Species at Risk Act
Management Plan Series

Report on the Progress of Management Plan Implementation for the Grass Pickerel (*Esox americanus vermiculatus*) in Canada for the Period 2012 to 2017

Grass Pickerel

2022

Canada

Recommended citation:

Fisheries and Oceans Canada 2022. Report on the Progress of Management Plan Implementation for the Grass Pickerel (*Esox americanus vermiculatus*) in Canada for the Period 2012 to 2017. *Species at Risk Act* Management Plan Report Series. Fisheries and Oceans Canada, Ottawa. iii + 34 pp.

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

Cover illustration: Joseph Tomelleri

Également disponible en français sous le titre
« Rapport sur les progrès de la mise en œuvre du plan de gestion du brochet vermiculé (*Esox americanus vermiculatus*) au Canada pour la période de 2012 à 2017»

ISBN 978-0-660- 29312-7
Catalogue no. En3-5/26-1-2020E-PDF

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for the protection of species at risk throughout Canada. Section 72 of the *Species at Risk Act* (S.C. 2002, c.29) (SARA) requires the competent minister to report on the implementation of the management plan for a species at risk, and on the progress towards meeting its objectives within five years of the date when the management plan was placed on the Species at Risk Public Registry and in every subsequent five-year period, until its goal and objectives have been achieved or the species becomes threatened or endangered under SARA at which point a recovery strategy would be required.

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 towards the conservation of the species. Management plans identify broad strategies and conservation measures that will provide the best chance of conserving species at risk. Some of the identified strategies and measures are sequential to the progress or completion of others; and not all may be undertaken or show significant progress toward implementation during the time frame of a report on the progress of management plan (progress report).

The Minister of Fisheries and Oceans and the Canadian Coast Guard and the minister responsible for the Parks Canada Agency (PCA), are the competent ministers under SARA for the Grass Pickerel 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 constituencies 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 PCA, 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 Grass Pickerel (*Esox americanus vermiculatus*) in Canada” for the benefit of the species and Canadian society as a whole.

Acknowledgments

This progress report was prepared by P.L. Wong and Josh Stacey (DFO). To the extent possible, this progress report has been prepared with inputs from Alain Kemp and Marie-Michèle Bourassa of DFO-Quebec. Fisheries and Oceans Canada would also like to express its appreciations to all individuals and organizations who have contributed to the recovery of the Grass Pickerel.

Executive summary

The Grass Pickerel was listed as special concern under the *Species at Risk Act* (SARA) in 2006. The “Management Plan for Grass Pickerel (*Esox americanus vermiculatus*) in Canada” was finalized and published on the Species at Risk Public Registry in 2012.

Key anthropogenic threats identified in the management plan for the Grass Pickerel include habitat loss and degradation, agricultural drainage, sediment loading, nutrient loading, and destruction of aquatic and riparian vegetation. Additional threats include contaminant inputs, water-level fluctuations, disease, barriers to movement, invasive species, climate change, interspecific interactions, and fishing pressure.

The goal of the management plan for the Grass Pickerel is to ensure the long-term persistence of Grass Pickerel throughout its current and historical distribution in Canada.

This report documents the progress made in implementing the management plan for Grass Pickerel between 2012 and 2017. It summarizes progress that Fisheries and Oceans Canada (DFO), Parks Canada Agency (PCA), the provinces of Ontario and Quebec, conservation authorities, and other stakeholders have made toward achieving the objectives set out in the management plan, which include:

- conducting population surveys and habitat monitoring in current and historical locations to confirm the presence of Grass Pickerel and to determine the current distribution of Grass Pickerel in Canada
- coordinating with invasive species early detection and monitoring programs within areas known to support Grass Pickerel (for example, Asian carp surveys have been conducted within Long Point Bay and Niagara River, among other locations)
- researching the seasonal habitat needs at various life stages, and the relationships between Grass Pickerel and the surrounding fish community
- conducting threat assessments and implementing mitigation measures to offset the impacts of drainage work on Grass Pickerel habitat
- conducting outreach and education events promoting Grass Pickerel stewardship within the Ausable River watershed and throughout southern Ontario

Collectively, these ongoing and/or completed activities indicate that substantial progress has been made towards achieving the management objectives for the Grass Pickerel in Canada. There were updates to distribution records (for example, several new locations in Ontario and reconfirmed presence of Grass Pickerel in the lower reaches of Twenty Mile Creek and Quebec after 26 years of no detections). Furthermore, in Quebec, a central database was completed in order to facilitate Grass Pickerel data synthesis and the transfer of species information such as habitat parameters. However, a number of research questions stemming from the management plan remain unanswered. For example, the quantity and quality of habitat required to ensure long-term conservation of Grass Pickerel to support management goals needs to be determined. Additionally, there needs to be the integration of long-term monitoring of Grass Pickerel populations with existing fish-community survey efforts, including research to further identify fish community associations. For this reason, it may be beneficial to focus future management activities on addressing these knowledge gaps.

Table of contents

1. Introduction

This progress report summarizes the progress made towards meeting the conservation measures listed in the "Management Plan for the Grass Pickerel (*Esox americanus vermiculatus*) in Canada" (Beauchamp et al. 2012) (management plan) from 2012 to 2017. This report should be considered as part of a series of documents 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 2005; COSEWIC 2014) and the management plan.

Section 2 of the progress report reproduces and summarizes key information on the anthropogenic threats that this species is facing, management objectives for conserving this species, and conservation approaches to achieve the objectives (for more details, readers should refer to the management plan). Section 3 reports on the progress of activities identified in the management plan to support achieving management objectives. Section 4 provides a concluding statement about the progress of actions taken and outcomes of these conservation efforts.

2. Background

2.1 COSEWIC assessment summary

The listing of Grass Pickerel under the *Species at Risk Act* (S.C. 2002, c.29) (SARA) in 2006 led to the development and publication of the management plan for the Grass Pickerel in 2012. The management plan is consistent with the information provided in the COSEWIC status report (COSEWIC 2005). This information has also been included in section 1.1 of the management plan.

Assessment summary: May 2005

Common name (population): Grass Pickerel

Scientific name: *Esox americanus vermiculatus*

COSEWIC status: Special concern

Reason for designation: A subspecies known from 10 locations between Lake St. Louis, Quebec and Lake Huron, Ontario. Its usual habitat is shallow water with an abundance of aquatic vegetation. An overall decline of approximately 22% in the area of occupancy has been observed. This decline appears to be related to degradation and loss of habitat due to channelization and dredging operations in wetland habitats where this species occurs.

Canadian occurrence: Ontario and Quebec

COSEWIC status history: Designated special concern in May 2005. Assessment based on a new status report.

In 2014, COSEWIC re-examined and confirmed the status of the Grass Pickerel as special concern (COSEWIC 2014).

Assessment summary: November 2014

Common name: Grass Pickerel

Scientific name: *Esox americanus vermiculatus*

Status: Special concern

Reason for designation: This fish is known from relatively few locations from southern Lake Huron to western Quebec. The subspecies has a scattered distribution in Canada and is not abundant in any area. The subspecies could become threatened if habitat quality continues to decline owing to changes in land use and invasive species.

Occurrence: Ontario and Quebec

Status history: Designated special concern in May 2005. Status re-examined and confirmed in November 2014.

2.2 Distribution

Since 2010, Grass Pickerel has been detected in several new locations within Ontario including: Kahshe Barrens, Bass Lake, as well as Grass Lake and one of its tributaries in Severn Region; Green Island in Georgian Bay; the Detroit River; Cedar Creek; Big Forks Creek; the lower Niagara River; North Bay in Prince Edward County; and, Graham Lake (figures 1, 2, 3 and 4). Furthermore, new detections have been made within Quebec waters in the Lake St. Francis area of the upper St. Lawrence River including: rivière aux Saumons and Fraser; ruisseaux Pike, McMillan, McPherson,McPhee, and Brunson; as well as the agricultural drain Le Bateau and two other unnamed watersheds (figure 5). Although Grass Pickerel has been historically found within Lake St. Francis, these detections were made within new locations found in that area.

