Proposed

Species at Risk Act
Recovery Strategy Series

Recovery Strategy and Action Plan for the Spotted Gar (*Lepisosteus oculatus*) in Canada

2022

Canada

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

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Preface

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

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

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

As stated in the preamble to SARA, success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions and actions set out in this recovery strategy and action plan, and will not be achieved by Fisheries and Oceans Canada (DFO) and the 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 this recovery strategy and action plan for the benefit of the Spotted Gar and Canadian society as a whole.

Acknowledgments

This recovery strategy and action plan was prepared by DFO, Species at Risk Program, Ontario and Prairie Region, through collaborative efforts and contributions from many individuals and organizations. Many thanks go to the following DFO people for their review comments and input into this document: Josh Stacey, John Jimmo, Shelly Dunn, Shawn Staton, William Glass and Andrew Drake.

Executive summary

The Spotted Gar was listed as threatened under the *Species at Risk Act* (SARA) when the Act came into force in 2003. In 2019 the status of Spotted Gar was uplisted to endangered. This recovery strategy and action plan is 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 status report, the recovery potential assessment, and a recovery strategy published in 2012. The recovery of this species has been determined to be biologically and technically feasible.

The Spotted Gar is a relatively large (up to 760 mm in total length), heavily armoured, predatory species with a long, narrow body and elongated snout with many sharp teeth. The back and upper sides are olive green to velvety brown above the lateral line, dull silvery below, and adults have brown spots on the snout, head, body, and fins. The Spotted Gar is distinguished from the more common Longnose Gar by its shorter, wider snout. The species has a wide, but disjunct, distribution in the Mississippi River and Great Lakes drainages of eastern North America. The Canadian range of Spotted Gar appears to be restricted to three coastal wetlands in Lake Erie: Long Point Bay and Big Creek National Wildlife Area (NWA), Point Pelee National Park, and Rondeau Bay. Single specimens have been recorded from Muddy Creek, Hamilton Harbour, and East Lake (Lake Ontario), while unconfirmed historical and potential occurrences from Lake St. Clair, Hamilton Harbour and Coote's Paradise, and the upper St. Lawrence River (near Kingston, Ontario) remain. These findings suggest that further sampling is required to determine if populations actually are present at these locations.

The main threats facing the species are described in section 5 and include habitat modifications, sediment loadings, nutrient loading, aquatic vegetation removal, exotic species, climate change, barriers to movement, and fishing pressure (incidental harvest). The population and distribution objectives (section 6) for the Spotted Gar are to maintain current distributions and densities of extant populations of Spotted Gar in the three coastal wetlands of Lake Erie (Point Pelee National Park, Rondeau Bay, and Long Point Bay and Big Creek NWA). The action plan component of this document outlines measures that provide the best chance of achieving the aforementioned population and distribution objectives, including the measures to be taken to address the threats and monitor the recovery of the species. A description of the broad strategies to be taken to address threats to the species' survival and recovery, as well as research and management approaches needed to meet the population and distribution objectives, are included in section 7.

For the Spotted Gar, critical habitat is identified to the extent possible, using the best available information, and provides the functions and features necessary to support the species' life cycle processes and to achieve the species' population and distribution objectives. This recovery strategy and action plan identifies critical habitat for Spotted Gar as the coastal wetlands and connected quiet backwater areas, including interconnected flooded riparian areas and contributing channels, of Point Pelee National Park, Long Point Bay (including Long Point NWA) and Big Creek NWA, and Rondeau Bay. The majority of critical habitat at these locations was identified in an earlier recovery strategy in 2012, while this document identifies further critical habitat in Rondeau Bay and in Long Point Bay (including Long Point NWA). The protection of the species' critical habitat was accomplished in Point Pelee National Park and in Big Creek NWA through a critical habitat description published in the *Canada Gazette* under subsection 58(2) of SARA, which triggers the prohibition against the destruction of any part of that critical habitat. The critical habitat description will be amended to include Long Point NWA. Critical

habitat in Rondeau Bay and in other areas of Long Point Bay (i.e. outside the NWA) is protected through a SARA critical habitat order made under subsections 58(4) and (5), which invokes the prohibition in subsection 58(1) against the destruction of any part of the identified critical habitat (section 2.3). An evaluation of the socio-economic costs of the action plan, and the benefits to be derived from its implementation are provided in section 9.

Recovery feasibility summary

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

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

   Yes. Reproducing populations currently exist within the Canadian range of the species (for example, Point Pelee National Park and Rondeau Bay).

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

   Yes. Sufficient habitat appears to be present at one or more locations with extant populations. Habitat restoration activities may also be of benefit at other locations.

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

   Yes. Significant threats such as sedimentation and nutrient enrichment, increased levels of turbidity, and loss of wetland habitat can be mitigated through established restoration methods.

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

   Yes. Techniques to reduce identified threats (for example, best management practices to reduce sedimentation and nutrient enrichment) and restore wetland habitats are well known and proven to be effective.

The effort expended to achieve recovery will not be uniform across all populations. Locations with extirpated or reduced populations may require substantial effort to improve habitat and possibly repatriate populations.

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

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Background

1. Introduction

The Spotted Gar (*Lepisosteus oculatus*) was listed as threatened under the *Species at Risk Act* (SARA) when the Act came into force in 2003 and uplisted to endangered in 2019. This recovery strategy and action plan is part of a series of documents regarding Spotted Gar that should be taken into consideration together, including the "Recovery Strategy for the Spotted Gar (*Lepisosteus oculatus*) in Canada" (DFO 2012), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) "Assessment and Status Report on the Spotted Gar *Lepisosteus oculatus* in Canada" (COSEWIC 2015) and the Science Advisory Report from the Recovery Potential Assessment (RPA) (DFO 2010).

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets objectives, identifies the main areas of activities to be undertaken, and provides background information on the species and its threats, as well as its critical habitat. The action plan component provides the detailed recovery planning that supports the strategic direction set out in a recovery strategy for the species.

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

2. COSEWIC species assessment information

Date of assessment: November 2015

Species common name: Spotted Gar

Scientific name: *Lepisosteus oculatus* (Winchell, 1864)

Status: Endangered

Reason for designation: This species has a very limited distribution in Canada and populations are known from only three coastal wetlands of Lake Erie. Shallow vegetated habitats that are required for all life stages continue to be degraded and are at risk from invasive aquatic vegetation, removal of native vegetation, filling, dredging, and siltation.

Canadian occurrence: Ontario

Status history: Designated Special Concern in April 1983. Status re-examined and confirmed in April 1994. Status re-examined and designated Threatened in November 2000 and in May 2005. Status re-examined and designated Endangered in November 2015.

3. Species status information

Table 1. Summary of existing protection or other status designations assigned to Spotted Gar

Jurisdiction	Authority or organization	Year(s) assessed and/or listed	Status and/or description	Designation level
Ontario	*Endangered Species Act, 2007*	2005	Threatened	Population
Ontario	NatureServe	2017	S1: critically imperiled	Population
Canada	Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	2015	Endangered	Population
Canada	*Species at Risk Act* (SARA)	2005	Threatened	Population
Canada	NatureServe	2017	N1: critically imperiled	Population
United States	NatureServe	1996	N5: Secure	Population
International	NatureServe	2012	G5: Secure	Species
International	International Union for the Conservation of Nature (IUCN)	2012	Least concern	Species

Upon listing as a threatened species, the Spotted Gar became protected wherever it is found by section 32 of SARA:

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

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

4. Species information

4.1 Description

Gars are readily distinguished from other fish species by their long, narrow, armoured bodies and long snouts. The body of the Spotted Gar (*Lepisosteus oculatus)* (Winchell 1864) is heavily armoured with non-overlapping, bony ganoid scales and the snout and jaws are elongated into a relatively broad beak with many sharp teeth (figure 1). The length of the Spotted Gar's snout is approximately 40 to 80% of the head length; the least width is approximately 10 to 16% of snout length (COSEWIC 2005). The total length (TL) of this species is typically 200 to 600 mm, but it can reach lengths and weights of 1,120 mm TL and 2,700 g, respectively (Coker et al. 2001). In Canada, the largest specimen recorded measured 767 mm TL and was caught in Rondeau Bay in 2007 (N.E. Mandrak, DFO, pers. comm. 2007). The Spotted Gar has a short, deep, caudal peduncle (that is, point of attachment between the body and the tail). The vertebral column is curved upward in the tail, extending a short way into the upper lobe of the rounded tail. The back and upper sides are olive-green to velvety brown above the lateral line and the colouration is dull silvery below. Adults have brown spots on the snout, head, body, and fins. Larval Spotted Gar have a fleshy extension of the spine above the upper edge of the tail and are brightly coloured with wide dark brown stripes on the back, sides, and belly.

The Spotted Gar is distinguished from the only other native gar species found in Canada, the Longnose Gar (*L. osseus*), by its shorter, wider snout and a shorter, deeper caudal peduncle (Scott and Crossman 1998) (figure 2). Since both species are spotted, this characteristic should not be used to distinguish between these two species. Florida Gar (*L. platyrhincus*) have been found in the Great Lakes basin as a result of aquaria releases. Florida Gar are very similar to Spotted Gar in appearance, but lack the bony, translucent plates on the isthmus between gill openings found on the Spotted Gar (figure 3) (COSEWIC 2005).

Figure 1. The Spotted Gar (*Lepisosteus oculatus*).

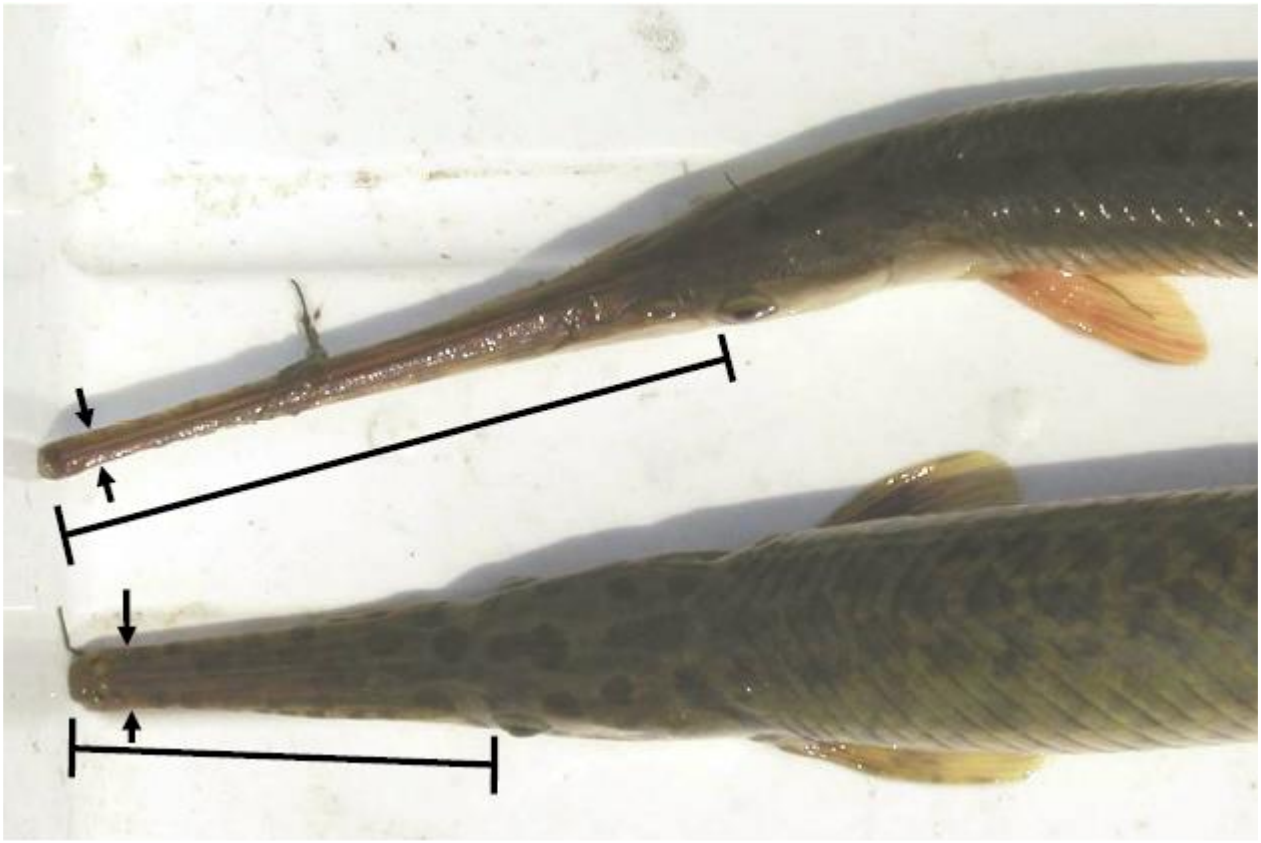


Figure 2. Differences in snout length and width can be used to distinguish Spotted Gar (bottom) from Longnose Gar (collected in Rondeau Bay, 2002 and modified from COSEWIC 2005).

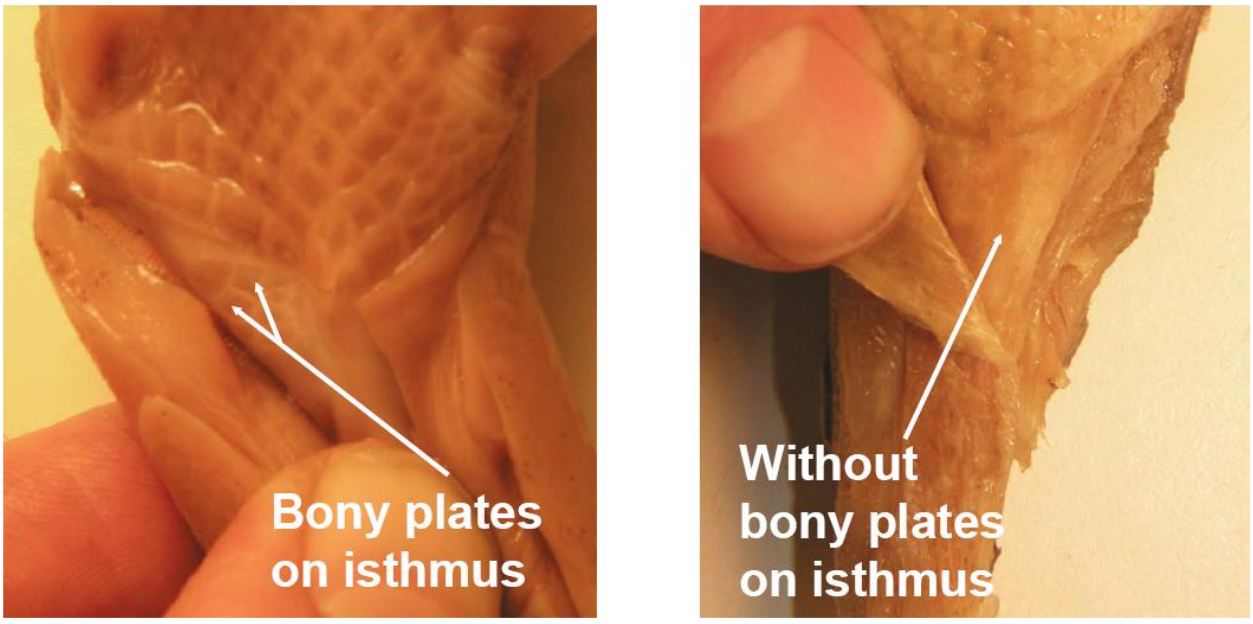
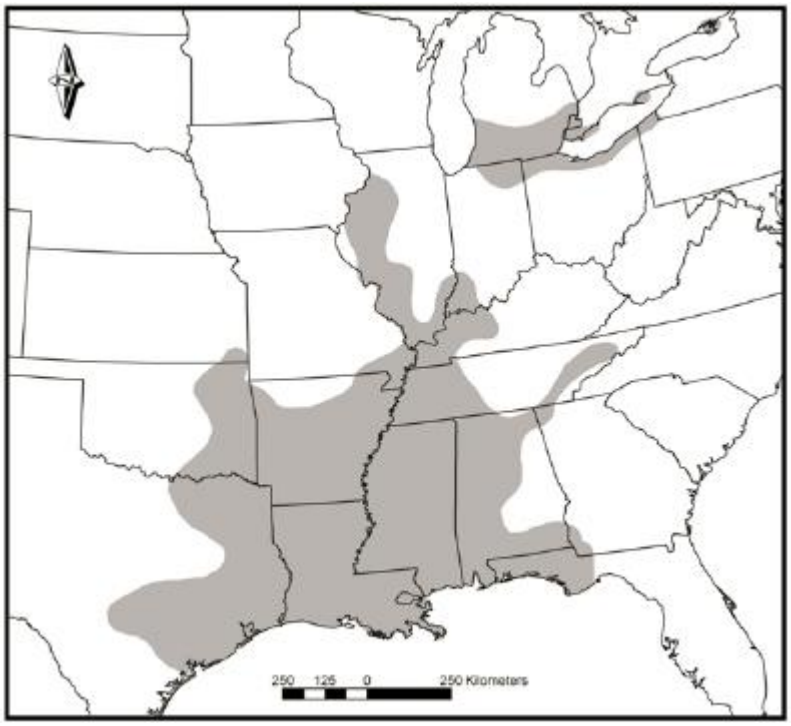


Figure 3. The Spotted Gar (left) can be distinguished from the Florida Gar by the presence of bony plates on the isthmus (photo by E. Holm, Royal Ontario Museum).

4.2 Population abundance and distribution

4.2.1 Global distribution and population abundance

The Spotted Gar is only found in North America where it has a wide, but disjunct distribution in the Mississippi River drainage, Great Lakes and Gulf Coast drainages of eastern North America, occurring in 18 states and the province of Ontario (figure 4). In the Great Lakes drainage, the Spotted Gar occurs in Indiana, Michigan, Ohio, Ontario, and Pennsylvania (Lee et al. 1980, Page and Burr 1991). In the Mississippi River drainage, it is found from Illinois in the north to Alabama and Texas in the south, and from Tennessee and Florida in the east to Oklahoma in the west (Lee et al. 1980, Page and Burr 1991). Less than 1% of the species' global range is found in Canada.



(Modified from Page and Burr (1991))

Figure 4. Global distribution of the Spotted Gar.

4.2.2 Canadian distribution and population abundance

The current range of the Spotted Gar in Canada includes the coastal wetlands of Lake Erie (Point Pelee National Park, Rondeau Bay, Long Point Bay [including Long Point National Wildlife Area (NWA), Long Point Provincial Park and Turkey Point] and Big Creek NWA); and remains unconfirmed in Hamilton Harbour, Frenchman's Bay, and East Lake along the north shore of Lake Ontario (figure 5).

Canadian collections have been made sporadically, making it difficult to assess population sizes and trends. The first confirmed captures of Spotted Gar were at Point Pelee National Park in 1913, at Long Point Bay in 1947, and at Rondeau Bay in 1955. Other captures recorded by commercial fishermen in 1925 and 1938 were likely also from Rondeau Bay.

Lake St. Clair: A single specimen of Spotted Gar was captured in Lake St. Clair in 1962, not far from the mouth of the Thames River (COSEWIC 2015). Since then, no specimens have been detected in Lake St. Clair despite numerous sampling surveys that have been conducted using a variety of suitable gear types. For example, 20 sites at the St. Clair NWA were sampled by DFO in 2005 using fyke nets (a total of 480 hours of effort were expended) and no Spotted Gar were detected (Mandrak et al. 2006a).

Sydenham River: There are two records of Spotted Gar in the Sydenham River from 1975; however, one was thought to be a Longnose Gar by a larval fish expert, and the other lacked a voucher specimen (COSEWIC 2005). Subsequent sampling in 2002 and 2003 by boat electrofishing, fyke netting, and seining (N.E. Mandrak, DFO, unpublished data) in the vicinity of the original records, failed to find any Spotted Gar. Hence, the original records have been deemed questionable. Other specimens, reported as Spotted Gar in southwestern Ontario, have either been re-identified as Longnose Gar or voucher specimens were not retained by the collector and identification is, therefore, unconfirmed (COSEWIC 2005).

