephalus thompsonii*) in Canada (Great Lakes-Western St. Lawrence Populations) for the Period 2016 to 2021

Deepwater Sculpin, Great Lakes-Western St. Lawrence Populations

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Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[1] agreed to establish complementary legislation and programs that provide for protection of species at risk throughout Canada. Under Section 46 of the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the competent ministers are responsible for reporting on the implementation of the management plan for a species at risk, and on the progress towards meeting its objectives within 5 years of the date when the management plan was placed on the Species at Risk Public Registry and in every subsequent 5 year period.

Reporting on the progress of management plan implementation requires reporting on the collective efforts of the competent minister(s), provincial and territorial governments and all other parties involved in conducting activities that contribute to the species' conservation. Management plans identify broad strategies and approaches that will provide the best chance of conserving species at risk to prevent them from becoming threatened or endangered. Some of the identified strategies and approaches are sequential to the progress or completion of others and not all may be undertaken or show significant progress during the timeframe of a report on the progress of management plan implementation (progress report).

The Minister of Fisheries and the Minister responsible for Parks Canada are the competent ministers under SARA for the Deepwater Sculpin Great Lakes-Western St. Lawrence Populations and have prepared this progress report.

As stated in the preamble to SARA, success in the conservation of species at risk depends on the commitment and cooperation of many different groups that will be involved in implementing the directions set out in the management plan and will not be achieved by Fisheries and Oceans Canada (DFO) and Parks Canada, 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 the management plan for the Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) for the benefit of the species and Canadian society as a whole.

Acknowledgments

This progress report was prepared by Joshua Stacey, Annabelle Mercier-Morache and France Pouliot (DFO). To the extent possible, this progress report has been prepared with information and data provided by Mark Vinson, Daniel Yule, Darryl Hondorp, Ed Roseman, Brian Weidel and Brian O'Malley (United States Geological Survey). Some of the data provided through them was made available from the New York State Department of Environmental Conservation, the Ontario Ministry of Natural Resources and Forestry, and the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs. DFO would also like to express its appreciations to all individuals and organizations who have contributed to the conservation of the Deepwater Sculpin and have reviewed this document.

[1] The Quebec government has not signed the 1996 Accord for the Protection of Species at Risk.

Executive Summary

The Deepwater Sculpin (*Myoxocephalus thompsonii*) Great Lakes-Western St. Lawrence Populations were listed as special concern under SARA in 2007. The Management Plan for Deepwater Sculpin (*Myoxocephalus thompsonii*) in Canada (Great Lakes-Western St. Lawrence Populations) was finalized and published on the Species at Risk Public Registry in 2016.

The primary threats identified for the Deepwater Sculpin include: invasive species and disease; water quality issues including nutrient loading and contaminant and toxic substances; and climate change.

The management goal as identified in the management plan for this species is to ensure the long-term persistence of Deepwater Sculpin throughout its current and historical distribution in the Great Lakes – Western St. Lawrence designatable unit (DU). Management should be directed towards ensuring the conservation and restoration of habitat for known populations; some distinction between management actions is expected between Deepwater Sculpin in the Great Lakes compared with smaller lake populations. The short-term objectives to be implemented over a 5 to 10 year time period include:

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

This report documents the progress of management plan implementation for Deepwater Sculpin between 2016 and 2021. It summarizes progress that Fisheries and Oceans Canada, the governments of Quebec and Ontario, the United States Geological Survey, United States Environmental Protection Agency, New York State Department of Environmental Conservation, academic institutions, and other interested parties have made towards achieving the goals and objectives set out in the management plan including:

- conducting annual trawling surveys in Lakes Superior, Huron, and Ontario to better understand the population trends of Deepwater Sculpin within the Great Lakes (as a result of the COVID-19 pandemic, sampling was greatly restricted in 2020 and 2021)
- conducting research projects to improve our knowledge of Deepwater Sculpin genetics, life history, fish community interactions, and to model population trends in the Great Lakes
- conducting threat assessments to evaluate threat factors that may be impacting Deepwater Sculpin (for example, invasive species, contaminants, and toxic substances)
- collaborating through existing networks, such as the Cooperative Science and Monitoring Initiative to coordinate implementation of management actions of benefit to Deepwater Sculpin
- promoting aquatic species awareness, reporting, and monitoring

Collectively, these ongoing and/or completed activities indicate that substantial progress has been made towards achieving the management objective for Deepwater Sculpin in Canada. Continued fish community sampling in the Great Lakes paired with population modelling has revealed temporal trends in Deepwater Sculpin abundance and distribution. However, a number of research questions stemming from the management plan remain unanswered. For example, further research and surveys are required to understand the current status of Deepwater Sculpin in inland lakes of Ontario and Quebec. Similarly, further sampling is needed on the Canadian waters of Lake Huron, including Georgian Bay where Deepwater Sculpin was historically detected. Additionally, the quantity and quality of habitat required to ensure long-term conservation of Deepwater Sculpin to support the management goal remains to be determined. For this reason, it may be beneficial to focus future management activities on addressing these knowledge gaps.

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1. Introduction

The "Report on the Progress of Management Plan Implementation for the Deepwater Sculpin (*Myoxocephalus thompsonii*) in Canada (Great Lakes-Western St. Lawrence Populations) for the Period 2016[2] to 2021" outlines the progress made towards meeting the objectives and implementing the actions listed in the management plan for the Deepwater Sculpin from 2016 to 2021 Management Plan for the Deepwater Sculpin (*Myoxocephalus thompsonii*) in Canada (Great Lakes-Western St. Lawrence populations) (DFO 2016) and should be considered as part of a series of documents for this species that are linked and should be taken into consideration together; including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports (COSEWIC 2006; COSEWIC 2017) and the management plan.

Section 2 of the progress report reproduces or summarizes key information on the threats to the species, the management goal and objectives for achieving its conservation, and approaches to meeting these objectives. For more details, readers should refer back to the management plan. Section 3 reports the progress of implementing activities identified in the management plan while section 4 summarizes the progress of actions taken toward achieving its objectives.

2. Background

2.1 COSEWIC assessment summary

The listing of the Deepwater Sculpin in 2007, which led to the development and publication of the Management Plan for Deepwater Sculpin (*Myoxocephalus thompsonii*) in Canada (Great Lakes-Western St. Lawrence Populations) in 2016 was based on the information provided in the COSEWIC Status Report (COSEWIC 2006). This information has also been included in Section 1.1 of the management plan.

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 extirpated in Lake Ontario, it now appears to be re-established in that lake, albeit in small numbers. Populations have been extirpated 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 Mussels.
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.

[2] This document primarily represents the 2016-2021 time period; however, in some cases progress that occurred in 2013 to 2015 (the time period when the management plan was waiting to be posted) that was not covered in the management plan, but is considered pertinent to measures prescribed for implementation, is reported.

In 2017, COSEWIC re-examined and confirmed the status of the Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) as “special concern” (COSEWIC 2017).

Date of assessment: April 2017
Common name (population): Deepwater Sculpin (Great Lakes – Western St. Lawrence populations)
Scientific name: *Myoxocephalus thompsonii*
COSEWIC status: Special concern
Reason for designation: This small-bodied fish occurs in the deeper parts of at least 11 coldwater lakes in Ontario and Quebec, including lakes Superior, Huron and Ontario. Previously, it was thought to be extirpated in Lake Ontario, but now appears to have re-established in that lake, with catches currently comparable to those in lakes Huron and Michigan. The population in 1 lake in Quebec may be extirpated due to eutrophication; the threat of invasive species is ongoing in the other lakes.
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. Status re-examined and confirmed in April 2017.

3. Distribution

Since 2016, Deepwater Sculpin has continued to be detected through bottom trawl surveys in Lakes Superior, Huron, and Ontario, and larval sampling has led to detections in the St. Marys River and the Huron Erie Corridor. Tables 1 to 4 list historical and recent records of Deepwater Sculpin within the Canadian waters of Lakes Superior, Huron, and Ontario that resulted from surveys conducted by the United States Geological Survey (USGS), the New York State Department of Environmental Conservation (NYSDEC), the Ontario Ministry of Natural Resources and Forestry (MNR), and from the Royal Ontario Museum’s (ROM) records. Figures 1 to 3 display historical and recent records of the species throughout Lakes Superior, Huron, and Ontario including both United States (US) and Canadian waters. Table 5 lists historical and recent records of Deepwater Sculpin within various inland lakes that are part of the Great Lakes and Upper St. Lawrence River watershed found in Ontario including Upper and Middle Shebandowan lakes, Dog Lake, Walotka Lake, Sparkling Lake, Lake Nipigon, Obonga Lake, Little Moraine Lake, Wakomata Lake, Bay Lake, Matinenda Lake, Fairbank Lake, and Raven Lake from data sources including MNR, the Canadian Distribution Database, University of Manitoba, and the ROM. The distribution of Deepwater Sculpin in the aforementioned inland lakes of Ontario are displayed in figures 4 to 13. Table 6 lists historical and recent records of Deepwater Sculpin within various inland lakes that are part of the Great Lakes and Upper St. Lawrence River watershed found in Quebec including Lac Heney, Roddick Lake/Grand Lac Rond, Lac Des Iles, Lac des Trente et Un Milles, Lac des Écorces, and Lac Pemichagan from the ROM database, the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP), Sheldon et al. 2008, and Kilgour 2017. The distribution of Deepwater Sculpin in these inland lakes of Quebec are displayed in figures 14 to 16. Table 7 lists historical and recent records of Deepwater Sculpin larvae detected in the St. Marys River, Lake Huron, the St. Clair River, Lake St. Clair, the Detroit River, and the Western Basin of Lake Erie in both Canadian and US waters. The locations where larvae were detected in these waterbodies are displayed in figures 17 to 20.

While further information about the details of these surveys may not be available for all of the records, various USGS reports (for example, Status and trends in the Lake Superior fish

community; Status and trends of the Lake Huron offshore demersal fish community) and collaborative multiagency reports from USGS, NYSDEC, and MNR (for example, Lake Ontario benthic prey fish assessment; bottom trawl assessment of Lake Ontario pelagic prey fishes) that describe sampling effort in the Great Lakes in more detail have been published for certain years. Further details regarding such sampling information from these reports relevant to the focal period of this progress report (2016-2021) will be described in table 9. It is important to note that information provided in tables 1 to 7 serves to provide an account of where Deepwater Sculpin has been detected over time and are not meant to convey changes in abundance or infer population trends. Furthermore, it is important to mention that this species is very cryptic and lives deep in lakes that are often difficult to access; therefore, it is likely that there are undetected populations in other lakes. Tables 1 to 6 are focused on detections of the species within Canadian waters, which is the focus of this progress report. In contrast, figures 1 to 3 (Lake Superior, Lake Huron, and Lake Ontario) include US records to give a visual representation of the entire populations over time. Furthermore, US records are included in table 7 and figures 17, 19 and 20 (St. Marys River and areas of the Huron-Erie Corridor), which show detections of Deepwater Sculpin larvae. These records are included since these figures are focused on connecting rivers where a record on the US side likely infers that larvae may also be found on the nearby Canadian side.

Table 1. Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) detections at Lake Superior nearshore sampling stations in Canadian waters.

Location description	USGS station #	Time period	Years detected (# captured)	Data Source
Little Trout Bay	400	Historic (Pre 2000)	1989 (22), 1990 (13), 1991 (7), 1992 (1), 1993 (1), 1994 (12), 1995 (4), 1997 (2), 1998 (5)	United States Geological Survey (USGS)
Little Trout Bay	400	2000-2016	2002 (1), 2004 (3), 2006 (1), 2007 (1), 2016 (3)	USGS
Pie Island	403	Historic (Pre 2000)	1990 (4), 1991 (1), 1992 (4), 1993 (1), 1994 (3), 1995 (5), 1996 (9), 1998 (1)	USGS
Pie Island	403	2000-2016	2002 (2), 2004 (1), 2005 (1), 2013 (2)	USGS
Thunder Bay	401, 402	Historic (Pre 2000)	1989 (26), 1990 (20), 1991 (30), 1992 (16), 1993 (3), 1994 (8), 1995 (21), 1996 (36), 1997 (22), 1998 (15), 1999 (2)	USGS
Thunder Bay	401, 402	2000-2016	2001 (5), 2003 (2), 2004 (4), 2009 (2), 2011 (1), 2013 (1)	USGS
Thunder Cape		Historic (Pre 2000)	1989 (14), 1990 (16), 1991 (9), 1992 (3), 1993 (4), 1994 (5), 1995 (35), 1997 (12), 1998 (3), 1999 (5)	USGS
Thunder Cape	404	2000-2016	2000 (1), 2002 (2), 2003 (1), 2004 (6), 2015 (1), 2016 (1),	USGS
Thunder Cape	404	2017-2021	2019 (1)	USGS
Black Bay	405, 406, 407, 408	Historic (Pre 2000)	1990 (4), 1991 (3), 1992 (3), 1994 (1), 1996 (2), 1997 (3)	USGS
Black Bay	405, 406, 407	2000-2016	2001 (3), 2002 (2), 2004 (1), 2006 (1)	USGS
Borden Island	410	Historic (Pre 2000)	1994 (2),	USGS
Shesheeb Bay	411	Historic (Pre 2000)	1990 (1)	USGS
Nest Island	N/A	Historic (Pre 2000)	1955 (N/A)	USGS
Nipigon Bay	412, 413, 414, 415	Historic (Pre 2000)	1922 (1), 1989 (1), 1990 (1), 1991 (7), 1992 (4), 1993 (2), 1995 (1), 1996 (1), 1997 (3), 1999 (1)	Royal Ontario Museum (ROM), USGS,
Nipigon Bay	413	2000-2016	2002 (1)	USGS
Simpson Island	416	Historic (Pre 2000)	1989 (2), 1990 (8), 1991 (1), 1992 (2), 1994 (32), 1998 (1)	USGS
Rossport area	417	Historic (Pre 2000)	1990 (7), 1991 (3), 1992 (2), 1993 (1), 1994 (1), 1995 (5), 1996 (1), 1997 (3), 1999 (1)	USGS
Terrace Bay	418	Historic (Pre 2000)	1997 (1)	USGS
Terrace Bay	418	2000-2016	2002 (1)	USGS

Location description	USGS station #	Time period	Years detected (# captured)	Data Source
St. Patrick Island	419	Historic (Pre 2000)	1995 (1), 1996 (1), 1998 (1)	USGS
Santoy Bay	419	Historic (Pre 2000)	1993 (1)	USGS
Ashburton Bay	420	Historic (Pre 2000)	1997 (1)	USGS
Heron Bay	422	2000-2016	2004 (1), 2011 (1), 2016 (4)	USGS
Northeast Coast (Pukaskwa National Park to Michipicoten Bay)	451, 462, 463, 464, 465, 466,	Historic (Pre 2000)	1981 (2), 1989 (5), 1990 (17), 1991 (85), 1992 (167), 1993 (79), 1994 (89), 1995 (78), 1996 (174), 1997 (120), 1998 (53), 1999 (45)	ROM, Canadian Distribution Database, USGS
Northeast Coast (Pukaskwa National Park to Michipicoten Bay)	451, 462, 463, 464, 465, 466,	2000-2016	2000 (12), 2001 (66), 2002 (92), 2003 (90), 2004 (49), 2005 (28), 2006 (31), 2007 (13), 2008 (12), 2009 (10), 2010 (4), 2011 (35), 2012 (80), 2013 (62), 2014 (13), 2015 (60), 2016 (41)	USGS
Northeast Coast (Pukaskwa National Park to Michipicoten Bay)	462, 463, 464, 465, 466	2017-2021	2017 (40), 2018 (17), 2019 (16)	USGS
Michipicoten Island	450	Historic (Pre 2000)	1922 (N/A), 1989 (25), 1990 (2), 1991 (8), 1992 (3), 1994 (3), 1995 (1), 1996 (11), 1997 (3), 1998 (1)	USGS
Michipicoten Island	450	2000-2016	2001 (8)	USGS
Caribou Island	N/A	Historic (Pre 2000)	1954 (1)	ROM
Eastern Coast (Lake Superior Provincial Park)	454, 455, 456, 457,	Historic (Pre 2000)	1989 (325), 1990 (29), 1991 (17), 1992 (10), 1993 (36), 1994 (27), 1995 (25), 1996 (80), 1997 (43), 1998 (76)	USGS
Eastern Coast (Lake Superior Provincial Park)	454, 455, 457	2000-2016	2001 (7), 2002 (8), 2003 (2), 2004 (14), 2005 (5), 2006 (5), 2007 (1), 2008 (38), 2009 (1), 2010 (7), 2011 (6), 2012 (18), 2014 (26), 2015 (10), 2016 (5)	USGS
Eastern Coast (Lake Superior Provincial Park)	454, 455, 456, 457	2017-2021	2017 (11), 2018 (4), 2019 (2)	USGS
Whitefish Bay	459, 460, 461	Historic (Pre 2000)	1990 (3), 1991 (4), 1992 (7), 1993 (6), 1994 (3), 1995 (2), 1996 (10), 1997 (12), 1998 (5)	USGS
Whitefish Bay	459, 460, 461	2000-2016	2000 (13), 2001 (26), 2002 (5), 2003 (1), 2004 (3), 2006 (2), 2008 (3), 2009 (1), 2010 (3), 2011 (19), 2012 (9), 2013 (35), 2014 (27), 2015 (9)	USGS
Whitefish Bay	459, 460, 461	2017-2021	2018 (6)	USGS

Table 2. Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) detections at Lake Superior offshore sampling stations in Canadian waters.

Location description	USGS station #	Time period	Years detected (# captured)	Data source
Central Basin	2155	2000-2016	2012 (247), 2013 (79), 2015 (81)	United States Geological Survey (USGS)
Central Basin	2155	2017-2021	2017 (316), 2018 (128), 2019 (170)	USGS
Central Basin	2127	2000-2016	2011 (181), 2012 (106), 2013 (330), 2015 (430), 2016 (70)	USGS
Central Basin	2127	2017-2021	2017 (492), 2018 (302), 2019 (249),	USGS
Central Basin	753	2000-2016	2012 (150), 2013 (78), 2014 (210), 2015 (104)	USGS
Central Basin	753	2017-2021	2017 (173), 2018 (1), 2019 (351)	USGS
Central Basin	2123	2000-2016	2011 (999), 2016 (414)	USGS
Central Basin	2139	2000-2016	2011 (185), 2012 (1839), 2013 (1009), 2014 (743), 2015 (338), 2016 (9)	USGS
Central Basin	2139	2017-2021	2017 (1200), 2018 (23), 2019 (480)	USGS
Eastern Basin	2135	2000-2016	2011 (45), 2012 (68), 2013 (86), 2014 (58), 2015 (16)	USGS
Eastern Basin	2135	2017-2021	2017 (328), 2018 (14), 2019 (61)	USGS
Eastern Basin	2119	2000-2016	2011 (282), 2012 (328), 2013 (411), 2014 (187), 2015 (111), 2016 (98)	USGS
Eastern Basin	2119	2017-2021	2017 (597), 2018 (247), 2019 (327)	USGS
Eastern Basin	2165	2000-2016	2012 (79), 2015 (30)	USGS
Eastern Basin	2165	2017-2021	2017 (31), 2018 (4), 2019 (49)	USGS
Eastern Basin	2145	2000-2016	2012 (102), 2013 (55), 2014 (8), 2015 (61)	USGS
Eastern Basin	2145	2017-2021	2017 (667), 2019 (128)	USGS
Eastern Basin	2059	2000-2016	2011 (4), 2013 (5), 2014 (17), 2016 (23)	USGS
Eastern Basin	2059	2017-2021	2017 (12), 2019 (7)	USGS
Eastern Basin	2129	2000-2016	2011 (343), 2012 (887), 2013 (909), 2014 (1,277), 2015 (1120), 2016 (438)	USGS
Eastern Basin	2129	2017-2021	2017 (1066), 2018 (1,078), 2019 (597)	USGS
Eastern Basin	2153	2000-2016	2012 (143), 2013 (272), 2014 (8), 2015 (38)	USGS
Eastern Basin	2153	2017-2021	2017 (377), 2019 (132)	USGS

Location description	USGS station #	Time period	Years detected (# captured)	Data source
Eastern Basin	2121	2000-2016	2011 (1,426), 2012 (235), 2013 (917), 2014 (687), 2015 (618), 2016 (420)	USGS
Eastern Basin	2121	2017-2021	2017 (342), 2018 (611), 2019 (679)	USGS
Eastern Basin	2137	2000-2016	2011 (977), 2012 (3,235), 2013 (2,509), 2014 (1,327), 2015 (814), 2016 (1,085),	USGS
Eastern Basin	2137	2010-2019	2017 (327), 2018 (417), 2019 (534)	USGS

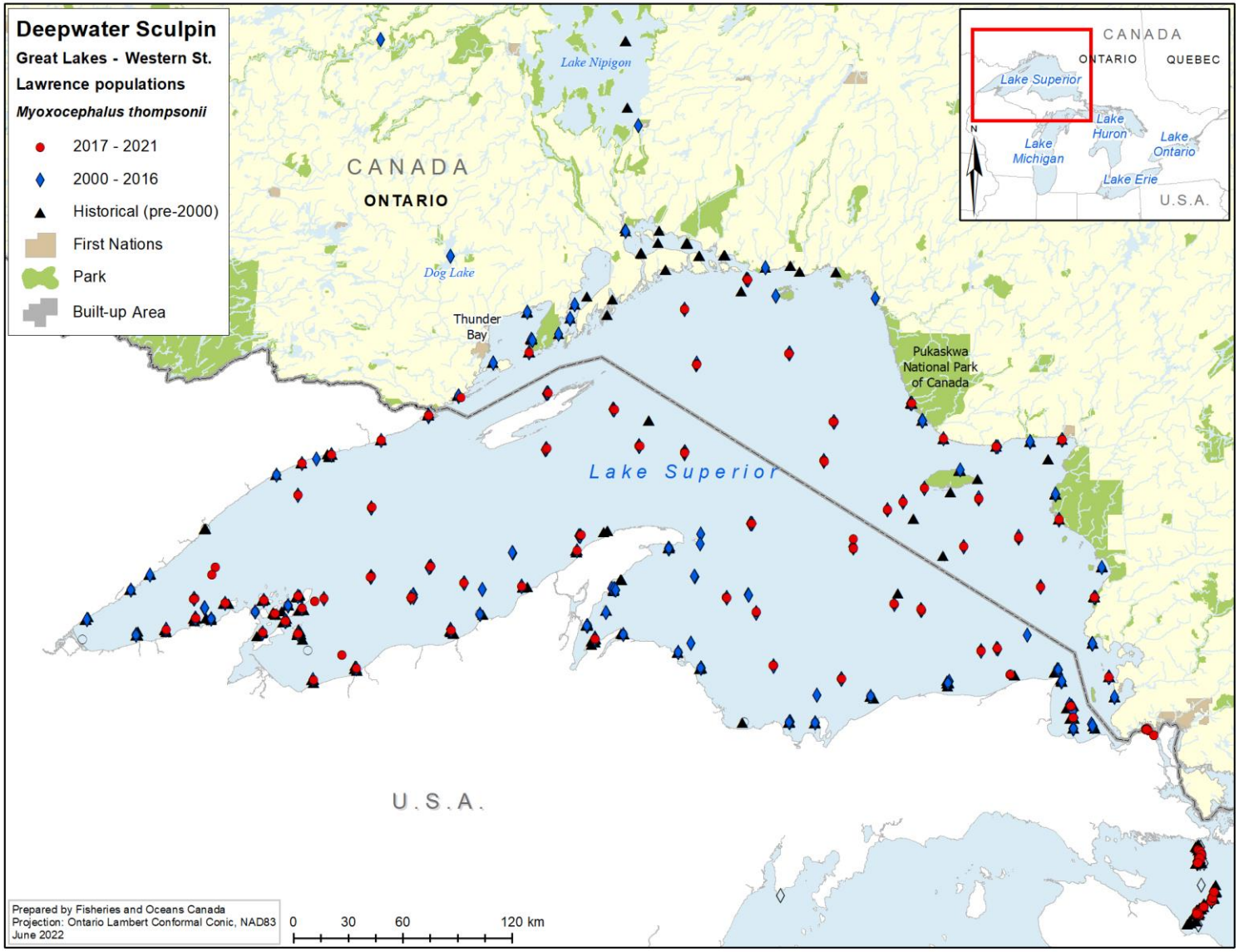

Figure 1. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Lake Superior.

Table 3. Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) detections in Canadian waters of Lake Huron.

Location/port description	USGS station #	Time period	Years detected (# captured)	Data source
Lake Huron (Grid 3425)	N/A	Historic (pre 2000)	1986 (2)	Ontario Ministry of Natural Resources and Forestry (MNR)
Bayfield River outlet area	N/A	Historic (pre 2000)	1998 (10)	Royal Ontario Museum (ROM)
Goderich (near Maitland River outlet)	N/A	Historic (pre 2000)	1977 (47)	ROM
Offshore from Goderich, Ontario[3]	326	Historic (pre 2000)	1998 (4.42), 1999 (0.86)	United States Geological Survey (USGS)
Offshore from Goderich, Ontario	326	2000-2016	2003 (3.43), 2004 (2.57), 2007 (0.86), 2011 (70.39), 2013 (1.77), 2014 (0.86)	USGS
Offshore from Goderich, Ontario	326	2017-2021	2017 (1.71), 2018 (3.43), 2019 (1.71)	USGS
Offshore of Southampton	N/A	Historic (pre 2000)	1960, 1961 (number captured not recorded), 1986 (60)	ROM, MNR
Offshore from Bruce Peninsula (Grid 1730)	N/A	Historic (pre 2000)	1985 (1), 1978 (4)	MNR, ROM
Offshore from Manitoulin Island in main basin	N/A	Historic (pre 2000)	1951 (2)	ROM
Georgian Bay near Lonely Island	N/A	Historic (pre 2000)	1976 (8)	MNR
Georgian Bay near Halfmoon Island	N/A	2017-2021	2019 (6)	Parks Canada, Saugeen Ojibway Nation
Georgian Bay offshore from Cabot Head (Bruce Peninsula)	N/A	Historic (pre 2000)	1979 (1), 1985 (1)	ROM, MNR
Georgian Bay, Owen Sound	N/A	Historic (pre 2000)	1975 (4)	MNR
Georgian Bay Cape Rich area	N/A	Historic (pre 2000)	1979 (3)	MNR
Georgian Bay, Nottawasaga Bay, area 2045	N/A	Historic (pre 2000)	1976 (4)	MNR

[3] The number of Deepwater Sculpin detected by USGS offshore from Goderich is based off of the sum of counts that have been standardized to 10 minute trawl tows (catch per 10 minutes on bottom). For more information see Status and Trends of the Lake Huron Offshore Demersal Fish Community, 1976-2018 (Riley et al. 2019).