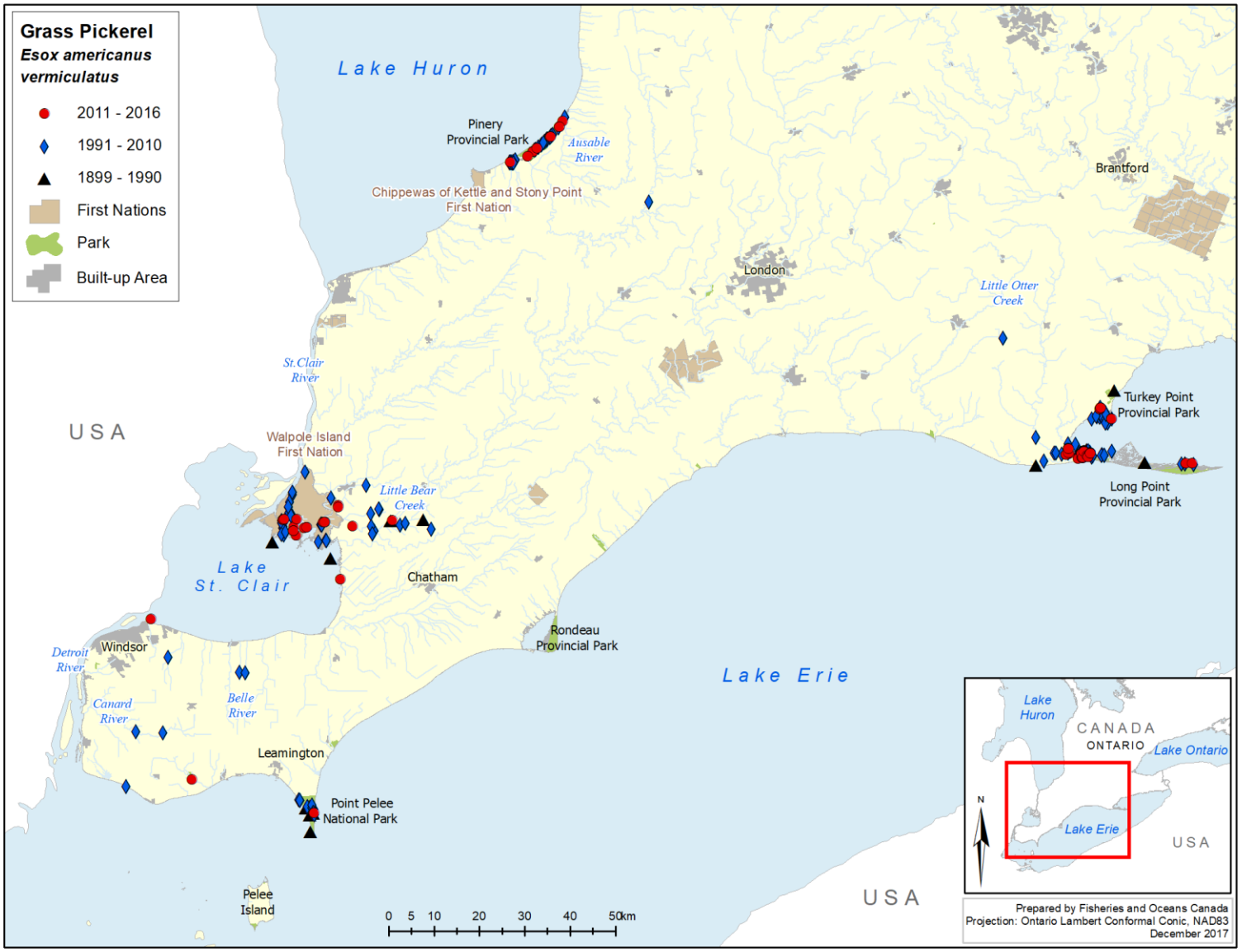

Figure 1. Historical distribution and recent detections of Grass Pickerel in southwest Ontario

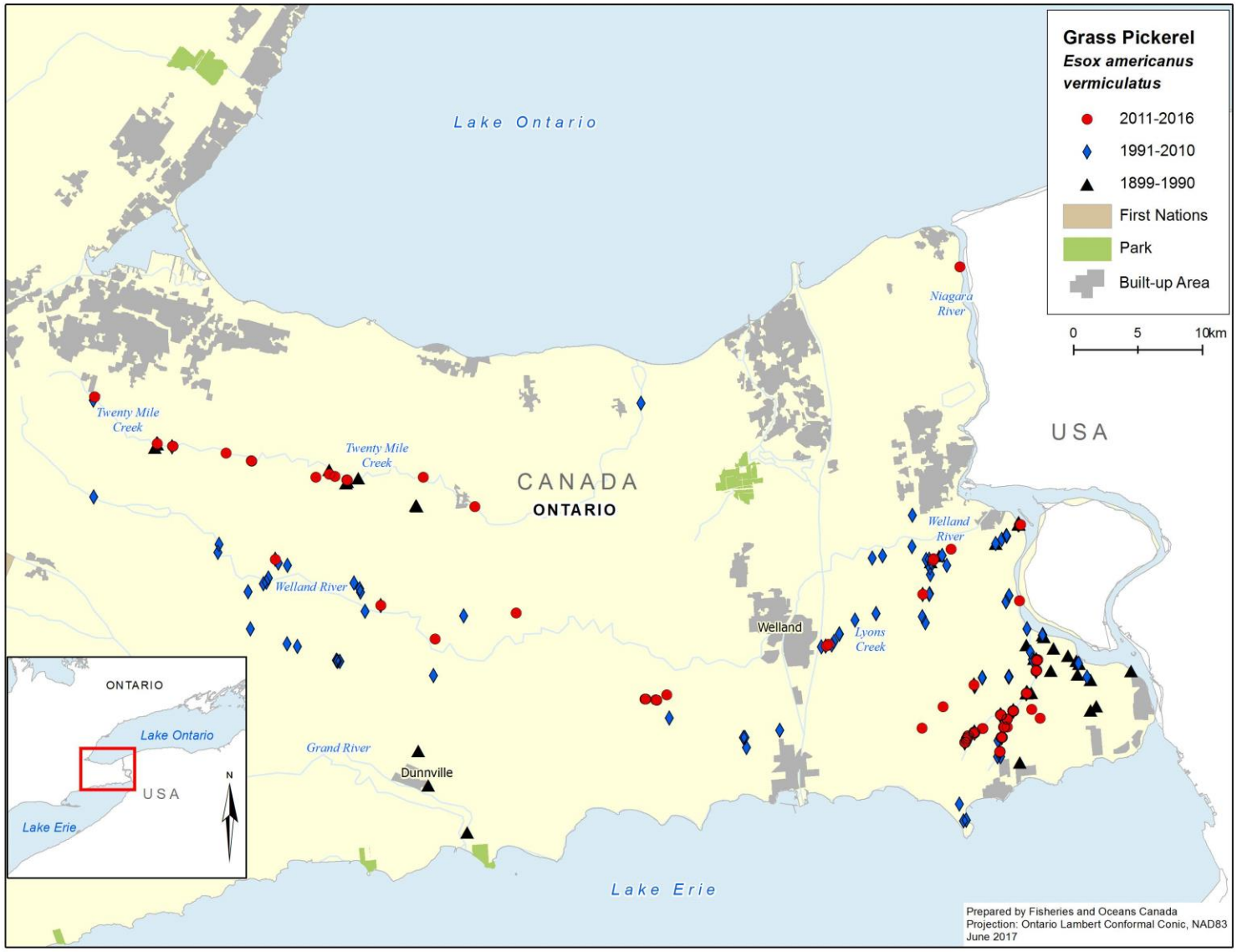

Figure 2. Historical distribution and recent detections of Grass Pickerel in southwestern Ontario (Niagara region)