Thames River: A single specimen was captured in 1962 in Lake St. Clair near the mouth of the Thames River and eDNA sampling conducted in 2012 (Boothroyd et al. 2016) led to a positive detection in Jeanette's Creek. However, the species has not been captured through conventional sampling, despite relatively extensive surveys conducted by DFO and the Ontario Ministry of Natural Resources and Forestry (OMNRF) within the Thames River and three of its tributaries: Jeanette's Creek, Baptiste Creek, and Big Creek.

Cedar Creek: Spotted Gar was detected for the first time in Cedar Creek, a tributary of Lake Erie approximately 10 km west of Kingsville, in 2019. Further sampling is required to determine if there is indeed a population at this location or whether this individual is a transient immigrant from Rondeau Bay or Point Pelee. Breaches have occurred along barrier beaches of Point Pelee, allowing for the emigration of Spotted Gar.

Point Pelee: Only one specimen had been captured in Point Pelee before 2002 (1913), despite various sampling events that occurred in the 1980s and 1990s (COSEWIC 2015). In contrast, sampling conducted for several different projects between 2002 and 2009 led to the detection of 122 specimens (COSEWIC 2015) (figure 6) in areas such as West Cranberry, East Cranberry, Lake, Redhead, and Harrison ponds. No sampling targeting Spotted Gar has been conducted at this location since 2009 and no incidental captures have occurred.

The distribution and population size of Spotted Gar in Point Pelee is not currently clear; however, Glass et al. (2012) conducted a mark and recapture study in 2009 using Passive Integrated Transponder (PIT) tags in Lake Pond, where the species has historically been detected, and recaptured 6 of 93 tagged individuals, allowing them to estimate a population size of 483 individuals within a 220 hectare (ha) area. It is possible that the species is more widely distributed within Point Pelee in areas such as Sanctuary, Girardin, and Crossing ponds, but more extensive, targeted sampling is required to investigate this potential. Research that characterized the genetic structure and diversity of Spotted Gar (Glass et al. 2015) suggests that populations within Point Pelee are reproductively isolated from outside populations and, consequently, may be genetically bottlenecked. Furthermore, these authors speculate that the limited genetic diversity and gene flow with other populations may leave Spotted Gar within Point Pelee more vulnerable to environmental perturbation and habitat degradation. However, recent weather events have led to the breach of barrier beaches along Point Pelee, allowing Spotted Gar within previously isolated wetlands to emigrate.

Hillman Marsh: No Spotted Gar have ever been captured at this location; however, eDNA surveys conducted in 2012 led to positive detections (Boothroyd et al. 2016). Further sampling using conventional approaches is needed to confirm the presence of the species at this location.

Muddy Creek: Spotted Gar was detected for the first time at Muddy Creek, a tributary of Lake Erie located near Wheatley Provincial Park, in 2011 (figure 6). Further sampling is required to determine if there is indeed a population at this location or whether this individual is a transient moving between Rondeau Bay and Long Point Bay, which is a possibility, considering gene flow between these two locations has been documented (Glass et al. 2015).

Rondeau Bay: Spotted Gar was first detected in Rondeau Bay in 1955, and only six specimens had been captured there by the turn of the century (COSEWIC 2015). Between 2000 and 2010 (2010 being the last year reported in the 2012 recovery strategy) a total of 500 individuals were captured in the bay as the result of multiple sampling projects using a variety of gear types (COSEWIC 2015). Between 2011 and 2017, 154 Spotted Gar were captured in the Bay and 82 were captured in tributaries to the bay including Wood (13), Mill (16), Flat (10), Indian (36), and McLean's (7) drains (figure 7). This sampling provides a detailed understanding of the distribution of Spotted Gar within Rondeau Bay and tributaries; however, it is likely that the species is present further upstream within the tributaries where sampling has not been conducted but suitable habitat features are likely present. For example, Glass and Mandrak (2014) captured individuals upstream of the first major road crossing in Maclean's Drain and Mill Creek and suggest that Spotted Gar likely occur from the bay to the first permanent barrier to fish passage, which in the majority of cases would extend beyond the critical habitat identified in the 2012 recovery strategy. In addition, radio-telemetry studies conducted in 2007 to 2009 and 2016 to 2017 further document habitat use by Spotted Gar, including locations where the species had not been detected using conventional methods (that is, Third Concession Drain), as well as more open water areas of the Bay (figure 8).

The Spotted Gar population size within Rondeau Bay is estimated to be 8,121 individuals based on an extrapolation of the abundance estimated within the 220 ha area of Lake Pond in Point Pelee, which is comprised of similar habitat (Glass et al. 2012). Investigations regarding the population genetics of Spotted Gar (Glass et al. 2015) indicate that there are five distinct populations within Rondeau Bay that occur sympatrically, potentially as a result of philopatry in the use of spawning locations. These authors note that, as a whole, the population found within Rondeau Bay appears to be robust in terms of genetic diversity; however, the maintenance of some of the individual subpopulations may be much more sensitive to habitat alterations.

Long Point Bay, Big Creek Marsh, and Turkey Point: Spotted Gar was first detected at Long Point Bay in the inner part of the bay near Port Rowan in 1947. A second specimen was captured in the Long Point Unit of Long Point NWA (located at the tip of the point) in 1984. No further specimens were detected in the Long Point Bay area until 2003. Between 2003 and 2010 (2010 being the last year reported in the 2012 recovery strategy) 10 Spotted Gar were captured in Long Point Bay, as well as two in the Big Creek Marsh NWA (Big Creek is a tributary of Long Point Bay) and three in Turkey Point Marsh (adjacent to inner Long Point Bay) (COSEWIC 2015). From 2011 to 2017, the species was detected more frequently, with 45 individuals captured throughout inner Long Point Bay and a single individual detected in each of the following locations: Turkey Point, Big Creek NWA, and the Long Point Unit of Long Point NWA (figure 9).

The size of the Spotted Gar population within Long Point Bay has not been estimated, considering only a limited number of individuals had been captured in the area at the time when

the Glass et al. (2012) study was being undertaken (COSEWIC 2015). Glass et al. (2015) postulate that the Long Point Bay location is a sink[2] with a small population comprised of immigrants from Rondeau Bay and Point Pelee. This conclusion was based on the comparison of genetic population structure among populations found in Point Pelee, Rondeau Bay, and Long Point Bay, as well as the limited number of individuals captured at the latter location, despite comparable sampling effort (Glass et al. 2015); however, the genetic analysis conducted in the study was based on five individuals captured at Long Point Bay, and the species has been more widely detected throughout this location since the publication of this study.

Hamilton Harbour and Coote's Paradise: Additional reports existed for Spotted Gar in Hamilton Harbour that had not been substantiated with voucher specimens until 2010, when a single specimen was captured by the OMNRF (OMNRF, unpublished data). Subsequent sampling for the species, including traditional sampling methods (fyke nets) in 2011 (Glass and Mandrak 2014) and eDNA surveys (Boothroyd et al. 2016) in 2012, did not detect Spotted Gar, although eDNA surveys in 2013 did lead to a positive detection in Spencer Creek, a tributary of Coote's Paradise that is connected to Hamilton Harbour (Glass and Mandrak 2014). Conventional sampling was conducted in Coote's Paradise in 2014 but did not result in the capture of Spotted Gar (Glass and Mandrak 2014). Further sampling is required to determine whether a reproducing population exists at these two connected locations.

Frenchman's Bay: One Spotted Gar specimen may have been detected in Frenchman's Bay (a coastal inlet of Lake Ontario) in 2018 through DFO's Asian Carps Monitoring Program. Unfortunately, voucher photos that were taken of the specimen cannot be used to rule out the possibility that it may have been an introduced Florida Gar, which is a closely related species.

East Lake: In May 2007, a single specimen was collected by a commercial fisherman in East Lake. It is believed the same individual was caught multiple times; catches of Spotted Gar ceased after the specimen was provided to the OMNRF (J. Bowlby, OMNRF, pers. comm. 2009). Beyond these catches, no other individuals have been captured. Intensive sampling was conducted in East Lake in 2008, using gear types proven effective in detecting the species, to verify the presence of a reproducing population; however, sampling failed to detect Spotted Gar (B. Glass, UW, unpublished data). In addition, non-target sampling conducted by DFO in 2010, as well as extensive commercial hoop netting in East Lake, has not resulted in any further records of Spotted Gar. Therefore, the reports from a commercial fisherman, potentially of a single individual, remain the only record(s) for East Lake and it is unlikely that a reproducing population exists at this location (Bouvier and Mandrak 2010).

Bay of Quinte (North Channel): The first verified record of Spotted Gar within the Lake Ontario drainage was a single specimen caught in the Bay of Quinte (North Channel) in 1985. Despite extensive commercial fishing in the area, as well as substantial netting programs conducted by the OMNRF, no additional Spotted Gar have been captured and it is possible that this record is the result of an introduction due to its highly disjunct nature.

[2] A location with poor habitat quality where there is a demographic deficit, which receives immigrants of a species from a source location where habitat conditions are of high quality and carrying capacity has been reached leading to a surplus of individuals (Dias 1996).

Spotted Gar has not been detected at any other localities in Canada, despite extensive sampling for species at risk throughout southwestern Ontario. Populations within the Bay of Quinte and Lake St. Clair (if anomalous records are representative of historic populations), are presumed to be extirpated, based on recent sampling of suitable habitats at these locations (COSEWIC 2005).

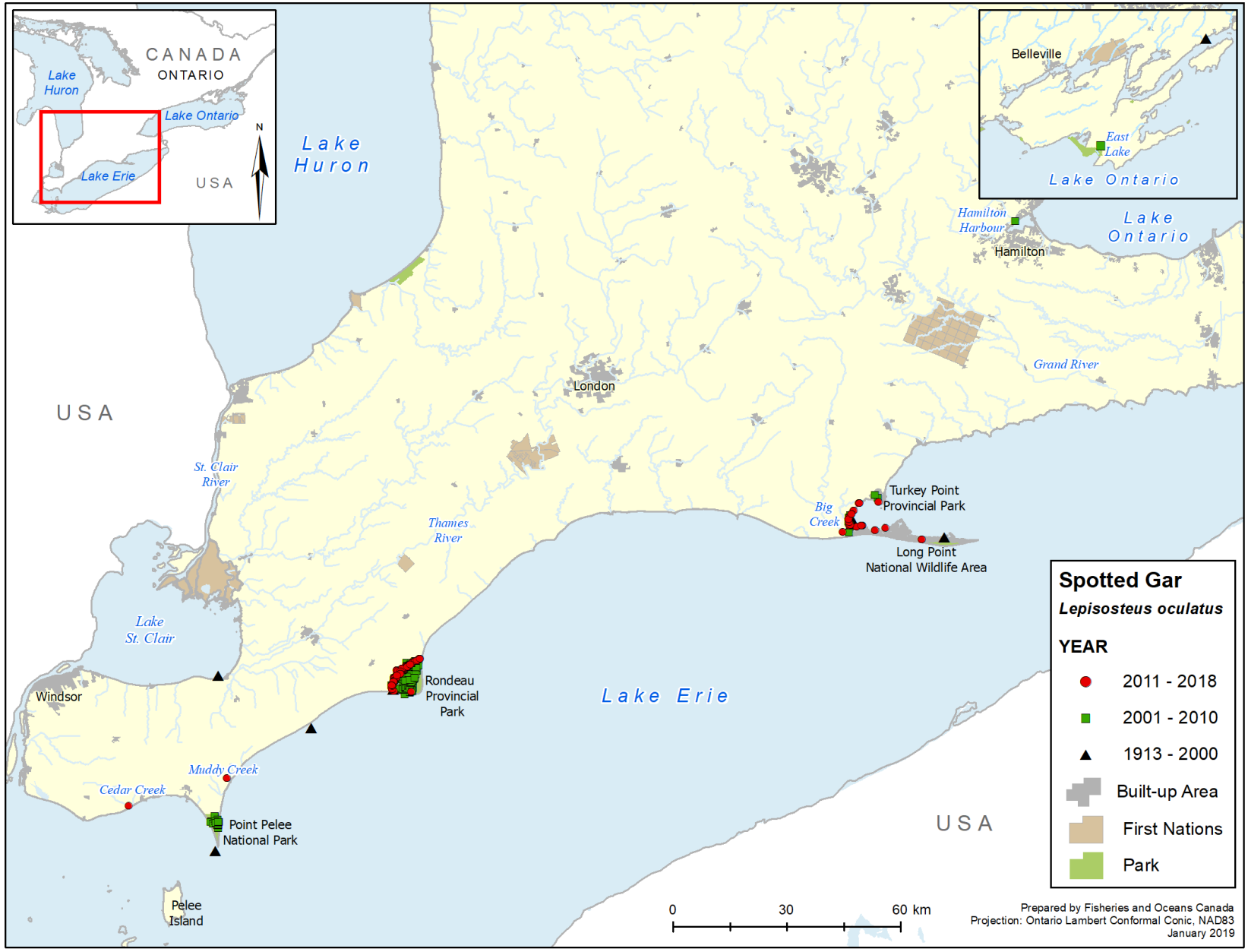


Figure 5. Canadian distribution of the Spotted Gar.

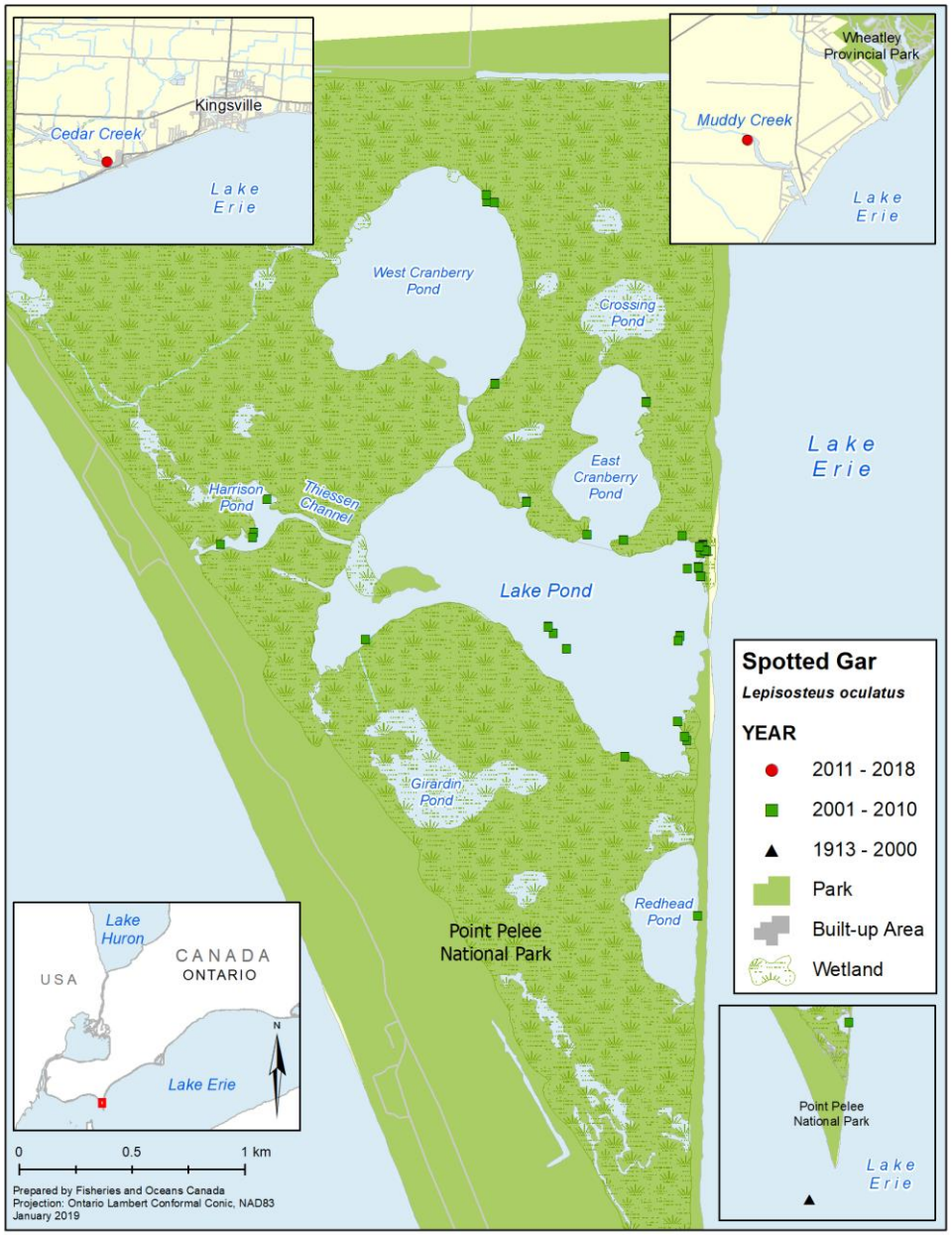


Figure 6. Distribution of Spotted Gar captured within Point Pelee and surrounding areas.

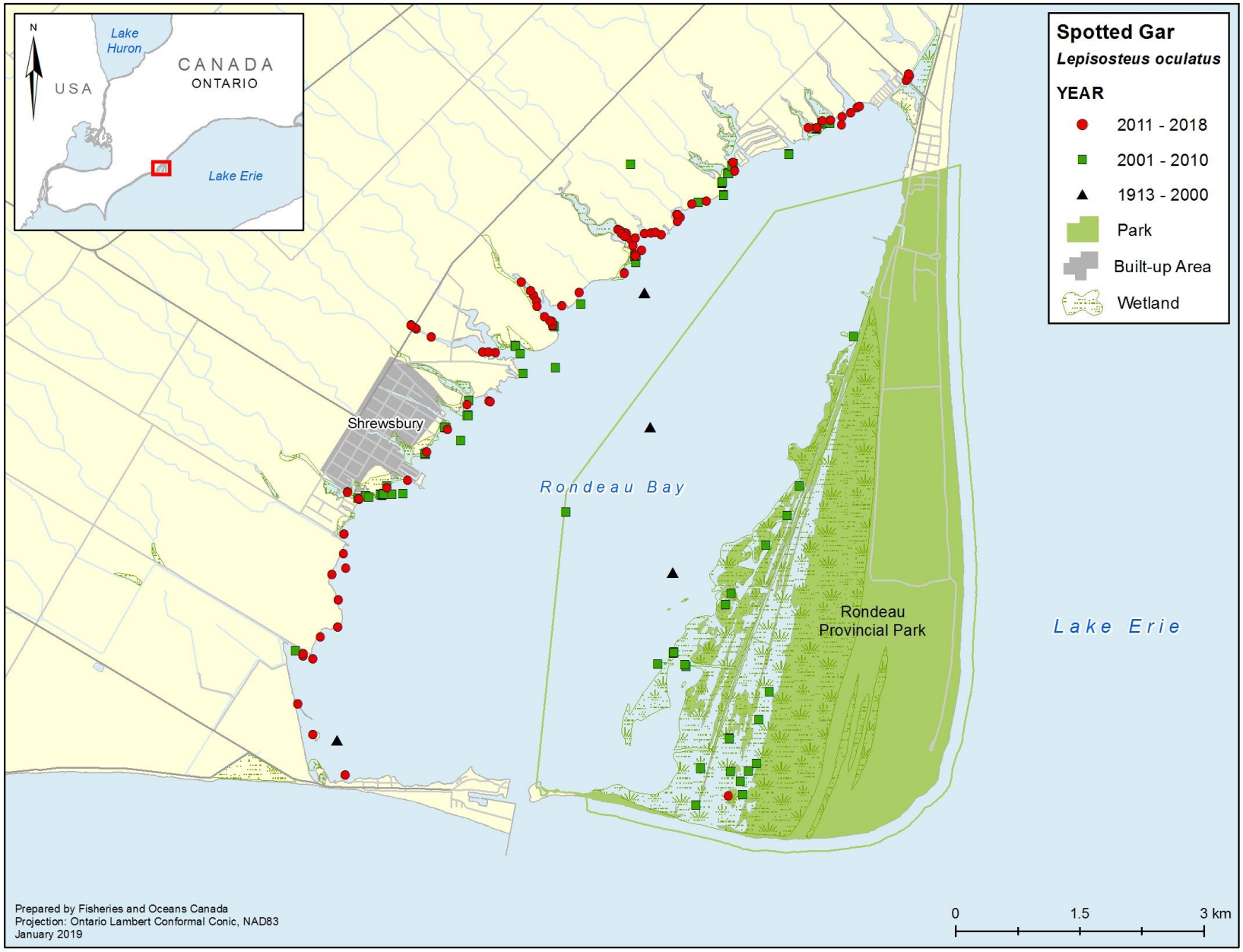


Figure 7. Distribution of Spotted Gar captured within Rondeau Bay.