Location/port description	USGS station #	Time period	Years detected (# captured)	Data source
Georgian Bay west Of Christian Island	N/A	Historic (pre 2000)	1976 (2)	MNR

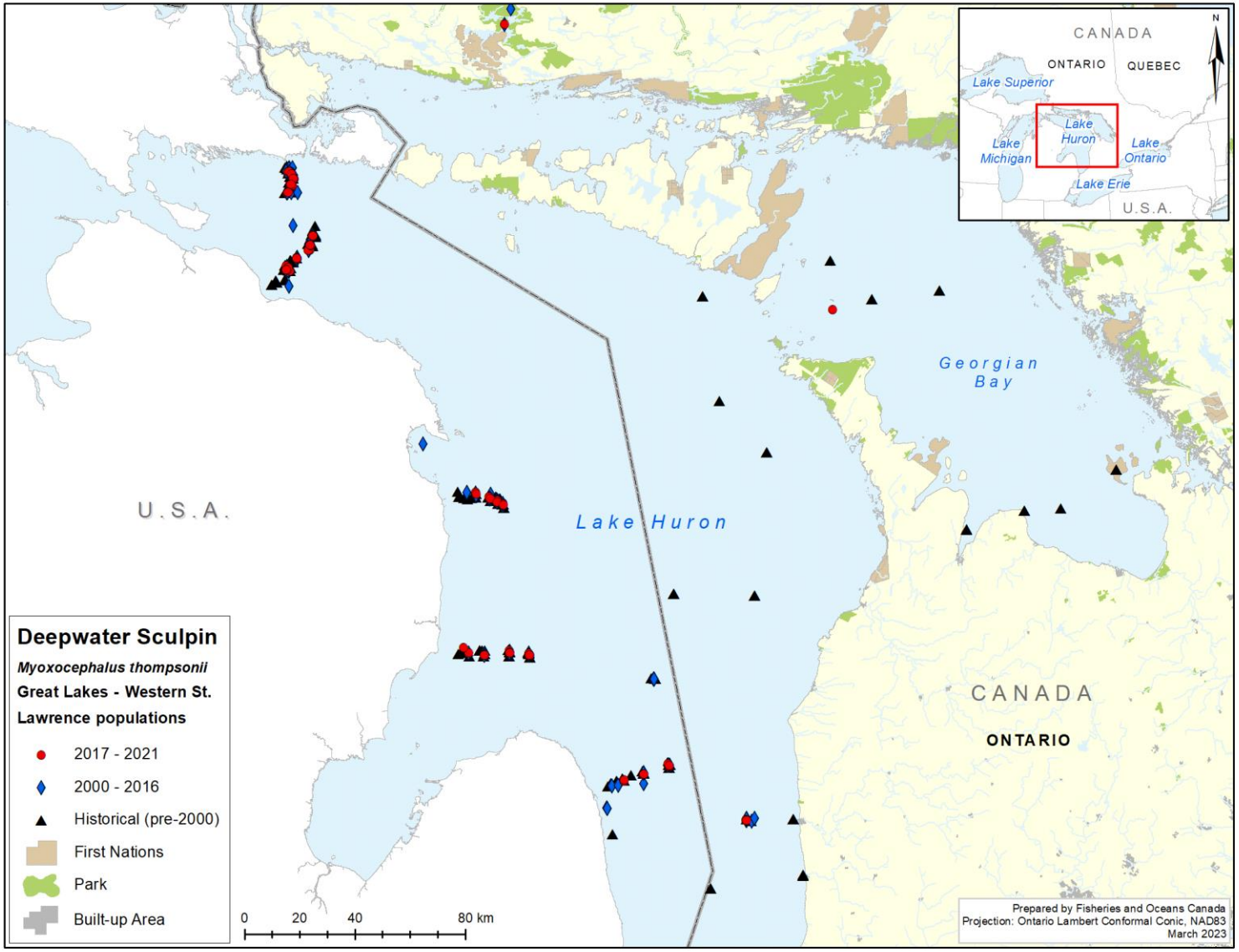

Figure 2. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Lake Huron.

Table 4. Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) detections in Canadian waters of Lake Ontario.

Location/port description	Time period	Years detected (# captured)	Data source
Offshore from Niagara	2000-2016	2005 (1)	Canadian Distribution Database (CDD)
Bay West of Fifty Point	Historic (pre 2000)	1917 (N/A)	CDD
Shell Park Shoreline	Historic (pre 2000)	1917 (N/A)	CDD
Offshore from Hamilton	2000-2016	2015 (11), 2016 (90)	United States Geological Survey (USGS), Ontario Ministry of Natural Resources and Forestry (MNR)
Offshore from Hamilton	2017-2021	2017 (45), 2018 (19), 2019 (47), 2021 (681)	USGS, MNR
Offshore from Oakville	Historic (pre 2000)	1926 (2), 1941 (N/A)	MNR, CDD
Port Credit	Historic (pre 2000)	1926 (N/A), 1927 (139), 1930 (N/A)	CDD, ROM
Offshore of Port Credit	Historic (pre 2000)	1905 (39), 1926 (3), 1927 (111), 1930 (4)	USGS, MNR, CDD, ROM
Offshore of Port Credit	2000-2016	2015 (15), 2016 (103)	USGS, MNR, CDD, ROM
Offshore of Port Credit	2017-2021	2017 (583), 2018 (488), 2019 (1,405), 2021 (699)	USGS, MNR, CDD, ROM
Offshore from Toronto	2000-2016	2015 (478), 2016 (2,229)	USGS, MNR
Offshore from Toronto	2017-2021	2017 (1,521), 2018 (1,037), 2019 (745), 2021 (2,128)	USGS, MNR
Offshore from Pickering	2017-2021	2017 (191), 2018 (90), 2019 (1,011), 2021 (578)	USGS, MNR
Offshore of Oshawa -Whitby	Historic (pre 2000)	1905 (1)	USGS, MNR
Offshore of Oshawa -Whitby	2000-2016	2015 (75), 2016 (769)	USGS, MNR
Offshore of Oshawa -Whitby	2017-2021	2017 (888), 2018 (444), 2019 (470), 2021 (591)	USGS, MNR
Port Darlington Area	Historic (pre 2000)	1931 (N/A),	CDD
Offshore of Bouchette Point	2017-2021	2017 (2,805), 2018 (1,604), 2019 (3,014), 2020 (564), 2021 (5,007)	USGS, MNR
Port Hope - Cobourg	Historic (pre 2000)	1941 (N/A), 1942 (N/A), 1972 (3), 1996 (1)	CDD, ROM, MNR
Port Hope - Cobourg	2000-2016	2015 (289), 2016 (4,104)	USGS, MNR
Port Hope - Cobourg	2017-2021	2017 (7,196), 2018 (6,705), 2019 (8,424), 2020 (1,857), 2021 (9,286)	USGS, MNR
Offshore of Scotch Bonnet National Wildlife Area	2017-2021	2017 (161), 2019 (1,343)	USGS, MNR
Salmon Point	Historic (pre 2000)	1953 (1)	ROM
Offshore of Salmon Point	Historic (pre 2000)	1953 (1), 1963 (4),	MNR
Point Petre	2017-2021	2017 (31), 2018 (2), 2019 (86), 2021 (536)	USGS, MNR

Location/port description	Time period	Years detected (# captured)	Data source
Rocky Point	Historic (pre 2000)	1996 (1)	MNR
Rocky Point	2000-2016	2015 (214), 2016 (2,339)	USGS, MNR
Rocky Point	2017-2021	2017 (4,144), 2018 (833), 2019 (992), 2020 (696), 2021 (2,331)	USGS, MNR
Offshore from Marys Cove	Historic (pre 2000)	1996 (1)	MNR
Adolphus Reach	2017-2021	2019 (1)	USGS, MNR
Main Duck Island	Historic (pre 2000)	1928 (2)	ROM
Offshore from Duck Islands	2000-2016	2015 (1)	USGS, MNR
Offshore from Duck Islands	2017-2021	2020 (1)	USGS, MNR

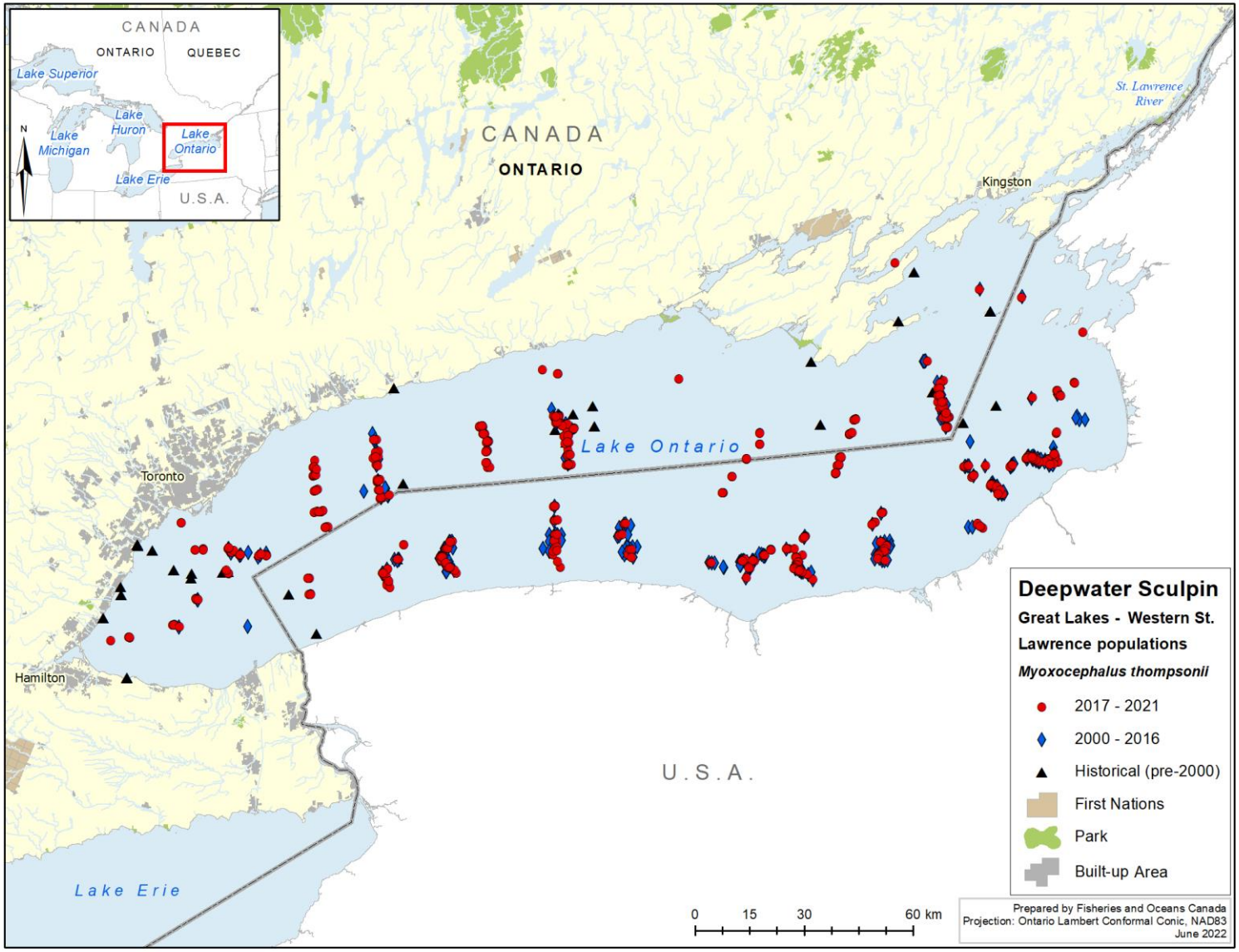

Figure 3. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Lake Ontario.

Table 5. Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) detections inland lakes of Ontario.

Lake	Location	Time period	Years detected (# captured)	Data source
Upper Shebandowan Lake	N/A	2017 to 2021	2018 (7)	Ontario Ministry of Natural Resources and Forestry (MNR)
Middle Shebandowan Lake	Near Martin Bay	2017 to 2021	2018 (7)	MNR
Dog Lake	Near Big Island	2000 to 2016	2013 (1)	MNR
		2017 to 2021	2018 (3)	MNR
Walotka Lake	N/A	2017 to 2021	2018 (2)	MNR
Sparkling Lake	N/A	2000 to 2016	2013 (2)	MNR
Lake Nipigon	Offshore northeast of Gillespie Island	Historic (pre 2000)	1921 (N/A), 1922 (N/A), 1925 (N/A)	CDD
Lake Nipigon	Southeast of Cedar Island	Historic (pre 2000)	1922 (N/A)	CDD
Lake Nipigon	Offshore east of Green Mountain	2000 to 2016	2004 (2)	University of Manitoba
Lake Nipigon	Offshore of Dawson Island	2017 to 2021	2018 (7), 2019 (12)	MNR
Obonga Lake	N/A	2017 to 2021	2018 (1)	MNR
Little Moraine Lake	N/A	2000 to 2016	2016 (3)	MNR
Wakomata Lake	N/A	2017 to 2021	2018 (4)	MNR
Bay Lake	N/A	2000 to 2016	2016 (4)	MNR
Matinenda Lake	Near Merseth's Bay	2000 to 2016	2014 (2), 2018 (10)	MNR
Fairbank Lake	Main Basin	Historic (pre 2000)	1970 (N/A)	CDD
Fairbank Lake	Main Basin	2000 to 2016	2004 (6), 2016 (1)	University of Manitoba, MNR
Raven Lake	Main Basin	Historic (pre 2000)	1970 (3)	ROM

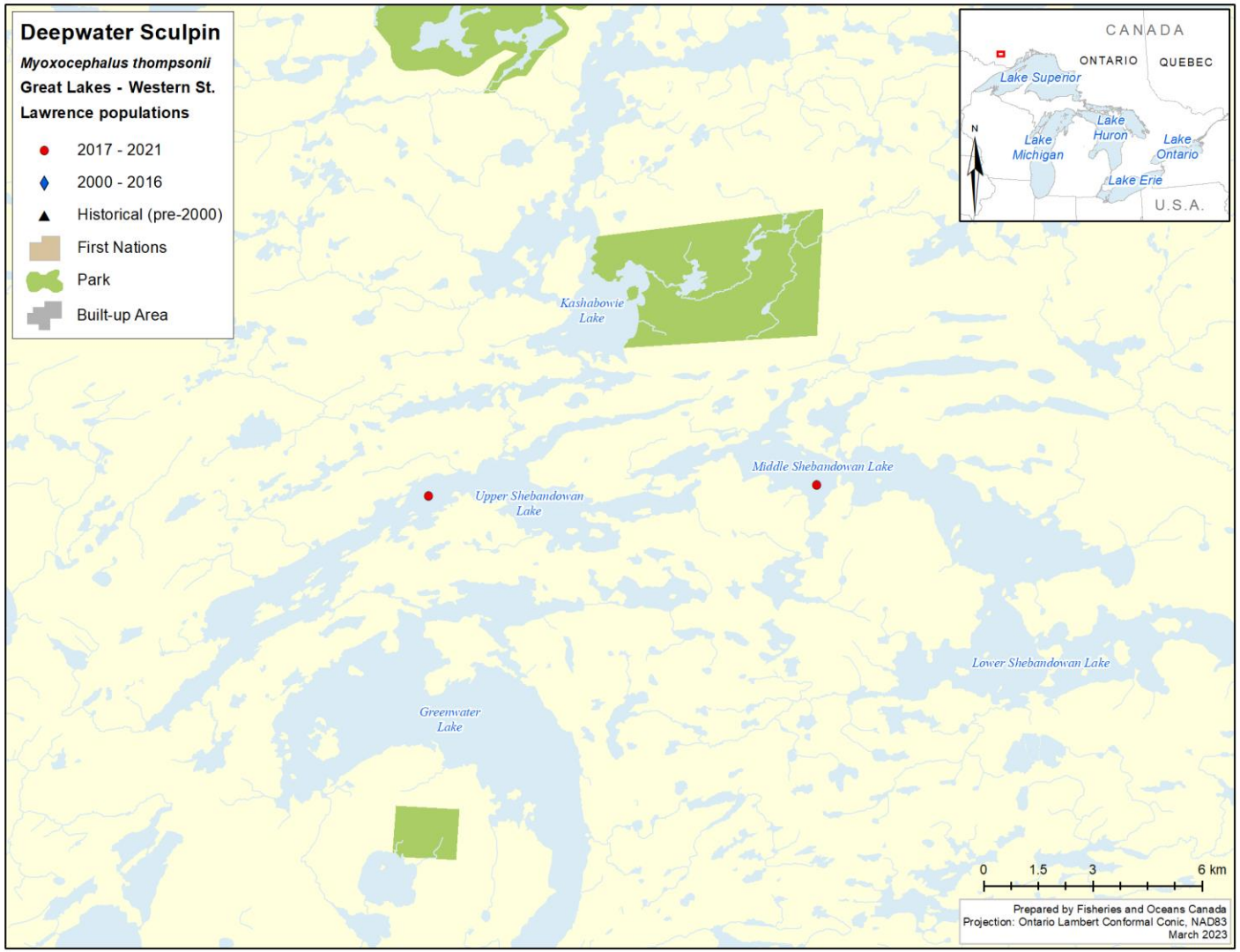

Figure 4. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Upper and Middle Shebandowan lakes, Ontario. If a symbol is missing from the map, there are no records for that time period.

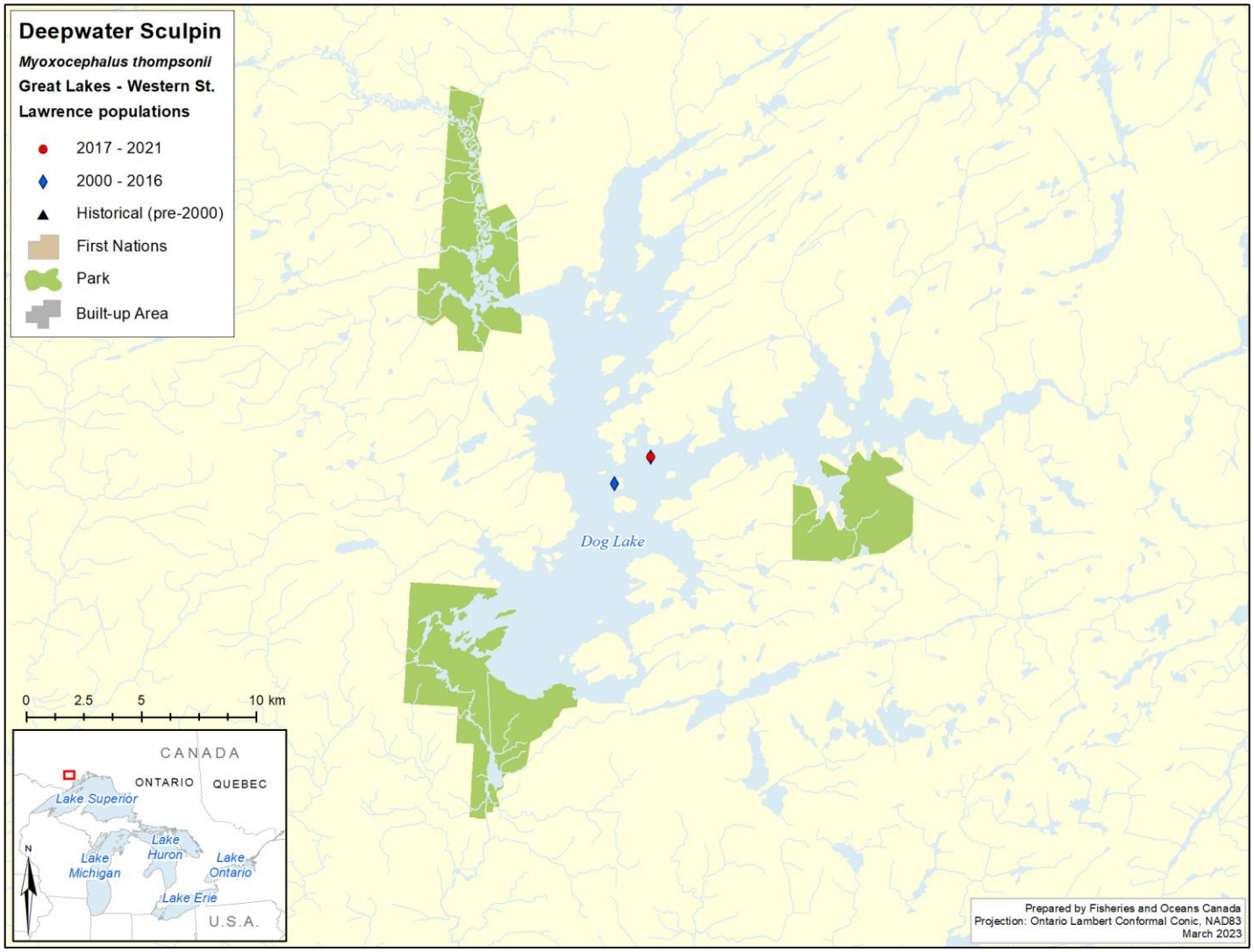

Figure 5. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Dog Lake, Ontario. If a symbol is missing from the map, there are no records for that time period.

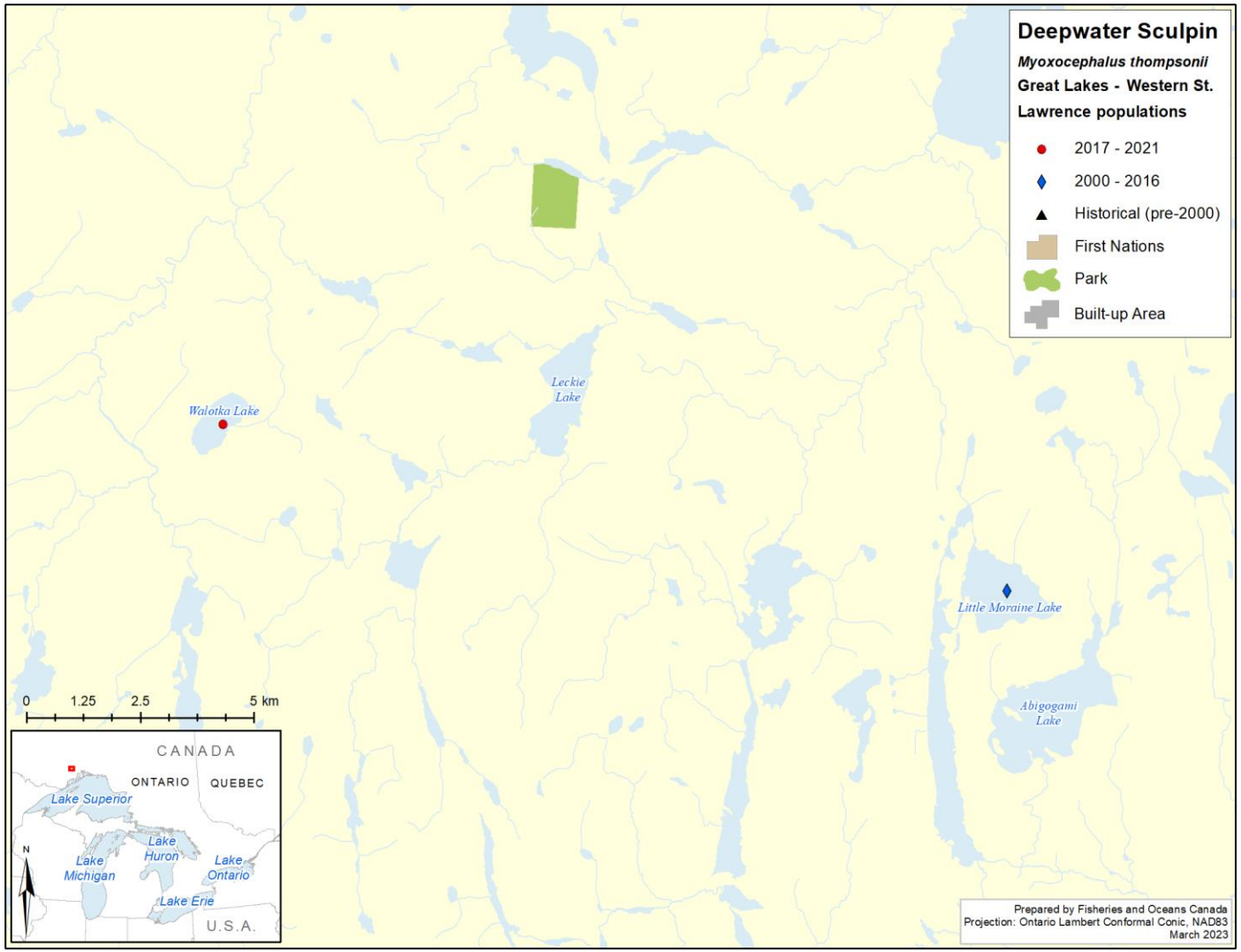

Figure 6. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Walotka and Little Moraine lakes, Ontario. If a symbol is missing from the map, there are no records for that time period.

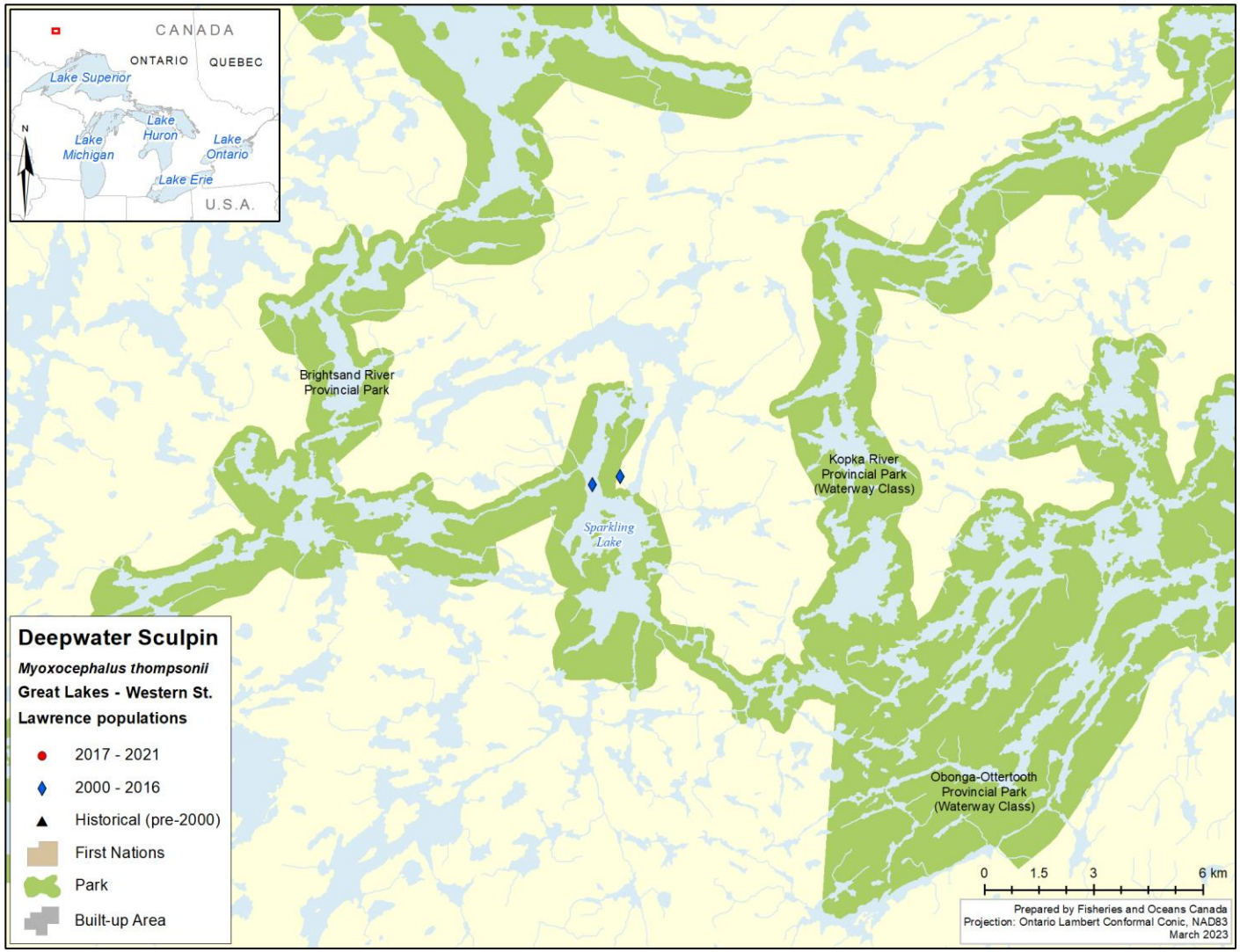

Figure 7. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Sparkling Lake, Ontario. If a symbol is missing from the map, there are no records for that time period.