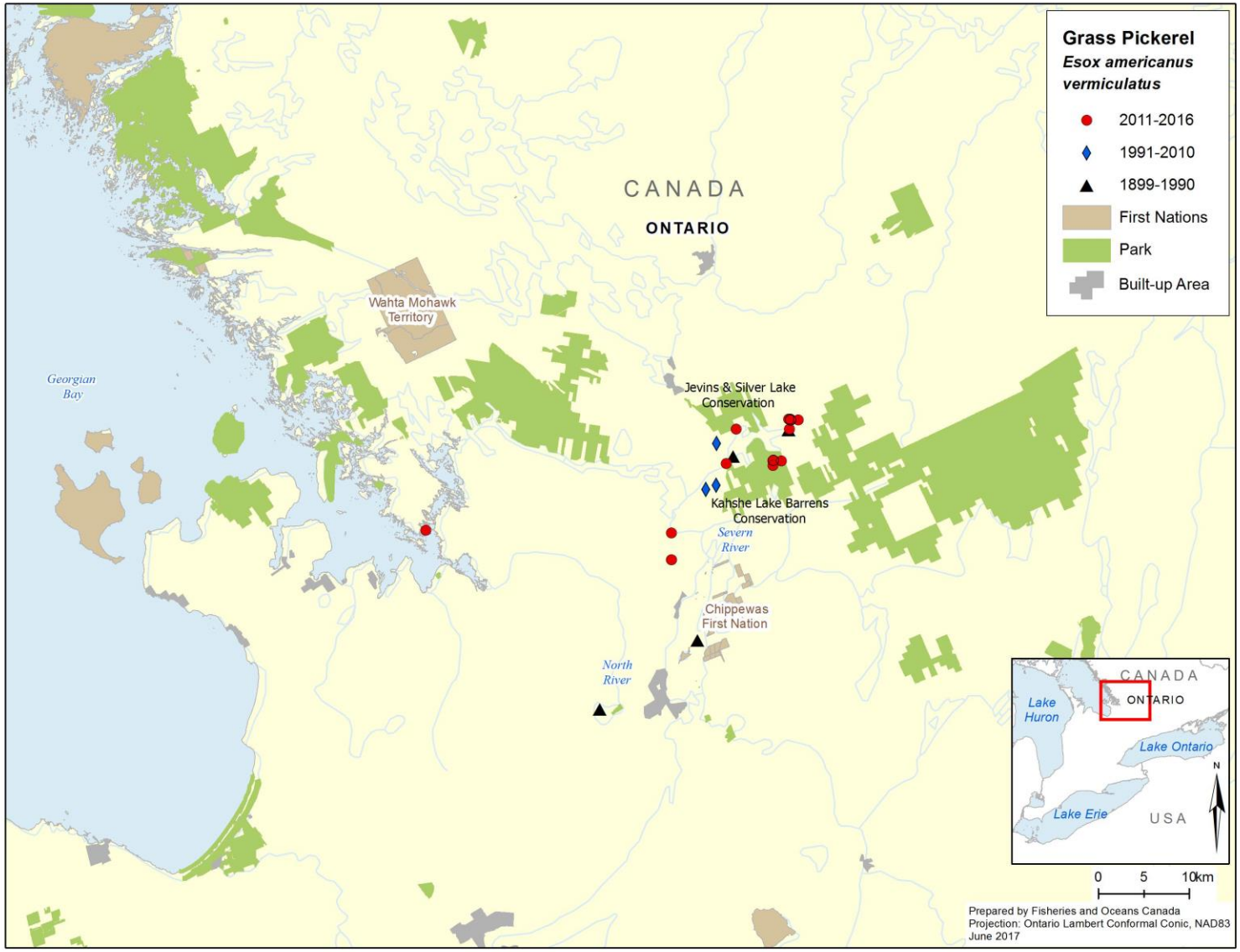

Figure 3. Historical distribution and recent detections of Grass Pickerel in southwestern Ontario (Georgian Bay watershed)

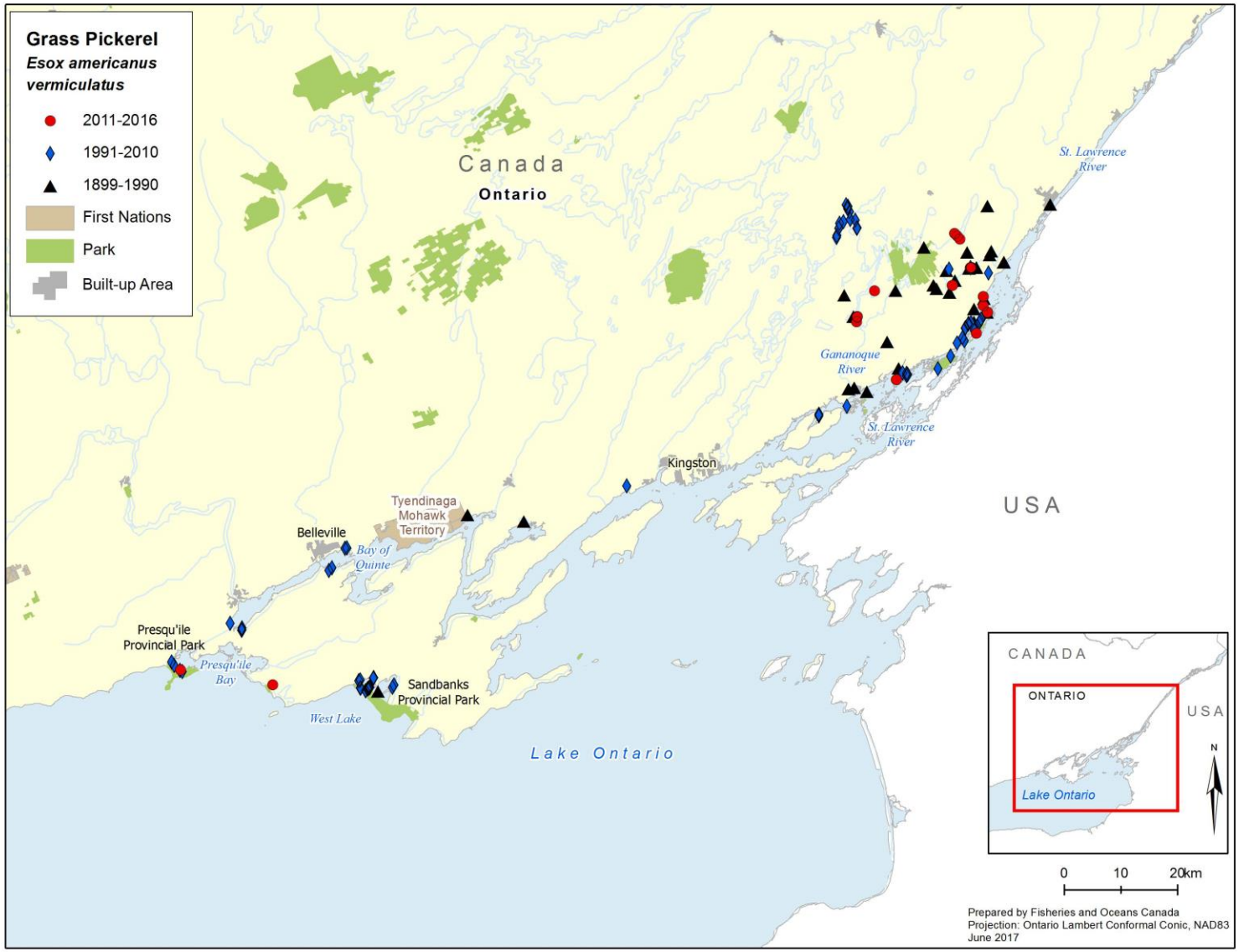

Figure 4. Historical distribution and recent detections of Grass Pickerel in eastern Ontario

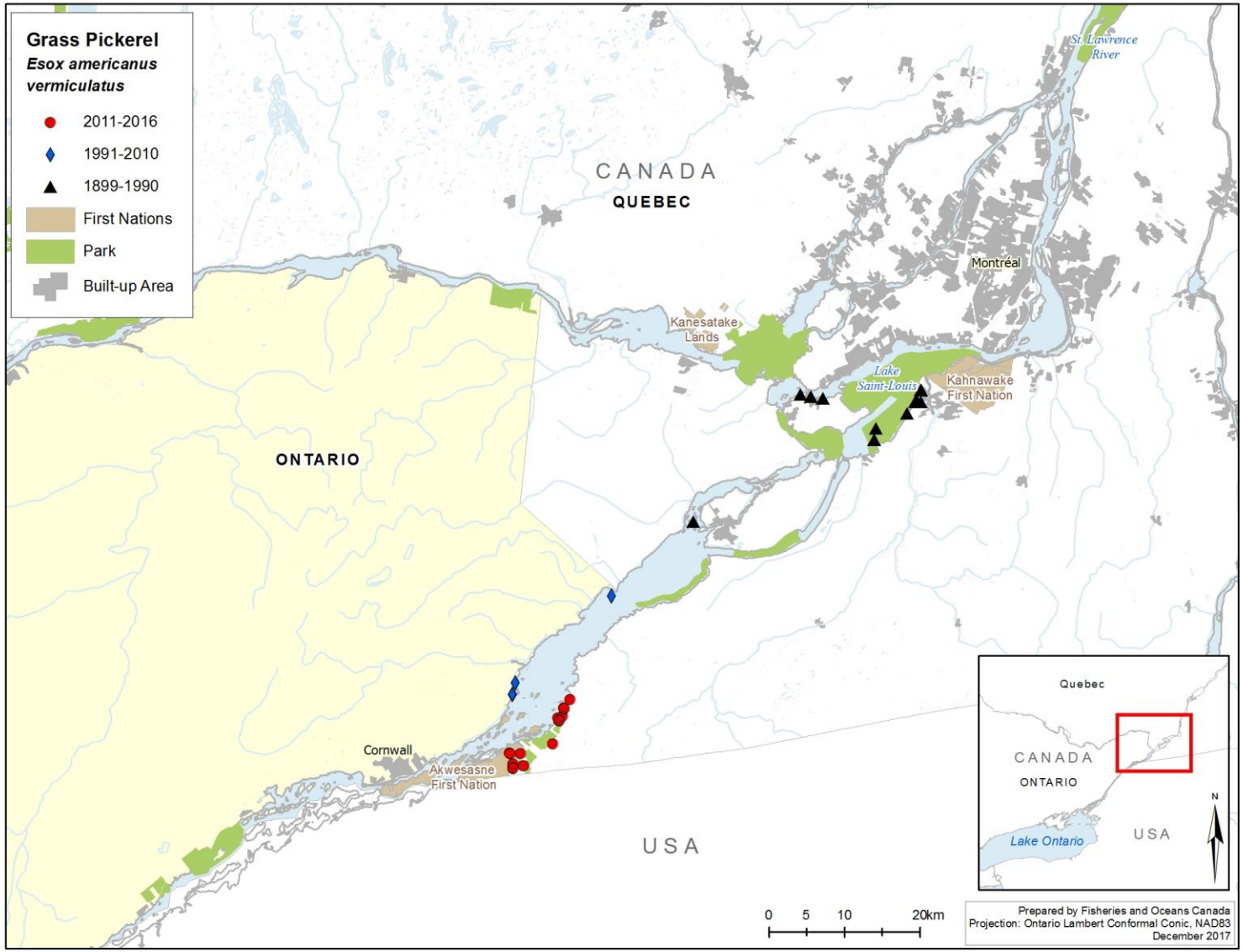

Figure 5. Historical distribution and recent detections of Grass Pickerel in Quebec

2.3 Threats to the Grass Pickerel

This section summarizes the information found in the management plan on threats to the conservation of Grass Pickerel.