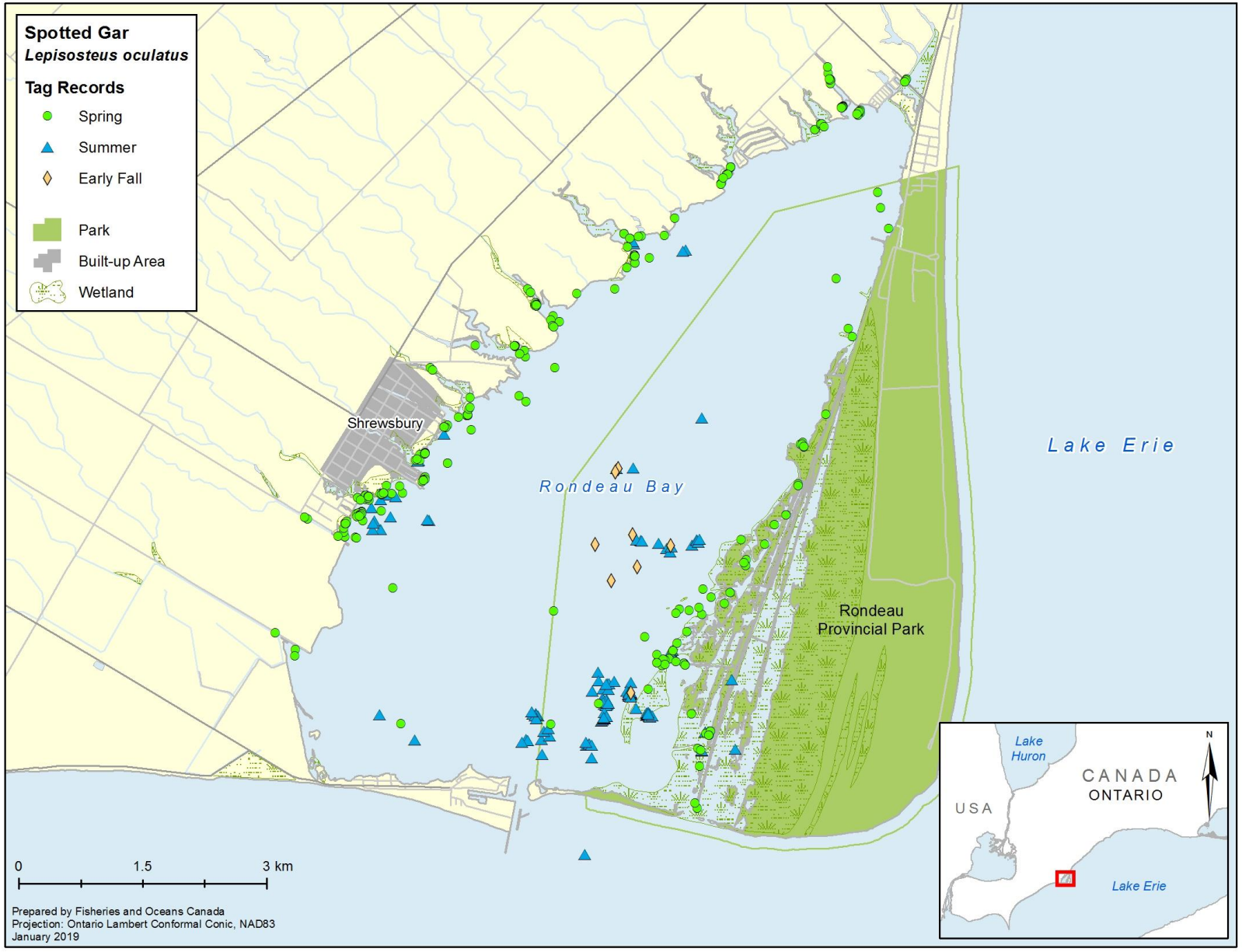


Figure 8. Spotted Gar tracked using radio-telemetry in the spring (2007, 2008, 2009, 2016 and 2017), summer and early fall (2007 only) in Rondeau Bay as well as visual observations of Spotted Gar in the spring.

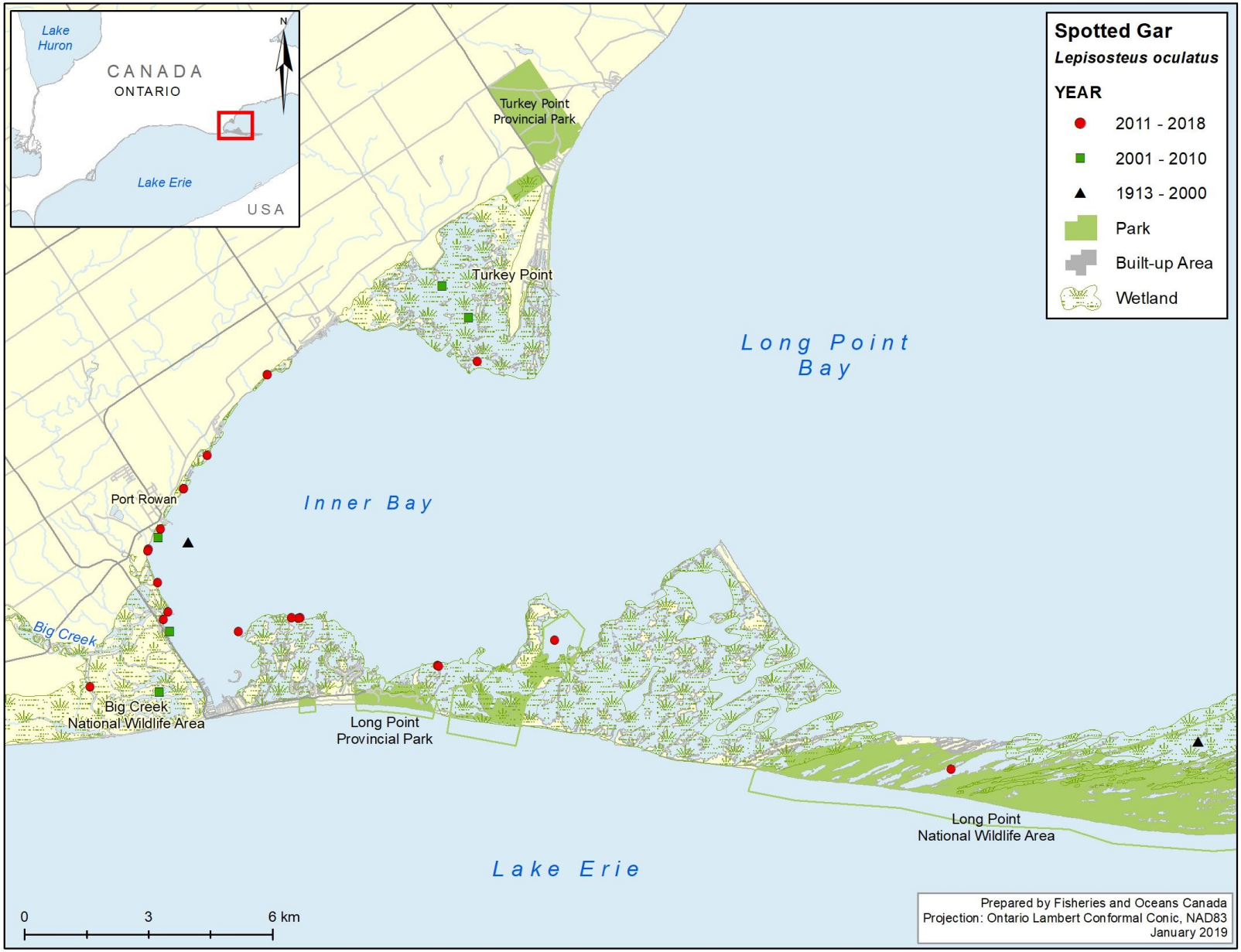


Figure 9. Distribution of Spotted Gar captured within Long Point Bay.

4.3 Needs of the species

4.3.1 Habitat and biological needs

Spawn to larvae (yolk-sac) stage: Adult Spotted Gar begin to move from over winter habitats to shallow waters once water temperatures begin to reach 15°C (Glass and Mandrak 2014). Spawning then occurs in the spring (May and June), when water temperatures reach 21° to 26°C, in nearshore shallow water containing dense aquatic vegetation (Glass et al. 2012), such as marshes, flooded riparian areas (Goodyear et al. 1982, Scott and Crossman 1998, Snedden et al. 1999, Cudmore-Vokey and Minns 2002), and slow moving tributaries and drainage canals (Glass and Mandrak 2014). In Rondeau Bay, adult Spotted Gar showed a strong preference for both shallow (< 0.5 m) and deep (> 2.5 m) water in the spring where pH values were less than 8.5 (Glass et al. 2012); however, the selection of waters > 2.5 m is likely representative of individuals who are staging, not spawning, that year or are post-spawn (B. Glass pers. comm. 2019). Furthermore, Spotted Gar have been observed spawning over aquatic vegetation beds that included milfoil (*Myriophyllum* sp.), Coontail species (*Ceratophyllum sp.*) (Glass et al. 2012), curly pondweed (*Potamogeton crispus*) (B. Glass, UW, pers. comm. 2009) and other emergent species (Glass and Mandrak 2014). Recent research to investigate the habitat used by Spotted Gar for spawning in Rondeau Bay in 2017 used radiotelemetry to measure the physiochemical features associated with spawning site selection. Results indicated that preferred spawning sites: 1) are close to shore (within < 10 m of shoreline preferred); 2) typically contain pondweed species (Potamogeton spp.); 3) are comprised of substrate features that support macrophyte growth; and 4) are of greater stream depth (0.8 to 1.6 m preferred) than surrounding areas. These variables explained 30%, 13.5%, 11.3% and 8.9% of spawning site selection, respectively (A. Drake pers. comm. 2019).

While previous research has observed that Spotted Gar begin to spawn in Canadian waters when water temperatures reach 21 to 26°C, recent research has been conducted to understand the cumulative growing degree days that lead to the initiation of spawning activity (A. Drake pers. comm. 2017). Growing degree days (GDD) represent a temperature index that can be used to predict growth in plants, insects, and fish or alternatively, the initiation of a specific life-stage, in this case Spotted Gar spawning, based on the accumulation of thermal energy during the spring period. The results of research indicate that there is a 50% and 90% probability of spawning taking place after 210 and 291 cumulative growing degree days (CGGD), respectively, with a base temperature of 10°C. Alternatively, using a base water temperature of 15°C, there is a 50% and 90% probability of spawning taking place after 62 and 85 CGGD, respectively (A. Drake pers. comm. 2017). This approach provides a means of better understanding the timing of Spotted Gar reproduction based on when the spring warming period is initiated.

Once spawning has occurred, the demersal and adhesive fertilized eggs attach to aquatic vegetation and debris in gelatinous masses (Coker et al. 2001, COSEWIC 2005) and hatch within one week (Cudmore-Vokey and Minns 2002). Fish eggs collected in the vicinity of Spotted Gar spawning activity have been found on a number of aquatic plant species, primarily Coontail (*Ceratophyllum demersum*), Flat-stem Pondweed (*Potamogeton zosteriformis*), Reed Canary Grass (*Phalaris arundinacea*) and European Frogbit (*Hydrocharis morsus-ranae*) (A. Drake pers. comm. 2019); however, genetic analysis is currently underway to confirm the identity of the eggs.

Spotted Gar eggs hatch into larvae within approximately one week (Cudmore-Vokey and Minns 2002). Spotted Gar larvae have an adhesive organ (suctorial disk) on their snout (Simon and Wallus 1989) and, although capable of swimming, they often hang vertically from aquatic vegetation and other objects. The yolk-sac is absorbed at approximately 17 mm TL or greater, based on a growth rate of 1.3 to 1.7 mm/day (Alfaro et al. 2008), over an approximate period of 10 to 13 days. Spotted Gar found in Canadian waters become sexually mature after three years (Glass et al. 2011) and are iteroparous[3] (Redmond 1964). Recent tracking studies conducted in Rondeau Bay suggest that at least some individuals do not spawn every year (B. Glass pers. comm. 2019), which may be attributable to environmental conditions or the nutritional condition of individuals as has been reported for other fish species (Rideout and Tomkiewicz 2011). Furthermore, Spotted Gar has been observed to exhibit spawning site fidelity returning to the same locations over multiple years (B. Glass pers. comm. 2019).

Larvae to young-of-the-year (YOY): Young-of-the-year remain at the spawning site until their yolk-sacs are absorbed at which point they disperse and begin feeding (Simon and Wallus 1989), remaining in shallow (less than 1 m) littoral zones containing vegetation and substrates of mud, silt, and sand (Goodyear et al. 1982). Sampling was conducted for larval Spotted Gar in Rondeau Bay in 2018 in two tributaries (McDougall Drain/Flat Creek and Bates Bloomfield Drain), as well as lakeshore areas adjacent to the mouths of these tributaries, where spawning is known to occur based on previous radiotelemetry studies (Gáspárdy et al. 2021). A total of 37 larval gar, confirmed through genetic analysis to determine species identity, were first captured in early June (Gáspárdy et al. 2021). The results of this study demonstrated that larval gar were much more common in nearshore habitats (in many cases < 1 m from shore, but in almost all cases, < 5 m from shore) within tributaries and along the lakeshore when compared to more offshore locations. Specifically, 27% and 68% of the larval Spotted Gar were captured in nearshore tributary areas, respectively, while only 5% were captured in offshore lake and offshore tributary areas defined as areas in the centre channel of a tributary (Gáspárdy et al. 2021).

Glass and Mandrak (2014) demonstrated that YOY Spotted Gar, captured in Rondeau Bay, preferred shallower depths (< 0.5 m), and water temperatures > 23.5˚C and moderate turbidity levels (50-149 NTU). Similarly, they were associated with emergent, floating and submerged aquatic vegetation (mean total coverage >70%).

Juvenile (age 1 until sexual maturity [2 to 3 yrs males; 3 to 4 yrs females]): There is limited published information on the habitat requirements for juvenile Spotted Gar; however, they are likely to be similar to those of YOY and adults.

Adult: In Canada, adult Spotted Gar are found in the shallow (0 to 5 m), warm waters of coastal wetlands with abundant vegetation in Lake Erie (Lane et al. 1996). In general, the species prefers quiet pools, backwaters, and bays with an abundance of aquatic vegetation (Parker and McKee 1984, Page and Burr 1991, Glass et al. 2012) or submerged branches (Snedden et al. 1999). Dense vegetation provides necessary camouflage and reduces visibility to potential prey (Coen et al.1981), likely facilitating an ambush foraging strategy (COSEWIC 2015). Furthermore, Glass et al. (2012) indicate that mixed macrophyte beds provide optimal habitat for Spotted Gar in Lake Erie coastal wetlands. For example, collection sites in Lake Erie had dense vegetation and included water lily (*Nuphar* sp.), cattails (*Typha* sp.), Canada waterweed (*Elodea canadensis*), pondweed (*Potamogeton* sp.), stonewort (*Chara* sp.), milfoil, water celery

[3] Will spawn multiple times within their lifetime.

(*Vallisneria* sp.), and hornwort (*Ceratophyllum* sp.) (Parker and McKee 1984, B. Glass, UW, pers. comm. 2009). Similarly, in other areas of the species' range such as Oklahoma, Spotted Gar are primarily associated with smartweed (*Polygonum* sp.), pondweed, milfoil, and water-willow (*Justicia* sp.) (Tyler and Granger 1984).

Preferred substrates include silt, clay, and sand (Lane et al. 1996). Canadian Spotted Gar capture sites had Secchi depths of 0.3 to >3 m, dissolved oxygen levels of 9 to 11 mg/L, and water temperatures of 15 to 17°C (in September) (Parker and McKee 1984). Experimental studies examining the growth of Spotted Gar collected from inland lakes in southern Michigan document that individuals held in water at 16°C experienced minimal growth and decreased in weight, while individuals held in 23°C and 30°C treatments experienced significantly higher growth rates and fed more frequently (David 2012). This suggests that Spotted Gar are likely to utilize habitats with warmer water temperatures to maximize their growth potential, which is similar to behavior observed by Glass et al. (2012).

Diel and seasonal movements of the Spotted Gar have been studied in Louisiana by Snedden et al. (1999). Greatest movement occurred as water temperatures and levels rose during the spring. Large home ranges were established in the spring, typically in inundated floodplains, which provided suitable spawning and nursery habitat. Glass et al. (2012) observed that post-spawn adults selected locations with pH < 8.5 and no macrophytes present. They postulate that Spotted Gar are likely moving into these areas to forage on minnow species such as Spottail Shiner (*Notropis hudsonius*) that use sandy-bottomed areas for spring-spawning. Furthermore, adult Spotted Gar were selective of waters > 2.5 m in the spring when not engaged in spawning activities (B. Glass pers. comm 2019). Small home ranges were usually established during summer, fall, and winter (median 6.6 ha) (Snedden et al. 1999). However, approximately one-third of tracked Spotted Gar established significantly larger home ranges (median 265 ha) that were usually considerable distances from initial capture sites (Snedden et al. 1999). These new home ranges consisted of seasonally inundated floodplain habitats and heavily vegetated marshes with little or no flow. Similarly, Glass et al. (2012) observed that adult Spotted Gar in Rondeau Bay exhibited a strong preference in the summer for offshore areas characterized by mixed macrophyte (at least two or more genera) beds and tended to occupy defined home ranges. Furthermore, a strong selection for the deepest depths (>2.5 m) and shallowest depths (<0.5 m) within Rondeau Bay was observed along with pH values between 8.0 and 8.49 (Glass et al. 2012). Except in spring, Spotted Gar is more active at night, which is thought to coincide with their feeding period.

4.3.2 Ecological role

Spotted Gar is one of the most abundant predators in structurally complex shallow water habitats in the southern United States (COSEWIC 2005) and is considered to be a key element of the food web (Snedden et al. 1999); in areas where they are locally abundant (for example, Rondeau Bay) they may also have a key ecological role. The Spotted Gar is primarily a piscivorous ambush predator that also consumes crayfishes and aquatic insects (COSEWIC 2005). In Ontario, Scott (1967) listed Yellow Perch (*Perca flavescens*) and minnows (*Cyprinidae*) as forming a large part of the diet, while more recent studies indicate Central Mudminnow (*Umbra limi*) and YOY Centrarchids are important prey for Spotted Gar (W. Glass. pers. comm. 2019). Since Spotted Gar tends to remain close to the surface, prey species that occupy these areas are more susceptible to predation (Ostrand et al. 2004). Also, as the Spotted Gar is able to inhabit waters with low oxygen levels, it is able to forage in areas where other predators cannot (Burleson et al. 1998, Snedden et al. 1999). Spotted Gar co-occurs with Longnose Gar in Long Point Bay, Point Pelee National Park, and Rondeau Bay, but are absent

from many suitable habitats in southwestern Ontario where Longnose Gar is abundant (N.E. Mandrak, DFO, unpublished data); further investigation is required to determine the interspecific interactions between these species.

The Spotted Gar is a known host for a freshwater mussel, the Round Pearlshell (*Glebula rotundata*); a freshwater mussel with a life-cycle that includes an obligate parasite larval stage, usually on a fish host), in the United States (Parker et al. 1984) and, therefore, has the potential to be a freshwater mussel host in Canadian waters. In addition, other species of gar are known hosts for some species of freshwater mussels found in Canada. For example, the Longnose Gar is one host for the Giant Floater (*Pyganodon grandis*) (D. Woolnough, Trent University, pers. comm. 2007).

4.3.3 Limiting factors

There are several limiting factors that may influence the recovery potential of the Spotted Gar. Water temperature likely limits the distribution of the species in southwestern Ontario; however, expansion of its range northward may occur under climate warming scenarios (Mandrak 1989). The availability of quiet, backwater areas with dense aquatic vegetation is limited in the waters of southwestern Ontario. Some of the currently occupied habitats only intermittently provide access to Lake Erie, thus limiting migration and dispersal opportunities. Such isolation limits gene flow (Glass et al. 2015), which can lead to low reproductive fitness and inbreeding depression.