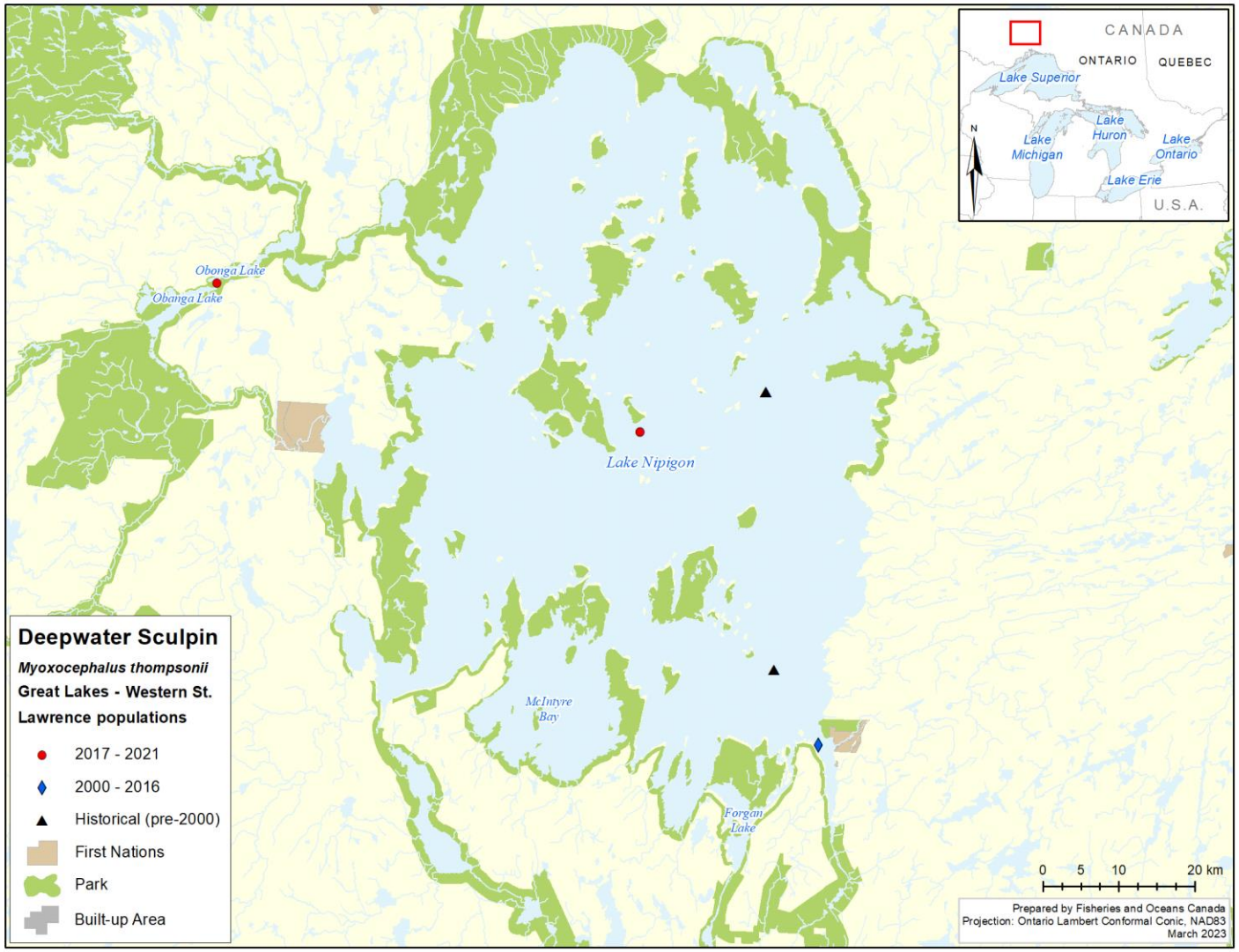

Figure 8. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Lake Nipigon, Ontario.

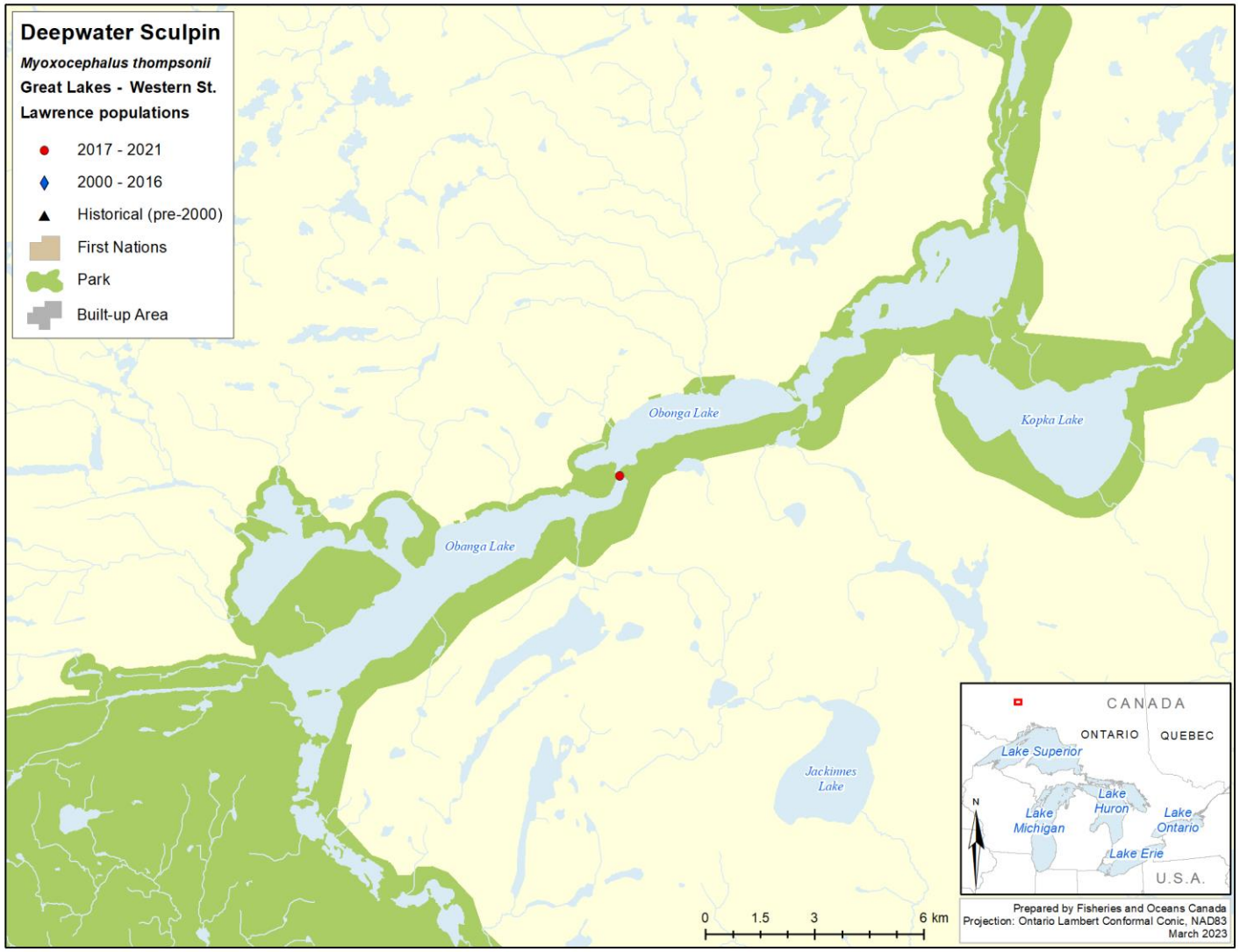

Figure 9. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Obonga Lake, Ontario. If a symbol is missing from the map, there are no records for that time period.

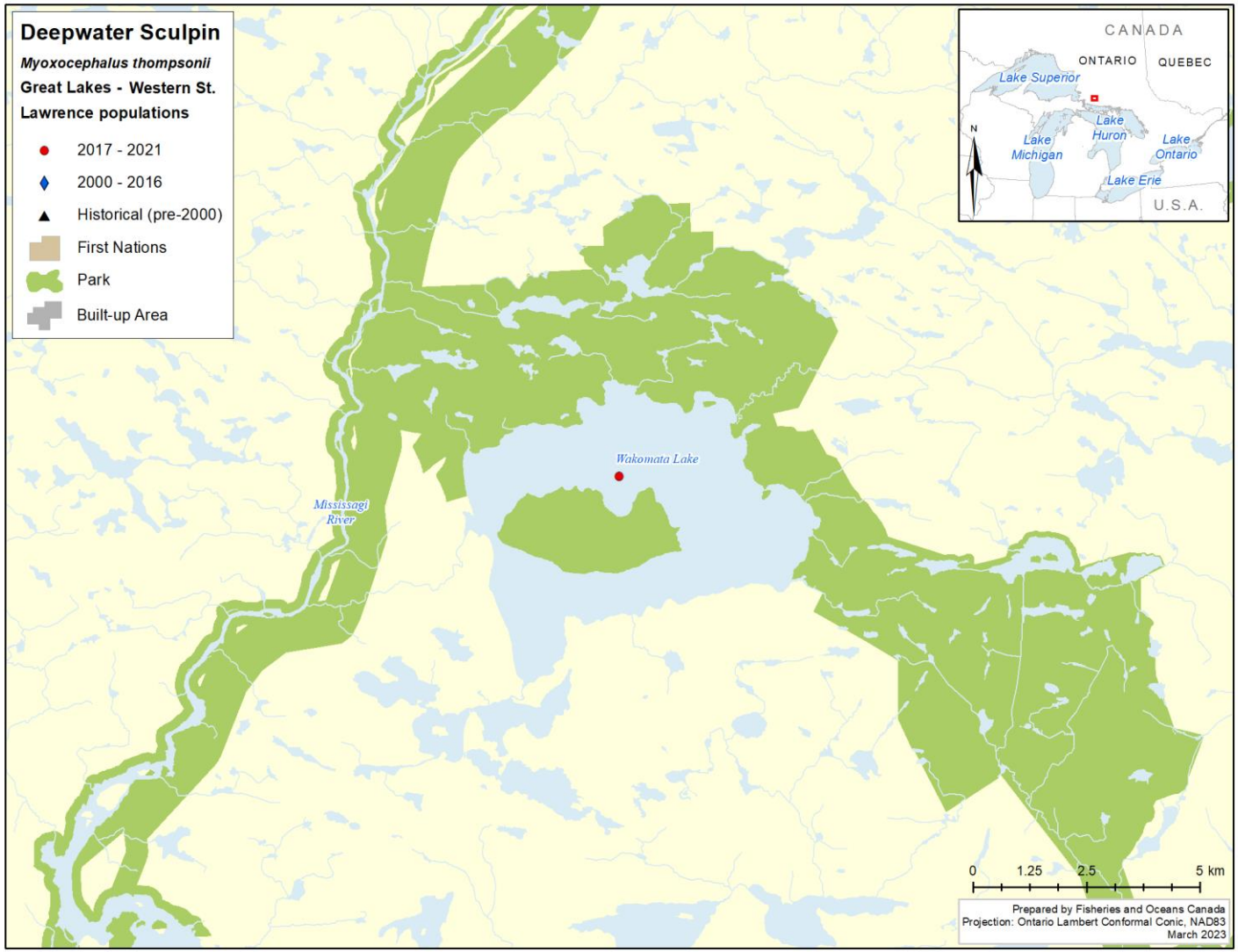

Figure 10. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Wakomata Lake, Ontario. If a symbol is missing from the map, there are no records for that time period.

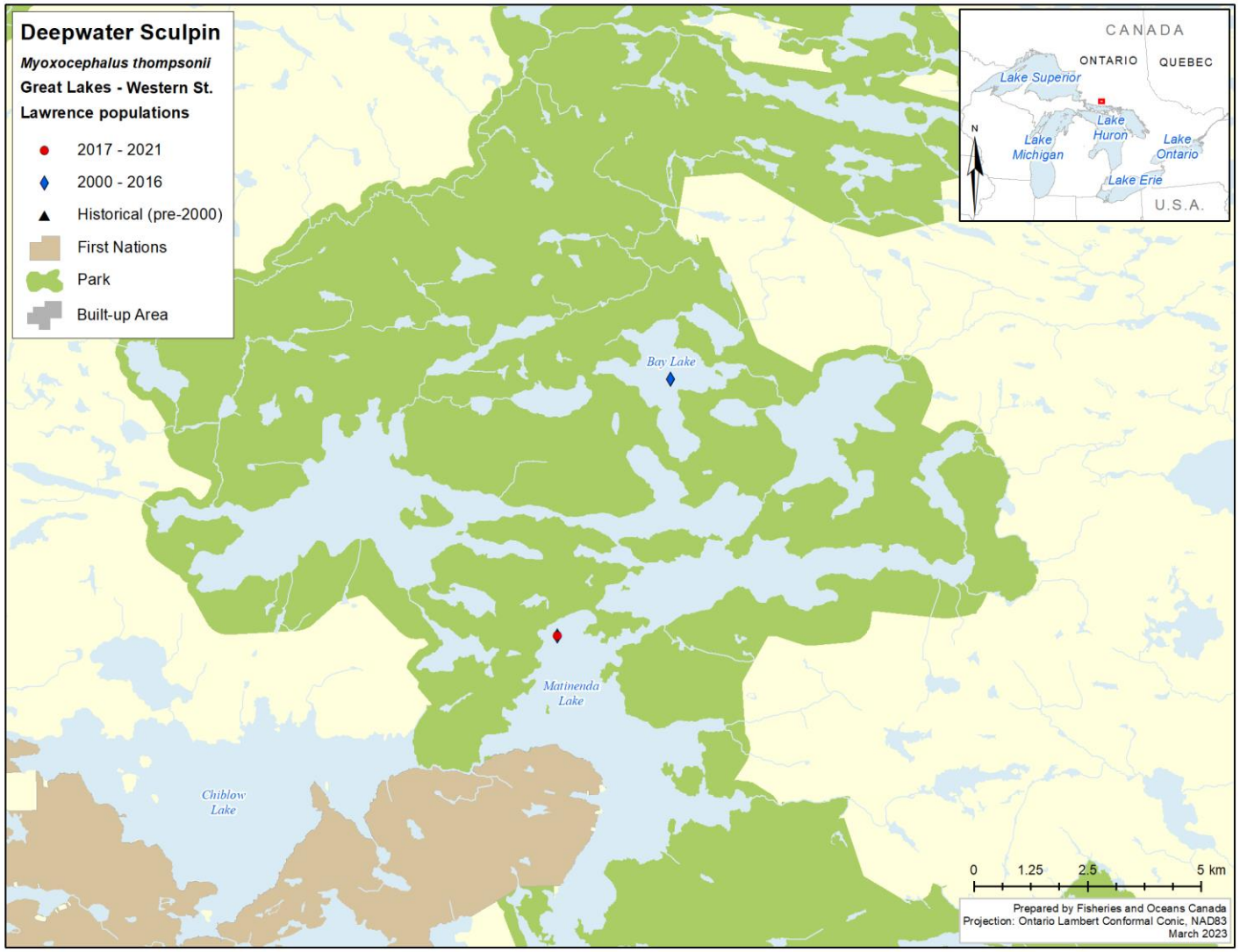

Figure 11. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Bay and Matinenda lakes, Ontario. . If a symbol is missing from the map, there are no records for that time period.

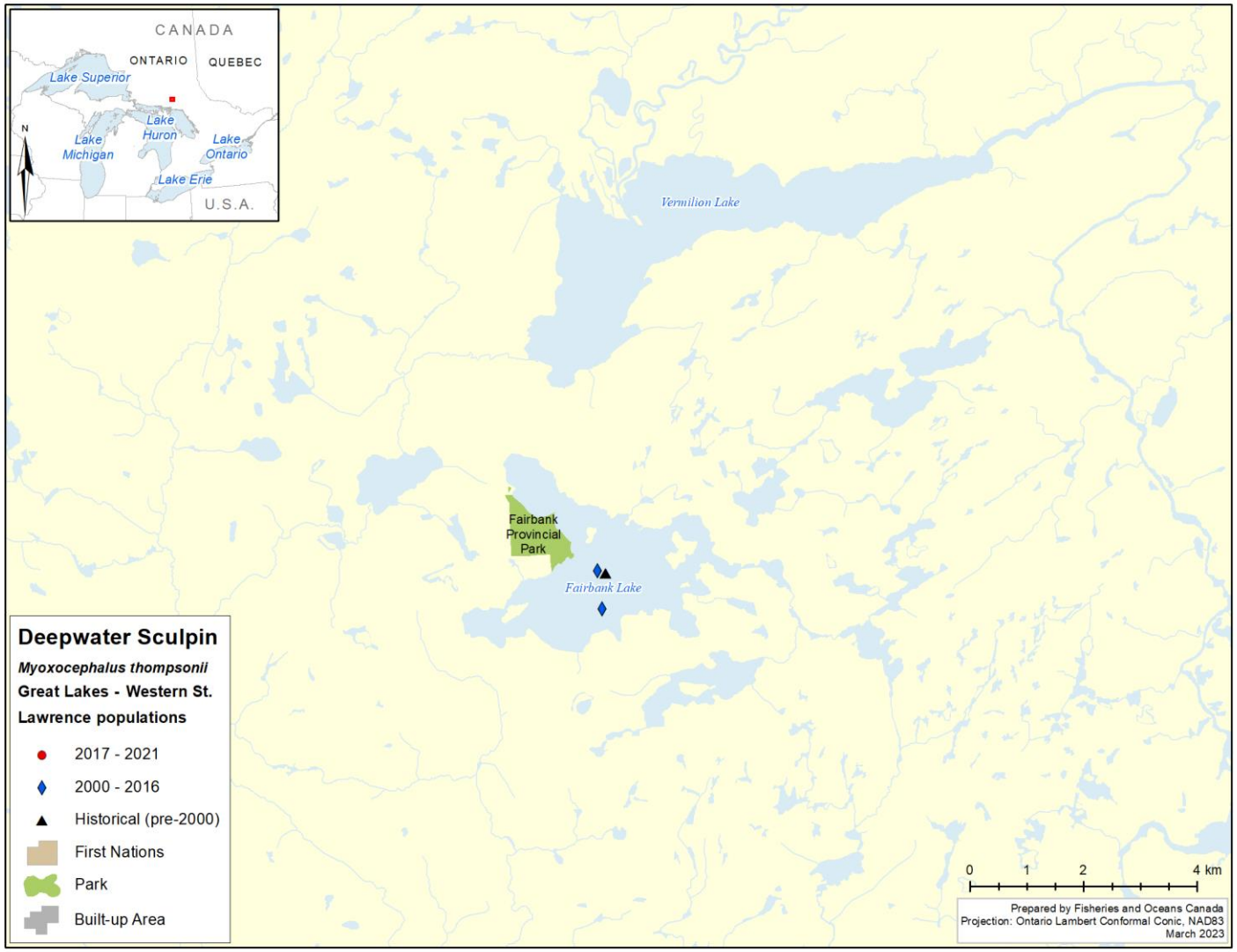

Figure 12. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Fairbank Lake, Ontario. If a symbol is missing from the map then that means there are no records for that time period.

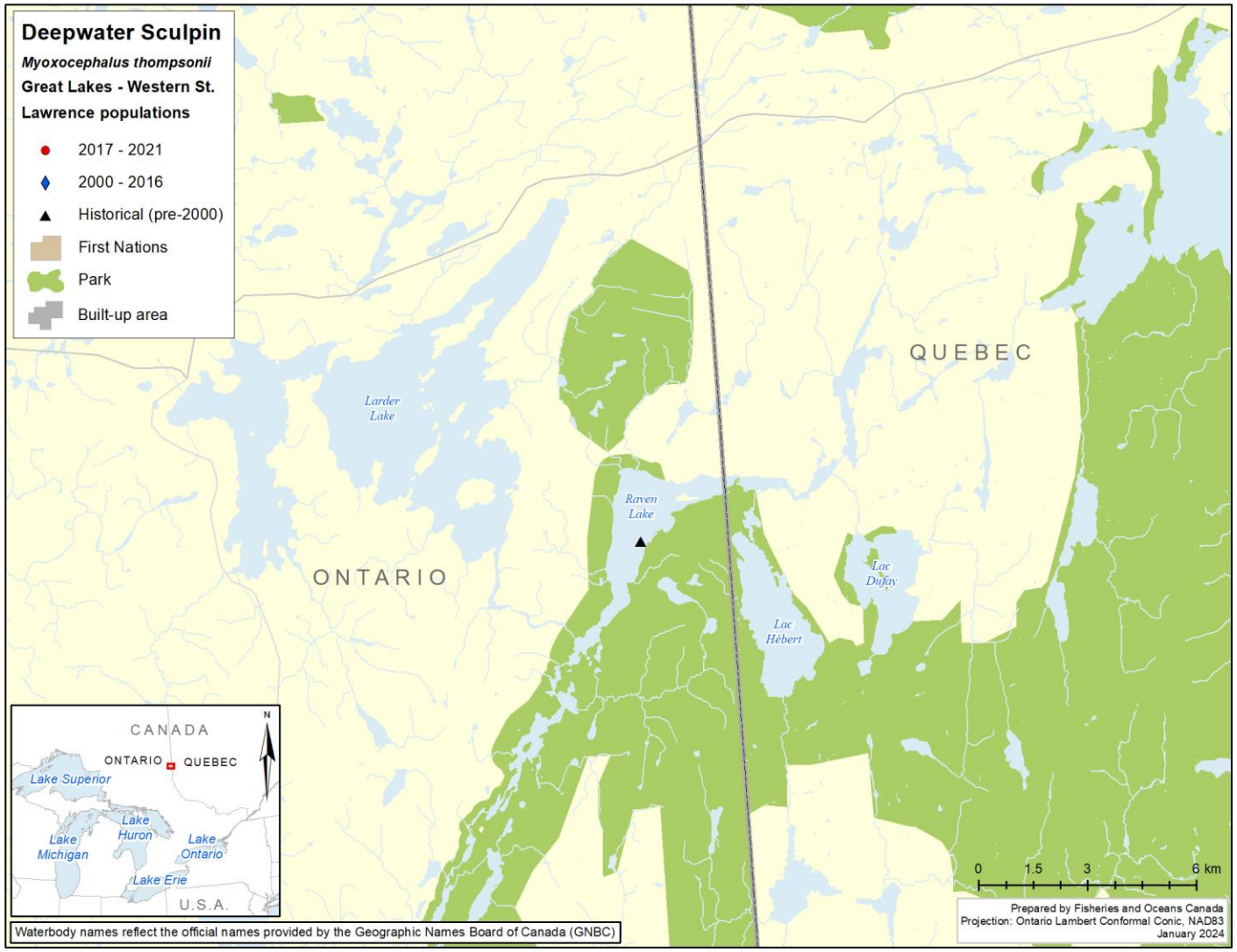

Figure 13. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Raven Lake, Ontario. If a symbol is missing from the map, there are no records for that time period.

Table 6. Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) detections inland lakes of Quebec.

Lake	Location	Time period	Years detected (# captured)	Data source
Lac Heney	Baie de la Mine	Historic (pre 2000)	1968 (11)	Royal Ontario Museum (ROM)
Roddick Lake/Grand Lac Rond	N/A	Historic (pre 2000)	1971 (13)	ROM
Roddick Lake/Grand Lac Rond	N/A	2000 to 2016	2004 (8)	Kilgour 2017
Roddick Lake/Grand Lac Rond	N/A	2017 to 2021	2016 (2)	Kilgour 2017
Lac Des Iles	Main basin	Historic (pre 2000)	1968 (4)	ROM
Lac Trente et un Milles	N/A	2000 to 2016	2004 (6), 2016 (8)	Sheldon et al. 2008, Kilgour 2017
Lac des Écorces	Main basin	2000 to 2016	2005 (n/a), 2021 (n/a)	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP)
Lac Pemichagan	Main basin	2017 to 2021	2017 (1)	MELCCFP

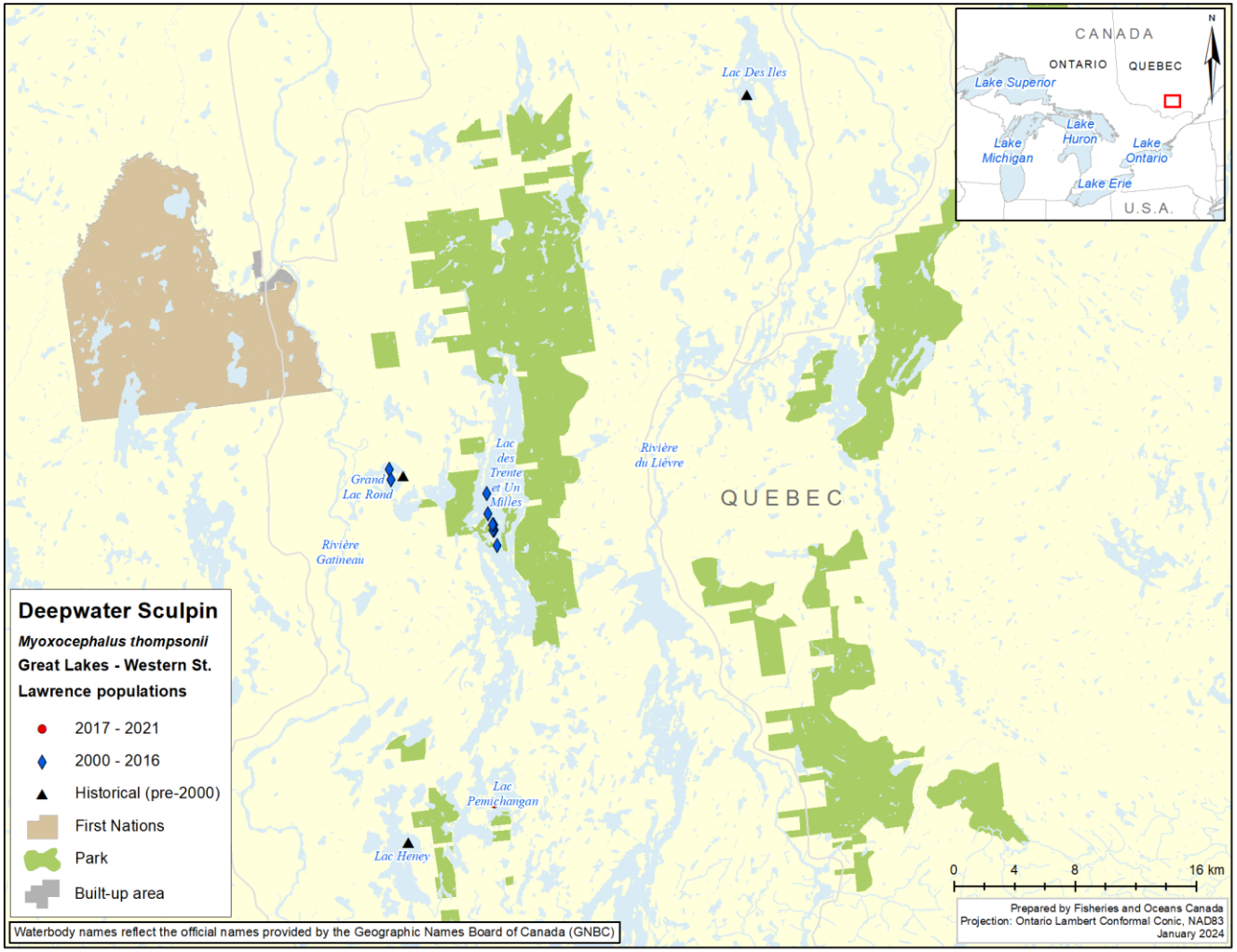

Figure 14. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Lac Heney, Roddick Lake/Grand Lac Rond, Lac Trente et un Milles, and Lac Des Iles. If a symbol is missing from the map, there are no records for that time period.