Tables 1 and 2 summarize the threats to extant populations of Grass Pickerel in Ontario and Quebec, respectively. Please refer to section 1.5 of the management plan for more information on these threats. Since the management plan's publication in 2012, the 2014 COSEWIC status report (COSEWIC 2014) identified invasive species as a significant threat to Grass Pickerel in certain locations.

Another Esocid species, the Chain Pickerel (*Esox niger*), has seen a range expansion into eastern Lake Ontario, likely originating from Quebec or American waters. Competition from, and predation by Chain Pickerel potentially poses a significant threat to Grass Pickerel in eastern Lake Ontario (Hoyle and Lake 2011).

In addition, an invasive plant called the European Common Reed (*Phragmites australis australis*) has spread throughout much of the Grass Pickerel's range and has had profound impacts within coastal wetlands of Lake Erie including Long Point Bay (Badzinski et al. 2008), Point Pelee National Park (Vis et al. 2014), and Lake St. Francis and some of its tributaries where Grass Pickerel is present. Dense stands of European Common Reed have been implicated in the reduction of wetted habitat within coastal wetlands (Gilbert and Locke 2007; Rook et al. 2016), which is important habitat for Grass Pickerel at multiple life stages. This may be especially problematic for recruitment of young-of-the-year (YOY) when European Common Reed replaces native nearshore aquatic and riparian vegetation used as spawning and nursery habitat (COSEWIC 2005).

The spread of Grass Carp (*Ctenopharyngodon idella*), a large, herbivorous fish within the Great Lakes, may also pose a significant future threat to Grass Pickerel in coastal wetland habitats. Grass Carp has recently been detected within lakes Erie (Cudmore et al. 2017) and Ontario, including several locations where Grass Pickerel occurs, such as the Niagara River, Jordan Harbour (<5 km downstream of a Twenty Mile Creek Grass Pickerel record), and the Bay of Quinte (DFO 2017a). Furthermore, spawning Grass Carp have been confirmed within a tributary of Lake Erie located in Ohio (Chapman et al. 2013; Embke et al. 2016) and a specimen capable of reproduction was detected within Jordan Harbour (DFO 2017a). A number of coastal wetland areas, currently occupied by Grass Pickerel, have been identified that have a high potential to be colonized by Grass Carp based on the depth and density of aquatic vegetation including: Georgian Bay, Lake St. Clair, Long Point, the Niagara River, the Bay of Quinte, and the St. Lawrence River (Gertzen et al. 2016). Furthermore, Gertzen et al. (2016) have postulated that Grass Pickerel has a high potential to be affected by Grass Carp invasions based on the life-history needs of the former species.

Table 1. Threat classification table for Grass Pickerel in Ontario (Beauchamp et al. 2012).

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)
Habitat loss or degradation: drainage (that is, local modification of natural hydrological regimes)	Widespread	Current	Continuous	High	High	High
Habitat loss or degradation: sediment loading/turbidity	Widespread	Current	Seasonal	High	High	High
Habitat loss or degradation: damage/destruction of aquatic vegetation	Widespread	Current	Seasonal	High	High	High
Habitat loss or degradation: damage/destruction of riparian vegetation	Widespread	Current	Continuous	High	Medium	Medium
Habitat loss or degradation: nutrient loading	Widespread	Current	Continuous	Medium	High	Medium
Habitat loss or degradation: contaminant inputs	Widespread	Current	Seasonal	Medium	Medium	Medium
Invasive species	Widespread	Unknown/ anticipated	Continuous	Low	Medium	Medium
Climate change	Widespread	Current/ anticipated	Continuous	Medium	Unknown	Medium
Interspecific interactions	Localized	Current	Unknown	Low	Unknown	Low
Disease	Widespread	Current	Continuous	High	Unknown	Medium
Fishing pressure	Localized	Unknown	Seasonal	Low	Unknown	Low
Barriers to movement	Localized	Current	Unknown	Medium	Unknown	Low
Water level fluctuations (beyond natural seasonal variability)	Widespread	Current	Continuous	Low	Low	Low

Table 2. Threat classification table for Grass Pickerel in Quebec (Beauchamp et al. 2012).

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)
Habitat loss or degradation: drainage	Widespread	Current	Continuous	High	High	High
Habitat loss or degradation: sediment soading/turbidity	Widespread	Current	Continuous	High	High	High
Habitat loss or degradation: damage/destruction of aquatic vegetation	Widespread	Current	Seasonal	High	High	High
Habitat loss or degradation: damage/destruction of riparian vegetation	Widespread	Current	Seasonal	High	High	High
Habitat loss or degradation: nutrient loading	Widespread	Current	Continuous	High	High	High
Habitat loss or degradation: contaminant inputs	Widespread	Current	Continuous	Medium	Medium	Medium
Habitat loss or degradation: water level fluctuations (beyond natural seasonal variability)	Widespread	Current	Continuous	Medium	Medium	Medium
Barriers to movement	Widespread	Current	Continuous	Medium	Medium	Medium
Invasive species	Widespread	Imminent	Continuous	Medium	Medium	Medium
Climate change	Widespread	Current/ anticipated	Continuous	Low	Unknown	Low
Interspecific interactions	Localized	Anticipated	Seasonal	Low	Unknown	Low
Fishing pressure	Localized	Unknown	Seasonal	Low	Low	Low
Disease	Unknown	Anticipated	Continuous	High	Unknown	Low

2.4 Management

This section summarizes the management objectives identified in the management plan (Beauchamp et al. 2012) as necessary for Grass Pickerel conservation.

2.4.1 Goal

The goal of this management plan is to ensure the long-term persistence of Grass Pickerel throughout its current and historical distribution in Canada. Management should be directed towards ensuring the conservation and restoration of habitat for known populations.

2.4.2 Objectives

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

i. to understand the health and extent of existing populations
ii. to improve our knowledge of the species' biology, ecology, and habitat requirements
iii. to understand trends in populations and habitats
iv. to maintain and improve existing populations
v. to ensure the efficient use of resources in the management of this species
vi. to improve awareness of the Grass Pickerel and engage the public in the conservation of this species

3 Progress towards conservation

Section 72 of SARA requires the competent Minister(s) to report on the implementation of the management plan and the progress towards meeting its objectives, within five years after it is included in the Species at Risk Public Registry and in every subsequent five-year period, until its objectives have been achieved, or the species becomes threatened or endangered under SARA at which point a recovery strategy would be required. In the interest of capturing the most recent progress on the conservation of Grass Pickerel, this document includes actions completed by the end of March 2017. The management plan for the Grass Pickerel divides conservation efforts into five broad strategies required to protect, maintain, and improve Grass Pickerel populations and habitat:

1. surveys and monitoring
2. management and coordination
3. research
4. stewardship, habitat protection and improvement, and threat mitigation
5. outreach and communication

Progress in carrying out these actions is reported in table 3.

3.1 Actions supporting management objectives

Table 3 provides information on the implementation of activities undertaken to achieve the management plan objectives identified in the implementation schedule table of the management plan (Beauchamp et al. 2012).

Table 3. Details of activities supporting the conservation of Grass Pickerel from 2012 to 2017.