The recovery potential of Spotted Gar populations may be influenced by factors impacting specific life-stages. Ferrara (2001) studied the life-stages of the Spotted Gar to determine which had the greatest influence on population growth rates. Results suggested that the survival of juvenile Spotted Gar had the highest influence on population growth rate. Therefore, in theory, management actions that enhance the survival of juveniles should result in the largest population growth rate as compared to actions targeting other life-stages.

5. Threats

5.1 Threat assessment

An assessment and prioritization of threats to survival and recovery of the species was undertaken as part of the RPA. To assess the threat status of Spotted Gar populations in Canada, each threat was ranked in terms of the threat likelihood and threat impact on a population basis (see Bouvier and Mandrak 2010 for complete details on classification approach). Threat impact categorization was location-specific, in that impact categorization was assigned on a location-by-location basis. If no information was available on the threat impact at a specific location, a precautionary approach was used - the highest level of impact from all sites was applied. The threat likelihood and threat impact for each population were subsequently combined in the threat status matrix, resulting in the final threat status for each location (table 2).

Table 2. Threat status for all Spotted Gar populations, resulting from an analysis of both the threat likelihood and threat impact.

	Lake Erie drainage			Lake St. Clair drainage	Lake Ontario drainage	
Threat*	**Point Pelee**	**Rondeau Bay**	**Long Point**	**Lake St. Clair**	**Hamilton Harbour**	**East Lake**
Habitat modifications	High (3)	High (3)	Low (3)	High (3)	Low (3)	Low (3)
Aquatic vegetation removal: mechanical	Low (3)	High (3)	Low (3)	Unknown (3)		Low (3)
Aquatic vegetation removal: chemical		High (3)	Low (3)	Low (3)		
Turbidity and sediment loading	Low (3)	High (3)	High (3)	Medium (3)	Medium (3)	Unknown (3)
Nutrient loading	Low (3)	High (3)	High (3)	Low (3)	Low (3)	Unknown (3)
Exotic species	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)
Incidental harvest	Low (3)	Low (3)	Low (2)	Low (3)	Low (3)	Low (3)

*The number in brackets refers to the level of certainty assigned to each threat status, which relates to the level of certainty associated with threat impact. Certainty has been classified as: 1= causative studies; 2=correlative studies; and 3=expert opinion. Gray cells indicate that the threat is not applicable to the population due to the nature of the aquatic system where the population is located. Clear cells do not necessarily represent a lack of a relationship between a population and a threat; rather, they indicate that either the threat likelihood or threat impact was unknown.

5.2 Description of threats

Habitat modifications: Quiet, vegetated, shallow habitats, vital to all stages of the Spotted Gar life-history, are rapidly disappearing, or are being degraded as a result of siltation, dredging, filling, and harbour improvements (COSEWIC 2005). Habitat loss can result from shoreline hardening and the construction of in-water and shoreline structures (for example, piers, groynes, docks) within Spotted Gar habitat. In Rondeau Bay, historic losses and degradation of nearshore habitat has occurred where shoreline development resulted in shoreline hardening.

Aquatic vegetation removal: The removal of aquatic vegetation via chemical or mechanical means may be pursued for socio-economic reasons, such as to facilitate boat access or commercial fishing. This is a type of habitat modification that merits special attention due to the importance of aquatic vegetation to Spotted Gar. The physical act of removing aquatic vegetation can be harmful to the species; the mechanical removal of vegetation disturbs sediments and creates turbid conditions; and, vegetation removal using herbicides introduces potentially harmful chemicals into the water. The removal of dense monoculture stands of exotic plant species such as Eurasian Water Milfoil (*Myriophyllum spicatum)* and European Common Reed (*Phragmites australis australis*) is often desired in areas such as Rondeau Bay to clear boating channels and swimming areas, as well as shorelines. At the time that the last recovery strategy was developed, it was believed that vegetation removals of dense submerged Eurasian Watermilfoil beds may benefit Spotted Gar. Since that time, significant research has been conducted that investigates Spotted Gar habitat use at multiple life-stages. These studies, which are described in more detail in the Updated Guidelines for the Removal of Aquatic Vegetation within Spotted Gar Critical Habitat (DFO 2020), indicate that Spotted Gar rely heavily on vegetated nearshore areas of embayments and tributaries for spawning, egg, larval, and young-

of-year life-stages. Furthermore, gar larvae were found in habitats dominated by milfoil 60% of the time suggesting that the removal of such vegetation could have significant consequences for Spotted Gar recruitment in Rondeau Bay, where sub-populations exist (Glass and Mandrak 2015) that are already likely below the minimum viable population size of 13,840 individuals reported by Young and Koops (2010) (see section 8.1: population viability). In addition, adult Spotted Gar have been observed to have a storing preference for both shallow (<0.5) and deeper habitats (>2.5 m) in both the spring and summer, some of which included milfoil and other vegetation types. Overall, these findings suggest that vegetation removal could impact Spotted Gar at all life-stages in both shallow and deep, and nearshore and offshore, areas within Rondeau Bay, as well as other locations where the species occurs such as Long Point Bay and Point Pelee.

Aquatic vegetation removal is also occurring in the Inner Bay at Long Point, especially within the cottage community channels, where aquatic vegetation is becoming more of a management issue (due to overgrowth). Additionally, the draw seine fishery within Long Point Bay removes aquatic vegetation in the spring to facilitate fishing (J. Robinson, CWS, pers. comm. 2009).

In the Point Pelee area, close to 60% of the historic marshes that once hydrologically connected the existing park with present day Hillman Marsh were drained between the 1890s and 1950s for agricultural use. This likely led to a considerable reduction in the amount of habitat available for the Spotted Gar population within the Point Pelee area (V. McKay, Parks Canada Agency [PCA], pers. comm. 2008).

The extent to which exotic emergent species such as European Common Reed affect Spotted Gar at various life-stages is currently unclear, although limited information regarding the potential impacts of this invasive species is presented below, under the category of exotic species. More research is needed to explore if and where vegetation removal of European Common Reed may be warranted to improve habitat conditions for Spotted Gar.

Sediment loading: Sediment loading affects inland watercourses, coastal wetlands, and nearshore habitats by decreasing water clarity by increasing siltation of substrates, and may have a role in the selective transport of pollutants including phosphorus. Sediment loading is often caused by a variety of sources, including poor agricultural and land management practices, improper drain maintenance practices, dredging activities, and the removal of riparian vegetation.

Increased turbidity as a result of sediment loading, as documented at Point Pelee National Park (H. Surette, University of Guelph, pers. comm. 2007), can limit the ability of the Spotted Gar to feed. Turbidity and siltation can negatively impact species by causing reductions in respiration, vision, and prey abundance, as well as smothering their eggs. Gray et al. (2012) found that there was a 24% decrease in the hatching success of Spotted Gar eggs in mildly turbid water (~5 NTU) when compared with those held in clear water. Siltation, from tile drainage, has also been evidenced in Rondeau Bay, particularly during storm events (Gilbert et al. 2007). Water entering Rondeau Bay from tributaries on the north and west shores is high in nutrients and suspended solid concentrations (including sediment) and has resulted in considerable long-term impacts on the bay, nearshore areas, and riparian wetland habitat (Gilbert et al. 2007).

Nutrient loading: Nutrient loading, which is often associated with sediment loading, has been identified as a primary threat to the three coastal wetlands currently occupied by the Spotted Gar (EERT 2008). Nutrient (nitrates and phosphorus) enrichment of waterways can negatively influence aquatic health through algal blooms and associated reduced dissolved oxygen

concentrations that occur once these blooms die off and begin to decompose. Elevated nutrient (nitrogen and phosphorus) concentrations can impact Spotted Gar populations directly (for example, altering habitat) or indirectly (for example, reducing prey abundance). This is particularly evident in Rondeau Bay where nutrient loading from adjacent agriculture and residential areas is negatively impacting wetland habitats (Gilbert et al. 2007). It is believed that high nutrient levels led to an algal bloom in 2005 that covered 70% of Rondeau Bay and led to decreased oxygen concentrations throughout the bay (Gilbert et al. 2007). Where nutrient inputs are elevated, vegetation diversity has declined and native species of emergent and submergent wetland vegetation, preferred by Spotted Gar, are outcompeted by cattail and Common Reed (*Phragmites australis australis)*. Although wetlands are highly valued for their water filtering capacity, these systems are negatively impacted when nutrient (and chemical) concentrations exceed background levels (Gilbert et al. 2007).

Exotic species: Exotic species may affect the Spotted Gar in several different ways, including competition for space, habitat, and food, and restructuring of aquatic food webs. There are now at least 182 exotic species known from the Great Lakes (Ricciardi 2006) and some of these species are likely to impact the Spotted Gar or its habitat. The Common Carp (*Cyprinus carpio*), Round Goby (*Neogobius melanostomus*), and Zebra and Quagga mussels (*Dreissena* spp.), are exotic species that have had a dramatic effect on the aquatic community of Lake Erie and will continue to alter and transform ecosystems and ecosystem processes. The Round Goby has spread throughout Lake Erie. Beach seining surveys on Pelee Island and along the north shore of Lake Erie in 2005-06 found Round Goby present at all 34 sites surveyed (Reid and Mandrak 2008). Since Spotted Gar typically feed on fishes near the surface, the shift to a fish community increasingly dominated by Round Goby (a bottom-dwelling species) may negatively impact this species; however, Round Goby are not abundant in vegetated areas of Rondeau Bay; therefore, it is unlikely that there is a large degree of overlap between this invasive and Spotted Gar. Exotic species such as Common Carp, and possibly hybrid cattails are a concern for existing populations of Spotted Gar, since these species can cause significant alterations of native wetland habitats.

In addition, the European Common Reed has spread throughout the coastal wetland habitats where Spotted Gar occurs and has had profound ecological impacts within Long Point Bay (Badzinski et al. 2008), and Point Pelee National Park (Vis et al. 2014). 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 Spotted Gar at multiple life-stages. Research has been conducted that models potential impact scenarios stemming from the combined effects of climate change and the increased expansion of Common Reed within Long Point Bay (McCusker 2017). One of the scenarios demonstrated that climate change may allow European Common Reed to colonize areas in Long Point Bay that are currently up to 1 m in depth, which could drastically change the availability of wetland habitat. This study was focused on impacts to Warmouth (*Lepomis gulosus*); however, the findings may be applicable for Spotted Gar, considering its use of nearshore habitat and selectivity of diverse macrophyte beds at critical life-stages. It is also possible that Common Reed may provide suitable habitat for younger life-stages; therefore, further research is warranted to fully understand the interaction between this invasive plant species and Spotted Gar and to investigate the costs and benefits of activities aimed at controlling it.

The spread of Grass Carp (*Ctenopharyngodon idella*) within the Great Lakes may also pose a significant future threat to the coastal wetland habitats upon which Spotted Gar depend through their consumption of aquatic macrophytes (Wittman et al. 2014). Grass Carp has been detected within Lake Erie in both Canadian and U.S. waters since the 1980s (Cudmore et al. 2017).

Furthermore, spawning Grass Carp have been confirmed within tributaries of Lake Erie located in Ohio (Chapman et al. 2013; Embke et al. 2016). A number of coastal wetland areas have been identified that have a high potential to be colonized by Grass Carp, based on the depth and density of aquatic vegetation, including Long Point and Rondeau Bay (Wittman et al. 2014; Gertzen et al. 2016) where Spotted Gar occur. Furthermore, an ecological risk assessment for Grass Carp in the Great Lakes (Cudmore et al. 2017) indicates that Lake Erie has a high probability of reproductively viable (diploid) Grass Carp occurring, as well as a high magnitude of ecological consequences in the next 20 years. With regard to species-specific impacts, Gertzen et al. (2016) postulate that Spotted Gar has a high potential to be affected by Grass Carp invasions based on their life-history needs at multiple life-stages, which are centred on the presence of aquatic macrophytes.

The exotic Florida Gar has been collected in the Great Lakes basin (likely the result of aquaria releases). This related species could represent an additional threat to the Spotted Gar, either through hybridization or competition, if the species becomes established. There are reports of hybridization where these species overlap in Florida (Lee et al. 1980) and Florida Gar are sometimes available in local aquarium stores.

Climate change: Climate change is expected to have significant effects on aquatic communities of the Great Lakes basin through several mechanisms, including increases in water and air temperatures; changes in water levels (that is, lowering); shortening of the duration of ice cover; increases in the frequency of extreme weather events; emergence of diseases; and, shifts in predator-prey dynamics (Lemmen and Warren 2004; Alexander 2012). It is anticipated that the effects of climate change will be widespread and should be considered a contributing impact to species at risk and all habitats. Not all of the effects of climate change will negatively affect species at risk; those species that are limited in their range by cool water temperature, such as the Spotted Gar, may expand their distribution, provided that dispersal corridors of suitable habitat are available. However, a suite of reactions related to changes in evaporation patterns, vegetation communities, lower lake levels, increased intensity and frequency of storms, and decreases in summer stream water levels may offset the direct benefits of increased temperatures. Furthermore, the increased effects of climate change will likely continue to promote the expansion of European Common Reed along coastal Great Lakes shorelines (Alexander 2012).

Climate change scenarios were modelled in Great Lake Coastal Wetland Communities, including Long Point, Turkey Point, and Rondeau Bay (Mortsch et al. 2006). Wetland community modelling indicates that lower water levels projected under most climate change scenarios will have an impact on the distribution and abundance of wetland habitat and wildlife communities. Lower water levels favour succession to drier vegetation types, particularly along the upper margins of the wetland and reduced open water habitat, including submerged vegetation utilized by Spotted Gar, in most embayments. Further assessment of the projected impacts of climate change on coastal wetland fish communities in the lower Great Lakes, Doka et al. (2006) predicted several fishes at risk as most vulnerable. Their results showed that the Spotted Gar ranked fifth highest in vulnerability scores of 99 fish species that use lacustrine (lake) habitats. Vulnerabilities were based on an assessment of climate change risk associated with coastal wetland and thermal preferences for different life-stages, as well as species' distributions. Similarly, Spotted Gar has been identified as highly vulnerable to future climate change within the Great Lakes by the Michigan Department of Natural Resources (Hoving et al. 2013).

Barriers to movement: Natural or man-made barriers may afford protection for some species from competitors, exotic species, and predators. Therefore, any breaches in the barrier could

have negative impacts on local fish communities. For example, another fish species at risk, the Lake Chubsucker (*Erimyzon sucetta*) is found in two diked wetlands where water level management is ongoing (Big Creek NWA and St. Clair NWA); in this instance, it appears as though the dikes are maintaining Lake Chubsucker habitat (Staton et al. 2010). Natural barriers at Point Pelee National Park are breached naturally on occasion; however, breaches may be occurring more frequently as a result of human alterations to the shoreline coastal processes that have increased the rates of coastal erosion (V. McKay, PCA, pers. comm. 2007). Conversely, barriers may prevent access to suitable habitat, lead to fragmentation of populations, and limit any rescue effect. In some instances, culverts present a physical or velocity barrier (for example, perched above the streambed or sized improperly) to fish passage between wetland areas and upstream habitat.

Wetlands with natural or artificially maintained barriers include Point Pelee National Park and Big Creek NWA (Long Point region). Spotted Gar have not been recorded from waterbodies where water level management occurs.

Incidental harvest: Although it is not legal to fish for the Spotted Gar (either commercially or recreationally), the species may still be captured incidentally. The extent to which the Spotted Gar may be affected by such incidental harvest is unknown, but is believed to be low. The potential for incidental harvest as a result of baitfishing, coarse fish spearing, and sport fishing require further investigation. The potential for incidental harvest as a result of commercial fishing (for example, trap-netting and draw seining at Long Point) is the subject of ongoing investigations by the OMNRF. A study was conducted during the spring and fall fishing seasons of 2009 in areas of inner Long Point Bay and Turkey Point to investigate the potential for incidental harm to species at risk (Gislason et al. 2010). A total of 368 commercial net sets were examined for species at risk leading to the capture of one Spotted Gar, which demonstrates that commercial fisheries are likely a low threat to this species. In addition, further research is underway that involves setting nets of similar gear type to those used by commercial fishers during the same time periods within inner Long Point Bay where Spotted Gar are known to occur. The aim of this study is to investigate the health of the commercial fishery as well as the overall fish community, which includes species at risk. Some initial sampling was conducted in 2018 to test gear types, which led to the capture of four Spotted Gar (OMNRF Unpub. 2019). Overall, it is unlikely that commercial fisheries represent a major threat to species at risk considering the gear types used (hoopnets) have low to no mortality and any species at risk that are caught should be released (OMNRF Unpub. 2019).

Knowledge gaps: There are numerous aspects regarding the biology, ecology, distribution, and abundance of the Spotted Gar that remain unknown. This information is required to refine recovery approaches and to aid in refining critical habitat identification. While much has been learned in terms of the habitat use of Spotted Gar in Rondeau Bay, information is lacking regarding home range size, habitat use, seasonal movements, and connectivity of populations at Point Pelee National Park, Big Creek NWA, and Long Point Bay. Primary threats that may be impacting populations have not been fully assessed (for example, source of threat, extent). Competition with the more abundant Longnose Gar may pose a threat to the Spotted Gar. The association of these two closely related species, as well as the likelihood of Florida Gar becoming established in Canada, need to be further investigated.

Recovery

The following goals, objectives, and recovery approaches were adapted from the Essex-Erie Recovery Strategy (EERT 2008), which includes the three extant populations of Spotted Gar within the coastal wetlands of Lake Erie.

6. Population and distribution objectives

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

> **Population objective:** Ensure populations in Point Pelee, Rondeau Bay and Long Point Bay (inner Long Point Bay, Big Creek NWA, Turkey Point and Long Point NWA) are viable and are stable or increasing through protection and enhancement.
>
> **Distribution objective:** Maintain the species within its extant distribution in Point Pelee, Rondeau Bay and Long Point Bay (inner Long Point Bay, Big Creek NWA, Turkey Point and the entire point (Long Point Provincial Park and Long Point NWA).

The populations at these locations could be considered recovered when they demonstrate active signs of reproduction and recruitment throughout their distribution. Additionally, threats acting on these populations would need to be reduced to low levels. It is important to note that the Rondeau Bay location contains source populations and, as such, supplies immigrants to the Point Pelee (at least historically) and Long Point Bay populations. This underlines the importance of defining recovery as “active signs of reproduction and recruitment throughout the species distribution” to ensure that locations where populations are viable and stable or increasing (for example, Rondeau Bay) remain protected and that their functionality as source locations is maintained. Furthermore, in the case of Spotted Gar, historic populations were likely naturally precarious with limited resilience[4] due to the fact that this is the northern extent of the species range. Therefore, it is important to consider these two aforementioned factors when considering allowable harm to important source populations such as those found in Rondeau Bay.

More quantifiable objectives will be developed once necessary surveys and studies have been completed (refer to section 7.5 “schedule of studies to identify critical habitat”). The population and distribution objectives are based on current information. If additional extant populations (for example, Muddy Creek, Hamilton Harbour, and Frenchman’s Bay) of the Spotted Gar are found and/or repatriating an extirpated population is deemed to be feasible, the population and distribution objectives will be revised.

[4] Resilience: A species that has large enough population size(s) to rebound from periodic disturbance and avoid demographic and genetic collapse is more likely to survive over the long term.

7. Broad strategies and general approaches to meet objectives

7.1 Actions already completed or currently underway

A "Recovery Strategy for the Spotted Gar (*Lepisosteus oculatus*) in Canada" was drafted in 2012, which listed a number of recovery measures involving broad strategies such as monitoring, research, stewardship, and outreach for implementation. Since the publication of this strategy, a fair degree of progress has been made towards completing the measures laid out in the recovery strategy. Some examples are provided for each broad strategy below. For more information, refer to the "Report on the Progress of Recovery Strategy Implementation for the Spotted Gar (*Lepisosteus oculatus*) in Canada for the Period 2012 to 2017".