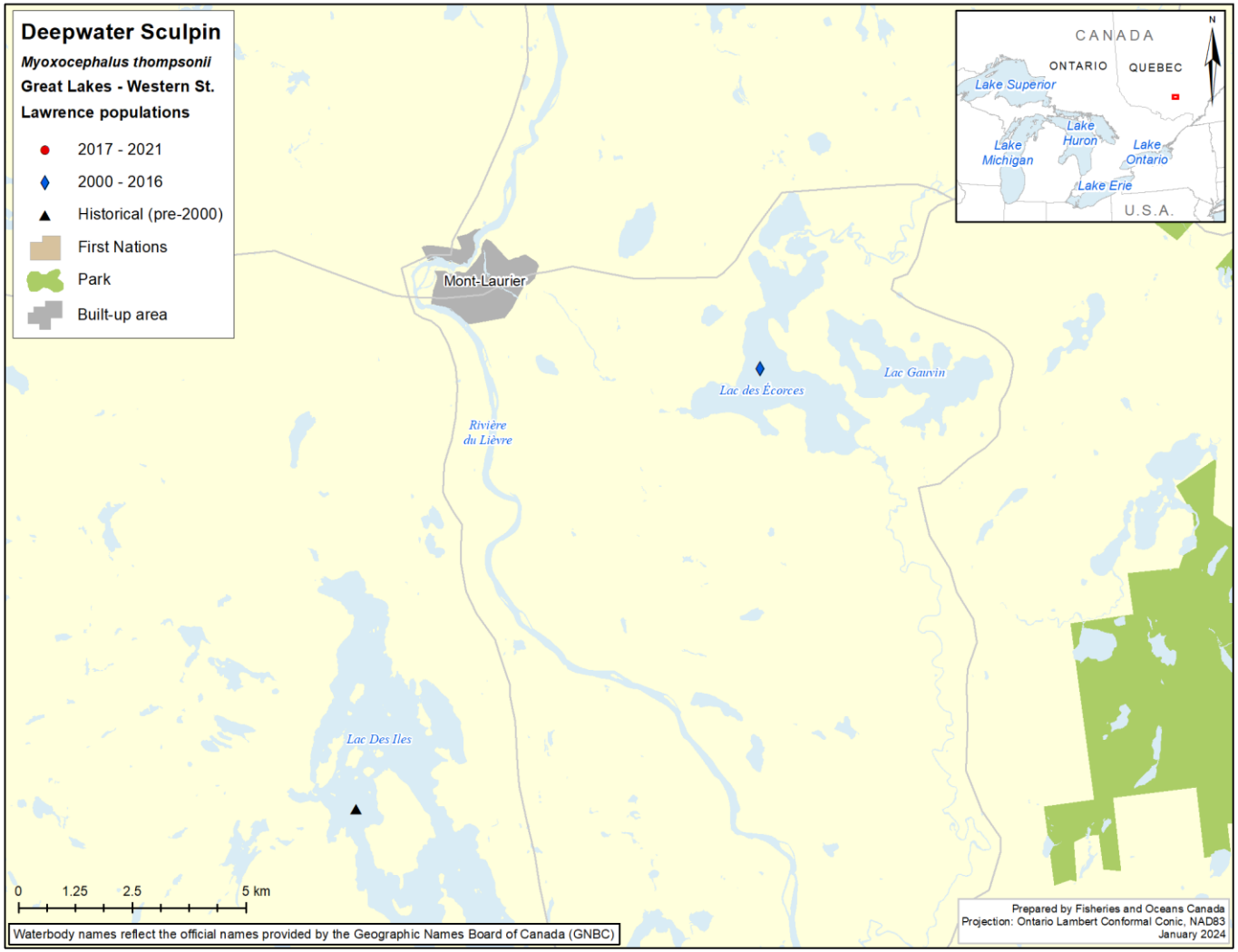

Figure 15. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Lac des Écorces. If a symbol is missing from the map, there are no records for that time period.

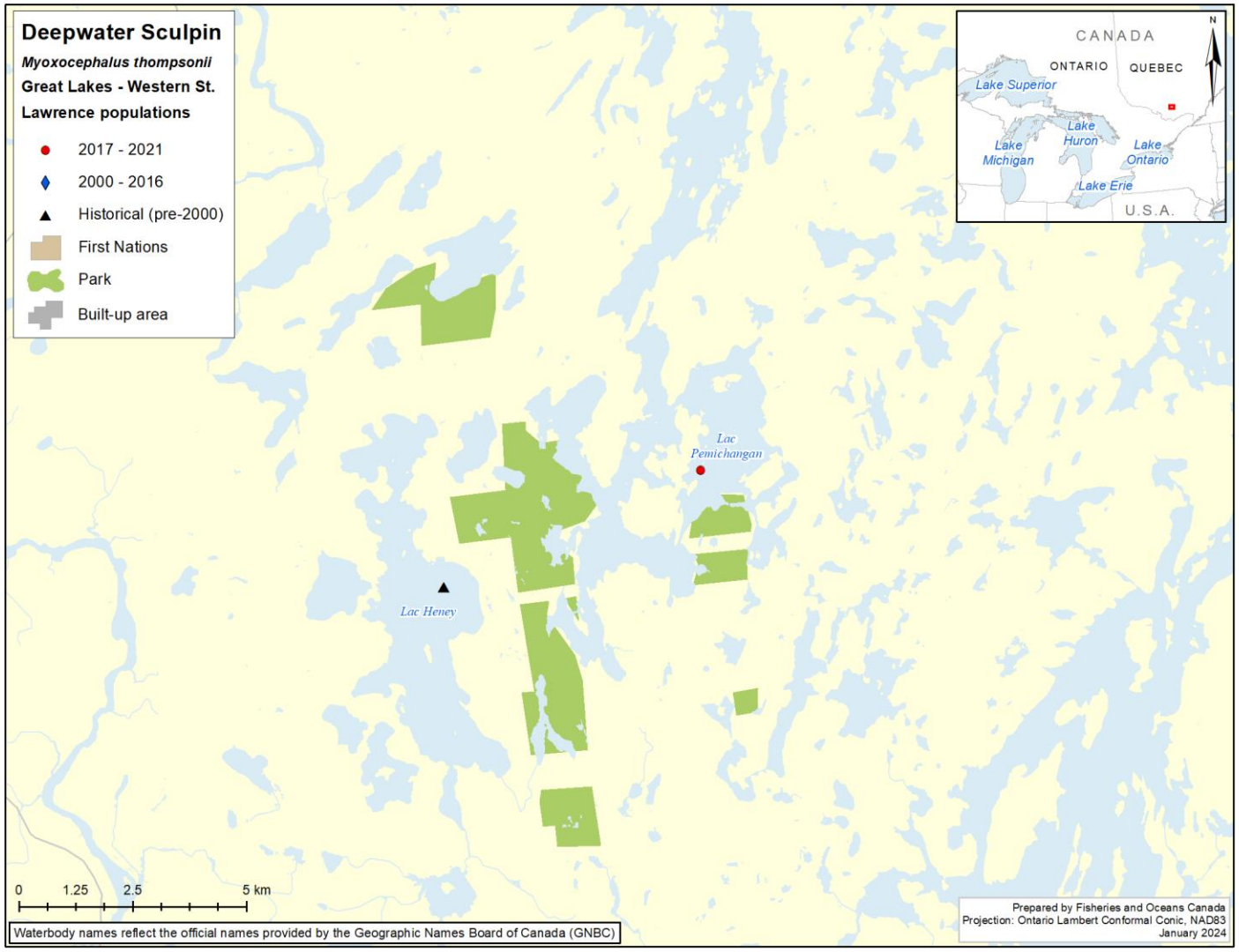

Figure 16. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in Lac Pemichagan. If a symbol is missing from the map, there are no records for that time period.

Table 7. Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) larvae detected in the St. Marys River and the Huron-Erie Corridor in both Canadian and United States waters.

Waterbody	Location	Country	Time period	Years detected (# captured)	Data source
St. Marys River	Main Channel downstream of Sault Ste Marie International Bridge	USA	2017-2021	2018 (22)	United States Geological Survey (USGS)
St. Marys River	Main Channel downstream of Sault Ste Marie International Bridge	Canada	2017-2021	2018 (1)	USGS
St. Marys River	Canadian shore, Downstream of Canadian recreation locks	Canada	2017-2021	2018 (1)	USGS
St. Marys River	Offshore from Canadian Bush Plane Heritage Centre, mid-north channel	Canada	2017-2021	2018 (1)	USGS
Lake Huron	Offshore from Peters Island	Canada	2017-2021	2019 (1)	Parks Canada
St. Clair River	Mouth of Pine River	USA	2000-2016	2010 (1)	USGS
St. Clair River	Downstream of Pine River mouth	USA	Historic (pre 2000)	1978 (9)	USGS
St. Clair River	Downstream of Fawn Island	Canada	2000-2016	2010 (1)	USGS
St. Clair River	Upstream of Russell Island	USA	2000-2016	2010 (1)	USGS
St. Clair River	East of Russell Island	USA	2017-2021	2018 (1), 2019 (1)	USGS
St. Clair River	West of Russell Island (Point Aux Chenes)	USA	2017-2021	2019 (18)	USGS
Lake St. Clair	Offshore from the Mouth of the North Channel	USA	2017-2021	2018 (1)	USGS
Lake St. Clair	Near the mouth of the South Channel	USA	2000-2016	2011 (2)	USGS
Lake St. Clair	Offshore from St. Clair Shores, Michigan	USA	2017-2021	2019 (1)	USGS
Detroit River	Upstream of Belle Isle, mid channel	USA	2000-2016	2016 (1)	USGS
Detroit River	Upstream of Grassy Island	USA	2017-2021	2019 (15)	USGS
Detroit River	Eastern shore of Fighting Island	Canada	2000-2016	2016 (1)	USGS
Detroit River	Upstream from tip of Grosse Ile-Trenton Channel	USA	2000-2016	2007 (2)	USGS

Waterbody	Location	Country	Time period	Years detected (# captured)	Data source
Detroit River	West side of Trenton Channel	USA	2000-2016	2007 (2)	USGS
Detroit River	East of Grosse Ile	USA	2000-2016	2007 (4)	USGS
Detroit River	Downstream of Fighting Island	Canada	2000-2016	2007 (1)	USGS
Detroit River	Lower middle Trenton Channel East of Gibraltar	USA	2000-2016	2006 (1), 2007 (4)	USGS
Detroit River	Lower Trenton Channel near Grosse Ile	USA	2000-2016	2007 (1), 2012 (1), 2013 (1)	USGS
Detroit River	Lower Livingstone Channel	Canada	2000-2016	2006 (1), 2007 (7),	USGS
Western Basin of Lake Erie	Offshore from Rockwood	USA	2000-2016	2007 (3)	USGS
Western Basin of Lake Erie	Offshore from the mouth of the Huron River	USA	2000-2016	2016 (1)	USGS
Western Basin of Lake Erie	Main navigational channel in Lake Erie, south of Livingstone Channel	Canada	2000-2016	2006 (1)	USGS
Western Basin of Lake Erie	Offshore south of Lakewood Beach	Canada	2000-2016	2007 (1)	USGS

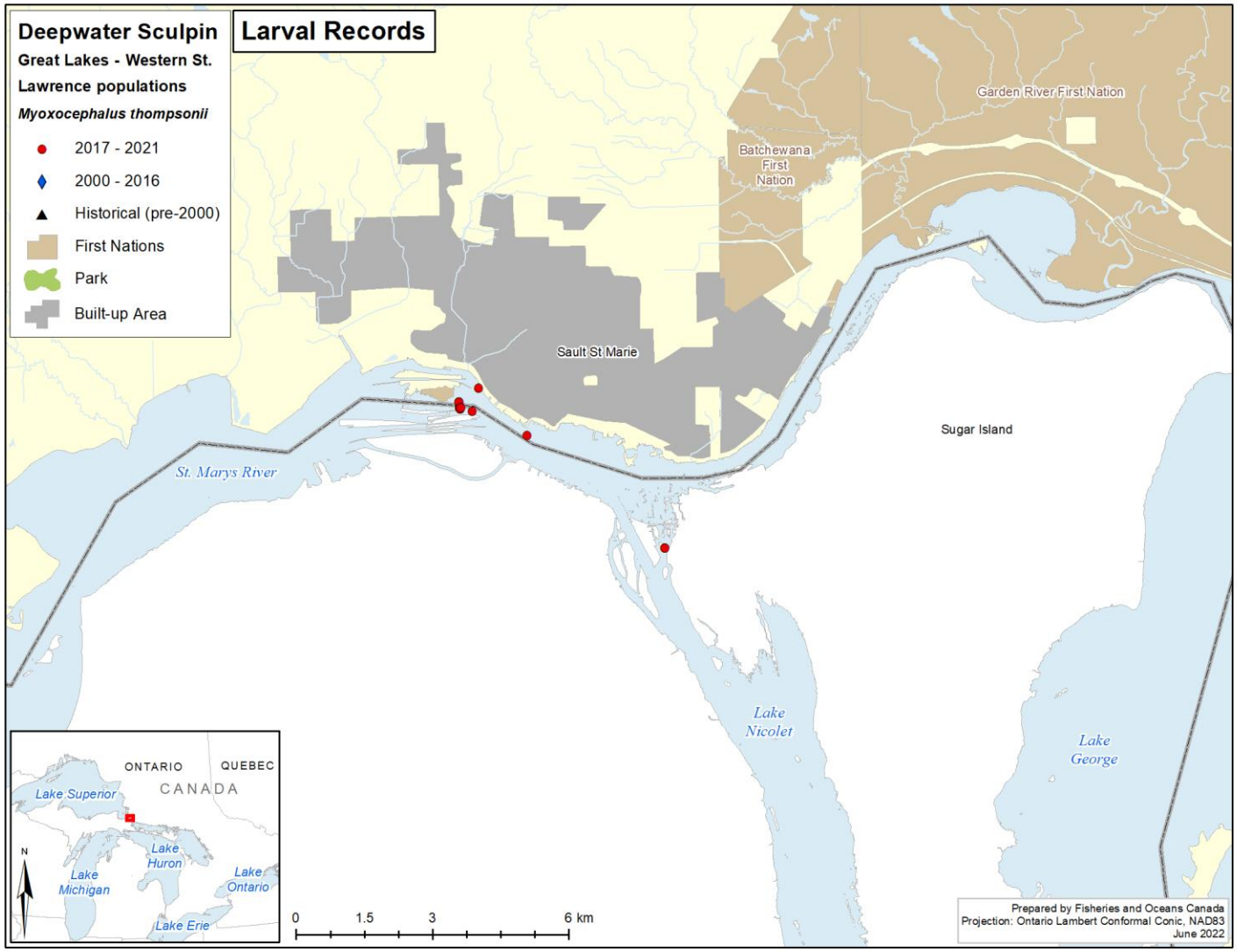

Figure 17. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) Larvae in the St. Marys River. If a symbol is missing from the map, there are no records for that time period.

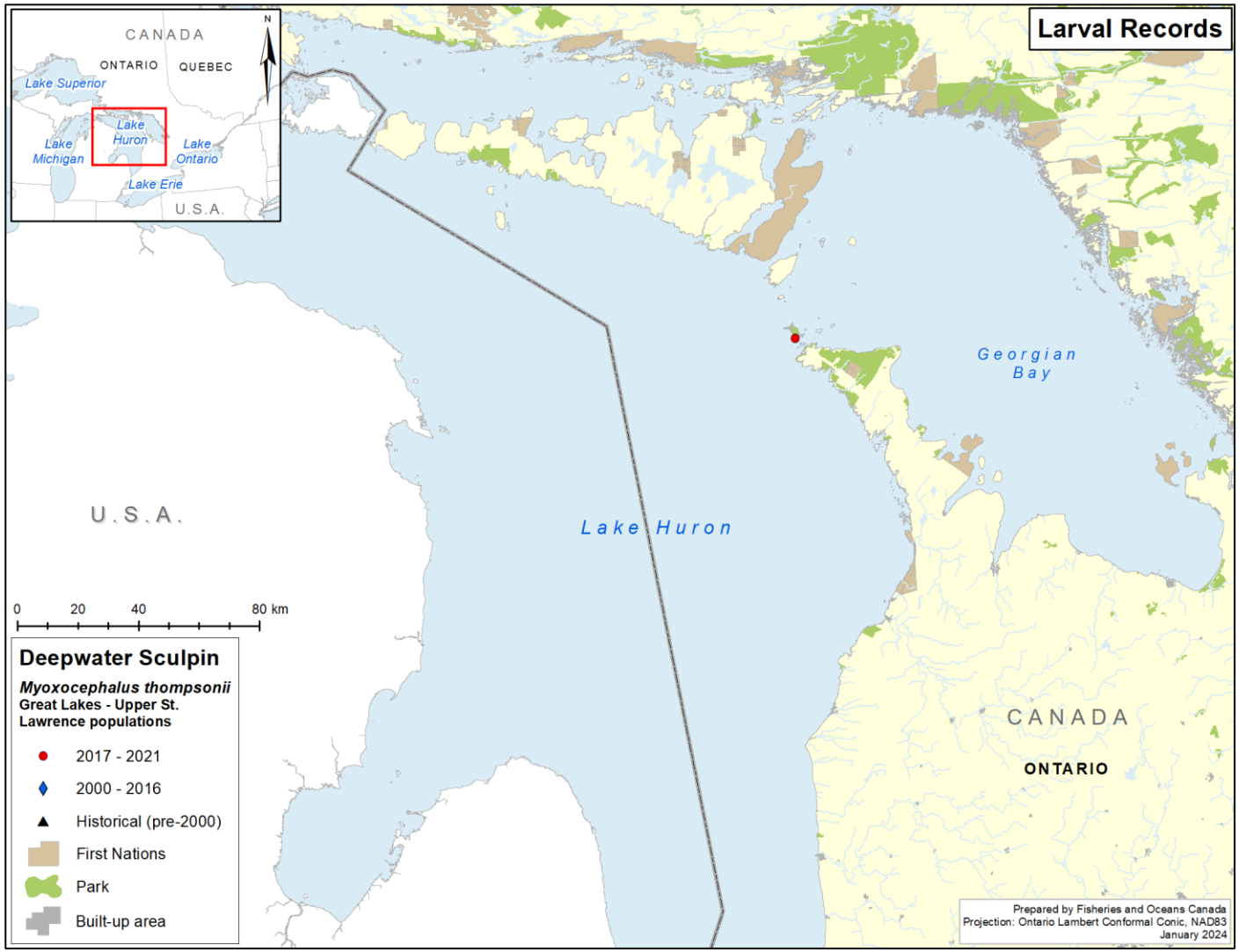

Figure 18. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) Larvae in Lake Huron. If a symbol is missing from the map, there are no records for that time period.

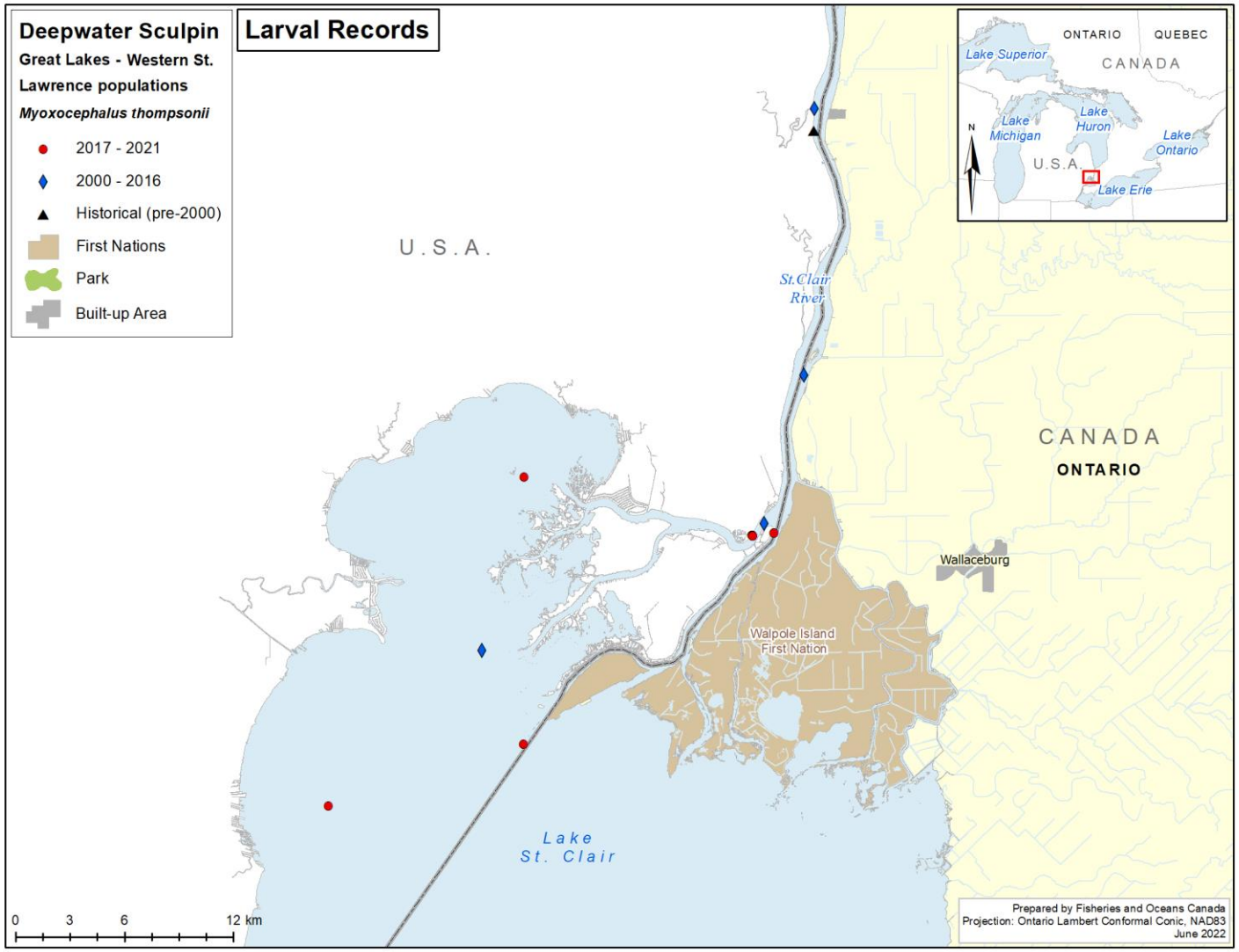

Figure 19. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) Larvae in the St. Clair River and Lake St. Clair. If a symbol is missing from the map, there are no records for that time period.

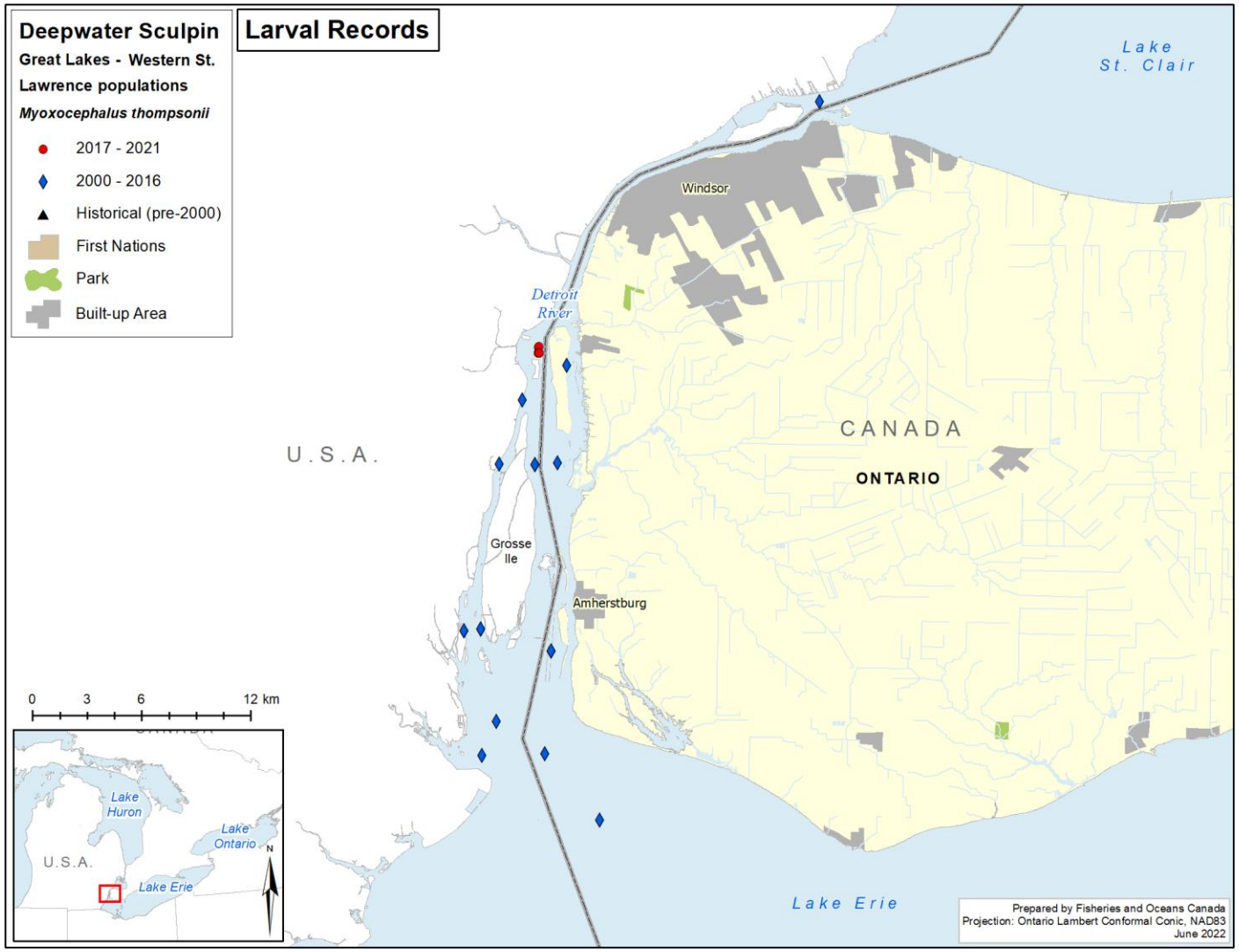

Figure 20. Detections of Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) Larvae in the Detroit River and the Western Basin of Lake Erie. If a symbol is missing from the map, there are no records for that time period.