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
Develop consistent protocols for surveying and monitoring Grass Pickerel populations, including the collection of genetic material should genetic analysis be required	Protocol development	Surveys and monitoring (populations and habitat)	Fisheries and Oceans Canada (DFO) has conducted research in Beaver Creek/Outlet Drain, Fort Erie, Ontario, which included the development of survey and monitoring protocols for Grass Pickerel (J. Colm, DFO, pers. comm. 2016). Research has been conducted (DFO, Ontario Ministry of Natural Resources and Forestry [OMNRF] and the University of Toronto [U of T]) to inform the development of sampling guidance for the detection and monitoring of species at risk found within Great lakes coastal wetlands. This work involved species-specific analyses that included Grass Pickerel (Scott Reid, OMNRF, pers. com. 2016).	i, ii, iii, iv	**DFO, OMNRF**, Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA), Municipalities, Academic institutions (AIs), Conservation authorities (CAs), private consultants, Environmental non-governmental organizations (ENGOs), U of T

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
Conduct background surveys at sites of known occurrence	Baseline surveys	Surveys and monitoring (populations and habitat)	In Ontario, DFO has sampled a total of 22 waterbodies in seven watersheds/locations where Grass Pickerel is known to occur. Non-targeted surveys were conducted using potentially suitable gear types in 12 of these waterbodies. A total of 137 Grass Pickerel were captured at eight of 12 locations. Surveys specifically targeting Grass Pickerel were conducted in: Beaver, Jones, Leeders, Michael Henry, and Twenty Mile creeks; Gananoque, Gartersnake, Kahshe, Severn, and Welland rivers; and, Gananoque and Kahshe lakes. A total of 943 Grass Pickerel were detected at seven of 11 locations. A total of 68 Grass Pickerel were detected in Ontario by external agencies in waterbodies including the Kahshe Barrens, Old Ausable Channel, Lake St. Clair, Detroit River, Long Point Bay, Big Creek, Turkey Point Marsh, Lyon's Creek, and Thousand Islands National Park. All of the historical sites in Quebec, which are in the St. Lawrence River or in the Lake St. Francis and Lake St. Louis watersheds, were sampled in 2012, 2013, or 2014. In those historical sites, no Grass Pickerel were caught (AECOM 2013, 2014, 2015).	i	**DFO, OMNRF**, Ausable Bayfield Conservation Authority (ABCA), Long Point Region Conservation Authority (LPRCA), Parks Canada Agency (PCA), private consultants
Conduct surveys in areas with suitable habitat where Grass Pickerel	Baseline surveys	Surveys and monitoring (populations and habitat)	In Ontario, targeted sampling for Grass Pickerel has been conducted in a number of watersheds and lakes where the species has yet to be detected, despite the presence of suitable habitat. A total of 13 waterbodies were sampled, in which four (Graham,	i	**DFO, OMNRF**, CAs, PCA

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
has not previously been detected			Bass, and Grass lakes, and Big Forks Creek) yielded Grass Pickerel. Two Grass Pickerel were also detected in Big Forks Creek and the Lower Niagara River (Niagara Region) during non-target surveys. A single Grass Pickerel was detected in the vicinity of Green Island in Georgian Bay during non-targeted assessments in Severn Sound (D. Reddick, DFO, pers. comm., 2016). In total, 23 Grass Pickerel were detected among six waterbodies. In addition, 24 Grass Pickerel were observed in a new location, La Rue Mills Creek, during a non-targeted survey in Thousand Islands National Park (J. Van Wieren, PCA, pers. comm.). In Quebec, surveys were conducted in Lake St. Francis and some of its tributaries in 2014, 2015, and 2016, and 28, 10, and 7 Grass Pickerel were caught, respectively (AECOM, 2014, 2015; Groupe BC2-Synergis 2017). Grass Pickerel was captured in nine waterbodies, mainly in streams in farming areas. All captures were made on the south shore of Lake St. Francis. Sampling efforts in three watercourses on the north shore of the lake including the Beaudette River, Cooper Marsh, Raisin River, and Fraser Creek, failed to collect any Grass Pickerel (AECOM 2015, 2016; Groupe BC2-Synergis 2017).		

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
Integrate the long-term monitoring requirements of Grass Pickerel with existing fish community survey efforts, where possible.	Long-term monitoring	Surveys and monitoring (populations and habitat)	Depending on the lead agencies, different approaches may be taken to integrate the monitoring requirements in Ontario and Prairie Region (formerly Central and Arctic Region) and Quebec Region. In Quebec, the Réseau de suivi ichtyologique (RSI) monitors species present in the St. Lawrence River, including Lake St. Francis and Lake St. Louis. The Grass Pickerel has never been captured through this network's sampling campaigns. The likelihood of the species being detected by the network is probably low, as it does not cover small streams, which the species seems to prefer.	i	**DFO, OMNRF, PCA**, LPRCA, ABCA, Ministère des Forêts, de la Faune et des Parcs (**MFFP**)
Monitor the existence and potential arrival of invasive species in Grass Pickerel habitat. Where possible, this should be coordinated with relevant ecosystem-based programs.	Invasive species monitoring	Surveys and monitoring (populations and habitat)	Monitoring has been conducted to investigate the potential presence of Asian carps in areas where Grass Pickerel occur including Lake St. Clair, the Detroit River, Cedar Creek, Long Point Bay, and Jordan Harbour in 2013 to 2014 (Marson et al. 2016) and Jordan Harbour, the Sydenham and Niagara rivers, Long Point Bay, and the Bay of Quinte in 2015. In 2015, Grass Carp was detected in Jordan Harbour (one specimen), Muscote Bay in the Bay of Quinte (one specimen), and the Lower Niagara River (one specimen) (DFO 2017a).	i, iii	DFO, OMNRF, CA
Collaborate and share information with relevant groups, Indigenous	Collaborate	Management and coordination	Continued coordination with recovery teams (that is, Ontario Freshwater Fish Recovery Team [OFFRT], and Équipe de rétablissement des cyprins et petits percidés du Québec) and delivery of conservation initiatives across jurisdictions.	iv	**DFO, OMNRF**, CA, **MFFP**

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
groups, initiatives and recovery/manag-ement teams (for example, drainage superintendents [Ontario], area of prime concern [ZIP] committees [Quebec], watershed organizations [OBV] [Quebec]) to address management actions of benefit to Grass Pickerel.			Information regarding Grass Pickerel conservation and the threats that impact this species has been provided to key stakeholders and Indigenous groups during outreach meetings.		
Survey municipal drains proposed for maintenance activities before work occurs in locations suspected of supporting Grass Pickerel, but where records of such are lacking.	Survey drains (existing or proposed)	Management and coordination	A project is underway in Ontario to overlay the municipal drains of Ontario mapping layer with species at risk mapping layers (J. Colm, DFO, pers. comm. 2016). This mapping information will enable the sampling of locations suspected of supporting Grass Pickerel prior to drain maintenance or the construction of new municipal drains, if warranted, during *Fisheries Act* reviews. This is particularly important where high densities (that is, “hotspots”) of Grass Pickerel are known or believed to exist.	i, iii	**DFO, OMNRF**,CAs

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
Ensure that measures to mitigate potential impacts to Grass Pickerel are in place prior to and during in-water works (for example, municipal drain maintenance, improvements, new drainage works).	Mitigation	Management and coordination	Mitigation measures are recommended to proponents by DFO's Fish and Fish Habitat Protection Program staff based on DFO's "Updated Review Considerations and Mitigation Guide for Habitat of the Grass Pickerel" (Coker et al. 2021). This update includes new information on Grass Pickerel life-history/requirements (for example, movement patterns, habitat "hotspots", emphasis on the importance of refuge habitat) and how to mitigate for these needs, as well as additional techniques like stockpiling dredgeate to preserve the seed bank and promote recolonization.	ii, iii	DFO
Develop alternatives to drainage that will address land drainage needs while maintaining Grass Pickerel habitat.	Drainage alternatives	Management and coordination	Research in Beaver Creek (Outlet Drain Project) and Fort Erie, Ontario, investigated potential mitigative measures to help replicate and conserve habitat for the various life stages of Grass Pickerel and ensure they subsist through periods of low water levels, including the creation of refugia pools, application of natural channel design principles in drainage development to maintain habitat function for Grass Pickerel in the channel and floodplain, and culvert removal/replacement (DFO 2017b, 2021). Alternatives exist to provide drainage while minimizing fish and fish habitat impacts, including off-line storage, spot cleanouts in problem areas, culvert modifications to improve outlets, etc. A key conclusion of recent science advice on impacts of agricultural drain maintenance on Grass Pickerel	iv	**DFO, OMNR**, Priority Intervention Zone Committee (PIZ), Watershed Committees **(WCs), CAs**

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
			was to identify the root cause of the drainage problems prior to undertaking intervention activities (DFO 2021). Assessment of impacts of drain maintenance on species at risk in Little Bear Creek led to advice on maintenance design, mitigation measures, and offsetting options to maximize suitable habitat for species at risk. Guidance is provided that outlines potential negative impacts of drain maintenance (for example, increased turbidity) and solutions that would ameliorate such threats (Montgomery et al. 2016; DFO 2017c; Reid et al. 2016).		
Create a central database to facilitate Grass Pickerel data synthesis and transfer in Quebec (ongoing) for information such as habitat parameters.	Data management	Management and coordination	Records received through DFO's monitoring program and annual requests for new species at risk data (including Grass Pickerel) were added to DFO Ontario and Prairie Region's database for Ontario. A central database for five at-risk species in Quebec, including Grass Pickerel, has been developed (Couillard et al. 2013); however, Grass Pickerel habitat-related data are quite limited, as the species has only been recently reconfirmed (in 2014) in Quebec.	v	**DFO, OMNRF, PCA**, CA, AI, **MFFP**
Determine the seasonal habitat needs of the various life stages of Grass Pickerel.	Seasonal habitat needs	Research	Research has been conducted that has helped to identify and characterize summer habitat needs for adults and potentially juveniles (J. Colm, DFO, pers. comm. 2016), which is a step in the direction of achieving this objective. Additional young-of-the-year (YOY) specific studies have been identified as a research need.	i, ii, iii	**DFO, OMNRF,PCA**, CA, AI