Monitoring: Targeted surveys of historical and potential new locations were conducted in Lake Erie (Hillman Marsh; Flat, Georgie, Indian, Mill, and Willow creeks; and McLeans and Wood drains [all tributaries of Rondeau Bay]), Lake Ontario (Coote's Paradise; East Lake; and Hamilton Harbour) and Lake St. Clair (mouth of the Thames River; and Jeanette's, Baptiste, and Big creeks). A total of 47 Spotted Gar were detected in five sites (Glass and Mandrak 2014).

Research: Research has been conducted that investigates: habitat use for spawning and during the larval, juvenile, and adult life-stages (Glass et al. 2012; Glass and Mandrak 2014; DFO Unpub.); spawning site-fidelity (B. Glass pers. comm. 2019); threat evaluations such as the effects of increased turbidity on early life-stages of Spotted Gar (Grey at al. 2012); and the genetic variation among Spotted Gar populations (Glass et al. 2015).

Stewardship, outreach, and awareness: Habitat improvement activities such as vegetation plantings and riparian zone restoration projects have been conducted within the Point Pelee, Rondeau Bay, and Long Point Bay watersheds. In addition, presentations have been delivered to landowners, cottagers, and farmers regarding SARA, critical habitat, environmental issues, and initiatives in Rondeau Bay, and to the Ontario Aboriginal Lands Association (OALA) and the Ontario First Nations Economic Development Association (OFNEDA), regarding aquatic species at risk threats and protection measures in general. Furthermore, a Multi-Species Action Plan for Point Pelee National Park of Canada and Niagara National Historic Sites of Canada (PCA 2016), which prescribes measures that aid in the recovery of Spotted Gar, was developed.

7.2 Measures to be taken and implementation schedule

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

This recovery strategy and action plan provides a description of the measures that provide the best chance of achieving the population and distribution objectives for Spotted Gar, including measures to be taken to address threats to the species and to monitor its recovery, to guide activities to be undertaken by DFO and PCA, as well as those for which other jurisdictions, organizations, and individuals have a role to play. As new information becomes available, these measures and their respective priorities may change. DFO strongly encourages all Canadians to participate in the conservation of the Spotted Gar by undertaking measures outlined in this

recovery strategy and action plan. DFO recognizes the important role of the recovery team for the Spotted Gar and its member organizations and agencies in the implementation of measures for this species. For example, in 2016, PCA published the Multi-Species Action Plan for Point Pelee National Park of Canada and Niagara National Historic Sites of Canada (PCA 2016). While DFO has already implemented some of these measures, which were prescribed in the previous recovery strategy, the measures included in this recovery strategy and action plan will be subject to the availability of funding and other required resources. As indicated in the following tables, partnerships with specific organizations will provide expertise and capacity to carry out some of the listed recovery measures. Carrying out these actions will be subject to each group's priorities and budgetary constraints.

Table 3 identifies the measures to be undertaken by DFO to support the recovery of Spotted Gar. Table 4 identifies the measures to be undertaken collaboratively by DFO, PCA and its partners, and other agencies, organizations, or individuals. Implementation of these measures will be dependent on a collaborative approach, in which DFO is a partner in recovery efforts, but cannot implement the measures alone. Table 5 identifies the measures that represent opportunities for other jurisdictions, organizations, or individuals to lead. If your organization is interested in participating in one of these measures, please contact the Species at Risk Ontario and Prairie office. Implementation of this recovery strategy and action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations. Federal funding programs for species at risk that may provide opportunities to obtain funding to carry out some of the outlined activities include: the Habitat Stewardship Program for Species at Risk, the Aboriginal Fund for Species at Risk Program, and the Canada Nature Fund for Aquatic Species at Risk.

Four broad strategies were identified to meet the population and distribution objectives: 1) inventory and monitoring; 2) research; 3) management and coordination; and 4) stewardship and outreach. Recovery measures are ranked by priority (high, medium, low). A more detailed narrative is included following the tables (section 7.3).

Table 3. Measures to be undertaken by Fisheries and Oceans Canada.

#	Recovery measures	Broad strategy	Priority[5]	Threat(s) or objective(s) addressed	Timeline
1	**Population assessment:** implement a standardized index population monitoring program for all extant locations.	Inventory and monitoring	High	Achievement of population objectives and knowledge gaps	2 years
2	**Monitoring and enforcement:** continue to monitor, investigate and enforce penalties associated with illegal vegetation removal when it occurs in habitats occupied by the Spotted Gar. To be accomplished in collaboration with the Rondeau Bay Aquatic Vegetation Issues Working Group.	Inventory and monitoring	High	Habitat protection	Ongoing

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

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

Table 4. Measures to be undertaken collaboratively between Fisheries and Oceans Canada and its partners.

#	Recovery measures	Broad strategy	Priority[6]	Threat(s) or objective(s) addressed	Timeline	Partner(s)[7]
3	**Population assessment:** conduct targeted surveys of extant populations at locations such as Rondeau Bay and Point Pelee.	Inventory and monitoring	High	Achievement of population and distribution objectives	3 to 5 years	OMNRF, PCA conservation authorities
4	**Population assessment:** continue targeted surveys of suitable habitat at sites of limited and suspected capture or where positive eDNA samples have occurred in the Lake Ontario (Cootes Paradise, Frenchman's Bay, the Bay of Quinte area – North Channel), Lake Erie (Cedar Creek, Muddy Creek, Hillman Marsh, Turkey Point), and Lake St. Clair (Jeanette's Creek, Tremblay Beach) systems.	Inventory and monitoring	High	Achievement of population and distribution objectives	3 to 5 years	OMNRF, conservation authorities
5	**Habitat assessment:** implement a standardized index habitat monitoring program for all extant locations that can be used to refine mitigation measures for Spotted Gar as necessary. Monitoring should also be conducted to enable the early detection of exotic species.	Inventory and monitoring	High	Habitat protection	3 to 5 years	OMNRF, conservation authorities
6	**Threat evaluation:** investigate the impact of habitat modification resulting from the proliferation of the invasive species European Common Reed, as well as monoculture stands of Eurasian Watermilfoil (*Myriophyllum spicatum*), both of which may impact or benefit Spotted Gar depending	Research	High	All threats	Ongoing	OMNRF, ECCC-CWS, academic institutions

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

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

[7] Ministry of Natural Resources (OMNRF); Environment and Climate Change Canada (ECCC); Canadian Wildlife Service (CWS); Parks Canada Agency (PCA); Ministry of the Environment, Parks, and Conservation (MECP); Ontario Federation of Anglers and Hunters (OFAH); Rondeau Bay Aquatic Vegetation Issues Working Group (RBAVIWG).

#	Recovery measures	Broad strategy	Priority[6]	Threat(s) or objective(s) addressed	Timeline	Partner(s)[7]
	on life-stage.					
7	**Threat evaluation:** investigate the response of Spotted Gar to wetland management practices (for example, vegetation removal through both mechanical and chemical means, water level management, and other habitat alterations); this would include activities related to the control of European Common Reed.	Research	High	Habitat modification, turbidity, and sediment loading	Ongoing	OMNRF, PCA, academic institutions
8	**Threat evaluation:** investigate the relationship between Longnose Gar and Spotted Gar in areas where they coexist.	Research	Low	Interspecific interactions	3 to 5 years	OMNRF, PCA, academic institutions
9	**Threat evaluation:** investigate the impacts climate change is having, and will continue to have, on Spotted Gar and coastal wetland habitats.	Research	Low	Climate change	Ongoing	OMNRF, ECCC-CWS, academic institutions
10	**Threat evaluation:** in cooperation with relevant partners (for example, conservation authorities), assess watershed-scale stressors to occupied coastal wetlands.	Management and coordination	Medium	All threats	3 to 5 years	OMNRF, conservation authorities
11	**Threat mitigation:** ensure that existing guidelines on reducing, mitigating, and restoring areas of dredge, fill, and vegetation removal take the needs of the Spotted Gar into account and are refined as new and pertinent information becomes available; collaborate with partners to prevent the introduction of exotic species through best management practices (BMPs).	Management and coordination	Medium	Habitat loss and degradation	Ongoing	OMNRF, MECP, PCA, conservation authorities
12	**Threat mitigation:** work closely with drainage supervisors, engineers, and contractors to limit the effects of drainage activities on coastal wetland habitats.	Management and coordination	Medium	Habitat loss and degradation	3 to 5 years	Private enterprises, municipalities
13	**Inter-agency cooperation in Spotted Gar protection:** continue to monitor, investigate, and enforce penalties associated with illegal vegetation removal when it occurs in	Management and coordination	Medium	Habitat loss and degradation	Over 5 years	OMNRF, MECP, conservation authorities,

#	Recovery measures	Broad strategy	Priority[6]	Threat(s) or objective(s) addressed	Timeline	Partner(s)[7]
	habitats occupied by Spotted Gar.					and RBAVIWG
14	**Collaboration with planners:** encourage responsible agencies and jurisdictions to integrate recovery team recommendations into planning documents, including land management plans.	Management and coordination	Medium	All threats	Ongoing	OMNRF, MECP, conservation authorities
15	**Inter-agency cooperation:** work with relevant partners (for example, OMNRF, PCA, conservation authorities) to share knowledge and implement recovery actions.	Management and coordination	High	All threats	3 to 5 years	OMNRF, MECP, PCA, conservation authorities
16	**Awareness of stewardship opportunities and mitigation approaches:** promote stewardship among landowners, Indigenous groups and other interested parties (for example, anglers) within watersheds of the occupied coastal wetlands, particularly Rondeau Bay.	Stewardship and outreach	High	All threats	Over 5 years	Landowners, Indigenous groups, angling groups, environmental non-government organizations
17	**Awareness of stewardship opportunities and mitigation approaches:** provide a Spotted Gar information package to commercial and possibly recreational fishermen; request avoidance of occupied habitats, and the release and reporting of any Spotted Gar captured.	Stewardship and outreach	Low	Incidental harvest	1 to 2 years	OMNRF, MECP, conservation authorities, OFAH, angling groups
18	**Habitat improvement and threat reduction activities:** work with landowners to implement BMPs in areas where they will provide the most benefit; encourage the completion and implementation of Environmental Farm Plans and Nutrient Management Plans.	Stewardship and outreach	High	Sediment and nutrient loading, turbidity, habitat loss and degradation	Over 5 years	OMNRF, MECP, and conservation authorities

Table 5. Measures that represent opportunities for other jurisdictions, organizations or individuals to lead.

#	Recovery measures	Broad strategy	Priority[8]	Threat(s) or concern(s) addressed	Potential or confirmed jurisdictions or organizations[9]
19	**Threat evaluation:** identify point sources of nutrient and sediment inputs and their relative effects.	Research	High	Turbidity, sediment and nutrient loading	ECCC, OMNRF, MECP, and conservation authorities
20	**Threat evaluation:** evaluate the impacts of incidental harvest on Spotted Gar populations (for example, surveys of commercial catches).	Research	Medium	Incidental harvest	ECCC, OMNRF, MECP, and conservation authorities
21	**Threat evaluation:** measure sediment and nutrient loads (and possibly other contaminants) emitted from streams that are connected to wetlands occupied by Spotted Gar, as well as within coastal wetlands and connected quiet backwater areas along the north shore of Lake Erie.	Research	Medium	Turbidity, sediment and nutrient loading	ECCC, OMNRF, MECP, and conservation authorities
22	**Habitat improvement and threat reduction:** conduct recovery activities of benefit to Spotted Gar; for example, the improvement of spawning habitat in Long Point Bay is also recommended to increase the level of successful reproduction (Glass et al. 2015).	Stewardship and outreach	High	All threats	OMNRF, and conservation authorities
23	**Habitat improvement and threat reduction:** conduct habitat	Stewardship	High	Turbidity, sediment	OMNRF, ECCC-

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

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

[9] Ministry of Natural Resources and Forestry (OMNRF); Environment and Climate Change Canada (ECCC); Canadian Wildlife Service (CWS); Ministry of the Environment, Parks, and Conservation (MECP).

#	Recovery measures	Broad strategy	Priority[8]	Threat(s) or concern(s) addressed	Potential or confirmed jurisdictions or organizations[9]
	improvement projects within locations where Spotted Gar is present to reduce threats (for example, riparian planting and stabilization).	and outreach		and nutrient loading, and invasive species	CWS, and conservation authorities
24	**Awareness of stewardship activities and mitigation approaches:** encourage public support and participation by developing awareness materials and programs, which in turn will encourage participation in local stewardship programs and implementation activities to improve and protect habitat.	Stewardship and outreach	Medium	All threats	OMNRF, MECP, and conservation authorities

7.3 Narratives to support the recovery planning and implementation tables

Broad strategy 1: Inventory and monitoring

Recovery measures 1, 3 and 4 (population assessment): Further targeted sampling for Spotted Gar is needed at extant, historic, and suspected or potential new locations. In terms of extant locations, continued sampling is needed in Point Pelee, including West Cranberry, East Cranberry, Lake, Redhead and Harrison ponds, where sampling has not been undertaken since 2009. Similarly, further sampling is needed within Long Point Bay, where the species has recently begun to be detected with more frequency including areas such as Big Creek NWA, inner Long Point Bay, Turkey Point, Long Point Provincial Park, and Long Point NWA. Targeted sampling should also be conducted in Rondeau Bay to inform population monitoring and to address potential research questions.

There are also a number of historical and suspected or potential new locations that should be sampled. For example, within Lake Erie the species was detected through conventional sampling in Cedar Creek in 2019, Muddy Creek in 2011, and eDNA sampling led to detections in the nearby Hillman Marsh, warranting the need for conventional surveys to determine if populations exist at these locations and to assess connectivity between extant populations within Lake Erie. The species was also historically captured in Lake St. Clair in 1962 near the mouth of the Thames River and Tremblay Beach and eDNA sampling in 2012 led to positive detections within Jeanette's Creek, although conventional sampling at this location failed to capture the species. Further sampling may be warranted at these locations in the future. In addition, there are a number of locations of interest within the Lake Ontario watershed including: Hamilton Harbour (Spotted Gar detected in in 2010); Coote's Paradise and Spencer Creek (eDNA detection in 2013); Frenchman's Bay (unverified detection in 2018); and the Bay of Quinte and North Channel (where the species was historically detected).

A standardized monitoring program is needed to generate robust estimates of population size at extant locations. Population estimates have been established for Lake Pond in Point Pelee National Park, based on a mark and recapture study, and have been extrapolated to Rondeau Bay (Glass et al. 2012); however, Spotted Gar is known to be more widely distributed within Point Pelee, which may warrant further monitoring to broaden the population estimate at this location. Furthermore, population estimates have not been available for Long Point Bay, Turkey Point and Big Creek NWA, due to low catch numbers. Since 2012, the species has begun to be more widely detected among areas including inner Long Point Bay, Turkey Point, and Long Point NWA. If targeted sampling is successful in capturing Spotted Gar more regularly at these locations, monitoring approaches may be warranted that would allow for population estimates to be derived. Overall, suitable population monitoring approaches for Spotted Gar should ideally be undertaken in Rondeau Bay, where the species is known to be most prevalent, on an annual basis; and where feasible, to assess population trajectory, recovery feasibility and progress in meeting recovery objectives. Using information gathered from sampling approaches in Rondeau Bay, monitoring should also be conducted within Point Pelee National Park over broader intervals (at least every five years). Lastly, exploratory sampling should be conducted for Spotted Gar in Long Point Bay (at least every five years). If Spotted Gar are consistently captured at Long Point Bay, a monitoring plan could be initiated in the future.

Recovery measure 2 (monitoring and enforcement): DFO will continue to monitor, investigate and enforce penalties associated with illegal vegetation removal when it occurs in

habitats occupied by the Spotted Gar. In the case of Rondeau Bay, this task will be accomplished in collaboration with the Rondeau Bay Aquatic Vegetation Issues Working Group. Monitoring and enforcement of this nature will serve to reduce vegetation removal threats to populations and to create awareness that such areas constitute important habitat.

Recovery measure 5 (habitat assessment): Monitoring surveys should be conducted throughout watersheds where Spotted Gar is known to occur that will investigate changes in habitat conditions over time. These surveys will inform threat assessments for this species, and observed trends may be beneficial when assessing the trajectory of populations and the feasibility of their recovery.

Broad strategy 2: research

Recovery measures 6 to 9, 19 to 21 (threat evaluation): There are a number of threats that are currently affecting Spotted Gar or may potentially impact them in the future. The proliferation of European Common Reed within coastal wetlands such as Long Point Bay, Rondeau Bay, and Point Pelee may impact Spotted Gar at multiple life-stages by reducing the availability and quality of habitat for spawning, the egg and YOY stage, as well as by limiting access to upstream areas of tributaries where spawning takes place. Conversely, European Common Reed may provide beneficial habitat at certain life-stages. At this point, further research is needed to elucidate what effects this invasive plant species may be having on Spotted Gar populations. In addition, vegetation removal is a known threat to the species and permits for such activities are commonly applied for within Rondeau Bay, where the healthiest population of Spotted Gar occurs within Canada. There is a need to understand the degree to which vegetation removal projects can be carried out before significant impacts to the population, which jeopardize recovery objectives, begin to occur.

Investigations into fish community associations may also highlight additional pressures that limit the population growth of Spotted Gar. For example, interspecific competition with Longnose Gar may potentially further exacerbate the plight of Spotted Gar which is already threatened by a number of other factors. Understanding such interactions would likely lead to a better understanding of the population trajectory of Spotted Gar at locations where the two species co-occur. In addition, studies that model the potential impacts of climate change on Spotted Gar would also greatly inform recovery planning for this species. For example, it is not clear whether increases in water temperature may lead to higher growth and range expansion for Spotted Gar, a species at the northern edge of its continental range, or conversely, will lead to reductions in the availability of critical habitat through the dewatering of suitable nearshore areas or in concert with the spread of invasive species such as European Common Reed.

Research is still needed to examine the sources of point source nutrient and sediment inputs within watersheds where Spotted Gar occur, as well as their impacts on the species. For example, landuse practices in the surrounding watershed of Rondeau Bay and upstream of Big Creek NWA contribute high turbidity levels and sedimentation and impact the suitability of areas downstream where Spotted Gar occurs. This measure represents an opportunity for outside jurisdictions, such as conservation authorities and environmental non-government organizations, to examine the impacts of these threats to Spotted Gar and to identify areas within applicable watersheds from which major inputs of sediment and nutrients are emanating, to inform future stewardship initiatives.

Lastly, research is needed to explore the potential impact of the incidental harvest of Spotted Gar through commercial fisheries and recreational angling. This would involve conducting surveys of fishermen to gauge the frequency with which the species is captured.

Broad strategy 3: management and coordination

Recovery measure 10 (threat evaluation): Work with partner organizations and jurisdictions to identify and evaluate threats to Spotted Gar. This would include assessing watershed scale stressors by conducting many of the research measures discussed above in cooperative manner. This could include working with Environment and Climate Change Canada, the OMNRF, conservation authorities, ENGOs and other organizations to address the monitoring and research of threats that may be impacting Spotted Gar at extant locations.

Recovery measures 11 and 12 (threat mitigation): Work closely with partner organizations such as OMNRF, conservation authorities, ENGOs, landowner associations and municipalities to ensure that guidelines, mitigation approaches, and best management practices (BMPs) pertaining to Spotted Gar and its habitat are considered when in-water works (for example, dredging, in-filling, vegetation removal) are being conducted in areas where the species is known to occur.

Recovery measures 13 and 15 (inter-agency cooperation): Work with partner organizations such as the OMNRF to conduct enforcement and monitoring activities related to vegetation removal in Spotted Gar habitat, such as what is prescribed in measure two, as well as conduct investigations and enforce penalties, ensuring that the protection of the species is being thoroughly implemented.

Cooperation is also needed among jurisdictions and organizations to further the recovery of Spotted Gar by implementing stewardship and habitat improvement activities such as those prescribed in measures 18, 22, and 23.

Recovery measure 14 (collaboration with planners): Encourage municipalities to protect habitats that are important to the Spotted Gar in their Official Plans, and ensure that planning and management agencies are aware of habitats important to the species.