3.1 Threats

This section summarizes the information, found in the management plan, on threats to the survival and conservation of the Deepwater Sculpin (Great Lakes and Western St. Lawrence River Populations).

3.1.1 Threats to the Deepwater Sculpin

Table 8 summarizes the current and anticipated threats to the Deepwater Sculpin (Great Lakes and Western St. Lawrence River Populations). Please refer to Section 1.5 of the management plan for more information on these threats.

Table 8. Summary of the threats identified for the Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) in the management plan.

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
Nutrient loading[4]	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

3.2 Management

This section summarizes the management goal and objectives, identified in the management plan for the conservation of Deepwater Sculpin.

3.2.1 Goal

The long-term goal (> 20 years) of the management plan is to ensure the persistence of Deepwater Sculpin throughout its current and historical distribution in the Great Lakes – Western St. Lawrence DU. Management will 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

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

quantifiable objectives relating to individual populations will be developed once the necessary sampling and analysis have been completed.

3.2.2 Objectives

The following short-term objectives 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

4. Progress towards conservation

Section 72 of the *Species at Risk Act* (SARA) requires the competent Minister(s) to report on the implementation of the management plan, and the progress towards meeting its objectives, within 5 years after it is included in the public registry and in every subsequent 5-year period, until its objectives have been achieved. This document includes actions completed from 2016 up to 2021. The management plan divides the conservation effort into 5 categories: 1) Surveys and monitoring; 2) Management and coordination; 3) Research; 4) Stewardship, habitat protection and improvement and threat mitigation; and 5) Outreach and communication. Progress in carrying out actions under each category is reported in section 4.1.

4.1 Actions supporting management objectives

Tables 9 to 13 provide information on the implementation of activities undertaken to achieve the management plan objectives identified in the Implementation Schedule table of the management plan. Each activity has been assigned 1 of the 4 statuses:

1) Completed: the activity has been carried out and concluded
2) In progress: the planned activity is underway and has not concluded
3) Not started: the activity has been planned but has yet to start
4) Cancelled: the planned activity will not be started or completed

Table 9. Details of survey and monitoring activities supporting the conservation of the Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) from 2016 to 2021.

Action	Descriptions and results	Progress	Participants[5] [6]
1) Background surveys: Conduct surveys to confirm current status/abundance at sites of known occurrence	**Lake Superior:** The USGS has been undertaking bottom trawl surveys at nearshore locations, at depths of 15 to 80 m, along the United States (US) coastline of Lake Superior since 1978, and along the Canadian coastline since 1989 (Vinson et al. 2016). Bottom trawls have also been conducted in offshore locations (at depths of 100 to 300 m) since 2011 in both US and Canadian waters throughout Lake Superior (Vinson et al. 2016). A total of 79 and 36 long-term sampling stations have been established in nearshore and offshore waters, respectively (Vinson et al. 2017). While these surveys are conducted to assess the benthic fish community in general, they do routinely capture Deepwater Sculpin and provide population indices, including estimates of relative abundance and biomass for the species (Vinson et al. 2017). In 2016, 76 of the 79 nearshore locations were sampled in May and June and 35 of the 36 offshore locations were sampled in June and July (Vinson et al. 2017). A total of 86 and 7,044 Deepwater Sculpin were captured in the nearshore and offshore surveys,	In progress	**USGS**, NYSDEC, MNR, MELCCFP

[5] Lead participant(s) is/are listed on top and in bold. Not all activities have specific participants identified.
[6] United States Geological Survey (USGS), United Sates Environmental Protection Agency (US EPA), International Joint Commission (IJC), Great Lakes National Program Office (GLNPO), National Oceanic and Atmospheric Administration (NOAA), Great Lake Fishery Commission (GLFC), New York State Department of Environmental Conservation (NYSDEC), Natural Sciences and Engineering Research Council of Canada (NSERCC), Canada Research Chairs, Great Lakes Centre (GLC), Department of Natural Resources (DNR), Ontario Ministry of Natural Resources and Forestry (MNR), Fisheries and Oceans Canada (DFO), Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP), Ontario Ministry of the Environment, Conservation and Parks (MECP), Parks Canada (PC).

Action	Descriptions and results	Progress	Participants[5] [6]
	respectively (Vinson et al. 2017). Furthermore the estimated lake-wide mean biomass for Deepwater Sculpin in offshore locations was 0.9 kg/ha (Vinson et al. 2017)[7]. In 2017, 76 of the 79 nearshore locations were sampled in May and June and 36 offshore locations were sampled in July (Vinson et al. 2018). A total of 74 and 14,995 Deepwater Sculpin were captured in the nearshore and offshore surveys, respectively (Vinson et al. 2018). Furthermore the estimated lake-wide mean biomass for Deepwater Sculpin in offshore locations was 2.0 kg/ha (Vinson et al. 2018). In 2018, 77 of the 79 nearshore locations were sampled in May and June and 35 of the 36 offshore locations were sampled in July (Vinson et al. 2019a). A total of 132 and 6,970 Deepwater Sculpin were captured in the nearshore and offshore surveys, respectively (Vinson et al. 2019a). Furthermore the estimated lake-wide mean biomass for Deepwater Sculpin in offshore locations was 1.0 kg/ha (Vinson et al. 2019a). In 2019, 76 of the 79 nearshore locations were sampled in May and June and 35 of the 36 offshore locations were sampled in July (Vinson et al. 2020). A total of 32 and 11,073 Deepwater Sculpin were captured in the nearshore and offshore surveys, respectively (Vinson et al. 2020). Furthermore the estimated lake-wide mean biomass for Deepwater Sculpin in offshore locations was 1.7 kg/ha (Vinson et al. 2019a). In 2020, the COVID-19 pandemic limited the sampling effort in Lake Superior. A total of 9 nearshore locations were sampled, all of which were within US waters. These surveys led to the capture of 2,828 Deepwater Sculpin. No offshore locations were sampled in that year (Mark Vinson [USGS], pers. comm. 2022). In 2021, the COVID-19 pandemic limited the sampling effort in Lake Superior. A total of 45 nearshore locations were sampled, all of which were within US waters. These surveys led to the capture of 145 Deepwater Sculpin. No offshore locations were sampled in that year (Mark Vinson [USGS], pers. comm. 2022). Locations where Deepwater Sculpin were captured in Lake Superior as a result of these aforementioned surveys are displayed in figure 1 and listed in tables 1 and 2.		

[7] Lake-wide mean biomass estimates were not available that were specific to Deepwater Sculpin at nearshore sites given that Deepwater Sculpin, Slimy Sculpin, and Spoonhead Sculpin were pooled for these locations in each year.

Action	Descriptions and results	Progress	Participants[5] [6]
	Lake Huron: The USGS has continued to conduct their annual trawl surveys in Lake Huron with transects associated with port locations including Detour, Hammond Bay, Alpena, Au Sable Point, and Harbor Beach in US waters, and Goderich in Canadian waters. Relative to the scope of this progress report, surveys have been conducted in October in 2015 (43 trawls), 2016 (46 trawls), 2017 (n/a), 2018 (50 trawls), 2019 (48 trawls), 2020 (41 trawls), and 2021 (42 trawls) which have consistently captured Deepwater Sculpin at all locations in all years (Roseman et al. 2016; Riley et al. 2017 and 2019; Hondorp et al. 2022a; Hondorp et al. 2022b; O'Brien et al. 2022). Based on sampling conducted from 2015 to 2018, Riley et al. (2019) observed the highest densities of Deepwater Sculpin in US waters at Hammond Bay and Detour with comparatively lower densities observed at Goderich, in Canadian waters. Overall, Riley et al. (2019) document a trend of increasing Deepwater Sculpin abundance with 2018 estimates being the highest observed since 2004. Since then USGS conducted further trawling surveys and recorded mean biomass of Deepwater Sculpin among sites in the main basin of Lake Huron was 0.018 kg/ha, 0.075 kg/ha, 0.276 kg/ha, 0.904 kg/ha, 0.149 kg/ha, 0.113 kg/ha, and 0.145 kg/ha in 2015, 2016, 2017, 2018, 2019, 2020, and 2021, respectively (USGS data unpublished). Despite the aforementioned annual sampling at Goderich, very little sampling for Deepwater Sculpin has been undertaken within Canadian waters. In addition to these surveys, PC conducted sampling surveys with multi-mesh gillnets in 2019 and captured 6 Deepwater Sculpin in Lake Huron offshore from Halfmoon Island near the Bruce Peninsula (C. Harpur, PC, pers. comm. 2023). Locations where Deepwater Sculpin were captured in Lake Huron as a result of these aforementioned surveys are displayed in figure 2 and listed in table 3. **Lake Ontario:** The USGS and NYSDEC have been conducting spring bottom trawl surveys, primarily targeting Alewife (*Alosa pseudoharengus*) and Rainbow Smelt (*Osmerus mordax*), from April to June since 1978 with 12 transects spaced at 25 km intervals along the US shoreline (Walsh et al. 2014). Furthermore, USGS conducted bottom trawl surveys in the fall for benthic prey fish (September to November, primarily October) throughout 6 transects situated along the southern shore of Lake Ontario (Olcott to Oswego, NY) (Weidel et al. 2018). In 2015, the NYSDEC and MNR joined the fall survey effort and began sampling more locations throughout Lake Ontario including within Canadian waters (Weidel et al. 2015; Weidel et al. 2018). In 2016, the MNR also joined in the spring survey efforts expanding the monitoring program into Canadian waters (Weidel et al. 2018). Although, these bottom trawl surveys target the benthic prey fish community in general and do not specifically target Deepwater		

Action	Descriptions and results	Progress	Participants[5] [6]
	Sculpin, they provide excellent distribution and abundance information to track population trends for the species as well as associations between Deepwater Sculpin and the fish community. In addition, benthic trawl surveys have also been conducted that target Lake Trout (*Salvelinus namaycush*) in US waters in July, which have led to the additional capture of Deepwater Sculpin (Weidel et al. 2017a). In 2016, surveys conducted in the spring for Alewife (April to May), Rainbow Trout (*Oncorhynchus mykiss*) (May to June), and summer for Lake Trout (July) sampled a combined total of 303 trawls leading to the capture of 5,327 Deepwater Sculpin (Weidel et al. 2017a). In the fall benthic prey fish survey of 2016, 188 bottom trawls were conducted at 18 transects within the main basin of Lake Ontario with 142 occurring in US waters and 46 in Canadian waters (Weidel et al. 2017b). Overall, a total of 9,510 Deepwater Sculpin were captured in 57 of the 188 trawls sampled (Weidel et al. 2017b). The estimated lake-wide density was greater than 100 fish/ha (biomass density estimate of 2.7 $kg \cdot ha^{-1}$) with the highest catch per unit of effort occurring along 1 transect offshore from Cobourg in Canadian waters (Weidel et al. 2017b). In 2017 a total of 304 trawls, sampling depths ranging from 8 to 225 m, were conducted including 204 in the spring bottom trawl survey for Alewife, which captured 13,273 Deepwater Sculpin, and 137 from the fall benthic prey fish survey, which captured 15,081 Deepwater Sculpin (Weidel et al. 2018). Deepwater Sculpin were the most abundant benthic prey fish and accounted for 3.8% of the overall catch by number (Weidel et al. 2018). In 2018 a total of 326 trawls, sampling depths of 6 to 228 m, were conducted including 208 in the spring (April) bottom trawl survey for Alewife, which captured 10,245 Deepwater Sculpin, and 118 in the fall (October) benthic prey fish survey, which captured 5,886 Deepwater Sculpin (Weidel et al. 2019). Deepwater Sculpin accounted for 4% of the overall catch by number (Weidel et al. 2019). In 2019 a total of 412 trawls, sampling depths of 5 to 226 m in areas of the main basin and embayments, were conducted including 252 in the spring (April) bottom trawl survey for Alewife, which captured 16,074 Deepwater Sculpin, and 160 in the fall (October) benthic prey fish survey, which captured 12,699 Deepwater Sculpin (Weidel et al. 2020). Deepwater Sculpin accounted for 10% of the overall catch by number and were the second most abundant demersal prey fish captured (Weidel et al. 2020). The		

Action	Descriptions and results	Progress	Participants[5] [6]
	estimated lake-wide density of Deepwater Sculpin in the main basin was 148.4 fish/ha, while the estimated density within the Bay of Quinte embayment was much lower at 0.1 fish/ha (Weidel et al. 2020). In 2020 sampling was greatly impacted by COVID-19 restrictions. Only the fall benthic prey fish survey sampling was conducted from September to October and the majority of sampling was confined to the eastern half of Lake Ontario (O'Malley et al. 2021). A total of 82 bottom trawls, sampling depths of 6 to 226 m in areas of the main basin and embayments, were conducted in both US and Canadian waters, which captured 7,405 Deepwater Sculpin (O'Malley et al. 2021). Deepwater Sculpin accounted for 7% of the overall catch by number and were the third most abundant demersal prey fish captured (O'Malley et al. 2021). In 2021, a total of 248 bottom trawls were conducted at depths from 5 to 221 m during the spring survey (March to May) in both Canadian and US waters (Weidel et al. 2021). A total of 16,665 Deepwater Sculpin were captured through these surveys, which represented 1.7% of the overall catch by number (Weidel et al. 2021). A total of 195 bottom trawls were conducted in the fall benthic prey fish survey (September to October) at sites ranging in depth from 5 to 226 m (O'Malley et al. 2022). Deepwater Sculpin made up 17% of the catch by number with 18,060 individuals captured and were the second most common prey fish in trawls with an estimated lake-wide biomass of 2.98 ± 0.27 kg/ha (O'Malley et al. 2022). Locations where Deepwater Sculpin were captured in these aforementioned surveys are displayed in figure 3 and listed in table 4. **Inland Lakes of Ontario:** The Ontario Ministry of Natural Resources and Forestry has been conducting their annual Broad-Scale Monitoring Program for Inland Lakes since 2008 using standardized sampling approaches with multi-mesh gillnets, including mesh sizes suitable for targeting small-bodied fish species (Lester et al. 2021). Between 2016 and 2021 (period of relevance to this document) these monitoring surveys have captured Deepwater Sculpin in Lakes where the species is known to occur including: Dog Lake (3 specimens captured in 2018) and Lake Nipigon (7 and 12 specimens captured in 2018 and 2019, respectively) in the Lake Superior watershed; and Matinenda Lake (10 specimens captured in 2018) and Fairbank Lake (1 specimen captured in 2016) in the Lake Huron watershed.		

Action	Descriptions and results	Progress	Participants[5 6]
	Inland lakes of Quebec: Monitoring surveys using minnow traps were conducted in 2016 in 5 lakes within Quebec including Grand lac Rond, Lac Trente et Un Milles, and Lac Heney where Deepwater Sculpin had been historically detected (Kilgour 2017). This sampling led to the capture of Deepwater Sculpin in Grand lac Rond and Lac Trente et Un Milles, but no specimens were captured in Lac Heney (Kilgour, 2017). Conventional sampling, suitable to detect Deepwater Sculpin, was conducted from 2010 to 2017 during broodstock Spring Cisco (*Coregonus sp.*) inventories in Lac des Écorces where the species was detected in 2005; however, the species was not captured (Nadon 2020; DFO 2022). In contrast, environmental DNA (eDNA) surveys conducted in Lac des Écorces in 2021 led to positive detections for Deepwater Sculpin. **Sampling of Deepwater Sculpin Larvae:** Sampling for pelagic larval Deepwater Sculpin was initially conducted in the St. Clair River from 2010 to 2012 and in the Detroit rivers from 2007 to 2012 using a bongo sampler (a net designed to capture plankton), which was towed into the current (Roseman 2014). These surveys successfully captured larvae at locations within each river as well as within the Western Basin of Lake Erie, where larval Deepwater Sculpin had been historically captured in during plankton tows (Roseman et al. 1998) (figures 10 and 11, table 7). Similar sampling conducted in the US waters of Lake Huron led to the detection of Deepwater Sculpin (Roseman and O'Brien 2013; O'Brien et al. 2019). Further sampling, relevant to the time period this report is focused on, has been undertaken in the St. Marys River, St. Clair River, Lake St. Clair, Detroit River, and Western Basin of Lake Erie (USGS unpublished data). Deepwater Sculpin larvae were captured in each location (figure 10 to 12, table 7). In addition, PC has conducted larval trawls on the Canadian side of Lake Huron and captured one larval Deepwater Sculpin in April 2019 offshore from Peters Island just outside of Fathom Five National Park (figure 18, table 7). These detections help to further our understanding of the distribution of Deepwater Sculpin at all life stages, recruitment patterns among the Great Lakes, and will enhance regulatory decision making with respect to the conservation of this species.		
2) Background surveys: Conduct surveys in areas with suitable habitat and covered by glacial lakes but lacking Deepwater Sculpin records.	**Ontario:** The Ontario Ministry of Natural Resources and Forestry has been conducting their annual Broad-Scale Monitoring Program for Inland Lakes since 2008 using standardized sampling approaches with multi-mesh gillnets, including mesh sizes suitable for targeting small-bodied fish species (Lester et al. 2021). In the second cycle of this program (sampling years 2014 to 2018) a total of 688 inland lakes were sampled in Ontario (Lester et al. 2021). Between 2016 and 2021 (period of relevance to this document) these monitoring surveys have led to the detection of the species in several new lakes where they were not previously known to occur including: Upper	In progress	MNR, MELCCFP

Action	Descriptions and results	Progress	Participants[5 6]
	Shebandowan Lake (7 specimens captured in 2018), Middle Shebandowan Lake (7 specimens captured in 2018), Walotka Lake (2 specimens captured in 2018), Obonga Lake (1 specimen captured in 2018), and Little Moraine Lake (3 specimens captured in 2016) in the Lake Superior watershed; and Wakomata Lake (4 specimens captured in 2018) and Bay Lake (4 specimens captured in 2016) in the Lake Huron watershed. **Quebec:** Monitoring surveys using minnow traps were conducted in 2016 in 2 lakes within Quebec to investigate potential undetected populations of Deepwater Sculpin including Grand lac du Cerf, and Poisson Blanc; however, the species was not detected at these locations (Kilgour 2017). Deepwater Sculpin was detected for the first time in Lac Pemichangan in 2017 when 1 individual was captured during surveys conducted by MELCCFP.		
3) Background surveys: Integrate the long-term monitoring requirements of Deepwater Sculpin with existing fish community survey efforts, where possible.	**Lake Superior:** As mentioned in the description and results for action 1, long-term monitoring of the fish community in Lake Superior, which tracks Deepwater Sculpin abundance, has been ongoing in nearshore locations (79 sampling stations) since 1978, and offshore locations (36 sampling stations) since 2011. Both the nearshore and offshore sampling stations are situated throughout Lake Superior in both US and Canadian waters (Vinson et al. 2020). **Lake Huron:** As mentioned in the description and results for action 1, long-term monitoring of Deepwater Sculpin abundance in Lake Huron, at 5 port locations in US waters and 1 location in Canadian waters, has been integrated into annual trawl surveys conducted by USGS to assess the status and trends of the offshore demersal fish community (Riley et al. 2019). **Lake Ontario:** As described in the description and results for action 1, USGS, NYSDEC, and MNR monitor populations of Deepwater Sculpin in Lake Ontario through their spring bottom trawl survey and fall benthic prey fish survey.	In progress	**USGS**, NYSDEC, MNR
4) Threat assessment: 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.	**Lake Superior:** As mentioned in the description and results for action 1, long-term monitoring of the fish community using benthic trawls in Lake Superior has been ongoing in nearshore locations (79 sampling stations) since 1978, and offshore locations (36 sampling stations) since 2011. Both the nearshore and offshore sampling stations are situated throughout Lake Superior in both US and Canadian waters and detect the presence of invasive species including Alewife (in some years) and Rainbow Smelt (Vinson et al. 2020).	In progress	**USGS**, NYSDEC. MNR

Action	Descriptions and results	Progress	Participants[5] [6]
	In 2016, 3 Alewife were captured at nearshore sampling locations and none were captured at offshore locations (Vinson et al. 2017). A total of 11,002 Rainbow Smelt were captured at nearshore sites while only 6 were captured at offshore sites (Vinson et al. 2017). The lake-wide mean biomass of Rainbow Smelt estimated for nearshore habitats was 0.4 kg/ha (Vinson et al. 2017). In 2017, 3 Alewife were captured at nearshore trawls locations and 1 was captured at an offshore location (Vinson et al. 2018). A total of 19,236 Rainbow Smelt were captured at nearshore sites while only 8 were captured at offshore sites (Vinson et al. 2018). The lake-wide mean biomass of Rainbow Smelt estimated for nearshore habitats was 0.9 kg/ha (Vinson et al. 2018). In 2018, no Alewife were captured at nearshore or offshore locations (Vinson et al. 2019a). In contrast, 22,361 Rainbow Smelt were captured at nearshore sites while only 3 were captured at offshore sites (Vinson et al. 2019a). The lake-wide mean biomass of Rainbow Smelt estimated for nearshore habitats was 1.2 kg/ha (Vinson et al. 2019a). In 2019, 10 Alewife were captured at nearshore trawls locations; however, none were captured at offshore locations (Vinson et al. 2020). A total of 18,542 Rainbow Smelt were captured at nearshore sites while only 5 were captured at offshore sites (Vinson et al. 2020). The lake-wide mean biomass of Rainbow Smelt estimated for nearshore habitats was 1.0 kg/ha (Vinson et al. 2020). **Lake Huron:** As mentioned in the description and results for actions 1 and 3, long-term monitoring of Deepwater Sculpin abundance using benthic trawls in Lake Huron has been ongoing at 5 port locations in US waters since 1973 and 1 location in Canadian waters (Goderich) since 1998 (Riley et al. 2019). The overall aim of these surveys is to assess the status and trends of the offshore demersal fish community which includes monitoring and estimating trends in the abundance of introduced species including Round Goby (*Neogobius melanostomus*), Rainbow Smelt and Alewife (Riley et al. 2019). These surveys have been tracking Round Goby since 1997 and suggest that their abundance in offshore waters has fluctuated over the years, likely due to annual variation in environmental conditions such as water temperature (Riley et al. 2019). The most recent estimates from sampling conducted in 2018 suggest that Round Goby are currently in high abundance in offshore waters (Riley et al. 2019).		

Action	Descriptions and results	Progress	Participants[5] [6]
	Alewife abundance and biomass have remained low compared to historic estimates from 1970s to 1990s; however, sampling conducted in 2018 led to the highest estimates of young-of-year (YOY) biomass and abundance since 2005 (Riley et al. 2019). The estimated biomass and density of YOY Rainbow Smelt appears to be increasing since the 1970s to 1990s; however, similar estimates of adults appear to be decreasing over the same time scale (Riley et al. 2019), which may indicate that recruitment failure is driving the abundance of this introduced species down within Lake Huron. O'Brien et al. (2019) report the results of surface plankton tows in areas of St. Martin Bay, northwestern Lake Huron, over water depths ranging from 2.5 to 10 m from late April through early July in 2008 and 2009 to examine the spring-summer ichthyoplankton community. In both years their catches were dominated by Alewife, Rainbow Smelt, and Round Goby (27.8%, 24.6%, and 18.0% of the catch, respectively) despite reductions observed in the abundance of planktivorous fish since 2004 (O'Brien et al. 2019). **Lake Ontario:** As described in detail in the description and results for conservation measure #1, USGS, NYSDEC, and MNR conduct spring bottom trawl surveys and a fall benthic prey fish survey. Through these surveys they are able to monitor the abundance of introduced species including Alewife, Rainbow Smelt, Round Goby, and to some degree dreissenid mussels. Monitoring of Alewife and Rainbow Smelt has been ongoing since 1972 (Walsh et al. 2014), and populations of Round Goby have been monitored from the time of their first detection in 1998 through their dramatic rise in abundance in 2004 (Weidel et al. 2015). In 2016, a total of 188 trawls were conducted in US and Canadian waters leading to the capture of 31,635 Round Goby, 59,596 Alewife, 2,870 Rainbow Smelt, and 8.3 tons of dreissenid mussels (Weidel et al. 2017b). Overall, the benthic prey fish community was dominated by Round Goby with an estimated lake-wide density of approximately 600 fish/ha (Weidel et al. 2017b). In 2017, a total of 341 trawls were conducted in US and Canadian waters over the spring and fall surveys leading to the capture of 23,028 Round Goby, 678,731 Alewife, 8,426 Rainbow Smelt, and 5,335 kg of dreissenid mussels (Weidel et al. 2018).		

Action	Descriptions and results	Progress	Participants[5] [6]
	Overall, Alewife, Round Goby, and Rainbow Smelt comprised 90%, 3.1%, and 1.1% of the total catch, respectively (Weidel et al. 2018). In 2018, a total of 326 trawls were conducted in US and Canadian waters over the spring and fall surveys leading to the capture of 45,068 Round Goby, 305,964 Alewife, 10,181 Rainbow Smelt, and 4,026 kg of dreissenid mussels (Weidel et al. 2019). Overall, Alewife, Round Goby, and Rainbow Smelt comprised 80%, 12%, and 3% of the total catch, respectively (Weidel et al. 2019). In 2019, a total of 412 trawls were conducted in US and Canadian waters over the spring and fall surveys leading to the capture of 38,387 Round Goby, 189,735 Alewife, 11,902 Rainbow Smelt, and 5,459 kg of dreissenid mussels (Weidel et al. 2020). Overall, Alewife, Round Goby, and Rainbow Smelt comprised 67%, 14%, and 4% of the total catch, respectively (Weidel et al. 2020). The estimated lake-wide densities of Alewife, Round Goby, and Rainbow Smelt in main basin trawls were 1,716.4 fish/ha, 61.3 fish/ha, and 61.8 fish/ha, respectively (Weidel et al. 2020). The estimated lake-wide densities of Alewife, Round Goby, and Rainbow Smelt in embayment trawls conducted in the Bay of Quinte (the only embayment location where Deepwater Sculpin was captured) were 0.3 fish/ha, 25.3 fish/ha, and 3.1 fish/ha, respectively (Weidel et al. 2020). In addition, Western Tubenose Goby (*Proterorhinus semilunaris*) was detected for the first time in these trawl surveys indicating that this species is likely expanding its range in Lake Ontario (Weidel et al. 2020). Due to complications related to COVID-19, sampling in 2020 was greatly curtailed. Only the fall benthic prey fish survey was undertaken with the majority of sampling taking place in Eastern Ontario (O'Malley et al. 2021). A total of 82 bottom trawls were conducted at sites ranging from 6 to 226 m in depth in US and Canadian waters leading to the capture of 63,976 Round Goby, 29,200 Alewife, 3,479 Rainbow Smelt, and 2,041 kg of dreissenid mussels (O'Malley et al. 2021). Overall, Alewife, Round Goby, and Rainbow Smelt comprised 27%, 59%, and 3% of the total catch, respectively (O'Malley et al. 2021). In 2021, a total of 248 trawls were conducted in US and Canadian waters during the spring survey leading to the capture of 22,057 Round Goby, 844,640 Alewife, and 53,660 Rainbow Smelt (Weidel et al. 2022). Overall, Alewife, Round Goby, and Rainbow Smelt comprised 2%, 89%, and 6% of the total catch, respectively (Weidel et al. 2022). In the fall benthic survey, 195 bottom trawl tows were conducted at sites ranging in depth from 5 to 226 m, including new embayment sites at Bay of Quinte,		

Action	Descriptions and results	Progress	Participants[5] [6]
	Sodus, and Little Sodus Bay (O'Malley et al. 2022). These surveys led to the capture of 48,175 Round Goby, 12,544 Alewife, 8,547 Rainbow Smelt, and 9,472 kg of dreissenid mussels (O'Malley et al. 2022). The abundance of introduced species, including Alewife, Rainbow Trout and Round Goby as estimated through these annual trawl surveys, has fluctuated over the last 20 years (Weidel et al. 2017a; 2017c). Catch curve models of Alewife biomass from 1978 to 2019 show a general decline in abundance for both adults and age 1 individuals (Weidel et al. 2020) while the abundance index for adult Alewife calculated for 2016 was the second lowest recorded since 1997 (Weidel et al. 2017c). Similarly, the estimated abundance of Rainbow Smelt has declined since 1997 (Weidel et al. 2017c; 2020). The abundance of these 2 pelagic prey fish can be influenced by environmental conditions (for example, increased predation, food resource limitations, winter durations), which can have dramatic influences on recruitment and survivorship for cohorts of a given year class (Weidel et al. 2017c; 2020). Furthermore, the timing of trawl surveys greatly impacts the catchability of these species. Specifically, Alewife are particularly vulnerable to benthic trawls in the early spring when they are more likely to be congregated along the lake bottom (Weidel et al. 2017a). The estimated abundance of Round Goby at specific depths can also be influenced by environmental conditions that drive seasonal distribution patterns and is vulnerable to the limitations of the gear-type being employed in these surveys (Weidel et al. 2020). For example, the preference of Round Goby for rocky substrates paired with the ineffectiveness of bottom trawls to sample such substrates likely leads to underestimates of abundance in certain areas of Lake Ontario (Weidel et al. 2020). All of these factors demonstrate the difficulty faced when trying to accurately monitor population trends for these 3 introduced species. It is also important to consider that Alewife and Rainbow Smelt have become the main pelagic forage base supporting many of the predatory gamefish in Lake Ontario (Weidel 2017a) and Round Goby have become an increasingly important component of Lake Trout diets in Lake Ontario (Nawrocki et al. 2022). For this reason there has been somewhat of a paradigm shift from thinking of these species as threatening invaders to considering them relevant members of the benthic and pelagic prey fish communities that play an important role in transferring energy up the food web. It is possible that these species may no longer be relevant in the context of threats to be		

Action	Descriptions and results	Progress	Participants[5] [6]
	mitigated or managed for the conservation of Deepwater Sculpin, a species which appears to be recovering despite the presence of these exotic invaders.		