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
			A study on the movement of Grass Pickerel in Beaver Creek found no evidence of spawning migrations or differences in seasonal habitat use in the creek. Grass Pickerel showed movements on the scale of drain maintenance (0.5 to 1.0 km) indicating the potential to recolonize areas following maintenance activities with larger individuals in better condition displaying greater dispersal abilities (0.9 to 3.1 km) (Kramski 2014).		
Gather information on the population dynamics of Grass Pickerel and fish community associations in Canada.	Fish community dynamics	Research	Fish community associations with Grass Pickerel were investigated (Colm 2015). The assemblage of species was observed to be similar between sites regardless of the presence of Grass Pickerel, suggesting shared habitat preferences may be more important than biotic interactions in structuring fish communities in those systems. DFO has also investigated and compared lethal (cleithra) and non-lethal (scales) methods of determining the age and growth of Grass Pickerel within two Ontario populations (Beaver and Jones creeks) (Colm et al. 2020). The results of this study suggest that age interpretation using scales is generally unreliable; therefore, age estimations should be based on allometric modelling (bone radius vs. body length) derived from lethal (cleithra) interpretation conducted in the past. In addition, the results of this study elucidate population-specific demographic trends including inter-annual fluctuations in growth rate likely attributable to density dependent factors, and population specific mortality rates. Furthermore, DFO tagged Grass Pickerel with passive integrated transponder (PIT) tags at	i, ii, iii	**DFO, OMNRF**, PCA, CA, AI

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
			sampling sites within Beaver Creek to investigate movement and dispersal, and to calculate the abundance of this species through catch per unit effort (CPUE) (Colm and Mandrak 2021). Condition factor (body length x body weight) of this Grass Pickerel population was also assessed and it was found that condition varied among sites and sampling years, with some individuals being above average and others below average. Furthermore, this sampling led to the discovery of a blue morph of Grass Pickerel, which differs from the normal colouration, at least in the year one age-class. While the findings of Colm et al. (2020) and Colm and Mandrak (2021) do not address fish community associations, they are relevant in terms of characterizing the demographic traits of specific populations and monitoring population trends.		
Determine the quantity and quality of habitat required to ensure long-term conservation of Grass Pickerel and to support the long-term management goal.	Habitat quantity and quality	Research	Research has been conducted exploring the impacts of in-water work on the quality and quantity of Grass Pickerel habitat in relation to drainage activities; however, additional research is required to determine the overall quality and quantity of habitat needed to ensure long-term persistence of Grass Pickerel in stable conditions as a reference point.	i, ii, iii	**DFO, OMNRF**, PCA, CA, AI
Conduct a threat assessment to evaluate threat	Threat evaluation	Research	Research has been conducted exploring the impacts of European Common Reed in coastal wetlands of Lake Erie where Grass Pickerel is present. For	iii	**DFO, OMNRF**, CA, AI

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
factors that may be impacting Grass Pickerel (for example, invasive species, hybridization, interspecific competition with other esocids, water level management (for example, in National Wildlife Areas [NWAs]), which will be updated as new information becomes available.			example, the evaluation of habitat restoration activities for species at risk fishes involving the efficacy of wetland restoration (removal of European Common Reed), as a means of restoring species at risk habitat (for example, Grass Pickerel spawning), has been explored within the Crown Marsh of Long Point Bay. Recommendations were made regarding the design of constructed wetlands to maximize suitability for species at risk, including Grass Pickerel. Guidance is provided that outlines potential threats that can arise from these restoration activities (for example, low dissolved oxygen levels, stranding, genetic isolation) as well as design solutions that would prevent these threats from occurring (Rook et al. 2016; DFO 2017d). In addition, research has been conducted that investigates potential impact scenarios stemming from the combined effects of climate change and the increased expansion of European Common Reed within Long Point Bay. Although these studies focus on impacts to Warmouth (*Lepomis gulosus*), the findings are applicable for Grass Pickerel (McCusker 2017). Lastly, an investigation into the impacts of water-level fluctuations, stemming from drainage activities, on Grass Pickerel was undertaken by DFO in Beaver Creek/Outlet drain. The water depth was increased in the reconstructed section of Beaver Creek following drain maintenance and reconstruction using natural channel design features. Grass Pickerel abundance (measured by CPUE) in the reconstructed section was increased, relative to the control reach, in the time period		

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
			following reconstruction (DFO 2017b).		
Determine the mechanisms by which drainage activities have caused Grass Pickerel populations to decline (for example, through habitat loss or negative interspecific interactions). This will inform mitigation measures for drainage work.	Drainage evaluation	Research	The incorporation of mitigation measures into drain maintenance design was investigated as a component of the Beaver Creek/Outlet Drain project. The results of this study suggest habitat improvement activities provide effective mitigation to offset the effects of drain maintenance. These activities include: i) the creation of deeper pools, which serve as refuge habitat during winter or low-water periods (Glass et al. 2021); ii) access to shallow waters (<0.5 m) and/or functioning floodplain habitat, which is important for spawning; and, iii) the maintenance of connections between the floodplain and the main stream channel to allow access to suitable spawning habitat (DFO 2021). Further, mitigation measures for species at risk, including Grass Pickerel, have been investigated to offset the potential impacts of drain maintenance activities (Coker et al. 2021). Another study (DFO 2015) indicates that an additional measure to mitigate drain maintenance includes fish exclusion using seine nets.	ii, iii	**DFO, OMNRF**, CA, AI
If justified, conduct a genetic assessment of the species across its range.	Genetics	Research	Research is currently underway at U of T Scarborough (N. Mandrak, U of T, pers. comm. 2016). Based on preliminary results, there does not appear to be any population structure (genetic difference) among locations where Grass Pickerel is present.	i, iv, v	**DFO, OMNRF**, PCA, CA, AI, U of T
Coordinate stewardship activities with	Coordinate stewardship activities	Stewardship, habitat protection and	Community support has been raised through DFO outreach efforts that have improved the coordination of recovery efforts and have fostered partnerships.	Ii, iii, iv, v	**DFO, OMNRF**, PCA, CA

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
existing groups, Indigenous groups, and initiatives.		improvement, and threat mitigation	Applicable events include: the annual meeting of the Stewardship and Outreach Recovery Implementation Group, and the delivery of presentations to Indigenous groups, the Ontario Aboriginal Lands Association (OALA), and the Ontario First Nations Economic Development Association (OFNEDA) regarding threats to aquatic species at risk and protection measures that can be implemented to reduce risk within their areas.		
Promote stewardship initiatives (for example, federal/provincial funding programs) relating to Grass Pickerel conservation and ensure that information relating to funding opportunities for landowners and Indigenous is made available.	Promote stewardship	Stewardship, habitat protection and improvement, and threat mitigation	Stewardship promotion was carried out by external agency outreach programs. Through the Ausable River Recovery Strategy Implementation by the ABCA, media outreach and stewardship training has been conducted to increase awareness within the Ausable River watershed. Carolinian Canada is developing, implementing, and monitoring community-based conservation action plans for species at risk and ecosystem recovery in the Carolinian Life Zone, including media outreach and stewardship training conducted throughout southern Ontario. In Ontario, between 2012 and 2017, DFO's Species at Risk Program met face-to-face and provided web-based training to over 2,275 members of communities, stakeholder groups, and partner agencies. Outreach promoting species protection, conservation, and stewardship has also included the installation of species at risk information signs in sensitive habitat areas, notices in industry	Ii, iii, iv, v	**DFO, OMNRF**, PCA, CAs

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
			newsletters, species at risk distribution maps for project proponents to screen for presence of aquatic species at risk to avoid project impacts, and funding promotion for species at risk stewardship. Federal funding is available annually through the Aboriginal Funds for Species at Risk, Habitat Stewardship Program, and through various provincial funding initiatives, including the Species at Risk Stewardship Fund and Species at Risk Farm Incentive Program.		
Encourage the implementation of best management practices (BMPs) relating to livestock management, the establishment of riparian buffers, nutrient and manure management, tile drainage, etc.	BMP implementation	Stewardship, habitat protection and improvement, and threat mitigation	Through partnerships with watershed-based conservation organizations (CAs in Ontario), DFO staff have promoted the implementation of BMPs via presentations, project reviews, and site meetings with the agricultural community, drainage engineers, and the Ontario Drainage Superintendents Association. The use of BMPs is encouraged through project reviews and mitigation on rural properties, including: livestock restrictions (exclusion fencing); milkhouse washwater system installations; riparian buffers; streambank stabilization; wetland creation or enhancement; well decommissioning; septic upgrades; and, sediment control/trapping to prevent runoff and improve water quality. The Species at Risk Farm Incentive Program, through the Ontario Soil and Crop Improvement Association (OSCIA), includes information on what BMP farm activities can help species at risk including information on cost-share opportunities.	ii, iii	**DFO, OMNRF**, CAs, **OSCIA**, **OMAFRA**