Broad strategy 4: stewardship and outreach

Recovery measures 16 to 18 and 24 (awareness of stewardship opportunities and mitigation approaches): Conduct outreach and awareness activities that will target multiple stakeholder groups to promote audience specific information such as stewardship approaches and BMPs for land use activities to landowners, Indigenous Groups, and the general public, as well as Spotted Gar identification and reporting, and to encourage the release of captured fish and potential avoidance of occupied habitats (for example, spawning areas during the spring) by anglers and commercial fishermen. Furthermore, outreach activities targeting such stakeholder groups should provide information regarding the significance of Spotted Gar, its life-cycle and habitat, and encourage the implementation of activities to improve and protect habitat.

Recovery measures 22 and 23 (habitat improvement and threat reduction): Conduct habitat improvement activities at locations where Spotted Gar is extant (for example, Point Pelee, Rondeau Bay, Long Point Bay), as well as areas between extant locations, or where populations may occur (for example, Cedar Creek, Hillman Marsh, Muddy Creek, West Two

Creeks, East Two Creeks - Wheatley Provincial Park) where Spotted Gar populations may occur, or which provide “suitable stepping stone habitat for migrating individuals” (Glass et al. 2015). In terms of extant locations, habitat improvement activities could be conducted at Long Point Bay to improve the quality and quantity of spawning habitat and to increase the level of successful reproduction (Glass et al. 2015), or within tributaries of Rondeau Bay. This could include riparian planting and stabilization activities within the drains that flow into Rondeau Bay or within the Big Creek watershed, which flows into Long Point Bay.

8. Critical habitat

8.1 Identification of Spotted Gar critical habitat

8.1.1 General description of Spotted Gar critical habitat

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

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

For the Spotted Gar, critical habitat is identified to the extent possible using the best available information, and provides the functions and features necessary to support the species’ life-cycle processes and achieve the species’ population and distribution objectives. Details about the geographic location of critical habitat are also provided.

This recovery strategy and action plan identifies critical habitat for Spotted Gar as the coastal wetlands and connected backwater areas, including interconnected flooded riparian areas and contributing channels, of Point Pelee National Park, Long Point Bay (including Long Point NWA) and Big Creek NWA, and Rondeau Bay.

The current areas identified may be insufficient to achieve the population and distribution objectives for the species. As such, a schedule of studies has been included to further refine the description of critical habitat (in terms of its biophysical functions, features, and attributes, as well as its spatial extent) to achieve the species’ population and distribution objectives.

8.1.2 Information and methods used to identify critical habitat

For the Spotted Gar, critical habitat has been identified to the extent possible, using the best available information. The critical habitat identified in this recovery strategy and action plan describes the geospatial areas that contain the known habitat features necessary for the survival or recovery of the species.

Using the best available information, critical habitat has been identified using a “bounding box” approach for the three coastal wetlands where the species presently occurs. This approach uses the essential functions, features, and attributes of each life-stage of the Spotted Gar to identify

patches of critical habitat within the “bounding box”, which is defined by occupancy data for the species. Life-stage habitat information is summarized in chart form (table 7) using available data and studies referred to in section 4.3 (needs of the species). The “bounding box“ approach was the most appropriate given the limited information available for the species and the lack of detailed habitat mapping for these areas. Where habitat information was available (for example, Ecological Land Classification [ELC], Aquatic Landscape Inventory System segments, Aquatic Resource Area polygons, bathymetry data), it was used to inform the identification of critical habitat. Species detections, observations, and expert opinions were also used to inform the identification of critical habitat. Critical habitat for Spotted Gar was first identified in the 2012 recovery strategy. Since that time, further species detections and information pertaining to habitat use warranted the identification of further critical habitat in Rondeau Bay and in Long Point Bay.

Point Pelee National Park: Critical habitat was identified for Spotted Gar within the ponds of Point Pelee National Park in the 2012 recovery strategy using data from the following datasets: Surette (2006), Razavi (2006), A.-M. Cappelli (unpublished data, 2009), and B. Glass (unpublished data, 2009), as well as photographic documentation in 2007 (S. Staton, pers. obs.). Pond names were taken from the National Topographic System (NTS) series of maps. No additional critical habitat is being proposed at this time.

Rondeau Bay: Data used to identify critical habitat in Rondeau Bay was taken from the existing DFO database (from 1955 to 2004), in addition to extensive capture, sampling and tracking efforts from more current research (for example, Glass et al. 2011; Glass and Mandrak 2014; DFO 2018). Within Rondeau Provincial Park, critical habitat was first identified in the 2012 recovery strategy using available ELC data for the park. ELC assesses the distribution and groupings of plant species and attempts to understand them according to ecosystem patterns and processes. It also helps to establish patterns among vegetation, soils, geology, landform, and climate, at different scales. Using the factors relating to geology, soils, physiography, and vegetation, ELC can be used to map vegetation communities at varying organizational scales (Lee et al. 1998, Lee et al. 2001). Spotted Gar capture locations within the park were compared with the park ELC data (Dobbyn and Pasma 2005) to determine the wetland vegetation types used by the species. All areas containing these ELC types were initially included as critical habitat; however, aquatic habitats that were isolated from the waters of the bay were excluded, as these areas are inaccessible to Spotted Gar.

In addition, critical habitat has been further identified within the tributaries of Rondeau Bay as these areas provide spawning habitat for the species. Since the 2012 recovery strategy, Spotted Gar have been captured in tributaries to the bay including Wood Drain (also known as Georgie Creek), Cumming Drain (also known as Mill Creek), McDougall Drain (also known as Flat Creek), Indian Creek, and McLean Drain (figure 7). Similarly, radio-telemetry studies conducted in 2007 to 2009 and 2016 and 2017 further document habitat use by Spotted Gar including locations where the species had not been detected using conventional methods (that is, Third Concession Drain) (figure 8), as well as the capture of specimens that are likely larval Spotted Gar. It is likely that the species is present further upstream within the tributaries where sampling has not been conducted but suitable habitat features are likely present. For example, Glass and Mandrak (2014) captured individuals upstream of the first major road crossing in Maclean’s Drain and Mill Creek (Cumming Drain) and suggest that Spotted Gar likely occur from the bay to the first permanent barrier to fish passage, which in the majority of cases extends beyond the critical habitat identified in the 2012 recovery strategy. For this reason, critical habitat has been extended upstream in a number of tributaries based on sampling information and expert opinion. Critical habitat has also been identified in Third Concession Drain.

Long Point Bay (including Long Point NWA) and Big Creek NWA: Limited data are available for the Spotted Gar population in Long Point Bay. At the time of the 2012 recovery strategy there were only 11 records for Spotted Gar in Inner Long Point Bay and capture data for Big Creek NWA (connected to Long Point Bay) was taken from one location (L. Bouvier, DFO, pers. comm. 2008). In addition, three individuals had been captured at Turkey Point Marsh. Since that time, Spotted Gar has been detected more frequently, with 30 individuals captured throughout inner Long Point Bay and a single individual detected in each of the following locations: Turkey Point; Big Creek NWA; and the Long Point Unit of Long Point NWA (figure 9).

Critical habitat was originally identified in the 2012 recovery strategy within Big Creek NWA, Inner Long Point Bay, and the mouth of Big Creek using ELC, as the wetland (including marsh, meadow marsh, shallow marsh, common reed, floating-leaved and mixed shallow aquatic, and thicket swamp ELC community classes) and aquatic areas (less than 2 m depths including open aquatic, submerged shallow aquatic, and open-submerged-floating-leaved, mixed ELC community classes). Further critical habitat has been identified that includes: the entire point (Long Point Provincial Park and Long Point NWA) and Turkey Point Marsh, based on the recent species detections; and areas within inner Long Point Bay <3 m in depth, based on habitat use patterns of Spotted Gar in Rondeau Bay observed by Glass et al. (2012).

Population viability: Comparisons of the area of critical habitat identified for each population were made with estimates of the spatial requirements for a minimum sustainable population size. The minimum area for population viability (MAPV) for each life-stage of the Spotted Gar was estimated for populations in Canada (table 8). The MAPV is defined as the amount of exclusive and suitable habitat required for a demographically sustainable recovery target based on the concept of a minimum viable population size (MVP) (Vélez-Espino et al. 2008). Therefore, the MAPV is a quantitative metric of critical habitat that can assist with the recovery and management of species at risk (Vélez-Espino et al. 2008). The estimated MVP for adult Spotted Gar is approximately 14,000 individuals and the associated MAPV is estimated to be 35 km^2, given a 15% chance of a catastrophic event occurring per generation and an extinction threshold of 20 individuals (that is, the adult population size below which the population is considered extinct). For more information on the MVP and MAPV values for Spotted Gar refer to Young and Koops (2010).

MAPV values are somewhat precautionary in that they represent the sum of habitat needs calculated for each life-history stage of the Spotted Gar; these figures do not take into account the potential for overlap in the habitat of the various life-history stages and may overestimate the area required to support an MVP. However, since many of these populations occur in areas of degraded habitat (MAPV assumes habitat quality is optimal), areas larger than the MAPV may be required to support an MVP. In addition, for some populations, it is likely that only a portion of the habitat within that identified as the critical habitat extent would meet the functional requirements of the species' various life-stages.

8.1.3 Identification of critical habitat

Geographic information:

Using the best available information, critical habitat has been identified for Spotted Gar populations in the following areas:

1. Point Pelee National Park

2. Long Point Bay (Turkey Point Marsh, and entire point and bay) and Big Creek NWA
3. Rondeau Bay and tributaries

Areas of critical habitat identified at these locations may overlap with critical habitat identified for other co-occurring species at risk (for example, Lake Chubsucker in Point Pelee National Park, Rondeau Bay, and Long Point Bay); however, the specific habitat requirements within these areas may vary by species.

The location(s) of the critical habitat's functions, features and attributes have been identified using the "bounding box" approach. This means that the critical habitat is not comprised of the entire area within the identified boundaries but only those areas within the identified geographical boundaries where the described biophysical feature and the function it supports occur, as described in table 7.

Note that existing permanent anthropogenic structures that may be present within the delineated areas (for example, marinas, navigation channels) are specifically excluded (unless said structures are maintaining critical habitat); it is understood that maintenance or replacement of these features may be required at times[10].

The areas delineated on the following maps (figures 6 to 8) represent the area within which critical habitat is found at this time. Table 6 below provides the geographic coordinates that situate the boundaries within which critical habitat is found for the Spotted Gar at the three locations; these points are indicated on figures 6, 7 and 8.

Table 6. Coordinates* locating the boundaries within which critical habitat is found for the Spotted Gar at three locations.

Critical habitat extent number	Point Pelee National Park	Rondeau Bay	Long Point Bay and Big Creek National Wildlife Area
1	41.971147˚ N 82.535144° W	42.348050˚ N -81.850981˚ W	42.594381˚ N -80.482269˚ W
2	41.984177˚ N 82.517724˚ W	42.341470˚ N -81.840645˚ W	42.690747˚ N -80.339494˚ W
3	41.973534˚ N 82.503157˚ W	42.254411˚ N -81.874116˚ W	42.550381˚ N -80.040992˚ W
4	41.948715˚ N 82.505035˚ W	42.262122˚ N -81.937992˚ W	42.574400˚ N -80.468900˚ W
5		42.281344˚ N -81.978094˚ W	
6		42.320444˚ N -81.93138˚ W	
7		42.340183˚ N -81.881806˚ W	

*Riverine habitats are delineated to the midpoint of channel of the uppermost stream segment and lowermost stream segment (that is, two points only). Coordinates obtained using map datum NAD 83.

A brief explanation for the areas identified as critical habitat is provided for each of the three areas below.

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

Point Pelee National Park: The ponds within Point Pelee National Park, including Redhead Pond, Lake Pond, East Cranberry Pond, West Cranberry Pond, and Harrison Pond, are included in the area within which critical habitat is found. However, the watercraft passage between Harrison and Lake ponds, known as Thiessen Channel (figure 10), is excluded from this critical habitat description. Thiessen Channel has been highly managed (modified and maintained) since at least 1922 to allow for watercraft passage from the western boundary of the marsh into Lake Pond, and the other connecting ponds (Battin and Nelson 1978). Hence, this channel is considered an anthropogenic structure and not identified as part of the critical habitat.

Long Point Bay and Big Creek NWA: The area within which critical habitat is found in Long Point Bay includes the contiguous waters of the inner bay, the entire point, including Long Point Bay Provincial Park and Long Point NWA, Turkey Point Marsh, and all waters from the shore down to the 3 m contour (figure 11). Critical habitat extends up to the high water mark elevation for Lake Erie at 174.62 m above sea level (International Great Lakes Datum 1985). Furthermore, critical habitat includes Big Creek NWA (figure 11) excluding the interior diked cell where Spotted Gar have not been detected (the diked cell is not accessible to Spotted Gar). The area within which critical habitat has been identified includes all contiguous waters and wetlands, excluding permanently dry areas, from the causeway west to, and including, all of Big Creek NWA to the low-head dike, except habitat contained within the interior diked cell within the NWA; Big Creek proper and all contiguous wetlands to the north of Big Creek are included.

Rondeau Bay: The area within which critical habitat for Spotted Gar is found in Rondeau Bay is currently identified as the waters and wetland areas (including seasonally flooded wetlands) of the entire bay (figure 12). Within Rondeau Provincial Park, aquatic habitats that were isolated from the waters of the bay were excluded as these areas are inaccessible to Spotted Gar. In particular, the areas identified as wetlands to the east of Marsh Trail actually contain large sections of upland terrestrial habitats that isolate interior wetland pockets (that is, sloughs) (S. Dobbyn, OMNRF, pers. comm. 2009). Approximately half of the area within which critical habitat is identified, lies within Rondeau Provincial Park.

Critical habitat has also been identified in the tributaries of Rondeau Bay including the mouths of tributaries flowing into the bay, upstream to the point where a defined stream channel is observed. In addition, critical habitat has been identified further upstream in specific tributaries where Spotted Gar has been captured or observed or where suitable spawning habitat is likely present. The extent of critical habitat within these specific tributaries is listed below, starting from east to west:

- **McLean Drain** including both branches from the bay up to points where the wetted width begins to narrow
- **Stirling Drain** from the bay up to the point where the wetted width becomes unsuitable for Spotted Gar
- **Bates Bloomfield Drain** from the bay up to Rondeau Estates Line
- **Holdaway Drain** from the bay up to Rondeau Estates Line
- **Huntley Drain** from the bay up to Rondeau Estates Line
- **Coleman Drain** from the bay up to New Scotland Line
- **Hebblethwaite Drain** and connected private drain from the bay up to an area where the wetted width significantly decreases at the first crossing with a private road

- **A private drain west of Hebblethwaite Drain** from the bay and ending at the first barrier on the upstream end of the first pond
- **Indian Creek and Clendening Drain** from the bay up to New Scotland Line
- **Flat Creek (also known as McDougal Drain)** from the bay to a point approximately 650 m upstream of New Scotland Line
- **Hunter Gerow Drain** from the bay up to New Scotland Line
- **Mill Creek (also known as Cumming Drain)** from the bay to the culvert at a point approximately 1.4 km upstream of New Scotland Line
- **Buchanan Drain** from the bay upstream to a point approximately 700 m upstream of New Scotland Line
- **Willow Creek Drain** from the bay upstream to a point where the wetted width significantly decreases at a crossing approximately 1.5 km upstream of New Scotland Line
- **St. Georges Creek (also known as Georgie Creek and Wood Drain)** from the bay upstream to the crossing at Fargo Road
- **Third Concession Drain** from the bay upstream to Bisnett Line
- **Vanderpol Drain** to a point where the wetted width becomes significantly narrow approximately 600 m upstream of Lagoon Road and Third Concession
- **Burk Drain** from Third Concession Drain upstream to Bisnett Line

Figure 10. Boundaries within which critical habitat for the Spotted Gar is found in Point Pelee National Park.

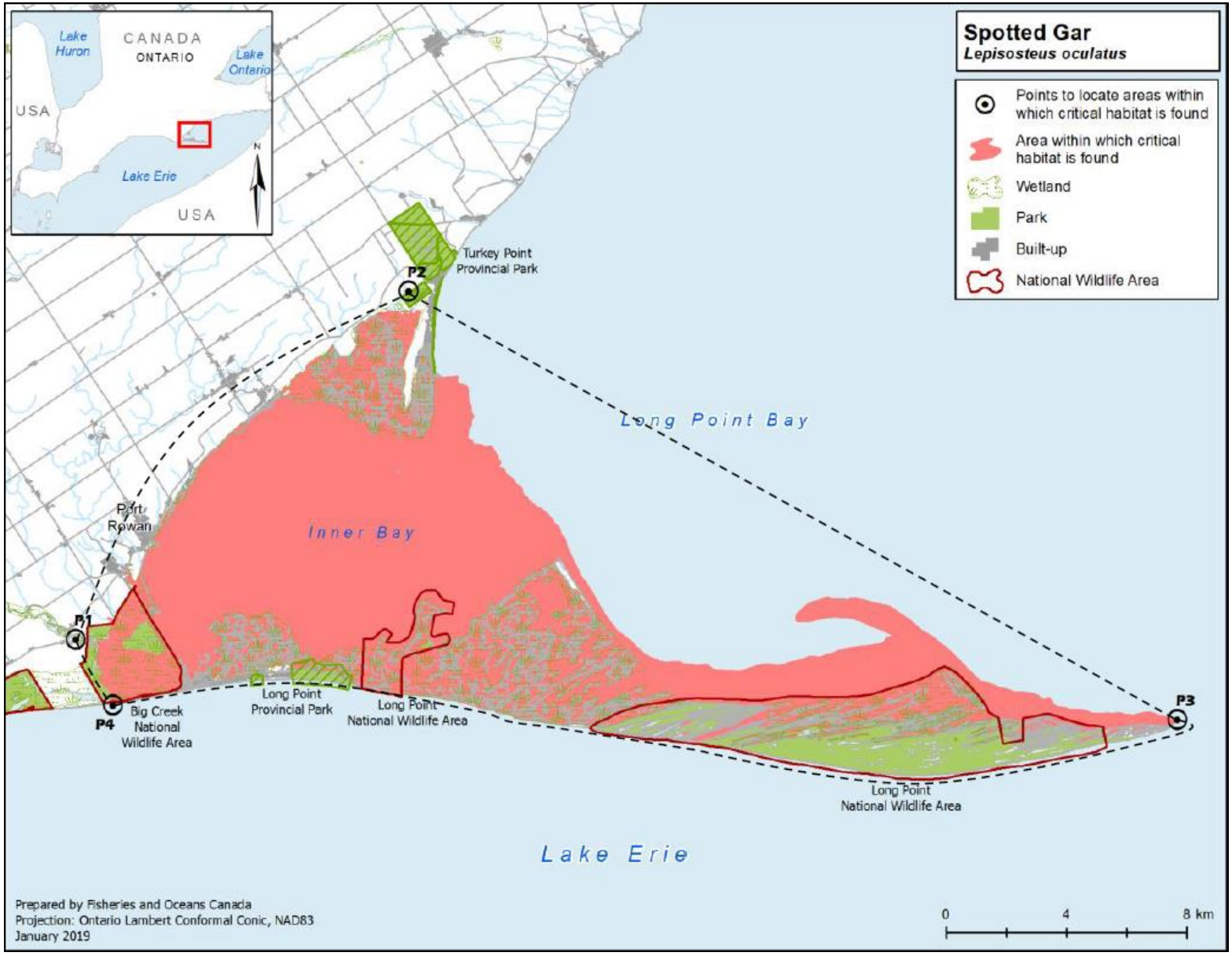


Figure 11. Boundaries within which critical habitat for the Spotted Gar is found in Long Point Bay and Big Creek National Wildlife Areas.