Table 10. Details of management and coordination activities supporting the conservation of the Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) from 2016 to 2021.

Action	Descriptions and results	Progress	Participants[8]
1) Coordination with other recovery teams and relevant organizations: Collaborate with and share information between relevant groups, initiatives and recovery/management teams (for example, Watershed Committees (WC), MNR, DFO, PC, Great Lakes Fishery Commission) to address management actions of benefit to Deepwater Sculpin.	DFO has collaborated with United States (US) and Canadian agencies at the Federal, Provincial and State, and municipal levels, Indigenous communities and organizations, as well as academic institutions to fund or participate in monitoring activities for the Cooperative Science and Monitoring Initiative, which serves to coordinate operations among jurisdictions on both sides of the border and monitor a variety of parameters in the Great Lakes on a 5 year basis (Richardson et al. 2012; Watkins et al. 2017). DFO has participated in the creation of the Lake Superior National Marine Conservation Area (NMCA), which is led by PC. Considerations for species at risk are contained within the Lake Superior NMCA of Canada Interim Management Plan. DFO has participated in and funded activities prescribed by the International Joint Commission (IJC) to achieve objectives laid out in the Great Lakes Water Quality Agreement (GLWQA), which are aimed at improving habitat conditions with the Great Lakes, which consequently would provide benefits to a wide array of aquatic species including the Deepwater Sculpin. The GLWQA is a commitment between the US and Canada to restore and protect the waters of the Great Lakes, and is led by the US EPA and Environment and Climate Change Canada (ECCC). The Great Lakes Executive Committee (GLEC) serves as a forum to advise and assist the parties in coordinating, implementing, reviewing and reporting on programs, practices and measures that support the implementation of the GLWQA. In Quebec, DFO works in collaboration with the MELCCFP to manage Deepwater Sculpin, particularly by sharing knowledge and data.	In progress	DFO, PC, MNR, IJC, ECCC, MECP, USGS, US EPA, GLNPO, NOAA, MELCCFP, CAs
2) Coordination with other recovery teams and relevant organizations:	As described above, DFO has participated in and funded activities prescribed by the IJC to achieve objectives laid out in the Great Lakes Water Quality Agreement, which are aimed at improving habitat conditions with the Great Lakes and involve a wide	In progress	DFO, IJC, ECCC, MECP, MNR, USGS, US EPA,

[8] United States Geological Survey (USGS), United Sates Environmental Protection Agency (US EPA), International Joint Commission (IJC), Great Lakes National Program Office (GLNPO), National Oceanic and Atmospheric Administration (NOAA), Great Lake Fishery Commission (GLFC), New York State Department of Environmental Conservation (NYSDEC), Natural Sciences and Engineering Research Council of Canada (NSERCC), Canada Research Chairs, Great Lakes Centre (GLC), Department of Natural Resources (DNR), Ontario Ministry of Natural Resources and Forestry (MNR), Fisheries and Oceans Canada (DFO), Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP), Ministry of the Environment, Parks, and Conservation (MECP), Parks Canada (PC).

Action	Descriptions and results	Progress	Participants[8]
Collaborate with American researchers involved in management actions benefiting the Great Lakes, and those involved in regular surveys capturing Deepwater Sculpin (for example, USGS).	array of partners including US agencies (that is, US EPA). The GLWQA has led to the development of the Lake Superior Lakewide Action and Management Plan (LAMP), which is a binational ecosystem-based strategy for protecting and restoring Lake Superior water quality. This plan is aimed at addressing threats to the Lake Superior ecosystem including chemical contamination, invasive species, and nutrients and algae, and also prescribes conservation measures focused on specific habitats and species, including Deepwater Sculpin (LSLAMP 2016); a new 2020 to 2024 LAMP is currently in development. DFO has participated in the Cooperative Science and Monitoring Initiative (CSMI). The CSMI is a bi-national effort by the US and Canada, pursuant to the GLWQA, to coordinate Great Lakes research and monitoring activities designed to guide management actions (CSMI 2008). CSMI, primarily USGS, US EPA, and other US agencies, conducts research on each Great Lake over staggered 5-year cycles. Research was conducted in Lake Superior in 2016 that investigated various facets of ecosystem health (for example, lower food web: Pawlowskia and Sierszen 2020; impacts of invasive species on the trophic transfer of energy: Matthias et al. 2021; trends in the macroinvertebrate community: Mehler et al. 2018; trends in the fish community: Vinson et al. 2019b). Similar research was undertaken in Lake Huron in 2017 (for example, spatial and temporal trends in dreissenids: Kirkendall et al. 2021, Bayba et al. 2022; benthic surveys: Karatayev et al. 2020) and in Lake Ontario in 2018 (for example, benthic community changes, invasive species, contaminants and toxic substances, all of which are described in Watkins et al. 2022).		GLNPO, NOAA, GLC, CAs, Academic institutions
3) Coordination with other recovery teams and relevant organizations: Consolidate existing data into a central database, including habitat parameters, to facilitate Deepwater Sculpin data synthesis and transfer in Quebec. A central database currently exists in Ontario.	All data on species at risk in Quebec are consolidated in the database of the Quebec Natural Heritage Data Centre (QNHDC) and the occurrences of these species are available in an interactive map.	In progress	MELCCFP

Table 11. Details of research activities supporting the conservation of the Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) from 2016 to 2021.

Action	Descriptions and results	Progress	Participants[9]
1) Population monitoring: develop standardized protocols for surveying and monitoring Deepwater Sculpin populations.	The USGS conducts annual sampling in the Great Lakes that has been used to assess fluctuations in the abundance of Deepwater Sculpin (for example, Vinson et al. 2018 and 2019 [Lake Superior]; Roseman et al. 2016; Riley et al. 2017 and 2019 [Lake Huron]; O'Malley et al. 2021, Weidel et al. 2019 [Lake Ontario]). Although these programs are not designed specifically for Deepwater Sculpin, they have provided the best available information to estimate population trends. Below are descriptions of sampling approaches and gears used in lakes Superior, Huron, and Ontario. **Lake Superior:** The USGS (Lake Superior Biological Station) conducts annual daytime bottom trawl surveys in nearshore (approximately 15 to 80 m depths) and offshore (approximately 100 to 300 m depths) waters of Lake Superior (see Vinson et al. 2019a). Although these programs are not designed specifically to monitor Deepwater Sculpin, they have provided the best available information to estimate population trends. The nearshore survey has been conducted annually since 1978 in US waters, and since 1989 in Canadian waters. The nearshore survey captures Deepwater Sculpin less frequently. The offshore survey has been conducted annually since 2011 in both US and Canadian waters. A total of 79 nearshore and 36 offshore sampling stations have been established. **Lake Huron:** USGS has undertaken trawl surveys at transects situated in relation to 5 ports in US waters (Detour, Hammond Bay, Alpena, Au Sable Point, and Harbor Beach in Michigan) and 1 port in Canadian waters (Goderich in Ontario). The US locations have been sampled annually since 1973 and the Canadian location has been sampled intermittently since 1998 (Roseman et al. 2016). Gear types used include 12 metre headrope and 21 m headrope bottom trawls conducted at depths ranging from 9 to 110 m (Riley et al. 2019). These surveys also monitor and track the abundance of introduced species including Round Goby (*Neogobius melanostomus*), Rainbow Smelt (*Osmerus mordax*), and Alewife (*Alosa pseudoharengus*) (for example, Riley et al.	In progress	USGS, NYSDEC, MNR

[9] United States Geological Survey (USGS), United Sates Environmental Protection Agency (US EPA), International Joint Commission (IJC), Great Lakes National Program Office (GLNPO), National Oceanic and Atmospheric Administration (NOAA), Great Lake Fishery Commission (GLFC), New York State Department of Environmental Conservation (NYSDEC), Natural Sciences and Engineering Research Council of Canada (NSERCC), Canada Research Chairs, Great Lakes Centre (GLC), Department of Natural Resources (DNR), Ontario Ministry of Natural Resources and Forestry (MNR), Fisheries and Oceans Canada (DFO), Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP), Ontario Ministry of the Environment, Conservation and Parks (MECP), Parks Canada (PC).

Action	Descriptions and results	Progress	Participants[9]
	2019). Currently there is only 1 trawl transect located within Canadian waters which leaves the vast area of potential Deepwater Sculpin habitat unsampled. Sampling surveys should be expanded throughout the Canadian waters of Lake Huron as well as historically occupied areas within Georgian Bay. **Lake Ontario:** The USGS and NYSDEC have been conducting spring bottom trawl surveys, primarily targeting Alewife and Rainbow Smelt, from April to June since 1978 with 12 transects spaced at 25 km intervals along the US shoreline (Walsh et al. 2014). Furthermore, USGS conducted bottom trawl surveys in the fall for benthic prey fish (September to November, primarily October) throughout 6 transects situated along the southern shore of Lake Ontario (Olcott to Oswego, NY) (Weidel et al. 2018). In 2015 the NYSDEC and MNR joined the fall survey effort and began sampling more locations throughout Lake Ontario including within Canadian waters (Weidel et al. 2015; Weidel et al. 2018). In 2016, the MNR also joined in the spring survey efforts expanding the monitoring program into Canadian waters (Weidel et al. 2018). Although, these bottom trawl surveys target the benthic prey fish community in general and do not specifically target Deepwater Sculpin, they provide excellent distribution and abundance information to track population trends for the species as well as associations between Deepwater Sculpin and the fish community. Weidel et al. (2017a) analyzed trawl survey data for Lake Ontario over the time period of 1996 to 2016. Through this analysis they observed that the change from nylon Yankee-style trawls to a polypropylene style bottom trawls referred to as “3N1”, to minimize the nuisance capture of dreissenid mussels, may have reduced the ability to effectively capture Deepwater Sculpin considering the 3N1 net has lighter bottom contact. Furthermore, both trawl types used in these surveys are only able to effectively sample depths ≤ 225 m, which limits the ability to detect Deepwater Sculpin at deeper depths where higher densities could potentially be found given the pattern observed by Weidel et al. (2017a) that density generally increases with depth. These authors critiqued the historic sampling design for Deepwater Sculpin in Lake Ontario and highlight the need for deeper sampling, and postulate that population densities may be under-realized in Lake Michigan and Lake Huron where maximum sampling depths are 110 m. These findings provide valuable insight towards the development of a standardized monitoring protocol for Deepwater Sculpin within the Great Lakes.		
2) Life-history characteristics: Increase knowledge of Deepwater	Roseman (2014) characterized the habitat use, diet, age, and growth of larval and age-0 Deepwater Sculpin collected from northern Lake Huron and the Detroit River. The larval fish were collected in 2007 at offshore sites in Lake Huron (depth of 91 m), as	In progress	USGS

Action	Descriptions and results	Progress	Participants[9]
Sculpin biology, particularly knowledge in areas currently limiting conservation planning (for example, spawning behaviour, reproductive life history, population demographics).	well as nearshore (depth of 37 m) and inshore sites (depths of 1 to 15 m) in coastal areas of Lake Huron including DeTour, Michigan, and Hammond Bay along the Michigan shoreline. Furthermore, larval fish were collected in the Detroit River from 2007 to 2012 at locations upstream and downstream of Peche Island, near Belle Isle, upstream of the Ambassador Bridge, in the vicinity of Fighting Island, Grosse Isle, and Bois Blanc Isle, as well as along the mouth of the Detroit River in western Lake Erie (Roseman 2014). Through examination of otoliths taken from sampled Deepwater Sculpin to back-calculate larval age, Roseman (2014) was able to estimate hatch dates in late March with larvae remaining pelagic for 40 to 60 days with the highest density of larvae found in the Detroit River in April. The first age-0 individuals were captured at offshore locations in Hammond Bay at greater than 25 mm total length (TL) in early September, indicating that the switch from larval to age-0 fish life-stages likely occurs in late summer (Roseman 2014). Pelagic larvae (10 to 21 mm TL) were zooplanktivorous with diets comprised primarily of Calanoid copepods at all sampling locations, while other prey items including rotifers and cladocerans were also consumed in northern Lake Huron. Conversely, age-0 fish captured in benthic habitats had diets that varied by location and depth but generally consisted of benthic macroinvertebrate prey including *Mysis spp.* and chironomids, as well as *Diporeia spp.*, although some individuals still fed on zooplankton including *Bythotrephes spp.* (Roseman 2014). Although this research was conducted prior to the focal period of this report, the results were not captured in the management plan and warrant mention considering they contribute significantly to our understanding of Deepwater Sculpin life-stages and recruitment throughout the Great Lakes. This study (Roseman 2014), paired with the results of an earlier study (Roseman et al. 2013), demonstrate that inshore areas of northern Lake Huron provide critical nursery habitats for Deepwater Sculpin larvae; therefore, negative perturbations to conditions amenable to larvae in the nearshore will effect recruitment of deepwater Sculpin to deepwater benthic zones. Weidel et al. (2017a) analyzed data collected from bottom trawls conducted in Lake Ontario from 1996 to 2016 and determined that the size at maturation for Deepwater Sculpin was approximately 116 mm and 110 mm for females and males, respectively. They calculated the gonadal somatic index[10] (GSI) for males and females to be up to		

[10] Weight of reproductive organs (ovaries or testes) as a proportion of body weight

Action	Descriptions and results	Progress	Participants[9]
	25% and 3.3% for females and males, respectively (Weidel et al. 2017a). They documented that individuals captured since 2009 exhibited maximum total lengths of 185 to 205 mm and observed a positive relationship between the mean length of individuals and the sampling depth (Weidel et al. 2017a). Ludwig et al. (2022) observed GSIs of 1.3 ± 0.7% and 7.9 ± 6.2% in male and female Deepwater Sculpin, respectively. Through histological examinations, Ludwig et al. (2022) observed ovaries that contained oocytes at varying stages of maturity, which indicates females can spawn multiple times within a given season. Furthermore, they measured the absolute batch fecundity of females captured in 2018 and 2019 to be 723 ± 196 and 840 ± 268 eggs, respectively (Ludwig et al. 2022). Robinson et al. (2021) conducted an extensive literature review of the biology and ecology of sculpin species in the Laurentian Great Lakes, including Deepwater Sculpin. They document what is known to date about Deepwater Sculpin including aspects such as: connectivity, movement and dispersal; habitat use; reproduction timing and nesting behaviour and the potential for reproductive communication between sexes; early life history; age and growth patterns; diet; trophic position; and species interactions including with similar species, predators and invasive species. Refer to Robinson et al. (2021) for more details on the aforementioned topics. These authors conclude that more information is needed in several of the areas including but not limited to: further genetic research to examine effective population size, potential for population bottlenecks, and to delineate accurate and effective conservation units (designatable units in Canada); further research investigating habitat use at each life stage for Deepwater Sculpin across their range including seasonal, diel[11] and ontogenetic[12] changes in habitat use; and further examination of Deepwater Sculpin life history at the reproduction, early- and adult-life stages. Jude et al. (2022) used a remotely operated vehicle to examine Deepwater Sculpin habitat use in Grand Traverse Bay, Lake Michigan in December 2015, March 2017, and March 2021. They surveyed areas in depths ranging from 70 to 191 m and observed 1 nest with a Deepwater Sculpin present, presumably a male guarding the nest, at a depth of 190 m in an area comprised of sandy substrate and plant debris next to a branch in March of 2021. Furthermore, they also observed depressions in		

[11] Changes that occur within a 24 hour period (day and night)
[12] Changes that occur as the species progresses through its life cycle from one stage to the next

Action	Descriptions and results	Progress	Participants[9]
	areas with sandy substrates, which they postulate may be abandoned Deepwater Sculpin nests (Jude et al. 2022).		
3) Habitat Assessment\modelling: Determine the quantity and quality of habitat required to ensure long-term conservation of Deepwater Sculpin and to support the long-term management goal.	Currently no progress has been made that specifically sets out to examine the quantity and quality of Deepwater Sculpin habitat; however, van der Lee and Koops (2021) used sampling records from Lakes Superior, Huron and Ontario to project a spatial model of Deepwater Sculpin biomass in each lake that does identify areas likely inhabited by the species including density relative to bathymetric depth. This modelling data could be used to quantify the spatial area of habitat available for Deepwater Sculpin within the Great Lakes.	Not started	DFO, USGS
4) Re-establishment: Investigate the feasibility of population supplementation or repatriation for populations that may be extirpated or reduced. Develop a repatriation plan where appropriate.	Research has been conducted between 2013 to 2015 (Gorman and Keyler 2016) aimed at developing methods and protocols to minimize the impact of barotrauma[13] on Deepwater fishes found in the Great Lakes that typically inhabit waters > 60 m in depth including Lake Whitefish (*Coregonus clupeaformis*), Deepwater ciscoes (*Coregonus spp.*), Siscowet Lake Trout (*Salvelinus namaycush*), Burbot (*Lota lota*), Ninespine Stickleback (*Pungitius pungitius*), and Deepwater Sculpin. To mitigate the impacts of barotrauma and increase the likelihood of the survivorship of deep-caught fishes, a hyperbaric apparatus that provides rapid recompression and controlled decompression (RRCD) was developed and tested. A main goal of this study was to increase the survivorship of specimens of the aforementioned species, and allow for their transport for research and to rearing facilities to provide broodstock development, which is a pivotal first step that must be achieved if restoration efforts are ever to be undertaken. The RRCD treatments showed promise in reducing the signs of barotrauma in fish; however, only 25% of sculpins survived long-term, indicating further research is needed to limit the impacts of the removal and capture of Deepwater Sculpin from their natural environment, and increase the likelihood and longevity of their survival in captive rearing conditions.	In progress	USGS, Academic institutions
5) Population dynamics\fish community interactions: Gather information on population dynamics of Deepwater Sculpin and the	**Lake Superior (population dynamics):** Data collected from the annual nearshore and offshore bottom trawl surveys conducted by USGS between 2011 and 2019 was modelled and the first 4 years of data was compared to the last 4 years of data to	In progress	USGS, DFO, Academic institutions

[13] Traumatic physiological effects, also known as catastrophic decompression syndrome, caused by the rapid reduction of barometric pressure, which can include: distention of the swim bladder, torsion and volvulus of stomach and intestine, internal bleeding, and hematomas (see Gorman and Keyler 2016).

Action	Descriptions and results	Progress	Participants[9]
associated fish community, with particular emphasis on understanding the degree to which predator (for example, Alewife, Lake Trout and Rainbow Smelt) and prey (for example, *Diporeia* and *Mysis*) abundances impact population dynamics.	examine changes in catch per unit of effort (CPUE[14]) and occurrence[15] (van der Lee and Koops 2021). They found that occurrence was relatively stable over the years analyzed while there was more fluctuation in CPUE with a decline occurring over the 9 year time series (van der Lee and Koops 2021). Using expected catch rates derived from a model of CPUE, the authors estimated the mean growth rate of Deepwater Sculpin populations in Lake Superior to be 0.94 (confidence interval: 0.89 to 0.98), which is indicative of a gradual decline[16] (van der Lee and Koops 2021). In addition, van der Lee and Koops (2021) used a spatial hurdle model based on sampled depths to project the distribution of Deepwater Sculpin in Lake Superior and estimate density throughout this distribution, and to estimate the biomass of the population for the last year of the time series, in this case 2019. This model predicted that the highest densities of Deepwater Sculpin occur in the deepest sampled areas of the lake with the highest densities predicted offshore from the Minnesota shoreline (van der Lee and Koops 2021). The median population biomass of Deepwater Sculpin estimated from this model was 9,993.8 t (confidence interval: 1,705.1 to 63,247.2 t) with 31% occurring within Canadian waters (van der Lee and Koops 2021). Although the population within Lake Superior has been experiencing a decline over the 2011 to 2019 period, the biomass estimates suggest that the population is robust (van der Lee and Koops 2021). **Lake Superior Fish Community Interactions (interspecific competition):** Robinson et al. (2021) investigated the potential for trophic overlap of Deepwater Sculpin, Slimy Sculpin (*Cottus cognatus*) and Spoonhead Sculpin (*Cottus ricei*) in Lake Superior. They analyzed specimens of each species sampled in Lake Superior for the carbon isotope $\delta^{13}C$ and the nitrogen isotope $\delta^{15}N$. Based on the area of ellipses generated from bivariate plots of $\delta^{13}C$ and $\delta^{15}N$, they found that Slimy Sculpin occupied the largest trophic niche[17], Deepwater Sculpin occupied an intermediate sized trophic niche, and Spoonhead Sculpin had the smallest trophic niche size. The results of Robinson et al. (2021) indicate that there is substantial overlap in the trophic niches of the 3 sculpin species, with Slimy Sculpin and Spoonhead Sculpin overlapping with 94% and 27% of Deepwater Sculpin's trophic niche, respectively. However, the		

[14] A metric which can be used to estimate abundance.
[15] Presence/absence of a species at sampling sites.
[16] Population growth rates equal to 1 indicate neutral growth, greater than 1 indicate positive growth, and less than 1 indicate a declining population.
[17] Where a species occurs within the food chain based on what prey it consumes and what other species consume it.