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
			In Spring 2016, DFO participated on a multi-stakeholder government oversight committee tasked with reducing waterborne phosphorous inputs into the Great Lakes, specifically Lake Erie, by implementing BMPs to improve drainage and land management approaches. Through the Ontario Soil and Crop Association's Great Lakes Agricultural Stewardship Initiative, significant cost-share (up to 80%) is available to help farmers implement highly targeted BMPs. These actions support edge-of-field phosphorus reductions along the shores of Lake Erie in southwestern Ontario in eligible watersheds where Grass Pickerel is known to exist (including the jurisdictions of the ABCA, Essex Region CA, and Lower Thames Valley CA).		
Promote retirement of fragile lands that provide Grass Pickerel habitat through Ecological Gift Programs, easements, and tax incentives (for example, Conservation Land Tax Incentive Program [CLTIP; Ontario]).	Land retirement incentives	Stewardship, habitat protection and improvement, and threat mitigation	In Ontario, partner agencies (CAs and OMNRF) continue to promote retirement of fragile lands through various land and water management and stewardship programs as well as BMPs.	iv, v, vi	**DFO**, **OMNRF, PCA, CA**

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
Include the Grass Pickerel in existing and future communication and outreach programs for both ecosystem-based recovery as well as endangered and threatened aquatic species.	Existing/ future communicati on and outreach programs	Communication and outreach	Ongoing outreach to Indigenous communities, key stakeholders, and Canadian public includes information on Grass Pickerel and raises awareness of its status and need for conservation measures to prevent Grass Pickerel from becoming more imperilled.	iii, iv, v, vi	**DFO, CA**
Promote awareness with municipal planning offices, planning officials and drainage superintendents to develop and adopt land and water management practices that minimize impacts on Grass Pickerel	Promote awareness with planning offices, drainage superintend-ents, etc.		Municipal public works and planning departments, municipal drainage superintendents, and drainage engineers have been included in aquatic species at risk outreach activities conducted by DFO, that include reference to threats and mitigation that can be applied to conserve Grass Pickerel. DFO has developed and distributed aquatic species at risk guidance for municipalities to incorporate into municipal official plan updates, and have presented this information to Ontario East Municipal Conference participants. DFO has also disseminated information pertaining to Grass Pickerel within drains stemming from their mitigation research that has been conducted at Beaver Creek, Fort Erie, ON. This research has been presented at a number of events including the Latornell Conservation Symposium and as part of a transient ‘Water’ exhibit at the Royal Ontario	ii, iii, iv, v, vi	**DFO, OMNRF**, **CA**

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
			Museum. Outreach has also been specifically conducted with the Kahshe Lake Cottagers Association through an article in Kahshe newsletter about Grass Pickerel (J. Colm, DFO, pers. comm., 2016).		
Develop and distribute educational materials to interested parties (for example, local anglers, conservation biologists) that provide the key characteristics that distinguish the esocid species (particularly juveniles).	Educational materials for esocid species		Aquatic Species at Risk fact sheets for Grass Pickerel including general description, distribution, habitat, life history, diet, threats, and similar species information (noting distinguishing features) were developed by DFO. These fact sheets have been disseminated at a variety of outreach events and trade shows and are available to watershed landowners through various conservation authority offices across their range. Species profile information for Grass Pickerel is also available on the Species at Risk Public Registry and on DFO's Aquatic Species at Risk website. In addition, a number of stakeholders operating in the Lake St. Francis area were informed of the new records for Grass Pickerel (watershed organizations, ENGOs, baitfish harvesters and Lake Saint-François National Wildlife Area). They were provided with a fact sheet to help recognize the species and were asked to voluntarily report Grass Pickerel catches.	ii, iii, iv, v, vi	**DFO**, OMNRF, CA
Advise landowners of various tax incentive programs for conservation	Promote fragile land retirement		CAs and the OMNRF may promote retirement of fragile lands (for example, wetlands) through stewardship, land and water management, and rural water-quality improvement programs. The Government of Canada's Species at Risk Public	iv, v, vi	**DFO, OMNRF, CA**

Conservation measure	Approach	Broad strategy	Descriptions and results	Management objectives	Participants
lands (for example, Ecological Gifts Program, easements, CLTIP [Ontario]) to protect Grass Pickerel habitat.			Registry promotes funding and support for species at risk. Federal grants and incentive programs are also promoted alongside provincial programs on Ontario's grants for protecting Species at Risk website. In both Ontario and Quebec, there is the Ecological Gifts Program.		

4 Concluding statement

Overall, management activities conducted from 2012 to 2017 have helped to provide a clearer understanding of the range and extent of Grass Pickerel in Canada. Specifically, the evaluation of the species' distribution and abundance in known and new areas with suitable habitats confirmed its continued presence, while sampling in new areas helped confirm/refine the extent of the species' distribution. In addition, a regionally-specific threat of habitat destruction from cottage development/shoreline alterations in Muskoka region was identified, the quantity and quality of habitat required to ensure long-term conservation of Grass Pickerel was clarified, and the population dynamics of Grass Pickerel and fish community associations were investigated.

Research has identified and characterized the summer, and some winter habitat needs of adult and potentially juvenile Grass Pickerel, thus improving our understanding of the species habitat requirements. Genetic research has indicated that there is a lack of population structure throughout the geographic range of Grass Pickerel. Furthermore, several threats were investigated, including: the impacts of European Common Reed in coastal wetlands of Lake Erie; interspecific competition and predation; and, impacts of water-level fluctuations stemming from drainage activities. Better understanding of the impacts of these threats may help inform mitigation measures in the future. Additionally, the impacts of drainage activities on Grass Pickerel were further investigated, leading to the characterization of the mechanisms by which drainage activities have impacted Grass Pickerel populations. In a related project, fish exclusion using seine nets was studied as a mitigation measure to reduce the potential impacts of drain-maintenance activities on species at risk, including Grass Pickerel. Further research undertaken to explore measures to mitigate against impacts from dredging and drainage activities in Grass Pickerel habitat has provided a better understanding of the species' response to the physical removal of macrophytes, the alteration and reengineering of watercourse attributes, and other physical habitat alterations associated with drain maintenance activities in Ontario. Studies in Beaver Creek have resulted in recommendations to conduct monitoring prior to drain maintenance projects to identify "hotspots" such as pools that support larger numbers of adults and/or have higher recruitment success of YOY. Once such features have been identified, any inwater works should be conducted downstream to mitigate potential negative impacts.

Lastly, outreach activities including the promotion of stewardship approaches, best management practices (BMPs), as well as the retirement of fragile lands to protect aquatic species at risk have been undertaken. Some of these activities include: information packages pertaining to Grass Pickerel that have been delivered to Indigenous communities, key stakeholders, and the Canadian public; presentations and information provided to municipal planners and drainage superintendents; and, the dissemination of aquatic species at risk fact sheets, including Grass Pickerel.

Conservation and management of Grass Pickerel is also being implemented in areas under the jurisdiction of the Parks Canada Agency (PCA). PCA has published the "Multi-species Action Plan for Point Pelee National Park and Niagara National Historic Sites of Canada" (PCA 2016a) and the "Multi-Species Action Plan for Thousand Islands National Park of Canada" (PCA 2016b).

These ongoing and/or completed activities illustrate the progress that has been made towards the goal of conserving Grass Pickerel populations in Canada; however, further information is required in a number of areas that can only be obtained through:

- continued monitoring of the range expansion of Chain Pickerel in Lake Ontario

- integrating long-term monitoring surveys for Grass Pickerel with existing fish-community survey efforts to better understand species' associations and dependencies within the fish community
- continuing strategic outreach such as coordinating stewardship activities with Indigenous groups and others such as the cottagers associations in Muskoka region, where possible

Since 2010, Grass Pickerel has been detected at five new localities within Ontario and nine watercourses in Quebec that had not been historically identified as supporting Grass Pickerel populations. Despite all these efforts, further surveys are needed to refine the presence and distribution of Grass Pickerel in Canada. There are a total of 36 localities where Grass Pickerel has been detected in the past that have not been sampled in the last five years. Of these, several locations have not been sampled in more than 20 years, including Frenchman's and Long Point creeks, Lees Pond, and tributaries of the lower Grand River. Future management activities focusing on filling these knowledge gaps will support and inform ongoing conservation efforts for Grass Pickerel. 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.

References

AECOM. 2013. Inventaire et caractérisation des habitats utilisés par le brochet vermiculé et le méné d'herbe. [Survey and characterization of habitats used by the Grass Pickerel and Bridle Shiner]. Report submitted to Fisheries and Oceans Canada. 19 p. + appendices.