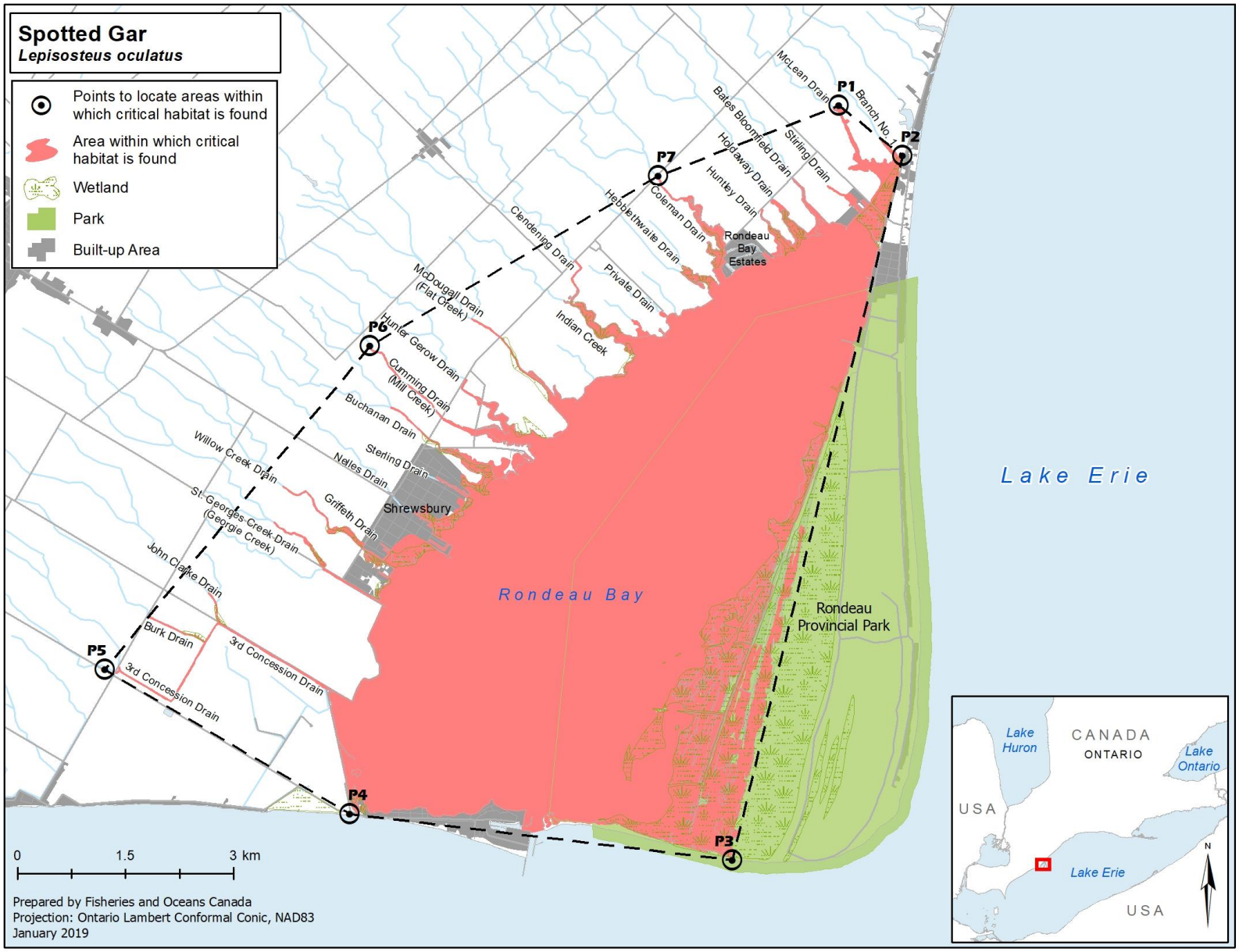


Figure 12. Boundaries within which critical habitat for the Spotted Gar is found in Rondeau Bay.

The identification of critical habitat within Point Pelee National Park, Long Point Bay and Big Creek NWA, and Rondeau Bay ensures that currently occupied habitat supporting Spotted Gar is protected, until such time as critical habitat for the species is further refined according to the schedule of studies laid out in section 8.2. These areas are necessary for survival and recovery. The schedule of studies outlines activities necessary to refine the current critical habitat description at confirmed extant locations, but will also apply to new locations with established population should they be confirmed (for example, East Lake, Hamilton Harbour). Critical habitat description will be refined as additional information becomes available to support the population and distribution objectives.

Biophysical functions, features, and attributes:

Table 7 summarizes the best available knowledge of the functions, features, and attributes for each life stage of the Spotted Gar (refer to section 4.3 “needs of the species” for full references). Note that not all attributes in table 7 must be present in order for a feature to be identified as critical habitat. If the features as described in table 7 are present and capable of supporting the associated function(s), the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table.

Table 7. Essential functions, features and attributes of critical habitat for each life-stage of the Spotted Gar.[11]

Life stage	Function [12]	Feature(s)[13]	Attribute(s)[14]
Adult and early life stage: from spawn to early larval stage (yolk sac or < 17 mm total length [TL])	Spawning (May to June) Nursery	Vegetated coastal wetlands and connected quiet backwater areas along the north shore of Lake Erie: including interconnected flooded riparian areas and contributing channels.	• Calm, clear water with little or no flow (for example, quiet backwaters) • Shallow water depths <1 m) in nearshore areas of tributaries and bays • Dense submergent and emergent vegetation (for example, milfoil [*Myriophyllum* sp.] and curly pondweed [*Potamogeton crispus*]) • Mixture of sand, silt, clay, or muck substrate • Underwater structure (for example, branches) • Warm water temperatures (spawning typically occurs from 21°C to 26°C; migration to spawning grounds observed at 18°C); 50% and 90% probability of spawning occurring after 210 and 291 CGDD[15] with a base 10°C water temperature[16], respectively, and a 50% and 90% probability of spawning after 62 and 85 CGDD with a base 15°C water temperature, respectively
Larvae (young-of-the-year [YOY] > 17 mm TL)	Nursery Cover	Same as above.	• Shallow, nearshore littoral zones (for example, water depths typically <1 m and/or areas <30 m from shore) in both tributaries and bays • Dense submergent and emergent vegetation (coverage > 70%) • Mixture of sand, silt, clay, or muck substrate
Juvenile (age 1 until sexual maturity [2 to 3 years males; 3 to 4 years females])	Feeding Cover	Same as above.	• No published information, but assumed to be the same as YOY and adults

[11] where known or supported by existing data. Note that existing permanent anthropogenic structures that may be present within the delineated areas (for example, boardwalks, marinas, navigation channels, pumping stations) are specifically excluded (unless said structures are maintaining critical habitat); it is understood that maintenance or replacement of these features may be required at times.
[12] Function: A life-cycle process of the listed species taking place in critical habitat (for example, spawning, nursery, rearing, feeding and migration).
[13] Feature: Features describe the essential structural component that provides the requisite function(s) to meet the species' needs. Features may change over time and are usually comprised of more than one part, or attribute. A change or disruption to the feature or any of its attributes may affect the function and its ability to meet the biological needs of the species.
[14] Attribute: Attributes are measurable properties or characteristics of a feature. Attributes describe how the identified features support the identified functions necessary for the species' life processes.
[15] Cumulative growing degree days (see section 4.3 for more details)
[16] Refer to explanation of cumulative growing degree days in section 4.3 "needs of the species: spawn to early larval (yolk-sac) stage".

Life stage	Function [12]	Feature(s)[13]	Attribute(s)[14]
Adult (from onset of sexual maturity [2 to 3 years for males; 3 to 4 years for females] and older)	Feeding Cover Migration	Same as above.	• Calm, clear water with little or no flow such as quiet backwater areas, nearshore (spring and summer) and relatively shallow offshore areas (summer) • Shallow (<0.5 m) and deeper (>2.5 m) water depths • Dense beds of mixed submergent and emergent vegetation (for example, water lily [*Nuphar* sp.], cattails [*Typha* sp.], Canada waterweed [*Elodea canadensis*], pondweed [*Potamogeton* sp.], stonewort [*Chara* sp.], milfoil, water celery [*Vallisneria* sp.], and hornwort [*Ceratophyllum* sp.]) • Mixture of sand, silt, clay, or muck substrate • Underwater structure (for example, branches) • Warm water temperature (ranging from 11.4°C to 31.3°C with an average being 22.6°C (± 0.19) • Adequate supply of prey species (for example, minnows [*Cyprinidae*] and Yellow Perch [*Perca flavescens*])

Summary of critical habitat relative to population and distribution objectives:

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

8.1.4 Population viability

Population sizes were estimated for Point Pelee and Rondeau Bay based on extrapolation of the abundance estimated within the 220 ha area of Lake Pond in Point Pelee, which is comprised of habitat that is representative of what is found in Rondeau Bay (Glass et al. 2012). Modelling conducted by Young and Koops (2010) estimated a minimum viable population (MVP) size for Spotted Gar of 1,424 or 13,840 adults assuming a 0.15 probability of catastrophic decline per generation based on quasi-extinction thresholds of 2 or 20 adults, respectively. Considering an extinction threshold of two adults does not account for inbreeding depression, the more conservative estimate of 13,840 adults based on an extinction threshold of 20 adults is used in this document. In addition, Young and Koops (2010) estimated the minimum area for population viability (MAPV) for each life-stage of the Spotted Gar, which is a quantitative metric of critical habitat that can assist with the recovery and management of species at risk (Vélez-Espino et al. 2008) to ensure that habitat is available to support and maintain the MVP. Comparisons were made with the extent of critical habitat identified for each population relative to the estimated MAPV in table 8. It should be noted that for some populations, it is likely that only a portion of the habitat within that identified as the critical habitat would meet the functional habitat requirements of the species' various life-stages as a whole, nor does it take into account the variation in habitat features needed by different life-stages. For example, the area of critical habitat identified for Spotted Gar in Long Point Bay may include: 1) areas where attributes described in table 7 do not occur; and 2) large areas comprised of open water habitat up to 3 m in depth, which may only be suitable for the adult life-stage, meaning it may not fulfil requirements needed for reproductive activities. In addition, since these populations occur in areas of degraded habitat (MAPV assumes habitat quality is optimal), areas larger than the MAPV may be required to support an MVP. Furthermore, a genetic assessment of Spotted Gar populations (Glass et al. 2015) has identified five subpopulations in Rondeau Bay that appear to be reproductively isolated; therefore, comparisons of the estimated population size of Rondeau Bay as a whole relative to the MVP estimate may not accurately reflect the vulnerability of subpopulations to habitat perturbations (that is, Rondeau Bay population size estimated to be 8,121 adults, while the average sub-population is estimated to be 1,624[17] adults). Future studies may help quantify the amount and quality of available habitat within critical habitats for all populations; such information, along with the verification of the MAPV model, will allow greater certainty for the determination of population viability. As such, the results in table 8 are preliminary and should be interpreted with caution. Overall, it is important to remember that MVP estimates represent what is required to maintain a population; therefore, where feasible, recovery targets should be aimed at exceeding these metrics.

[17] This an average based on the number of subpopulations and the estimate of the population size of Rondeau Bay as a whole. Subpopulations likely differ in size with some being much smaller than this value.

Table 8. Comparison of the area of critical habitat identified, estimated population size, minimum viable population size (MVP), and minimum area for viable population (MAVP*) for Long Point Bay (including Long Point NWA) and Big Creek NWA, Point Pelee, and Rondeau Bay populations. Population estimates are from Glass et al. (2012); MVP and MAVP are from Young and Koops (2010). MVP[1] represents P catastrophe = 0.15 and a quasi-extinction threshold of 2 adults; MVP[2] represents P catastrophe = 0.15 and a quasi-extinction threshold of 20 adults. Modified from DFO (2020).

Population	Area of critical habitat identified (km^2)	Estimated Population Size	MVP[1]	MVP[1] achieved?	MAVP[1]	MAVP[1] achieved?	MVP[2]	MVP[2] achieved?	MAVP[2]	MAVP[2] achieved
Long Point Bay (including Long Point NWA) and Big Creek NWA	205.68	Unknown	1,424 adults	Unknown	3.6 km^2	Yes	13,840 adults	Unknown	35 km^2	Yes
Point Pelee	2.20	483 adults	1,424 adults	No	3.6 km^2	No	13,840 adults	No	35 km^2	No
Rondeau Bay	36.98	8,124 adults	1,424 adults	Yes	3.6 km^2	Yes	13,840 adults	No	35 km^2	Yes

* The MAVP estimation is based on modeling approaches described above. For greater detail refer to Young and Koops (2010). There is limited information on the habitat needs for the various life-stages of the Spotted Gar. Table 7 summarizes available knowledge on the essential functions, features, and attributes for each life-stage (refer to section 1.4.1 “habitat and biological needs” for full references). Areas identified as critical habitat must support one or more of these habitat functions.

8.2 Schedule of studies to identify critical habitat

Further research is required to refine critical habitat necessary to support the species' population and distribution objectives and protect the critical habitat from destruction. This additional work includes studies identified in table 9.

Table 9. Schedule of studies to identify or refine critical habitat for the Spotted Gar.

Description of study*	Rationale	Timeline
Conduct studies to determine the habitat requirements for each life-stage of the Spotted Gar.	Determining the habitat requirements for each life-stage will ensure that all necessary features and attributes of critical habitat for this species will be identified. This would include seasonal habitat use of adults and juveniles and habitat that is used for developmental life-stages (for example, larvae and young-of-the-year). Specifically, research is needed to explore the young-of-the-year stage up to the point where sexual maturity is reached since little information currently exists regarding habitat use and behavior at these life-stages. Substantial progress exploring associations between habitat features and various life-stages of Spotted Gar has been made since the last recovery strategy within Rondeau Bay; however, while habitat association data is informative, further investigations are needed to understand how different habitat features influence vital rates of the species, such as recruitment, growth and survival, both within and among extant locations. Such research would identify the habitat features having the greatest influence on population trajectory and viability. Advanced research, focused on further understanding the habitat features limiting Spotted Gar population growth, should likely be conducted within Rondeau Bay where habitat associations are well understood. In addition, baseline investigations exploring habitat associations should also be conducted within the two other extent locations–Point Pelee and Long Point Bay–to explore variation in habitat use among these locations. Furthermore, observed differences in the availability of limiting habitat features may explain differences in Spotted Gar abundance and population trajectory among locations (for example, Rondeau Bay vs. Long Point Bay).	2021 to 2026
Investigate the role that adjacent riparian and terrestrial and semi-aquatic habitat may play in the overall habitat needs of the species.	This will assist with refining the identification of critical habitat for Spotted Gar and inform best management practices and mitigation approaches for landuse practices in areas adjacent to where Spotter Gar is known to occur.	2021 to 2026

Description of study*	Rationale	Timeline
Determine the influence that the invasive European Common Reed is having on Spotted Gar habitat needs and ultimately vital rates.	A substantial amount of research has been undertaken that examines changes in coastal habitats resulting from the spread of European Common Reed. It is likely, based on some of this previous work, that this invasive emergent plant species will have adverse impacts to Spotted Gar; however, European Common Reed may benefit Spotted Gar at certain life-stages (for example, egg and larval stages). Additionally, the control of European Common Reed is expected to negatively influence the species. For this reason, surveys and research are warranted to explore the potential impacts to Spotted Gar that European Common Reed may be having, and/or the potential use of this invasive species by Spotted Gar (at each life-stage).	2021 to 2026
Investigate the response of Spotted Gar to habitat perturbations.	Research centred on exploring how habitat alterations impact Spotted Gar habitat use or vital rates (for example, reproductive success, survivorship) will further update understanding of pathways of effect on critical habitat and inform decisions related to the protection of critical habitat. Specifically, this research could include investigations regarding the impacts of drain cleanouts, dredging, and vegetation removal projects, which are commonly proposed in areas of Rondeau Bay where Spotted Gar occur.	2021 to 2026
Survey and map habitat quality and quantity within historical and current sites.	The results of the surveys will strengthen confidence in data used to determine if sites meet the criteria for critical habitat and assist in refining the spatial boundaries of critical habitat. This measure is largely dependent on understanding the habitat requirements for each life-stage (discussed in the first row). Determining the habitat features that limit Spotted Gar population growth (refined functions, features, and attributes), and quantifying the availability of these features will allow for the refinement of population and habitat supply modelling, which will allow for a clearer understanding of recovery feasibility and the setting of suitable population and distribution objectives. Similarly, the mapping and quantification of limiting habitat will also inform habitat protection for Spotted Gar. For example, vegetation removal is a commonly proposed activity within Rondeau Bay and there is a need to understand what level of this form of habitat alteration is permissible before cumulative effects begin to impact Spotted Gar population dynamics.	2021 to 2028
Continue research related to cumulative growth degree day (CGDD) modelling for determining the timing of spawning.	Now that a CGDD model has been established that can be used to predict the timing of Spotted Gar spawning relative to fluctuating water temperatures within the spring season, one or two known spawning locations, likely within the Rondeau Bay watershed, should be established as monitoring stations to validate the predictive capability of the model. Specifically, temperature loggers should be installed within these monitoring tributaries, paired with further surveys, to confirm the timing of spawning and the CGDD model. Once this has been undertaken, these monitoring tributaries could be used as reference sites that are representative of other similar locations within Rondeau Bay, with annual temperature	Ongoing

Description of study*	Rationale	Timeline
	profiles for these streams indicating the timing of spawning activities within a given year. Lastly, research should also be conducted that would examine the relationship between air temperature and water temperature within tributaries of Rondeau Bay, which would investigate the potential to use air temperature data, which is much easier to obtain, to determine specific spawning times.	
Create a population-habitat supply model for each life-stage.	Once the habitat features that limit Spotted Gar productivity have been clearly identified (first measure in this table), and the limiting habitat features have been mapped (third measure in this table), then habitat supply models can be created for each life-stage. Such models will aid in developing recovery targets and determining the quantity of critical habitat required by each life-stage to meet these targets.	2021 to 2028
Based on information gathered, review population and distribution goals. Determine amount and configuration of critical habitat required to achieve goal if adequate information exists. Validate model.	Revision of recovery targets may be required to ensure that they are achievable and defensible; will allow further refinement of critical habitat description (spatial and biophysical attributes).	Ongoing

*Activities identified in this schedule of studies will be carried out through collaboration with other jurisdictions.

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

Under SARA, critical habitat must be legally protected within 180 days of being identified in a final recovery strategy or action plan. For those areas of critical habitat located within Point Pelee National Park and Big Creek NWA, a description of critical habitat was required to be published in the Canada Gazette 90 days after the posting of the original final recovery strategy in October of 2012, pursuant to subsection 58(2). The description for the critical habitat located within Point Pelee National Park and Big Creek NWA was published in the Canada Gazette in 2016. Ninety days following that publication in the *Canada Gazette, Part I,* the subsection 58(1) prohibition against destroying any part of the described critical habitat took effect. Furthermore, the critical habitat order for Spotted Gar was made in 2017, pursuant to subsections 58(4) and (5), triggering the prohibition in subsection 58(1) in all areas of critical habitat outside of Point Pelee National Park and Big Creek National Wildlife Area. This updated recovery strategy and action plan identifies further critical habitat in Rondeau Bay and in Long Point Bay for which the critical habitat order applies, including tributaries of Rondeau Bay, as well as the majority of Long Point Bay; however, the additional identification of critical habitat in the Thoroughfare and Long Point Units of Long Point NWA triggers the need for an amended critical habitat description in the *Canada Gazette*, pursuant to subsection 58(2), which will result in the subsection 58(1) prohibition applying to those new areas.

The following examples of activities likely to result in the destruction[18] of critical habitat (table 10) are based on known human activities that are likely to occur in and around critical habitat and would result in the destruction of critical habitat if unmitigated. The list of activities is neither exhaustive nor exclusive and has been guided by the threats described in section 5. The absence of a specific human activity from this table does not preclude or restrict the Department's ability to regulate that activity under the SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition, and does not mean the activity will inevitably result in destruction of critical habitat. Every proposed activity must be assessed on a case-by-case basis and site-specific mitigation will be applied where it is reliable and available. Where information is available, thresholds and limits have been developed for critical habitat attributes to better inform management and regulatory decision-making. However, in many cases knowledge of a species and its critical habitat's thresholds of tolerance to disturbance from human activities is lacking and must be acquired.