Action	Descriptions and results	Progress	Participants[9]
	authors demonstrate that differences in the depths utilized within Lake Superior by these 3 species (most notably between Deepwater Sculpin and the other 2 species), based on the recorded densities of each species captured at various depths during spring and fall bottom trawls in 2015 to 2019, likely minimizes interspecific competition for resources (Robinson et al. 2021). **Lake Superior Fish Community Interactions (predator-prey relationships):** Vinson et al. (2020) analyzed the stomach contents of sympatric Lake Trout morphs of Lake Superior, including the lean, Siscowet, humper, and redfin morphs, captured in 2013 and 2014 at multiple depths (<50 m, 50 to 100 m and >100 m) at 2 offshore shoal locations (Stannard Rock and Superior Shoal). Although they found that the diets of all morphs were largely comprised of invertebrates, Coregonids (*Coregonus spp.*) and Deepwater Sculpin were the most frequently consumed fish species, with Deepwater Sculpin being consumed by all 4 morphs. Keyler et al. (2019) examined the effect of light intensity and emission spectrum, and substrate type on the ability of Siscowet Lake Trout (*Salvelinus namaycush siscowet*) to forage on Deepwater Sculpin in Lake Superior. They found that reaction distance and the number of prey captures increased with light intensity, although, reaction distance remained consistent at light intensities > 6.0×10^9 photons m^{-2} s^{-1} and was not affected by substrate type (Keyler et al. 2019). Based on known light penetration and intensity in Lake Superior, the results of Keyler et al. (2019) indicate that Siscowet are capable of visually foraging below 150 m, with reaction distance not diminishing until depths of 200 m. Similarly, Keyler (2018) examined the behavior of Deepwater Sculpin, collected from Lake Superior, in the presence of Siscowet under varying ecologically relevant light conditions over substrate types including gravel, sand and black fabric. They observed that Deepwater Sculpin activity in the presence of Siscowet diminished with increasing light intensity at thresholds that are inverse to the aforementioned patterns exhibited by Siscowet in the Keyler et al. (2019); therefore, as light intensity decreased, consequently leading to reduced Siscowet Lake Trout activity, the average number of Deepwater Sculpin movements increased. Conversely, Deepwater Sculpin reaction distance was impacted by light intensity with greatest reaction distance observed at mid-ranges and lower reaction distances observed in the dark and at the highest light intensities (Keyler 2018). Furthermore, Deepwater Sculpin reaction distance was affected by substrate type with greater reaction distances to Siscowet observed over gravel substrates (Keyler 2018). Overall, Keyler et al. (2019) state that these studies		

Action	Descriptions and results	Progress	Participants[9]
	represent a step towards developing accurate foraging models, evaluating effects on habitat use by benthic and pelagic species, and ultimately understanding top-down impacts of fish community structure in the Great Lakes. **Lake Huron (population dynamics):** Van der Lee and Koops (2021) modelled data collected from annual bottom trawling surveys conducted by USGS to assess the offshore demersal fish community in Lake Huron using transects from US ports from 1976 to 2019. They used 2 spatial hurdle models including: a spatial model that projected Deepwater Sculpin density throughout the US portion of Lake Huron that was extrapolated from CPUE data collected from the annual surveys along the transects associated with US ports; and a port model that was based directly on the CPUE data collected along the transects associated with US ports, which offers a more fragmented and limited coverage of the main basin (van der Lee and Koops 2021). Of these 2, they found that the spatial model provided a better fit to the data, although there were a lot of similarities in temporal patterns observed between the 2, including an overall trend of decreasing occurrence over time, which began to transpire slowly in the 1980s and then occurred rapidly from 2004 to 2009 (van der Lee and Koops 2021). Similarly, declines in CPUE occurred in the early 2000s, and although catch rates have begun to increase in more recent years, they are still below historic levels (van der Lee and Koops 2021). In contrast to the time-scale of these macro trends, the model was used to draw comparisons of occurrence and CPUE from the 2004 to 2007 period to the 2016 to 2019 period, which is representative of the past 3 generations (van der Lee and Koops 2021). The models did not provide any evidence that any meaningful changes in occurrence or CPUE have transpired over the last 3 generations, and the population growth rate, as estimated from the mean expected catch rate, was 1.02, which suggests that the population has not increased or decreased, but rather has remained stable over these generations (van der Lee and Koops 2021). In addition, van der Lee and Koops (2021) used the spatial hurdle model based on sampled depths within US waters to project the distribution of Deepwater Sculpin within the US portion of Lake Huron and estimate density throughout this distribution. They also used this model to estimate the biomass of the population for the last year of the time series, in this case 2019. The highest densities of Deepwater Sculpin shifted over time to be more concentrated in the northern part of the lake near the ports of Hammond Bay and De Tour, which the authors note may be attributable to the		

Action	Descriptions and results	Progress	Participants[9]
	availability of Diporeia (van der Lee and Koops 2021). The median population biomass of Deepwater Sculpin estimated from this model was 159.2 t (confidence interval: 25.7 to 976.6) (van der Lee and Koops 2021). Ultimately the biomass projections are limited to sampled areas of the lake that are primarily within US waters and less than 110 m in depth; therefore, these estimates are not inclusive of, and may not be representative of the majority of Canadian habitat for this species. **Lake Huron Fish Community Interactions (diet):** Recent research has been undertaken that investigates the diets of Deepwater Sculpin in Lake Huron at various depths (Thompson et al. 2017). These authors compared diet data collected in the 2010 to 2014 period with data from 2003 to 2005, which was reported in O'Brien et al. (2009), to investigate if any changes were evident as a result of the invasion of Dressenid mussels (that is, Quagga Mussels – *Dreissena bugensis*, and Zebra Mussels – *D. polymorpha*), which are believed to have driven declines in *Diporeia hoyi*, an amphipod that was a historically preferred prey item of Deepwater Sculpin. Thompson et al. (2017) observed that Deepwater Sculpin diets were comprised of prey items including *Diporeia hoyi*, *Mysis diluviana* a shrimp like crustacean, Spiny waterflea (*Bythotrephes longimanus*), midge larvae (*Chironomidae*), as well as other less frequently consumed prey items including ostracods, copepods, sphaerid clams (*Sphaeriidae spp.*), and fish eggs. The authors observed that *Diporeia* was not found in the diets of Deepwater Sculpin from shallow depths (<55 m); however, the frequency of occurrence of this prey item within Deepwater Sculpin diets increased with water depth, with *Diporeia* remaining a substantial component of Deepwater Sculpin diets at deeper depths (>82 m). Inversely, at shallow depths, *Mysis* were often the sole prey item consumed, with the frequency of *Mysis* declining as depth increased. Thompson et al. (2017) calculated a prey-specific index of relative importance for each prey group to measure potential changes in diet between the 2 aforementioned time periods. They found that *Diporeia* importance increased offshore at deeper depths (≥82 m), while *Mysis* importance increased at shallow (≤55 m) and mid (64 to 73 m) depths since the 2003 to 2005 time period. The authors note that alterations to the food web that are causing declines in *Diporeia* may not yet be fully evident within the diets of Deepwater Sculpin as enough of this prey item are still present to remain a substantial component of their diets. **Lake Ontario (population dynamics):** Weidel et al. (2017a) assessed the status of Deepwater Sculpin in Lake Ontario by analyzing data collected from bottom trawl		

Action	Descriptions and results	Progress	Participants[9]
	surveys, at depths of 5 to 225 m, which were conducted over the time period of 1996 to 2016. They observed that density of Deepwater Sculpin, which was estimated annually, increased over this time period, and modeling of whole-lake population growth suggests that the rate of increase was approximately 59% per year. Weidel et al. (2017a) calculated the gonadal somatic index of both male and female Deepwater Sculpin captured in surveys throughout the aforementioned time period and used a sigmoid Hill function and estimated body length at maturation to be approximately 116 mm and 110 mm for females and males, respectively. These authors then used the estimated size at maturation of females as a benchmark to measure changes in size and condition overtime for the population. They found that both the mean total length and the proportion of fish greater than approximately 116 mm increased from 1996 to 2013. They observed that up until 2009, the largest specimen captured was 157 mm, but from 2010 to 2016, the maximum length of specimens captured has ranged from 185 to 205 mm (Weidel et al. 2017a). The average density of Deepwater Sculpin between from 2011 to 2016 was calculated to be 21 fish/ha; although, densities as high as 896 fish/ha were observed at some locations (Weidel et al. 2017a). Through the 1996 to 2016 trawl surveys, Deepwater Sculpin were captured at locations as shallow as 30 m up to depths of 225 m with densities generally increasing with depth, most notably past depths >150 m (Weidel et al. 2017a). In addition, mean length of all deepwater sculpin per trawl significantly increased with depth indicating that there does not appear to be any density dependent effects on condition, which may reflect that Deepwater Sculpin are not resource limited with prey items such as *Mysis diluviana* likely supporting the recovering population in Lake Ontario (Weidel et al. 2017a). van der Lee and Koops (2021) modelled data collected from annual spring and fall bottom trawling surveys conducted by USGS, NYSDEC, and MNR to assess the abundance of Alewife and the benthic fish community, respectively. Both surveys have captured Deepwater Sculpin consistently since the mid-2000s with the spring survey data covering a period from 2004 to 2019 and the fall survey data covering a period from 2015 to 2019. van der Lee and Koops (2021) used this data to develop 4 spatial hurdle models, including a model that examines long-term trends and a spatial model that examines lake-wide abundance for each of the 2 aforementioned surveys separately. Overall, both the occurrence and CPUE of Deepwater Sculpin increased dramatically and consistently year over year during the time periods of both the spring and fall surveys. The models were used to draw comparisons of occurrence and CPUE		

Action	Descriptions and results	Progress	Participants[9]
	from the 2004 to 2007 period to the 2016 to 2019 period for the spring survey, and the 2005 to 2008 and 2016 to 2019 period for the fall survey, which is representative of the past 3 generations (van der Lee and Koops 2021). The population growth rate, as estimated from the mean expected catch rate, was 1.56 based on the spring survey model and 1.48 based on the fall survey model, which further supports that the Deepwater Sculpin population has been growing prolifically over the last 15 to 16 years (van der Lee and Koops 2021). In addition, van der Lee and Koops (2021) used the lake-wide models for both the spring and fall surveys based on sampled depths to project the distribution and density of Deepwater Sculpin within Lake Ontario and estimate the biomass of the population for the last year of the time series, in this case 2019. The highest densities of Deepwater Sculpin were expected to be more concentrated in the deeper depths in the central areas of the lake (van der Lee and Koops 2021). The median population biomass of Deepwater Sculpin estimated for the spring and fall surveys was 7,231.5 t (confidence interval: 1,387 to 43,481 t) and 6,434.2 t (confidence interval:1,080.8 to 45,337.5 t), respectively, with 30% of this biomass projected to occur in Canadian waters (van der Lee and Koops 2021). **Lake Ontario Fish Community Interactions (interspecific competition)**: Mumby et al. (2018) examined niche overlap and resource and habitat partitioning among introduced Alewife, Rainbow Smelt, Round Goby, and native species Deepwater Sculpin and Slimy Sculpin in Lake Ontario. Specimens were collected in 2013 from 6 sites in US waters and 6 sites in Canadian waters monthly from April to November at depths ranging from 1 to 175 m (Mumby et al. 2018). The carbon stable isotopes $\delta^{13}C$ and nitrogen stable isotope $\delta^{15}N$ were used for analysis to assess changes in diet and habitat across seasons and determine the niche size for each species, and explore potential niche overlap between species, which could infer that interspecific competition may be occurring (Mumby et al. 2018). The results of Mumby et al. (2018) show that the introduced species Round Goby and Alewife occupied the largest and second largest isotopic niches[18], respectively, while Deepwater Sculpin occupied a comparably smaller niche. Furthermore, stable isotopes in Deepwater Sculpin did not vary with regard to location or season suggesting there is		

[18] An area of space in mathematical multivariate analysis that is defined by the isotopic values of elements, including but not limited to carbon, nitrogen, hydrogen and oxygen, which act as coordinates. These isotopes are found within an animal's tissues and can be used to understand its food resources and the habitats/areas where it has occurred.

Action	Descriptions and results	Progress	Participants[9]
	likely very little difference in diet or habitat among deepwater locations throughout the months sampled. Relationships between $\delta^{15}N$ and Deepwater Sculpin body length indicate that ontogenetic shifts in diet occurred in individuals ranging 59 to 186 mm TL (Mumby et al. 2018). Furthermore, Mumby et al. (2018) found that there was a larger degree of variation in $\delta^{15}N$ values among smaller individuals, which could indicate that they consume a wider variety of prey items than larger conspecifics. Mumby et al. (2018) found no evidence to suggest that niche overlap is occurring between Deepwater Sculpin and the aforementioned introduced species suggesting that resource and habitat partitioning have offset competitive interactions; however, a high isotopic niche overlap (>63%) was observed between Deepwater Sculpin and Slimy Sculpin suggesting the potential for interspecific competition is high. These authors hypothesize that the overlap observed between the native sculpin species may be attributable to the reduction in the availability of *Diporeia* and the increased consumption of *Mysis*. **Lake Ontario Fish Community Interactions (predation):** Nawrocki et al. (2022) examined the diets of 349 Lake Trout collected from the west, central, east, and Kingston basins of Lake Ontario in 2013 and 2018 using stomach content analysis and stable isotope analyses. They observed that Deepwater Sculpin were a component of the diets of Lake Trout, especially in the central basin in 2018. Nawrocki et al. (2022) postulate that Deepwater Sculpin are likely to become a more substantial component of Lake Trout diet as their overall abundance in Ontario increases. **Research that applies to all Deepwater Sculpin populations in the Canadian portion of the Great Lakes (availability of prey resources):** Burlakova et al. (2018) explored spatial and temporal patterns of change in the composition and abundance of benthic communities in both the littoral and profundal zones using data collected through the US Environmental Protection Agencies' (EPA) Great Lakes Biology Monitoring Program collected between 1998 and 2014. They found that the lakes with the highest productivity had the greatest benthic diversity and abundance with Lake Ontario having higher diversity than Lake Huron, followed by Lake Superior (Burlakova et al. 2018). They observed that large changes in the benthic community occurred in the profundal zones of Lakes Huron and Ontario including shifts in the dominant taxa and shifts in habitat use toward deeper waters; in contrast, Lake Superior did not experience significant changes. These changes in lakes Huron and Ontario were		

Action	Descriptions and results	Progress	Participants[9]
	largely driven by the introduction of dreissenid mussels. Most notably, *Diporeia hoyi* (*Diporeia*), a prey item consumed by Deepwater Sculpin that historically dominated the benthic community, has dramatically declined and been replaced by dreissenid mussels and *Oligochaetes* (Burlakova et al. 2018). In contrast, the invasion of dreissenid mussels appears to have had less of an impact in deepwater habitats of Lake Superior presumably due to calcium limitations in the benthic habitat found offshore (Burlakova et al. 2018). Jude et al. (2018) assessed the density and biomass of *Mysis diluviana* (*Mysis*), a prey item consumed by Deepwater Sculpin, in the Great Lakes using samples collected by the EPA's Great Lakes National Program Office's biomonitoring program between 2006 and 2016. Given the large declines in *Diporeia* that have been observed, specifically in Lakes Huron and Ontario, there are concerns that similar declines in *Mysis* may be occurring due to oligotrophication[19] resulting from the invasion and establishment of dreissenid mussels and efforts to reduce anthropogenic nutrient loading. Contrary to what was hypothesized, there were no significant trends in the abundance of *Mysis* in Lakes Huron and Ontario, while there was a significant increase observed for Lake Superior (Jude et al. 2018). They found that the density of *Mysis* was highest in Lake Ontario (13 to 30% of the total open-water crustacean biomass) followed by Lake Superior (14 to 18%) and lastly Lake Huron (3%) (Jude et al. 2018). While negative trends were not apparent within the 2006 to 2016 timeframe of this study, comparisons with historic data from the 1960s to 1990s indicate that the density of Mysids were historically 40% higher in Lake Superior, 5 times higher in Lake Huron and 2 times higher in Lake Ontario (Jude et al. 2018). These authors postulate that declines in the density of Mysids in the Great Lakes resulting from oligotrophication and predation may still occur in the future (Jude et al. 2018). **Other research not specific to Canadian Great Lakes or relevant to the Great Lakes as a whole (predation and interspecific competition):** Mychek-Londer et al. (2013) examined the stomach contents of Round Goby, Slimy Sculpin and Deepwater Sculpin captured at locations in Lake Michigan at depths ranging between 69 to128 m to assess potential diet overlap between these species and determine if Round Goby are consuming the eggs of the 2 native sculpin species. Diet overlap was evident between Deepwater Sculpin and Slimy Sculpin at 2 of the locations sampled suggesting possible interspecific competition (Mychek-Londer et al. 2013). In contrast, Mychek-Londer et al. (2013) did not observe diet overlap between invasive Round		

[19] The reduction of nutrients within an aquatic ecosystem or diminished rate of nutrient cycling.

Action	Descriptions and results	Progress	Participants[9]
	Goby and the 2 native sculpin species, and the frequency of occurrence of native sculpin eggs in the stomach contents of Round Goby was < 1%. Although this study was focused on Lake Michigan, which is outside of Canadian jurisdiction, and consequently the scope of this report, the results may represent interspecific relationships between these species in the other Great Lakes. Other than the Great Lakes, no research was conducted within the small inland lakes of Ontario or Quebec during the period of this report, and monitoring was too limited to allow for Deepwater Sculpin population dynamics or fish community interactions to be explored.		
6) Genetic assessment: Assess genetic variation across the Canadian range and investigate population structure among/within Canadian populations.	An assessment of genetic variation and population structure for Deepwater Sculpin populations was conducted that investigated the potential source of resurgent Lake Ontario populations (Welsh et al. 2017). Deepwater Sculpin was considered extirpated considering the species had not been detected in decades; however, the species was again detected in 1996 and has been consistently captured since 2005. There are 2 potential hypotheses for the increased occurrence of Deepwater Sculpin in Lake Ontario: 1) individuals from source populations in the Upper Great Lakes have recruited downstream and recolonized Lake Ontario; or 2) the population in Lake Ontario was never fully extirpated and may have persisted at deeper depths where sampling was not undertaken, and ecosystem improvements have allowed remnant populations to recover naturally. The authors note that these hypotheses are not necessarily mutually exclusive. Welsh et al. (2017) compared samples of all Great Lake populations, including the current Lake Ontario population and museum specimens from the historic Lake Ontario population using 8 microsatellite loci. Their results suggest that: 1) there appears to be low levels of spatial genetic structure in Great Lakes populations as a whole; 2) the recolonization scenario is the most likely source of current populations, with individuals from Upper Great Lakes populations recruiting approximately 50 years ago; 3) it is highly probable that admixture from Upper Great Lakes populations and the historic Lake Ontario population occurred, although the contribution from the historic population is likely to have been low; and 4) the population currently found in Lake Ontario has lower genetic diversity than conspecifics in the Upper Great Lakes indicating that founder effects are likely.	In progress	USGS, Academic institutions
7) Threat evaluation: Conduct a threat assessment, to evaluate threat factors that	**Anthropogenic Stressors (contaminants and toxic substances):** Long et al. (2022) investigated trends in polychlorinated biphenyls (PCBs) found in both surface sediment and suspended sediments collected from Canadian nearshore sampling stations in	In progress	USGS, OPG, MECP, US EPA, GLC, NOAA,

Action	Descriptions and results	Progress	Participants[9]
may be impacting the Deepwater Sculpin (for example, invasive species, eutrophication, diseases), which will be updated as new information becomes available.	Lake Ontario between 1994 and 2018. They found that PCB concentrations were elevated throughout the Niagara Basin at nearshore stations (Long et al. 2022). Deepwater Sculpin were historically found at nearshore locations along the shoreline in the vicinity of Burlington, Oakville, Mississauga, Stoney Creek and Niagara on the Lake, and given that the species is a benthic dweller, it is likely to have come in contact with contaminated sediments. Recent detections of Deepwater Sculpin have been in deeper waters further offshore; therefore, analyses of PCB concentrations in the sediments of deepwater habitats may provide a better understanding of how these contaminants are currently affecting the species. Codling et al. (2018) examined current and historical concentrations of Per- and polyfluoroalkyl substances (PFAS) within sediment samples collected from Lake Superior, Lake Michigan, Lake Huron and Georgian Bay, including a number of locations where Deepwater Sculpin have been detected. They detected 16 of the 22 PFASs they were investigating at locations throughout the aforementioned lakes with perfluoro-n-[1,2-13C2] undecanoic acid (PFuDA), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonic acid (PFHxS) occurring in more than 50% of core samples from Lake Superior and Perfluorobutanesulfonic acid (PFBS), perfluro-n-heptanoic acid (PFHpA), perfluorononanoic acid (PFNA) and perfluorodecanoic acid PFDA detected in more than 50% of the core samples from Lake Huron (Codling et al. 2018). The highest concentrations of PFASs were found in Lake Huron in waters in relatively close proximity to Wurtsmith Air Force base, Michigan, and in the southern end of the lake near the city of Sarnia, Canada. The highest concentrations in Lake Superior were found in proximity to the Town of Ontonagon, Michigan and near Duluth, Minnesota (Codling et al. 2018). Ren et al. (2022a) investigated the presence of PFAS within the aquatic ecosystem of Lake Huron through analyses of tissue samples collected from species at different levels of the food web from Rockport and Port Austin, Michigan. They found that perfluorooctanesulfonic acid (PFOS) was the predominant PFAS found, and C9 - C11 perfluorinated carboxylic acids (PFCA) was the second most observed PFAS (Ren et al. 2022a). Of these 2, the highest concentrations of PFCA was found in Deepwater Sculpin. Ren et al. (2022b) investigated the presence of PFAS within the aquatic ecosystem of Lake Ontario through analyses of tissue samples collected from species at different levels of the food web offshore of Oswego and North Hamlin, New York. The concentrations of perfluorooctane sulfonate (PFOS) and PFCA were found to be higher		Academic institutions

Action	Descriptions and results	Progress	Participants[9]
	than other measured PFAS. Deepwater Sculpin were found to have the highest concentrations of PFAS, likely a consequence of persisting PFAS in the sediment of the benthic zone at offshore locations where this species tends to occur (Ren et al. 2022b). Although the exact impacts of PFAS on Deepwater Sculpin are unknown, these contaminants have been documented to have immunotoxic and carcinogenic effects on mammals (Dietz et al. 2018). Conrad et al. (2021) collected tissue samples from prey fish that vary in habitat use and trophic niche, including Deepwater Sculpin, that were captured in Lake Michigan in order to analyze the concentration of 4 heavy metals, including chromium, copper, manganese, and total mercury. They found that Deepwater Sculpin, along with other species that inhabit the profundal zone, had high concentrations of total mercury (Conrad et al. 2021). Although this research was conducted using samples from Lake Michigan, the findings might provide insight regarding mercury concentrations found in Deepwater Sculpin elsewhere in the range of Great Lakes Western St. Lawrence populations. It is important to point out that the presence of these contaminants does not indicate that biological impairment is occurring. The research that has been described here represents a first step in the investigation of the potential impacts of these contaminants on Deepwater Sculpin. Overall, further research is required to determine if any of the aforementioned contaminants are actually impacting the health, fecundity, and ultimately the survivorship of the species. **Anthropogenic Stressors (nuclear generating station water intakes):** Thermal electric generating stations, which use steam to power turbines, including both nuclear and fossil fuel systems, can be found in each of the Great Lakes (Kelso and Milburn 1979). These generating stations take in water from the Great Lakes to cool and condense the steam, after which the water is returned back to the source. Such practices can lead to localized temperature increases where the water is released back into the lake, as well as the impingement of fish species against the screens of water intakes, and the entrainment of fish, particularly larvae and embryos, within these cooling systems (Kelso and Milburn 1979). From a DFO regulatory perspective, It has been hypothesized that such once-through cooling systems may negatively impact Deepwater Sculpin larvae; therefore, it is important to be able to identify larval Deepwater Sculpin within samples of fish and larvae that have been impinged or entrained by generating stations to estimate what level of impact this potential threat may pose to the species.		

Action	Descriptions and results	Progress	Participants[9]
	Patrick et al. (2020) collected entrainment data from samples taken from the water intake system at the Darlington Nuclear Generating Station located on the North Shore of Lake Ontario east of Oshawa Ontario. Fish eggs and larvae were identified to species under microscope and counted, and DNA barcoding[20] was used where there was uncertainty in species identification (Patrick et al. 2020). A total of 9 Deepwater Sculpin larvae were detected within the entrainment samples collected from January to April 2016 (Patrick et al. 2020). Considering that fish that have been impinged or entrained are often at the embryo and larvae stage, have been damaged and degraded and may be missing key identification features, and are often mixed with a myriad of species, it can be difficult to identify each species present in a sample using traditional approaches (Hulley et al. 2019). Hulley et al. (2019) investigated probe-based qPCR[21] (Polymerase Chain Reaction) assays that can be used to identify species through their DNA, which could provide a more accurate, cost effective, and time effective alternative to DNA barcoding, which has been in use for the last decade. The objective of this research, conducted by Hulley et al. (2019), was to develop and validate specific probe-based qPCR assays for 8 species found in the Great Lakes, including Deepwater Sculpin. Aside from improved cost and time effectiveness, probe-based qPCR assays are less prone to false-positive amplifications than DNA barcoding and allow for multiple samples to be processed simultaneously in the same reaction (Hulley et al. 2019). The efficacy of species specific probes were investigated by Hulley et al. (2019) through an examination of their ability to distinguish DNA from a target species from other species of the same genus, as well as species from different genera. The results of this study demonstrate that: 1) all primer probes were sufficient enough to positively identify their target species, with the primer probe specific to Deepwater Sculpin able to make detections with DNA concentrations as low as 0.001 ng; and 2) the species specific primer-probes can effectively identify their target species, including Deepwater Sculpin, when DNA from multiple species are combined in a single sample. These results indicate that probe-based qPCR assays may be a more suitable approach for analyzing and distinguishing species when samples are degraded and likely contain multiple species that cannot be separated, which is likely to be the case with samples taken from once-through cooling systems.		

[20] Method used to identify species through analysis of short sections of DNA from a specific gene or genes.
[21] A method where copies of a specific DNA region are generated in vitro to amplify DNA allowing for an increased ability to successfully identify a species.

Action	Descriptions and results	Progress	Participants[9]
	Invasive Species: Jude et al. (2022) used a remotely operated vehicle to examine Deepwater Sculpin habitat use in Grand Traverse Bay, Lake Michigan in December 2015, March 2017, and March 2021. They surveyed areas in depths ranging from 70 to 191 m and observed that Round Goby were substantially more abundant than Deepwater Sculpin in waters < 125 m, while the abundance of Round Goby tended to be more comparable to that of Deepwater Sculpin in depths > 166 m, where the latter tended to be more common (Jude et al. 2022). This indicates that there is habitat overlap between Round Goby and Deepwater Sculpin at deeper depths, which could possibly lead to interspecific competition and negative interactions. For example, Jude et al. (2022) observed Round Goby in close proximity to a Deepwater Sculpin nest; therefore it is possible that some degree of egg predation may be occurring. Although this sampling took place in the US waters of Lake Michigan the patterns of habitat use and overlap observed may provide insight regarding interactions between Round Goby and Deepwater Sculpin in the other Great Lakes. Burlakova et al. (2022) investigated long-term changes (last 54 years) in the benthic community of Lake Ontario and the factors driving them. They note that while 1 of the most profound changes occurred in the 1990s with the establishment and spread of Zebra Mussels (*Dreissena polymorpha*), since 2000, Lake Ontario has been in the midst of a similarly profound change brought on by the proliferation of Quagga Mussels (*Dreissena rostriformis*). This proliferation of Quagga mussels has been characterized by a spread deeper into the lake causing dramatic changes in the benthic community (Burlakova et al. 2022) including in areas currently occupied by Deepwater Sculpin. Benthic community changes described by (Burlakova et al. 2022) include the near disappearance of *Diporeia* and the decline of Sphaeriidae and the establishment of a community dominated by Quagga Mussels and Oligochaetes, which could consequently impact the resource availability and/or dietary nutrition available to Deepwater Sculpin. Similarly, Karatayev et al. (2022) examined changes in dreissenid mussels over the last several decades and found that while declines in the abundance of Quagga mussels have been observed at depths less than 90 m, the species has continued to increase in abundance at deeper depths. They indicate that the ecological impacts of Quagga Mussels are likely to continue into the future as the species continues to spread deeper (Karatayev et al. 2022), which could include further impacts to Deepwater Sculpin.		

Action	Descriptions and results	Progress	Participants[9]
8) Threat evaluation: Determine the mechanisms that have led to the loss/decline of Deepwater Sculpin in Lac des Iles.	The cause for the decline of Deepwater Sculpin in the Lac des Iles has not been determined at this time. Further research is required.	Not Started	

Table 12. Details of stewardship, habitat protection and improvement and threat mitigation activities supporting the conservation of the Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) from 2016 to 2021.

Action	Descriptions and results	Progress	Participants[22]
1) Coordination of activities: Coordinate stewardship activities with existing groups and initiatives.	The MELCCFP is working on an integrated approach to recovery (IAR) that targets all biodiversity (fauna and flora). The primary objective of this approach is to locate the major sources of threats affecting biodiversity and then prioritize conservation actions that are most likely to improve the ecosystem. The Deepwater Sculpin is 1 of the species targeted by IAR.	In progress	MELCCFP
2) Awareness: Promote stewardship initiatives (for example, federal/provincial funding programs) related to Deepwater Sculpin conservation and ensure that information related to funding opportunities for interested parties is made available.	DFO is continuing to fund the Habitat Stewardship Program (HSP), which provides support to program eligible recipients. Additionally, funding is available through the Indigenous Partnerships for Species at Risk (formerly the Aboriginal Fund for Species at Risk (AFSAR)), which supports the development of Indigenous capacity to participate actively in the implementation of SARA. The supported activities facilitate the implementation of conservation measures such as best management practices (BMPs) associated with water quality improvements.	In progress	DFO
3) Threat mitigation: 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.	DFO and MELCCFP regional analysts work to reduce the negative impacts of human activities by ensuring the protection of fish and fish habitat, and by integrating the BMPs required to achieve this objective in the watersheds of Quebec where Deepwater Sculpin occurs. DFO applies the provisions of the *Fisheries Act*, and MELCCFP applies the provisions of the *Environment Quality Act*.	In progress	DFO, MELCCFP

[22] Fisheries and Oceans Canada (DFO), Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs du Québec (MELCCFP).

Table 13. Details of outreach and communication activities supporting the conservation of the Deepwater Sculpin (Great Lakes-Western St. Lawrence Populations) from 2016 to 2021.