AECOM. 2014. Inventaire et caractérisation des habitats utilizes au printemps par le brochet vermiculé dans l'aire de repartition historique du fleuve Saint-Laurent et ses affluents. [Inventory and characterization of habitats used in the spring by the Grass Pickerel in the historical range of the St. Lawrence River and its tributaries]. Report submitted to Fisheries and Oceans Canada. 32 p. + appendices.

AECOM. 2015. Caractérisation et inventaire de cours d'eau dans l'aire de repartition historique et potentielle du brochet vermiculé au Québec. [Characterization and survey of streams in the Grass Pickerel's historical and potential range in Quebec]. Report submitted to Fisheries and Oceans Canada. 29 p. + appendices.

AECOM. 2016. Inventaire du brochet vermiculé dans les secteurs de captures de 2014 au sud du lac Saint-François. [Survey of the Grass Pickerel in 2014 capture areas in south of Lake St. Francis]. Report submitted to Fisheries and Oceans Canada. 25 p. + appendices.

Badzinski, S.S., S. Proracki, S.A. Petrie, and D. Richards. 2008. Changes in the distribution and abundance of common reed (*Phragmites australis*) between 1999 and 2006 in marsh complexes at Long Point - Lake Erie. Prepared for the Ontario Ministry of Natural Resources. (Accessed: 20 November 2014).

Beauchamp, J., A.L. Boyko, S. Dunn, D. Hardy, P.L. Jarvis, and S.K. Staton. 2012. Management plan for the Grass Pickerel (*Esox americanus venticulatus*) in Canada. *Species at Risk Act* Management Plan Series. Fisheries and Oceans Canada, Ottawa. vii + 47 p.

Chapman, D.C., J.J. Davis, J.A. Jenkins, P.M. Kocovsky, J.G. Miner, J. Farver, and P.R. Jackson. 2013. First evidence of Grass Carp recruitment in the Great Lakes Basin. Journal of Great Lakes Research (2013).

Coker, G.A., J.E. Colm, D.L. Ming, and N.E. Mandrak. 2021. Updated review considerations and mitigation guide for habitat of the Grass Pickerel (*Esox americanus vermiculatus*). Canadian Manuscript Report Fisheries Aquatic Sciences 3218: vi + 23 p.

Colm, J.E. 2015. Ecology of the imperilled Grass Pickerel (*Esox americanus vermiculatus*) in Ontario: distribution patterns and population decline. M.Sc. thesis, Department of Biology, Queen's University, Kingston, ON. 201 p.

Colm, J.E., J.M. Casselman, and N.E. Mandrak. 2020. Age, growth, and population assessment of Grass Pickerel (*Essox americanus vermiculatus*) in two northern populations. Canadian Journal of Zoology 98: 527-539.

Colm, J.E. and N.E. Mandrak. 2021. Summary of Grass Pickerel surveys in Beaver Creek Ontario, 2009-2015. DFO Canadian Science Advisory Secretariat Research Document 2021/047. v + 120 p.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2005. COSEWIC assessment and status report on the Grass Pickerel, *Esox americanus vermiculatus*, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 27 p.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2014. COSEWIC status appraisal summary on the Grass Pickerel *Esox americanus vermiculatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xix p.

Couillard, M.A., J. Boucher, and S. Garceau. 2013. Bilan de l'information disponible sur cinq espéces de poissons à statut précaire au Québec et de l'état d'avancement des activités de rétablissement. [Overview of the information available on five at-risk fish species in Quebec and status of the recovery activities]. Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs du Québec, Direction générale de l'expertise sur la faune et ses habitats. 58 p. + appendices.

Cudmore, B., L.A. Jones, N.E. Mandrak, J.M. Dettmers, D.C. Chapman, C.S. Kolar, and G. Conover. 2017. Ecological risk assessment of Grass Carp (*Ctenopharyngodon idella*) for the Great Lakes basin. DFO Canadian Science Advisory Secretariat Research Document 2016/118. vi + 115 p.

DFO. 2015. Fish exclusion options for aquatic species at risk for drainage activities in Little Bear Creek, Ontario. DFO Canadian Science Advisory Secretariat Science Response 2015/36: 1-17 p.

DFO. 2021. Impacts of agricultural drain maintenance in Beaver Creek on Grass Pickerel (*Esox americanus vermiculatus*), a fish species at risk. DFO Science Advisory Secretariat Science Advisory Report 2021/024.

DFO. 2017a. Update to the ecological risk assessment of Grass Carp (*Ctenopharyngodon idella*) for the Great Lakes Basin: Lake Ontario. Canadian Science Advisory Secretariat Science Response 2016/049. 1-16 p.

DFO. 2017b. Proceedings of the regional science peer review of impacts of agricultural drain maintenance in Beaver Creek on Grass Pickerel (*Esox americanus vermiculatus*), a fish species at risk: October 4-5, 2016. DFO Science Advisory Secretariat Proceedings Series 2017/027. v + 26 p.

DFO. 2017c. Assessment of the impacts of an agriculatural drain maintenance project on aquatic species at risk in Little Bear Creek, Ontario. DFO Canada Science Advisory Secretariat Science Advisory Report 2016/046. 1-10 p.

DFO 2017d. Evaluation of habitat restoration activities for species at risk fishes within Crown marsh (Long Point Bay). DFO Canada Science Advisory Secretariat Science Advisory Report 2016/56. 1-11 p.

Embke, H.S., P.M. Kocovsky, C.A. Richter, J.J. Pritt, C.M. Mayer, and S.S. Qian. 2016. First direct confirmation of Grass Carp spawning in a Great Lakes tributary. Journal of Great Lakes Research 42: 899-903.

Gertzen, E.L., J.D. Midwood, N.Wiemann, and M.A. Koops. 2016. Ecological consequences of Grass Carp, *Ctenopharyngodon idella*, in the Great Lakes Basin: vegetation, fishes and birds. DFO Canadian Science Advisory Secretariat Research Document 2016/117. v + 52 p.

Gilbert, J.M. and B. Locke. 2007. Restoring Rondeau Bay's ecological integrity. A report funded by the Lake Erie Management Unit, OMNR, the Canada/Ontario Agreement and the Lake Erie Habitat Restoration Section, Environment Canada. 40 p.

Glass, W.R., N.A. Rook, E. Ratajczyk, and N.E. Mandrak. 2021. Effect of drain maintenance and reconstruction on the abundance and habitat of Grass Pickerel (*Essox americanus vermiculatus*) in Beaver Creek, Ontario. DFO Canadian Science Advisory Secretariat Research Document 2021/046. iv + 31 p.

Groupe BC2-Synergis. 2017. Inventaire du brochet vermiculé (*Esox americanus vermiculatus*) dans le bassin versant du lac Saint-François [Survey of the Grass Pickerel (*Esox americanus vermiculatus*) in the watershed of Lake St. Francis]. Report submitted to Fisheries and Oceans Canada. 45 p. + appendices.

Hoyle, J.A. and C. Lake. 2011. First occurrence of Chain Pickerel (*Esox niger*) in Ontario: possible range expansion from New York waters of eastern Lake Ontario. Canadian Field Naturalist 125: 16-21.

Kramski, N. 2014. Conservation of fishes in altered ecosystems: the movement ecology of listed Grass Pickerel in an agriculatural drain. M.Sc. Thesis, Department of Integrative Biology, University of Guelph, Guelph, Ontario. 50 p.

Marson, D., E. Gertzen, and B. Cudmore. 2016. Results of Fisheries and Oceans Canada's 2014 Asian Carp early detection field surveillance program. Canadian Manuscript Report of Fisheries and Aquatic Sciences 3103: vii + 59 p.

McCusker, M. 2017. Species distribution model of Warmouth (*Lepomis gulosus*) in Long Point Bay, with evaluation of climate change and *Phragmites* impact scenarios. Canadian Manuscript of Fisheries and Aquatic Sciences 3132: iv +27 p.

Montgomery, F.A., N.E. Mandrak, and S.M. Reid. 2016. A modelling-based assessment of the impacts of drain maintenance on fish species at risk habitat in Little Bear Creek, Ontario. DFO Canadian Science Advisory Secretariat Research Document 2016/092. v + 20 p.

PCA (Parks Canada Agency). 2016a. Multi-species Action Plan for Point Pelee National Park and Niagara National Historic Sites of Canada. Parks Canada Agency. Ottawa. iv + 39 p.

PCA. 2016b. Multi-Species Action Plan for Thousand Islands National Park of Canada. Parks Canada Agency. Ottawa. v + 30 p.

Rook, N.A., N.E. Mandrak, and S.M. Reid. 2016. Evaluation of habitat restoration on

fish species at risk within Crown Marsh, Long Point Bay, Lake Erie, Ontario. DFO Canadian Science Advisory Secretariat Research Document 2016/059. v + 33 p.

Vis, C., J. Keitel, and C. Daniels. 2014. Predicting coastal wetland restoration outcomes using state-and-transition simulation models: a case study for Point Pelee National Park. From the 2014 Great Lakes Wetlands Day Proceedings: 91-95.