Activities that increase siltation and turbidity levels, or that result in the removal of aquatic vegetation can negatively impact Spotted Gar habitat. However, certain habitat management activities are recognized as being beneficial to the long-term survival and recovery of the species, and may be permitted if and when they are required. Such activities may include the removal or control of exotic aquatic or semi-aquatic vegetation; water level management (including dike maintenance); and habitat restoration activities (for example, fire management). For example, in some cases the exotic species European Common Reed may impact the suitability of habitat for Spotted Gar at specific life-stages; therefore, the removal and control of this species may be warranted in certain locations. In these situations, dependent on site-specific reviews, small-scale European Common Reed removal projects using approved chemical and/or physical means may be allowed to be undertaken. Moving forward, further

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

scientific advice is warranted to provide information regarding the potential benefits and impacts of European Common Reed removal on Spotted Gar populations. At the time that the previous recovery strategy was drafted, it was believed that the small-scale removals of monoculture stands of European Watermilfoil might be beneficial to Spotted Gar; however, since that time scientific review (DFO 2020) has indicated that such removals will not benefit Spotted Gar, but rather may threaten the longevity of populations in locations such as Rondeau Bay.

Table 10. Activities likely to result in the destruction of critical habitat for Spotted Gar. The pathway of effect for each activity is provided, as well as the potential links to the biophysical functions, features and attributes of critical habitat.

Threat	Activity	Effect – pathway	Function affected	Feature affected	Attribute affected
Habitat modifications	Dredging Grading Excavation Structure removal (for example, log salvage)	Changes in bathymetry and shoreline morphology caused by dredging and near-shore grading and excavation can remove (or cover) preferred substrates, change water depths, change flow patterns potentially affecting turbidity, nutrient levels, water temperatures, and migration. Removal of in-water structure can remove cover and affect feeding success and spawning.	Spawning Nursery Feeding Cover Migration	Coastal wetlands and connected quiet backwater areas along the north shore of Lake Erie: including interconnected flooded riparian areas and contributing channels.	• Calm, clear water with little or no flow (for example, quiet backwaters) • Shallow water depths (< 1m deep) • Dense submergent and emergent vegetation (for example, milfoil [*Myriophyllum* sp.] and curly pondweed [*Potamogeton crispus*]) • Mixture of sand, silt, clay, or muck substrate • Underwater structure (for example, branches, cover) • Warm water temperatures (spawning typically occurs from 21°C to 26˚C; migration to spawning grounds observed at 18ºC) • Adequate supply of prey species (for example, minnows [*Cyprinidae*] and Yellow Perch [*Perca flavescens*])
Same as above	Placement of material or structures in water (for example, groynes, piers, infilling, partial infills, jetties);	Placing material or structures in water reduces habitat availability (for example, the footprint of the infill or structure is lost). Placement of fill can cover preferred substrates, aquatic vegetation and underwater structure. Changing shoreline morphology can result in altered flow patterns, change	Spawning Nursery Feeding Cover Migration	Same as above	Same as above

Threat	Activity	Effect – pathway	Function affected	Feature affected	Attribute affected
	Shoreline hardening	sediment depositional areas, cause erosion, and alter turbidity levels. These changes can affect aquatic plant growth and cause changes to nutrient levels, and may affect fish movements. Hardening of shorelines can reduce organic inputs into the water and alter water temperatures, potentially affecting the availability of prey for this species.			
Same as above	Water extraction or draining of wetlands (for example, ditching, channelization, and diking); change in timing, duration, and frequency of flow	Water extraction can reduce the availability of wetland habitats. Draining wetlands can reduce the availability of habitat used by various life-stages of this species. Water depths can be reduced, affecting aquatic plant growth, underwater structure that would provide cover and impact water temperatures. Organic inputs from drained wetlands could be reduced, potentially affecting the availability of prey. Works associated with the draining of wetlands (for example, ditching, channelization and diking) can cause increased turbidity levels and alter flows. Altered flow patterns can affect sediment deposition (for example, changing preferred substrates), availability of flooded vegetation during spawn, turbidity and nutrient levels.	Same as above	Same as above	Same as above

Threat	Activity	Effect – pathway	Function affected	Feature affected	Attribute affected
Same as above	Unfettered livestock access to waterbodies	When livestock have unfettered access to waterbodies, damage or loss of riparian and aquatic vegetation can occur. Resulting damage to shorelines, banks, and watercourse bottoms can cause increased erosion and sedimentation, affecting turbidity and water temperatures. Such access can also increase organic nutrient inputs into the water, causing nutrient loading and potentially affecting aquatic plant growth, promoting algal blooms and decreasing prey abundance.	Spawning Nursery Feeding Cover	Same as above	Same as above
Aquatic and riparian vegetation removal	Vegetation clearing (mechanical and chemical removal)	Removal of aquatic or riparian vegetation, required by the species to spawn and for cover, can negatively affect recruitment and predation success. Plant die-off following chemical treatments and the removal of plant material can also negatively impact water quality, affect turbidity and water temperatures. These factors should also be considered with regard to the control of invasive species such as Common Reed and efforts should be taken to limit harm to Spotted Gar populations.	Spawning Nursery Feeding Cover	Same as above	Same as above
Turbidity and sediment loading	Work in or around water with improper sediment and erosion control (for example, use of industrial equipment, cleaning or maintenance of	Improper sediment and erosion control or inadequate mitigation can cause increased turbidity levels, potentially reducing feeding success or prey availability, impacting the growth of aquatic vegetation and possibly excluding fish from habitat due to physiological impacts of sediment in the water (for example, gill irritation).	Spawning Nursery Feeding Cover Migration	Same as above	Same as above

Threat	Activity	Effect – pathway	Function affected	Feature affected	Attribute affected
	bridges or other structures)				
Nutrient loadings	Over-application of fertilizer and improper nutrient management (for example, organic debris management, wastewater management, animal waste, septic systems, and municipal sewage)	Poor land management practices and improper nutrient management can result in overland run-off and nutrient loading of nearby waterbodies. Elevated nutrient levels can cause increased aquatic plant growth changing water temperatures. The availability of prey species can also be affected if they are sensitive to organic pollution.	Spawning Nursery Feeding Cover Migration	Same as above	Same as above
Exotic species	Deliberate or incidental introduction of exotic species	Feeding by Common Carp can increase turbidity and uproot aquatic vegetation that Spotted Gar may use for cover. The presence of Florida Gar may exclude Spotted Gar from preferred habitat and cause increased competition for prey.	Spawning Nursery Feeding Cover	Same as above	Same as above
Barriers to movement	Dams, weirs, and culverts (for example, fish passage issues)	The installation and operation of structures that restrict fish passage can limit the movement of individuals, fragmenting populations. Flow alterations sometimes associated with these structures can impact habitat availability further (see: Habitat modifications: change in timing, duration, and frequency of flow). Barriers can alter water levels upstream and downstream, affecting habitat availability.	Spawning Nursery Feeding Cover Migration	Same as above	Same as above

8.4 Proposed measures to protect critical habitat

Under SARA, critical habitat must be legally protected within 180 days after the final recovery strategy or action plan in which the critical habitat is identified is included in the Species at Risk Public Registry. For Spotted Gar, critical habitat was identified in the 2012 recovery strategy in Point Pelee National Park, Long Point Bay/Big Creek NWA and Rondeau Bay. In 2017, a critical habitat order was made, which triggered the prohibition in subsection 58(1) against the destruction of any part of critical habitat found outside the national park and Big Creek NWA (which are protected as described, below). The order also applies to all new areas of critical habitat identified in this recovery strategy and action plan outside the national park and NWAs.

For those areas of critical habitat located within Point Pelee National Park and Big Creek NWA, a description of the critical habitat was published in the *Canada Gazette, Part I,* Vol. 150, No. 42 in 2016, pursuant to subsection 58(2). The subsection 58(1) prohibition against destroying any part of this critical habitat came into effect ninety days following this publication in the *Canada Gazette*. The critical habitat description will be amended to include the additional areas in Long Point NWA, which were added in this recovery strategy and action plan. This prohibition provides additional protection to that already afforded and available under the *Canada National Parks Act* and *Canada Wildlife Act*, respectively, as well as the regulations associated with those statutes. Individuals of aquatic species listed as endangered, threatened or extirpated receive protection under SARA once the species is listed on Schedule 1 of SARA as a result of prohibitions in section 32.

Habitat of the Spotted Gar receives general protection from works, undertakings and activities under the habitat protection provisions of the federal *Fisheries Act*. The *Impact Assessment Act* (IAA) considers, among other things, the impacts of projects on certain listed wildlife species (including aquatic species) and their critical habitat (where critical habitat has been identified). Under s.79 of SARA, every person who (among others) is required under an Act of Parliament to ensure that an assessment of the environmental effects of a project is conducted must:

1. notify the competent minister(s) in writing of the project if it is likely to affect a listed wildlife species or its critical habitat,

2. identify the adverse effects of the project on the listed wildlife species and its critical habitat, and

3. if the project is carried out, that the person ensure that measures are taken to avoid or lessen those effects and to monitor them.

The measures must be taken in a way that is consistent with applicable recovery strategies or action plans.

Provincially, protection is also afforded under the provincial *Planning Act*. Planning authorities are required to be “consistent with subsection 2.1.7 of the Provincial Policy Statement, 2020 *Under the Planning Act* (Ontario), which prohibits development and site alteration in the habitat of regulated endangered and threatened species. Stream-side development in Ontario is managed through floodplain regulations enforced by local conservation authorities. Under the *Public Lands Act*, a permit may be required for work in the water and along the shore. The Spotted Gar is listed as a threatened species under Ontario’s *Endangered Species Act, 2007* (ESA). Under the ESA, the species itself is currently protected, and the habitat of the Spotted

Gar was protected under the general habitat protection provisions of the Act as of June 20, 2013.

Existing populations of Spotted Gar in Lake Erie are found in Point Pelee National Park, Rondeau Provincial Park (which represents the eastern portion of the bay only), Long Point Bay (including the NWA), and Big Creek NWA, which affords the habitat of the species some protection. Currently, occupied habitat receives additional protection afforded to NWAs through the *Canada Wildlife Act*, and provincial parks through the *Provincial Parks and Conservation Reserves Act*. Currently, recommended high priority areas for stewardship include Rondeau Bay watersheds, where land use impacts appear to be compromising habitat conditions within the bay.

9. Evaluation of socio-economic costs and of benefits

SARA requires that the action plan component of the recovery document (action plan)[19] include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation (SARA 49(1) (e), 2003). This evaluation addresses only the incremental socio-economic costs of implementing this action plan from a national perspective, as well as the social and environmental benefits that would occur if the action plan were implemented in its entirety, recognizing that not all aspects of its implementation are under the jurisdiction of the federal government. Its intent is to inform the public and to guide decision-making on implementation of the action plan by partners.

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

This evaluation does not address the socio-economic impacts of protecting critical habitat for Spotted Gar. Under SARA, DFO must ensure that critical habitat identified in a recovery strategy or action plan is legally protected within 180 days of the final posting of the recovery document. Where an order will be used for critical habitat protection, the development of the SARA critical habitat order will follow a regulatory process in compliance with the *Cabinet Directive on Regulatory Management*, including an analysis of any potential incremental impacts of the critical habitat order that will be included in the regulatory impact analysis statement. As a

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

consequence, no additional analysis of the critical habitat protection has been undertaken for the assessment of costs and benefits of the action plan.

9.1 Policy baseline

The policy baseline consists of the protection under SARA for Spotted Gar (the species was listed under SARA in 2003), along with continued protection under Ontario's *Endangered Species Act*, 2007. Other legislation that may provide direct or indirect habitat protection for Spotted Gar includes the federal *Fisheries Act* and provincial legislation[20]. The policy baseline also includes any recovery actions that were implemented prior[21] to and after Spotted Gar was listed under SARA. These recovery actions included various projects[22] funded by the federal government and province of Ontario.

9.2 Socio-economic costs

The majority of the recovery activities identified in this recovery strategy and action plan are short term (2020 to 2024), medium term, or ongoing. Most of these activities focus on research, monitoring, engagement, education, and management to reduce threats and to inform and promote species recovery. Some of the actions are one-time projects (for example, research and monitoring), likely funded from existing federal government resources. Implementation of local stewardship actions would be supported by programs such as the Species at Risk Habitat Stewardship Program. The highest cost component of the action plan portion of the document is expected to be research activities related to wetland management practices. These costs are not expected to exceed $100,000. In addition, most programs require a level of direct or in-kind support costs from applicants as matching funds[23]. The costs (direct and in-kind) associated with these short-term actions are estimated to be low[24] and spread over the next five years[25].

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[20] Examples of other provincial legislation that provide habitat protection include, but may not be limited to, considerations under section 2.1.7 of the Provincial Policy Statement (2014) under Ontario's *Planning Act*, which prohibits development and site alteration in habitat of endangered and threatened species, except in accordance with provincial and federal requirements, as well as protection under the *Lakes and Rivers Improvement Act* in Ontario.

[21] Management and recovery actions that will benefit Spotted Gar have been implemented under the "Management Plan for the Grass Pickerel (*Esox americanus vermiculatus*) in Canada", "Recovery Strategy for the Lake Chubsucker (*Erimyzon sucetta*) in Canada", "Recovery Strategy for the Pugnose Shiner (*Notropis anogenus*) in Canada", and the "Management Plan for the Blackstripe Topminnow, Pugnose Minnow, Spotted Sucker and Warmouth in Canada". The draft Essex-Erie recovery strategy is an ecosystem-based recovery strategy that will benefit Spotted Gar.

[22] Where recovery actions for several species at risk whose distributions partly overlap with Spotted Gar have been implemented.

[23] For example, matching funds for the Species at Risk Habitat Stewardship Program can come from landowners and/or provincial funding programs. This helps leverage additional support for recovery actions.

[24] Low costs are defined as less than $1 million annually, as per the socio-economic cost categories in the *Species at Risk Act* Implementation Guide for Action Plans for Fisheries and Oceans Canada May 2015.

[25] Future expenditures cannot be determined in great detail, as it is expected these activities would continue to be funded through existing government funding, including the Species at Risk Habitat Stewardship Program, where support is determined on a priority basis and based on availability of resources.

Costs would be incurred by the federal government to implement the activities listed in the action plan. In-kind costs, such as volunteer time, and providing expertise and equipment, would be incurred as a result of implementing activities listed in the action plan. Costs (including in-kind support) could be incurred by the province of Ontario and conservation authorities.

Long-term recovery activities will be developed through a cooperative approach following discussions among other agencies, levels of government, stewardship groups and stakeholders, allowing for consideration of costs and benefits during the process.

9.3 Socio-economic benefits

The benefits of the recovery actions required to return or maintain self-sustaining populations of Spotted Gar are not quantifiable but are expected to be positive, and to occur over the long term. In addition to the non-market benefits to Canadians that result from the preservation and conservation of species, the recovery measures may provide long-term benefits. Spotted Gar is among the most abundant piscivores in structurally complex, shallow-water habitats in the southern United States (COSEWIC 2015), which may result in it being a key food-web component (Snedden et al. 1999). As the species is relatively abundant in Rondeau Bay and, to a lesser extent, Point Pelee National Park, it is expected that Spotted Gar plays an important role as a top predator in these ecosystems. Furthermore, the species may be a host fish for freshwater mussel species. These ecosystem benefits would be maintained as a result of implementing the recovery actions proposed in the recovery strategy and action plan. The implementation of local stewardship programs to improve habitat conditions and reduce threats within critical habitat will help to improve wetland habitat and help lead to healthier watersheds through improved water quality.

Some unquantifiable non-market benefits would be enjoyed by the Canadian public as a result of implementing the recovery actions contained in the recovery strategy and action plan. Recent research (Rudd et al. 2016) found that Canadian households had positive and significant willingness to pay values for recovery actions that led to improvements for little known species at risk in southern Ontario. This research explicitly included Spotted Gar.

In the absence of information on biological outcomes of the measures identified in the recovery strategy and action plan, it is not possible to estimate the incremental benefits that can be directly attributed to the implementation of the recovery measures.

9.4 Distributional impacts

Governments and conservation authorities are expected to incur the majority of costs of implementing the action plan portion of this document.

The Canadian public is expected to benefit from the implementation of the action plan through expected non-market and ecosystem benefits associated with recovery and protection of the species and its habitat. Recovery actions that improve riverine habitat will help lead to healthier watersheds, with benefits such as improved water quality.

10. Measuring progress

10.1 Monitoring species' recovery

The recovery measures outlined in this recovery strategy and action plan will help to achieve the population and distribution objectives. When implemented, the measures are expected to advance the recovery of Spotted Gar in Canada. The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. A successful recovery program will protect, enhance, and maintain viable Spotted Gar populations within the three coastal wetlands of Lake Erie where extant populations occur. Progress towards meeting these objectives will be outlined in the report on the progress of recovery strategy implementation.

Performance indicators:

1. The continued presence of Spotted Gar within its current distribution by 2026
2. Population trajectories of Rondeau Bay populations determined by 2027
3. Assessment of Point Pelee populations explored through monitoring by 2027
4. Distribution of Spotted Gar within Long Point Bay examined through exploratory sampling by 2027
5. Exploratory sampling conducted in potential new or suspected locations by 2027

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

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

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

10.2 Monitoring and reporting on the implementation of the action plan

The Minister will monitor the implementation of the action plan portion of this document, and progress towards meeting its objectives, by assessing progress towards completing the recovery measures identified in this action plan (under section 55 of SARA), and the Minister will report on the plan's implementation five years after it comes into effect. This information will be published in a report on the progress of action plan implementation in five years and will be included in the public registry.

10.3 Reporting on ecological and socio-economic impacts

Ecological impacts may be defined as changes in the structure or function of ecosystems. The assessment of ecological impacts may be limited to species, their immediate habitats, or general natural resource categories. The broader ecological impacts of the implementation of the action plan portion of this document have been considered in its development. In order to report on the ecological impacts of implementation (under section 55 of SARA), monitoring data for one or more ecological components have been identified.

The Spotted Gar recovery strategy and action plan takes an ecosystem approach in addressing predominant threats in the watersheds where the species is found, in an effort to restore and improve aquatic habitat. By improving water and habitat quality in the system for some of the most sensitive aquatic organisms, habitat improvements will benefit biodiversity in general and help restore balance to the natural community. Work in the riparian areas will be conducted in such a way that it does not interfere with habitats and management of semi-aquatic and terrestrial species at risk. In most cases, riparian restoration will benefit terrestrial wildlife and plant species. Where possible, efforts through the Spotted Gar action plan will be combined with terrestrial efforts by stewardship practitioners.

The ecological impacts of the implementation of the recovery strategy and action plan will be reported on in the progress report five years after the plan comes into effect, using the monitoring methods outlined above, and will be included in the public registry.

Reporting on the socio-economic impacts of the action plan portion of the document (under section 55 of SARA) will be done by collecting data providing information on the costs incurred to implement the action plan.

The Minister must assess and report on its ecological and socio-economic impacts five years after the plan comes into effect. This information will be published in a report on the progress of action plan implementation in five years and included in the public registry.

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Appendix A: effects on the environment and other species

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

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

This combined recovery strategy and action plan will clearly benefit the environment by promoting the recovery of the Spotted Gar. In particular, it will encourage the protection and improvement of coastal habitats in Lake Erie. These habitats support species at risk from many other taxa (including birds, reptiles, fishes and plants) and thus the implementation of recovery actions for the Spotted Gar will contribute to the preservation of biodiversity in general. The potential for these recovery actions to inadvertently lead to adverse effects on other species was considered. The SEA concluded that the implementation of this document will clearly benefit the environment and will not entail any significant adverse environmental effects.

Appendix B: record of cooperation and consultation

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

Subject matter expert reviewers

Member or attendee	Affiliation
Andrew Drake	DFO Science
Dave Andrews	DFO Species at Risk Program
Dave Balint	DFO Species at Risk Program
William Glass	DFO Fish and Fish Habitat Protection Program
Richard Kavanaugh	DFO Fish and Fish Habitat Protection Program
Scott Gibson	Ontario Ministry of Natural Resources and Forestry
Scott Reid	Ontario Ministry of Natural Resources and Forestry
Lauren Sharkey	Ministry of the Environment, Conservation and Parks
Joanne Tuckwell	Parks Canada Agency
Tammy Dobbie	Parks Canada Agency
Juliana Galvis	Environment and Climate Change Canada
Jennifer Soetemans	Environment and Climate Change Canada
Mike Nelson	Essex Region Conservation Authority

Additional stakeholder, Indigenous, and public comments will be sought through the publication of the proposed document on the Species at Risk Public Registry for a 60-day public comment period. Comments received will inform the final document.