Action	Descriptions and results	Progress	Participants[23]
1) Awareness: 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.	No awareness materials or presentations have been delivered that included information related to Deepwater Sculpin	Not started	N/A
2) Communication and coordination: Promote awareness with municipal planning offices and planning officials to develop and adopt land management practices that minimize impacts on Deepwater Sculpin.	MELCCFP regional analysts work to reduce the negative impacts of human activities in the immediate watersheds of lakes containing Deepwater Sculpin in Quebec. In particular, the MELCCFP works with municipalities, to promote land use practices that consider the needs of fish and wildlife and the health of the environment.	In progress	MELCCFP
3) Awareness: Develop and distribute educational materials to interested parties that provide the key characteristics that distinguish the cottid species.	No educational material has been distributed that provides information on Deepwater Sculpin at this time.	Not started	N/A
4) Awareness: Increase public awareness of the impacts of aquatic invasive species (AIS) on the natural ecosystem and encourage the use of existing invasive species reporting systems.	Ontario's ongoing Invading Species Awareness Program helps address threats posed by AIS in Ontario by generating awareness and educational outreach information, addressing key pathways contributing to introductions and/or spread, and by facilitating monitoring and early detection initiatives. Furthermore, this program includes several reporting tools including the Invading Species Hotline and the Early Detection and Distribution Mapping System (EDDMapS).	In progress	DFO, MNR, OFAH, MNDNR,

[23] Fisheries and Oceans Canada (DFO), Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP), Ontario Federation of Natural Resources (OFAH), Minnesota Department of Natural Resources (MNDNR).

Action	Descriptions and results	Progress	Participants[23]
	Aquatic Invasive Species Regulations were enacted under the *Fisheries Act* in 2015. The regulations provide a national regulatory framework to help prevent intentional and unintentional introductions of aquatic invasive species in Canada from other countries, across provincial and territorial borders, and between ecosystems within a region. They also provide measures to facilitate response and control activities related to invasive species. As an ongoing effort, DFO distributes AIS educational information through public postings and direct engagement, including the dissemination of information through the Watercraft Inspection Program. Additionally, various United States entities are involved in the control of AIS and public outreach. For example, the MNDNR has an Invasive Species Program that has increased public awareness and understanding about invasive species in the Lake Superior watershed.		

5. Concluding Statement

Overall, actions implemented from 2016 to 2021 have helped to provide a clearer understanding of the abundance and population trends of Deepwater Sculpin within Lakes Superior, Huron, and Ontario. The benthic trawling conducted by USGS in the annual fish community surveys of Lake Superior are beginning to shed light on Deepwater Sculpin population dynamics, especially with the advent of the offshore survey, which has been conducted since 2011. Similarly, benthic trawling surveys conducted by USGS in Lake Huron as part of the offshore demersal fish community surveys have served to monitor Deepwater Sculpin populations over time in relation to influxes of invading species. Furthermore, both the spring bottom trawl surveys and the fall benthic prey fish surveys conducted by USGS in partnership with the NYSDEC and MNR in Lake Ontario have continued to document the rising Deepwater Sculpin populations in Lake Ontario as well as the abundance of several invasive species. All of the progress made with regard to monitoring activities is attributable to the work of other partner agencies, primarily USGS, MNR, MELCCFP, and NYSDEC. Without their efforts little would be known about the population trends and distribution of this species.

Research conducted during this time period has: advanced our understanding of population status in Lakes Superior, Huron and Ontario; provided a better understanding of genetic population structure and the processes through which populations in Lake Ontario have rebounded; elucidated knowledge gaps pertaining to Deepwater Sculpin life history; examined interactions with the fish community and invading species; and investigated potential impacts from contaminants and toxic substances.

The monitoring and control of invasive species is an ongoing mission that has been aided by the Provincial Government of Ontario's ratifying of the *Invasive Species Act* (2015), and federally by the enactment of the Aquatic Invasive Species Regulations under the *Fisheries Act* in 2015.

Collaboration with US partners is continuing in management and research activities relevant to the conservation of Deepwater Sculpin. For example, partnerships are leading to the development of a new 2020 to 2024 Lakewide Action and Management Plan, a binational ecosystem-based strategy designed to protect and restore the Lake Superior ecosystem. The ongoing USGS surveys and research activities continue to play a vital role in furthering our understanding of Deepwater Sculpin biology, distribution, and abundances within Lake Superior. Furthermore, the Cooperative Science and Monitoring Initiative is bringing together multiple organizations and agencies from both the US and Canada to direct and fund research that will contribute to the conservation of Deepwater Sculpin in the Great Lakes.

These ongoing and/or completed activities illustrate the progress that has been made towards the goal of ensuring the long-term persistence of Deepwater Sculpin populations in Canada; however, further information is required in several areas that can only be obtained through:

- continued monitoring surveys conducted in the inland lakes of Ontario and Quebec to understand the health, abundance, and distribution of known and potentially undetected Deepwater Sculpin populations. Further research exploring genetics and life history should be conducted to determine if designation units specific to these populations (small inland lakes vs large lakes) is warranted

- improving knowledge of Deepwater Sculpin life history including habitat use at each life-stage, reproductive behaviour and dispersal capacity

- determining habitat requirements (quantity and quality) to ensure long-term conservation of the species
- further understanding how threats such as invasive species and contaminants and toxic substances are impacting Deepwater Sculpin populations, as well as other threat factors which may be more significant in inland Lakes where the species is found in this designatable unit

Future research and monitoring efforts focusing on filling these knowledge gaps will support and inform ongoing conservation efforts for Deepwater Sculpin. The feasibility of the management goal and objectives may be reassessed in the future using updated distribution and abundance information, as well as threat information gathered since the publication of the management plan.

6. References

Bayba, S., L.E. Burlakova, A.Y. Karatayev, and R.J. Warren II. 2022. Non-native Dreissena associated with increased native benthic community abundance with greater lake depth. Journal of Great Lakes Research, 48: 734-745.

Burlakova, L.E., A .Y. Karatayev, A.R. Hrycik, S.E. Daniel, K. Mehler, L.G. Rudstam, J.M. Watkins, R. Dermott, J. Scharold, A.K. Elgin, T.F. Nalepa. 2022. Six decades of Lake Ontario ecological history according to benthos. Journal of Great Lakes Research, 48: 274-288.

Burlakova, L.E., R.P. Barbiero, A.Y. Karatayev, S.E. Daniel, E.K. Hinchey, and G.J. Warren. 2018. The benthic community of the Laurentian Great Lakes: Analysis of spatial gradients and temporal trends from 1998 to 2014. Journal of Great Lakes Research 44: 600–617.

Codling, G., S. Hosseini, M.B. Corcoran, S. Bonina, T. Lin, A. Li, N. C. Sturchio, K.J. Rockne, K. Ji, H. Peng, J. P. Giesy. 2018. Current and historical concentrations of poly and perfluorinated compounds in sediments of the northern Great Lakes e Superior, Huron, and Michigan. Environmental Pollution, 236: 373-381.

Conrad, W.M., B.S. Gerig, L.M. Lovin, D.B. Bunnell, and G.A. Lamberti. 2021. Metal accumulation in Lake Michigan prey fish: Influence of ontogeny, trophic position, and habitat. Journal of Great Lakes Research, 47: 1746–1755.

COSEWIC 2006. COSEWIC assessment and update status report on the deepwater sculpin *Myoxocephalus thompsonii* (Western and Great Lakes-Western St. Lawrence populations) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 39 pp.

COSEWIC. 2017. COSEWIC assessment and status report on the Deepwater Sculpin *Myoxocephalus thompsonii*, Great Lakes-Upper St. Lawrence populations, Southern Hudson Bay-James Bay populations, Saskatchewan-Nelson River populations, Waterton Lake population, Western Hudson Bay populations and Western Arctic populations in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxxvii + 61 pp.

Cooperative Science and Monitoring Initiative (CSMI) for the Great Lakes — Lake Ontario 2008. Journal of Great Lakes Research, 38:10–13. http://dx.doi.org/10.1016/j.jglr.2012.07.005.
DFO. 2016. Management Plan for the Deepwater Sculpin (*Myoxocephalus thompsonii*) in Canada (Great Lakes-Western St. Lawrence populations). Species at Risk Act Management Plan Series. Fisheries and Oceans Canada, Ottawa. vi + 30 pp.

DFO. 2022. Rapport d'activité 2021-2022 : Capture expérimentale du cisco de printemps au lac des Écorces et exploration du rôle de la prédation des œufs sur le rétablissement du cisco de printemps (*Coregonus sp*.), préparé par la DSDB pour la DGEP, 56 p.

Dietz, R., J.P., Desforges, K. Gustavson, F.F. Rigét, E.W. Born, R.J., Letcher, C. Sonne. 2018. Immunologic, reproductive, and carcinogenic risk assessment from POP exposure in East Greenland polar bears (*Ursus maritimus*) during 1983–2013. Environment International 118, 169–178.

Gorman, O.T. and T.D. Keyler. 2016. A hyperbaric holding and transport vessel for collection of deepwater fishes for research and broodstock development. Great Lakes Fishery Commission, 2016 Project Completion Report, pp 1-38.

Hulley, E.N., S. Tharmalingam, A. Zarnke, D.R. Boreham. 2019. Development and validation of probe-based multiplex real-time PCR assays for the rapid and accurate detection of freshwater fish species. PLOS ONE, DOI: https://doi.org/10.1371/journal.pone.0210165

Hondorp, D.W., T.P. O'Brien, P.C. Esselman, and E.F. 2022a. Roseman. Status and Trends of the Lake Huron Prey Fish Community, 1976-2019. U. S. Geological Survey Great Lakes Science Center 1451 Green Rd. Ann Arbor, MI 48105.

Hondorp, D.W., T.P. O'Brien, P.C. Esselman, and E.F. Roseman. 2022b. Status and Trends of the Lake Huron Prey Fish Community, 1976-2020. U. S. Geological Survey Great Lakes Science Center 1451 Green Rd. Ann Arbor, MI 48105.

Jude D.J., L.G. Rudstam, T.J. Holda, J.M. Watkins, P.T. Euclide, and M.D. Balcer. 2018. Trends in Mysis diluviana abundance in the Great Lakes, 2006–2016. Journal of Great Lakes Research, 44: 590–599.

Jude, D.J., H. W. Van Sumeren and J. Lutchko. 2022. First documentation of spawning by deepwater sculpins in the Great Lakes and potential impacts of round gobies. Journal of Great Lakes Research, 48: 614-619.

Karatayev, A.Y., L. E. Burlakova, K. Mehler, S. E. Daniel, A. K. Elgin, and T. F. Nalepa. 2020. Lake Huron Benthos Survey Cooperative Science and Monitoring Initiative 2017. Technical Report. USEPA-GLRI GL00E02254. Great Lakes Center, SUNY Buffalo State, Buffalo, NY.

Karatayev A.Y., L.E. Burlakova, K. Mehler, A.K. Elgin, L.G. Rudstam, J.M. Watkins, M. Wick. 2022. Dreissena in Lake Ontario 30 years post-invasion. Journal of Great Lakes Research, 48: 264–273.

Kelso, J.R.M. and G.S. Milburn. 1979. Entrainment and Impingement of Fish by Power Plants in the Great Lakes which use the Once-Through Cooling Process. Journal of Great Lakes Research, 5: 182-194.

Keyler TD. 2018. Visual sensitivity, behavior, and habitat of select North American fishes. Ann Arbor: University of Minnesota; 2018. 138 p. - Chapter 4: Deepwater Sculpin (*Myoxocephalus thompsonii*) behavior: the effect of light intensity and predator presence (pp. 54-63).

Keyler, T.D., T.R. Hrabik, A.F. Mensinger, L.S. Rogers, and O.T. Gorman. 2019. Effect of light intensity and substrate type on siscowet lake trout (*Salvelinus namaycush siscowet*) predation on deepwater sculpin (*Myoxocephalus thompsonii*). Hydrobiologia, 840:77–88. DOI: https://doi.org/10.1007/s10750-019-3944-5.

Kilgour and Associates Ltd. Environnemental Consultants. 2017. Évaluation de la présence d'une espèce en péril au Canada, le chabot de profondeur (*Myoxocephalus thompsonii*), de répartition historique au Québec, 42 p.

Kirkendall, D.S., D.B. Bunnell, P.M. Armenio, L.A. Eaton, A.S. Trebitz, and N.M. Watson. 2021. Spatial and temporal distributions of Dreissena spp. veligers in Lake Huron: Does calcium limit settling success? Journal of Great Lakes Research, 47: 1040-1049.

Lester N. P., S. Sandstrom, D.T. de Kerckhove, K. Armstrong, H. Ball, J. Amos, T. Dunkley, M. Rawson, P. Addison, A. Dextrase, D. Taillon, B. Wasylenko, P. Lennox III, H.C. Giacomini and C. Chu. 2021. Standardized broad-scale management and monitoring of inland lake recreational fisheries: an overview of the Ontario Experience. Fisheries, 46: 107-118.

Ludwig, J., B. Weidel, B. O'Malley, M. Connerton, and J. Rinchard. 2022. Insight of the Deepwater Sculpin Reproduction in Lake Ontario. SUNY Brockport Article/Review. [online]. Available from http://hdl.handle.net/20.500.12648/7243.

Long T., N. Benoit, T. Howell, L. Richman, and S.P. Bhavsar. 2022. Spatiotemporal trends of polychlorinated biphenyls (PCBs) in surface and suspended sediments from the Lake Ontario Canadian nearshore 1994–2018: A fish consumption advisory perspective. Journal of Great Lakes Research 48: 300–314.

Matthias B.G., T.R. Hrabik, J.C. Hoffman, O.T. Gorman, M.J. Seider, M.E. Sierszen, M.R. Vinson, D.L. Yule, and P.M. Yurista. 2021. Trophic transfer efficiency in the Lake Superior food web: Assessing the impacts of non-native species. Journal of Great Lakes Research 47: 1146–1158.

Mehler, K., Burlakova, L.E., Karatayev, A.Y., and Scharold, J. 2018. Major Findings from the CSMI Benthic Macroinvertebrate Survey in Lake Superior in 2016 with an Emphasis on Temporal Trends. Lake Superior Benthos: Cooperative Science and Monitoring Initiative, Final Report. USGS-GLRI G14AC00263. Great Lakes Center, SUNY Buffalo State, Buffalo, NY.

Mumby J.A., T.B. Johnson, T.J., Stewart, E. A. Halfyard, B.C. Weidel, M.G., Walsh, J.R., Lantry, and A.T. Fisk. 2018. Feeding ecology and niche overlap of Lake Ontario offshore forage fish assessed with stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences, 75: 759-771.

Mychek-Londer, J.G., D.B. Bunnell, W. Stott, J.S. Diana, J.R.P. French III, and M.A. Chriscinske. 2013. Using Diets to Reveal Overlap and Egg Predation among Benthivorous Fishes in Lake Michigan. Transactions of the American Fisheries Society, 142:492–504.

Nadon, L. 2020. Le cisco de printemps (*Coregonus sp*.) et la communauté de poissons du lac des Écorces, après sept années de retrait massif d'éperlans arc-en-ciel (*Osmerus mordax*), ministère des Forêts, de la Faune et des Parcs, 49 p. et annexes.

Nawrocki, B.M., B.W. Metcalfe, J.P Holden, B.F. Lantry, and T.B. Johnson. 2022. Spatial and temporal variability in Lake Trout diets in Lake Ontario as revealed by stomach contents and stable isotopes. Journal of Great Lakes Research, 48: 392–403.

O'Brien, T.P., S. Ireland, E.F. Roseman, A.S. Briggs, and W.W. Taylor. 2019. Phenology and species diversity in a Lake Huron ichthyoplankton community: Ecological implications of invasive species dominance. Journal of Great Lakes Research 45: 176–186.

O'Brien, T.P., D.W. Hondorp, P.C. Esselman, and E.F. Roseman. 2022. Status and Trends of the Lake Huron Prey Fish Community, 1976-2021. U. S. Geological Survey Great Lakes Science Center 1451 Green Rd. Ann Arbor, MI 48105.

O'Malley, B.P., J. Goretzke, J.P. Holden. 2021. Bottom trawl assessment of benthic preyfish community in Lake Ontario. Lake Ontario Annual Report 2020, 15 pp.

O'Malley, B.P., S.P. Minihkeim, T. Sanfilippo, J. Goretzke and J. P. Holden. 2022. Lake Ontario fall prey fish survey summary and results 2021. Lake Ontario Annual Report 2021 – draft.

Patrick, P.H., M. Di Giuseppe, H. Manolopoulos, M. Tai, J.S. Poulton, and J.A. Wright. (2020). Entrainment of fish eggs and larvae at an operating nuclear generating station using improved methodology. Lake and Reservoir Management, 37: 186 - 198.

Pawlowskia, M.B., and M.E. Sierszen. 2020. A lake-wide approach for large lake zooplankton monitoring: Results from the 2006–2016 Lake Superior Cooperative Science and Monitoring Initiative surveys. Journal of Great Lakes Research, 46: 1015-1027.

Ren J., A.D. Point, S.F. Baygi, S. Fernando, P.K. Hopke, T.M. Holsen, and B.S. Crimmins. 2022a. Bioaccumulation of polyfluoroalkyl substances in the Lake Huron aquatic food web. Science of the Total Environment 819: 152974.

Ren, J, A. Point, S.F. Baygi, S. Fernando, P.K. Hopke, T. M. Holsen, B. Lantry, B. Weidel, B.S. Crimmins. 2022b. Bioaccumulation of perfluoroalkyl substances in a Lake Ontario foodweb. Journal of Great Lakes Research, 48: 315–325.

Richardson, V., Warren, G.J., Nielson, M., Horvatin, P.J., 2012. Cooperative Science and Monitoring Initiative (CSMI) for the Great Lakes – Lake Ontario 2008. Journal of Great Lakes Research 38: 10-13.

Riley, S.C., E.F. Roseman, D.W. Hondorp, M.A. Chriscinske, E. Galassini, and M. Smith. 2017. Status and trends of the Lake Huron offshore demersal fish community, 1976-2016. US Geological Survey, Great Lake Science Center. Ann Arbor, Michigan. Prepared for the Great Lakes Fishery Commission Lake Huron Committee Meeting, Ypsilanti, MI, March 2017.

Riley, S.C., D.W. Hondorp, and E.F. Roseman. 2019. Status and trends of the Lake Huron offshore demersal fish community, 1976-2018. US Geological Survey, Great Lake Science Center. Ann Arbor, Michigan. Prepared for the Great Lakes Fishery Commission Lake Huron Committee Meeting, Ypsilanti, MI, March 2019.

Robinson, K.F., C.R. Bronte, D.B. Bunnell, P. T. Euclide, D. W. Hondorp, J.A. Janssen, M.S. Kornis, D.H. Ogle, W. Otte, S.C. Riley, M.R. Vinson, S.L. Volkel, and B.C. Weidel. 2021 A synthesis of the biology and ecology of sculpin species in the Laurentian Great Lakes and implications for the adaptive capacity of the benthic ecosystem. Reviews in Fisheries Science & Aquaculture, 29:1, 96-121. DOI: 10.1080/23308249.2020.1782341.

Roseman, E.F., D.J. Jude, M.K. Raths, T.G. Coon, and W. W. Taylor. 1998. Occurrence of the Deepwater Sculpin (*Myoxocephalus thompsoni*) in Western Lake Erie. International Association of Great Lakes Research, Journal of Great Lakes Research, 24: 479-483.

Roseman, E.F. , M.A. Chriscinske, D.K. Castle, and C. Prichard. 2016. Status and trends of the Lake Huron offshore demersal fish community, 1976-2015. US Geological Survey, Great Lake Science Center. Ann Arbor, Michigan. Prepared for the Great Lakes Fishery Commission Lake Huron Committee Meeting, Milwaukee, WI, March 21, 2016.

Roseman, E.F., and T.P. O'Brien. 2013. Spatial distribution of pelagic fish larvae in the northern main basin of Lake Huron. Aquatic Ecosystem Health & Management 16:311-321.

Roseman, E.F. 2014. Diet and habitat use by age-0 deepwater sculpins in northern Lake Huron, Michigan and the Detroit River. Journal go Great Lakes Research Supplement, 40: 110-117.

Sheldon, T. A., Mandrak, N. E., & Lovejoy, N. R. 2008. Biogeography of the deepwater sculpin (*Myoxocephalus thompsonii*), a Nearctic glacial relict. Canadian Journal of Zoology, 86, 108-115.

The Lake Superior Partnership. 2016. LSLAMP (Lake Superior Lakewide Action and Management Plan). Lake Superior Lakewide Action and Management Plan 2015 – 2019. The Lake Superior Partnership, September 2016. [online]. Available from https://www.epa.gov/sites/default/files/2016-10/documents/lake_superior_lamp_2015-2019.pdf

Thompson P.A., E.F. Roseman, K.M. Keeler, T.P. O'Brien, and D.A. Bowser. 2017. Continued feeding on Diporeia by deepwater sculpin in Lake Huron. Environmental Biology of Fishes, 100:407–419, DOI: 10.1007/s10641-016-0568-8.

van der Lee, A.S. and Koops, M.A. 2021. Modelling population trajectory of Deepwater Sculpin (*Myoxocephalus thompsonii*) in the Laurentian Great Lakes using bottom trawl survey data. Canadian Technical Report of Fisheries and Aquatic Science nnn: vi + 42 p.

Vinson, M.R., L.M. Evrard, O.T. Gorman, and D. L. Yule. 2016. Status and Trends in the Lake Superior Fish Community, 2015. In Compiled reports to the Great Lakes Fishery Commission of the annual bottom trawl and acoustics surveys, 2015. Accessed [online]. Available from http://www.glfc.org/pubs/lake_committees/common_docs/CompiledReportsfromUSGS2047616.pdf

Vinson, M.R., L.M. Evrard, O.T. Gorman, and D. L. Yule. 2017. Status and Trends in the Lake Superior Fish Community, 2016. In Compiled reports to the Great Lakes Fishery Commission of the annual bottom trawl and acoustics surveys, 2016. Accessed [online]. Available from http://www.glfc.org/pubs/lake_committees/common_docs/CompiledReportsfromUSGS2048317.pdf

Vinson, M.R., L.M. Evrard, O.T. Gorman, and D. L. Yule. 2018. Status and Trends in the Lake Superior Fish Community, 2017.In Compiled reports to the Great Lakes Fishery Commission of the annual bottom trawl and acoustics surveys, 2017. Accessed [online]. Available from http://www.glfc.org/pubs/lake_committees/common_docs/CompiledReportsfromUSGS2049018.pdf

Vinson, M.R, L.M. Evrard, O.T. Gorman, C. Rosinski, and D.L. Yule. 2019. Status and trends in the Lake Superior fish community, 2018. Prey Fish Report prepared for the Great Lakes Fishery Commission.

Vinson, M.R., D.L. Yule, L.M. Evrard, and C.L. Rosinski. 2019b. 2016 Lake Superior Cooperative Science and Monitoring Initiative Fish Community Assessment. US Geological Survey Great Lakes Science Center Lake Superior Biological Station Report.

Vinson, M.R., J.M. Hoffmann, A.M. Muir, C.L. Rosinski, C.C. Krueger, C.R. Bronte, M.J. Hansen, S.P. Sitar, E.W. Allen, L.F. Baker, and H.K. Swanson. 2020. Gut contents from multiple morphs of lake trout (*Salvelinus namaycush*) at two offshore shoals in Lake Superior. Journal of Great Lakes Research, 46: 1382-1390.

Walsh, M., B.C. Weidel, and M.J. 2014. Connerton. Status of important prey fishes in the US waters of Lake Ontario, 2013: Introduction and methods. NYSDEC Lake Ontario Annual Report 2013, Section 12, pp 1-5.

Watkins, J.M, B.C. Weidel, A.T. Fisk, and L.G. Rudstam. 2017. Cooperative science to inform Lake Ontario management: Research from the 2013 Lake Ontario CSMI program. Journal of Great Lakes Research, 43: 779-781.

Watkins, J.M., L.G. Rudstam, A.Y. Karatayev, W.J.S. Currie, A.E. Scofield, and T.P. Hollenhorst. 2022. Foreword: Stressors and successes, Lake Ontario CSMI intensive year 2018. Journal of Great Lakes Research 48: 261–263.

Weidel, B.C. and M. Walsh. 2015. Lake Ontario benthic prey fish assessment, 2014. NYSDEC Lake Ontario Annual Report, Section 12, pp 16-21.

Weidel, B.C., M. Walsh, J.P. Holden, and M.J. Connerton. 2016. Lake Ontario benthic prey fish assessment, 2015. NYSDEC Lake Ontario Annual Report 2015-12b, pp 12-23.

Weidel B.C., M.G. Walsh, M.J. Connerton, B.F. Lantry, J.R. Lantry, J.P. Holden, M.J. Yuille, and J.A. Hoyle. 2017a. Deepwater sculpin status and recovery in Lake Ontario. Journal of Great Lakes Research, 43: 854–862.

Weidel, B.C., M. Walsh, J.P. Holden, and M.J. Connerton. 2017b. Lake Ontario benthic prey fish assessment, 2016. NYSDEC Lake Ontario Annual Report 2016-12b, Section 12; 11 pp.

Weidel, B.C., M. Walsh, M.J. Connerton, and J.P. Holden. 2017c. Trawl-based assessment of Lake Ontario pelagic prey fishes including Alewife and Rainbow Smelt. NYSDEC Lake Ontario Annual Report 2016-12a; 13 pp.

Weidel, B.C., M.J. Connerton, and J. Holden. 2018. Bottom trawl assessment of Lake Ontario prey fishes. NYSDEC Lake Ontario Annual Report 2017, Section 12; 18 pp.

Weidel, B.C., M.J. Connerton, and J. Holden. 2019. Bottom trawl assessment of Lake Ontario prey fishes. 2018 Annual report, Chapter 12, 25 pp.

Weidel, B.C., B. O'Malley, M.J. Connerton, J. P. Holden, and C. Osborne. 2020. Bottom trawl assessment of Lake Ontario prey fishes, 2019. NYSDEC Lake Ontario Annual Report 2019, Section 12; 25 pp.

Weidel, B.C., S. Minihkeim, J. P. Holden, J. Goretzke, M. J. Connerton. 2021. Lake Ontario April prey fish survey results and Alewife assessment, 2021. A report from the Lake Ontario Prey Fish Working Group to the Great Lakes Fishery Commission's Lake Ontario Committee, 11 pp.

Welsh, A.B., K. Scribner, W. Stott, M. G. Walsh. 2017. A population on the rise: The origin of deepwater sculpin in Lake Ontario. Journal of Great Lakes Research, 43, 863-870.

Appendix A : Acronyms

AIS	Aquatic invasive species
COSEWIC	Committee on the Status of endangered Wildlife in Canada
CPUE	Catch per unit of effort
DFO	Fisheries and Oceans Canada
DNR	Department of Natural Resources
ECCC	Environment and Climate Change Canada
GLC	Research Chairs, Great Lakes Centre
GLEC	Great Lakes Executive Committee
GLFC	Great Lake Fishery Commission
GLNPO	Great Lakes National Program Office
GLWQA	Great Lakes Water Quality Agreement
IAR	Integrated approach to recovery
IJC	International Joint Commission
LAMP	Lakewide Action and Management Plan
MECP	Ministry of the Environment, Parks, and Conservation of Ontario
MELCCFP	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs du Québec
NOAA	National Oceanic and Atmospheric Administration
NSERCC	Natural Sciences and Engineering Research Council of Canada
NYSDEC	New York State Department of Environmental Conservation
OBV	Organismes de bassins versants
OFAH	Ontario Federation of Anglers and Hunters
MNR	Ontario Ministry of Natural Resources and Forestry
OPG	Ontario Power Generation
PC	Parks Canada
PCB	Polychlorinated Biphenyls
ROM	Royal Ontario Museum
SARA	Species at Risk Act
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey