COSEWIC
Assessment and Status Report

on the

Spotted Gar
Lepisosteus oculatus

in Canada

ENDANGERED
2015

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC. 2005. COSEWIC assessment and update status report on the spotted gar *Lepisosteus oculatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 17 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2000. COSEWIC assessment and update status report on the spotted gar *Lepisosteus oculatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 13 pp.

Campbell, R.R. 1994. Update COSEWIC status report on the spotted gar *Lepisosteus occulatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-13 pp.

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COSEWIC
Assessment Summary

Assessment Summary – November 2015

Common name
Spotted Gar

Scientific name
Lepisosteus oculatus

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.

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.

COSEWIC
Executive Summary

Spotted Gar
Lepisosteus oculatus

Wildlife Species Description and Significance

The Spotted Gar (*Lepisosteus oculatus*) is a member of a family of ray-finned fishes, the Lepisosteidae. It is characterized by a long, narrow body; long, relatively broad snout (length 43.6-82.8% of head length, least width 9.9-16.0% of snout length); short, deep caudal peduncle (least depth 43.4-49.4% of caudal peduncle length); and a rounded, abbreviate heterocercal caudal fin. The body of the Spotted Gar is olive-green to velvety brown with a lighter underside. Darker brown spots are present on the snout, head, body, and fins. The Spotted Gar is one of two gar species native to Canada. In comparison to the other native gar species, Longnose Gar (*Lepisosteus osseus*), the Spotted Gar has a shorter, wider snout and a shorter, deeper caudal peduncle.

Distribution

The Spotted Gar has a wide, but disjunct, distribution in the Mississippi River and Great Lakes drainages of eastern North America. It occurs in Canada at three coastal wetlands in Lake Erie: Long Point Bay (including the Big Creek wetland), Point Pelee National Park, and Rondeau Bay. Single specimens have been recorded from Hamilton Harbour and East Lake (Lake Ontario) and unconfirmed historical occurrences from Lake St. Clair and the upper St. Lawrence River (near Kingston, Ontario) have been recorded.

Habitat

Adult Spotted Gar prefer quiet, vegetated, shallow clear waters of lakes and rivers. Populations in the southern United States typically use submerged branches, fallen trees or log complexes as resting cover, while Canadian populations of Spotted Gar use aquatic vegetation. Shallow areas of dense vegetation constitute nursery and spawning habitat.

Biology

The maximum known age of Spotted Gar is 18 years, with a maximum recorded age in Canada of 10 years. Onset of maturity is 3 years of age in Canadian populations. The Spotted Gar is a spring spawner, with peak spawning activity in Canada during late May through early June. The Spotted Gar is primarily a piscivorous ambush predator, but also consumes crayfishes and aquatic insects. They are well adapted to heavily vegetated

habitats with low dissolved oxygen concentrations as they are able to breathe air and absorb atmospheric oxygen through a vascularized gas bladder with a direct connection to the gut allowing the fish to “gulp” air.

Population Sizes and Trends

A mark-recapture study conducted in 2009 estimated the Point Pelee population of Spotted Gar at between 433 and 519 mature adults. The Rondeau Bay population was estimated to be between 7,281 and 8,278 mature adults, assuming a population density equal to that calculated for the Point Pelee population. The Long Point Bay population is likely the smallest of the three Canadian populations; only 21 individuals have been collected from Long Point Bay since 1947. Long-term data are scarce for this species in Canada; therefore, there is no evidence of change in abundance over time.

Threats and Limiting Factors

An invasive plant species, the European Common Reed (*Phragmites australis australis*) is found in high abundance in Lake Erie wetlands and forms high density stands that can reduce the amount of available habitat for Spotted Gar. Habitat modification, removal of native aquatic vegetation, nutrient loading, and increases in turbidity due to human activity are threats to the coastal wetland habitat used by Spotted Gar. Very limited incidental capture has also been documented in the Long Point Bay commercial fishery and a single individual was confirmed to have been illegally for sale in a live fish market in Toronto, ON. The Spotted Gar is also highly vulnerable to potential impacts of climate change-induced decreases in water levels of Great Lakes’ coastal wetland habitats.

Protection, Status and Ranks

The habitat of the Spotted Gar populations in Rondeau Bay and Long Point Bay is partially protected by its occupancy within parks. The Long Point Bay population occurs within Long Point Provincial Park and Big Creek National Wildlife Reserve, while the Rondeau Bay population occurs within Rondeau Provincial Park. These populations occur both inside, and outside park boundaries and, thus, are partially protected. The Point Pelee population occurs entirely within Point Pelee National Park. Consequently, its habitat is fully protected. Spotted Gar is currently listed as a Threatened wildlife species on Schedule 1 of the Canadian *Species at Risk Act* (SARA), which makes it an offence to kill, harm, capture, take, possess, collect, buy, sell or trade a Spotted Gar, as well as damage or destroy its residence. Spotted Gar is also listed as Threatened under the Ontario *Endangered Species Act* (2007), which prohibits the killing, harming, harassing, or taking of a living member of the species. The provincial act also prohibits damage or destruction of the species’ habitat.

TECHNICAL SUMMARY

Lepisosteus oculatus

Spotted Gar Lépisosté tacheté

Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used) (see Glass *et al.* 2011)	6 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. Long term monitoring for this species has not been conducted	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	Not applicable
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence 2005-2014 = 3,800 km² (excludes sites with single records with no documentation of viable populations – see Figure 4) 2005-2014 = 13,930 km² (includes sites with single records with no documentation of viable populations) 1995-2004 = 2,462 km² Pre-2005 = 20,989 km² Note: changes in EOO among time periods are due to variation in sampling effort, which was increased in the 2005-2014 time period. The pre-2005 time period includes all individuals captured before 2005, and includes areas with no currently known self-sustaining populations.	3,800 - 13,930 km²

Index of area of occupancy (IAO) 2005-2014 = 112 km² 1995-2004 = 36 km² Pre 2005 = 72 km² Note: changes in IAO among time periods are due to variation in sampling effort, which was increased in the 2005-2014 time period. The pre-2005 time period includes all individuals captured before 2005, and includes areas with no currently known self-sustaining populations.	112 km²
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse? The Canadian populations are separated by large distances; however, the available habitat patches in all three confirmed locations are larger than the minimum viable population area proposed by Young and Koops (2010). Glass *et al.* (2015) indicate that some gene flow between populations occurs.	a. No b. No
Number of "locations"* (use plausible range to reflect uncertainty if appropriate) The most serious plausible threat to Spotted Gar that could happen rapidly is habitat loss as a result of invasive *Phragmites australis australis.* Known Spotted Gar populations exist in three Lake Erie wetlands: Point Pelee, Rondeau Bay, Long Point Bay. Given the distance between these populations and the spatial and temporal scale of the *Phragmites* threat, each population should be considered to occupy a separate location. Individual specimens have been collected in East Lake and Hamilton Harbour of Lake Ontario, and Muddy Creek of the Lake Erie watershed; however, subsequent sampling failed to confirm populations at these three locations.	3
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an inferred decline in area of habitat? Continuing vegetation removal in Rondeau Bay (both authorized and unauthorized) and the increase in abundance of the invasive *Phragmites* results in a decline in the area of habitat available for Spotted Gar.	Yes
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"*?	No
Are there extreme fluctuations in extent of occurrence?	No

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term

Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Point Pelee Estimated by mark – recapture; 95% CI = 433 – 519 (Glass *et al.* 2012).	483
Rondeau Bay Estimated by extrapolation of population density to available habitat area; 95% CI = 7,281 – 8,278 (Glass *et al.* 2012).	8,121
Long Point Bay Likely very small, only 21 individuals confirmed captured since 1947 (DFO unpubl. data)	Unknown
Total	Approximately 7, 735 – 8,661

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown

Threats (actual or imminent, to populations or habitats, from highest impact to least)

i. Invasive species, such as European Common Reed (*Phragmites australis australis*) and Eurasian Milfoil (*Myriophyllum spicatum*).
ii. Habitat modification and destruction, including removal of aquatic vegetation and loss of wetland habitat
iii. Increased turbidity and nutrient loading due to agriculture and development
iv. Incidental harvest

Was a threats calculator completed for this species and if so, by whom? Yes; completed via threats calculation conference call with report writers, jurisdiction and co-chair.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada. Closest populations are in Ohio and are designated as Endangered. Designated as species of special conservation concern in Michigan and Endangered in Pennsylvania.	Endangered
Is immigration known or possible? Immigration is unlikely due to large distance between suitable habitat patches. Genetic evidence suggests that Canadian populations are distinct from populations in southern United States, indicating that gene flow is likely not occurring (Glass 2012). Closest populations (Ohio, Pennsylvania) are Endangered, not likely to provide migrants.	No
Would immigrants be adapted to survive in Canada? Closest populations are also found in Great Lakes coastal wetlands; thus habitat would be similar.	Yes
Is there sufficient habitat for immigrants in Canada?	Yes

Are conditions deteriorating in Canada?[+] Habitat loss and degradation due to removal of vegetation and loss of wetland habitat, along with increased abundance and density of European Common Reed is ongoing and results in a loss of habitat quantity and quality in Canada	Yes
Are conditions for the source population deteriorating?[+]	Not applicable
Is the Canadian population considered to be a sink?[+] The Canadian population is not a sink overall; however, the Long Point Bay population is likely to be a sink (Glass *et al.* 2015)	No
Is rescue from outside populations likely? Canadian populations isolated by large distance of unsuitable habitat. Nearest populations are Endangered and not likely to provide migrants.	No

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: 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.

Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: B2ab(iii)
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.	

Applicability of Criteria

Criterion A: Not applicable. No quantitative data on declines.
Criterion B: Meets Endangered B2ab(iii) as IAO (112 km²) is below threshold, sub-criterion a (three known locations) is below threshold, and meets sub-criterion b(iii) as there is a continuing decline in the extent and quality of habitat owing to the wetland drainage and expansion of invasive plants. Meets Threatened B1 as maximum plausible EOO (13,930 km²) is below threshold.
Criterion C: Does not meet criteria. Population is likely fewer than 10,000 mature individuals, but no estimates of rate of continuing decline.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Criterion D: Does not meet criteria. Although there are probably fewer than five locations, the threats to the species are unlikely to make it become extinct, extirpated or critically endangered in a very short time (1-2 generations; 6-12 years).
Criterion E: Not applicable. Required data for estimation not available.

PREFACE

The Spotted Gar remains a relatively understudied species in Canada, despite increased sampling effort since the last report was prepared. Recent sampling has been conducted in each of the three Lake Erie wetlands where the Spotted Gar has been found historically. The species was found in each of the three wetlands. Additionally, individual Spotted Gar have been found in Hamilton Harbour and East Lake, which are coastal wetlands of Lake Ontario, as well as Muddy Creek, a tributary to Lake Erie in close proximity to one of the known sites of Spotted Gar occurrence (Point Pelee). Subsequent sampling in the Lake Ontario sites where Spotted Gar have been found historically has not resulted in further captures and, thus, it remains uncertain if populations exist in these areas. It is also uncertain whether the Muddy Creek specimen is part of a separate population or a single transient individual. No captures were reported from the Upper St. Lawrence River or Lake St. Clair and it is presumed that these areas do not have populations of Spotted Gar.

Despite recent sampling effort, the juvenile life stage of this species remains understudied. There have been a small number of juveniles captured, and the habitat use by juveniles in Rondeau Bay has been described. The habitat use by juveniles in other sites remains unknown.

Long-term monitoring data do not exist for this species, although it appears that the populations in Point Pelee and Rondeau Bay are stable. The level of natural reproduction in Long Point Bay is unknown, but likely very low, because juveniles were not detected during targeted sampling in 2014. Population genetic data also suggest that the Long Point population is a sink and is sustained by immigrants from other Lake Erie sites.

Population genetic data indicate that there are several distinct populations of Spotted Gar within the Canadian range, with low levels of inferred gene flow between them. Due to its isolation and small size, the Point Pelee population appears to be a source of novel genetic diversity that is exported through asymmetrical gene flow to the other Lake Erie populations.

Ongoing threats to this species in Canada include the proliferation of the invasive European Common Reed (*Phragmites australis australis*) and the loss of wetland habitat through human activities. A federal recovery strategy has been completed (Staton *et al*. 2012) that summarizes these threats and research needs to facilitate recovery of the Spotted Gar.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2015)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Kingdom Animalia

Phylum Chordata

Class Actinopterygii

Order Semionotiformes

Family Lepisosteidae

Genus and species: *Lepisosteus oculatus* Winchell, 1864

English Common Name: Spotted Gar (Page *et al.* 2013)

French Common Name: lépisosté tacheté (Page *et al.* 2013)

Morphological Description

The Spotted Gar (*Lepisosteus oculatus*) is a member of the family Lepisosteidae (Page *et al.* 2013). It is characterized by: a long, narrow body; long, relatively broad snout (length 43.6-82.8% of head length, least width 9.9-16.0% of snout length); short, deep caudal peduncle (least depth 43.4-49.4% of caudal peduncle length); and rounded, abbreviate heterocercal caudal fin (Figure 1; Scott and Crossman 1998). The body of the Spotted Gar is olive-green to velvety brown with a lighter underside. Darker brown spots are present on the snout, head, body, and fins.

Figure 1. The Spotted Gar (*Lepisosteus oculatus*). Illustration by Joe Tomelleri. Used with permission of DFO.

The Spotted Gar is one of two native gar species found in Canada (Scott and Crossman 1998). In comparison to the Longnose Gar (*Lepisosteus osseus*), the Spotted Gar has a shorter, wider snout (Figure 2) and a shorter, deeper caudal peduncle (Scott and Crossman 1998). Both species are spotted; consequently this character should not be used to distinguish between them.

The exotic Florida Gar (*Lepisosteus platyrhinchus)* has also been collected in the Great Lakes basin, undoubtedly the result of release from aquaria (Cudmore-Vokey and Crossman 2002). The Spotted Gar closely resembles the Florida Gar, but has bony, translucent plates on the isthmus between the gill openings, which are absent in the Florida Gar (Page and Burr 2011).

Figure 2. Differences in snout length and width in similar-sized Longnose Gar (top) and Spotted Gar (bottom) collected in Rondeau Bay, 2002. Photo by Jason Barnucz, DFO.

Population Spatial Structure and Variability

Glass *et al.* (2015) investigated the spatial population genetic structure across the species' range, including the three wetlands of Lake Erie where the species is found in Canada. The analysis, based on eight microsatellite loci, indicated that the northern populations (three Canadian sites plus Michigan) are genetically distinct from populations in the southern portion of the species' range. Within the northern sites, significant genetic structure was also uncovered. Bayesian assignment methods recovered eight genetic populations, six of which were found in the northern sites. Point Pelee was found to be genetically isolated from all other sites and the other northern sites (Michigan, Rondeau Bay, and Long Point Bay) clustered together. Point Pelee was found to be a source of novel genotypes, which were exported to the other Lake Erie sites via asymmetrical gene flow. The asymmetrical gene flow from Point Pelee to Rondeau Bay is likely facilitated by the barrier beach at Point Pelee and the infrequent nature of breach events. There have been

seven recorded breaches of the barrier beach due to high water levels and storm events since 1973, with another eight that have been predicted to have occurred (Surette 2006). These breaches are likely to result in emigration of Point Pelee individuals due to proximity and predominant water flows towards Rondeau Bay (Glass *et al.* 2015). The habitat between Point Pelee and Rondeau Bay lacks shallow vegetated areas suitable for Spotted Gar (Staton 2012). Of the 250 Rondeau Bay individuals that were genotyped, 37 were determined to be migrants originating from Point Pelee. By contrast, no Point Pelee caught individuals were determined to be immigrants from other areas (Glass *et al.* 2015). Five distinct populations with varying degrees of admixture are found in Rondeau Bay, and Long Point Bay appears to be a population sink, receiving migrants from Rondeau Bay (Glass *et al.* 2015). The observed admixture between the Michigan sample sites and Lake Erie was attributed to shared ancestry and not recent movement between sites (Glass *et al.* 2015).

Designatable Units

All Canadian populations are found within the Great Lakes-Upper St. Lawrence National Freshwater Biogeographic Zone (NFBZ) of the NFBZ classification system adopted by COSEWIC and constitute a single designatable unit (DU) in Canada. The Canadian populations have varying degrees of connectivity; however, contemporary rates of gene flow are relatively low, ranging from near-complete isolation to approximately five percent per generation, or less than one percent per year (Glass *et al.* 2015). Given estimates of the effective number of breeders (a measure related to effective population size – see Waples 2005) of between ~20 and 500 in each of the Canadian populations (see **Abundance**), this translates to fewer than one to perhaps five individuals moving between populations per year. Asymmetrical gene flow exists between Point Pelee and Rondeau Bay, with individuals migrating from Point Pelee to Rondeau Bay when breaches to the isolation of the Point Pelee marsh occur. Consequently, although there is some evidence of genetic discreteness among sites, there is no evidence of long-term phylogeographic distinctiveness or of behavioural or life-history differences that might trigger the significance criterion for identification of multiple DUs.

Special Significance

Spotted Gar is among the most abundant piscivores in structurally complex shallow water habitats in the southern United States. This high relative abundance and predatory potential suggest that they are key components of the food web (Snedden *et al.* 1999). This species is relatively abundant in Point Pelee and Rondeau Bay (Glass *et al.* 2012) and likely plays an important role as a top predator in these ecosystems.

DISTRIBUTION

Global Range

The Spotted Gar has a wide, but disjunct, distribution in the Mississippi River and Great Lakes drainages of eastern North America (Figure 3). In the Mississippi River drainage, it is found from Alabama to Texas in the south, to Illinois in the north, and from Tennessee in the east to Oklahoma in the west (Lee *et al.* 1980; Page and Burr 2011). The populations in the Great Lakes are widely disjunct from the Mississippi River drainage populations. In the Great Lakes drainage, populations are found in Illinois, Indiana, Ohio, Ontario, and Michigan (Lee *et al.* 1980; Page and Burr 2011).

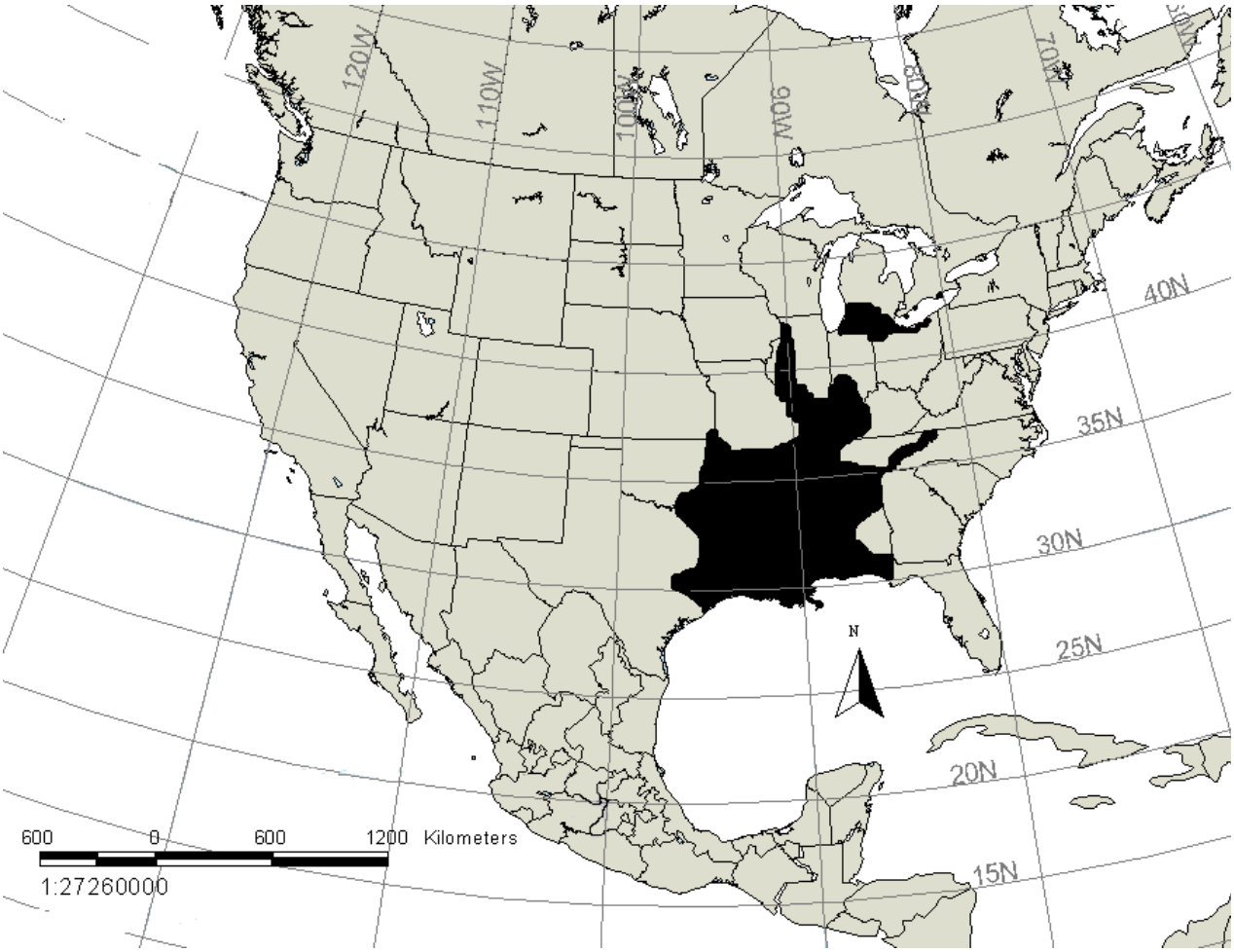

Figure 3. Global distribution of the Spotted Gar [modified from Page and Burr (2011)].

Canadian Range

In Canada, the occurrence of Spotted Gar has been verified at seven sites. Populations are present in three coastal wetlands of Lake Erie: Point Pelee, Rondeau Bay, and Long Point Bay. Individual specimens have also been collected in Lake St. Clair and Muddy Creek, a tributary to Lake Erie in the vicinity of Point Pelee, Hamilton Harbour, and East Lake in Lake Ontario, and the upper St. Lawrence River near Kingston, Ontario (Figure 4). The first confirmed record of Spotted Gar at Point Pelee was collected in 1913, in Long Point Bay in 1947, and in Rondeau Bay in 1955 (there are records of Spotted Gar caught by a commercial fisherman at “Merlin” in 1925, and at “Port Crewe” in 1938 — these were likely caught in Rondeau Bay).

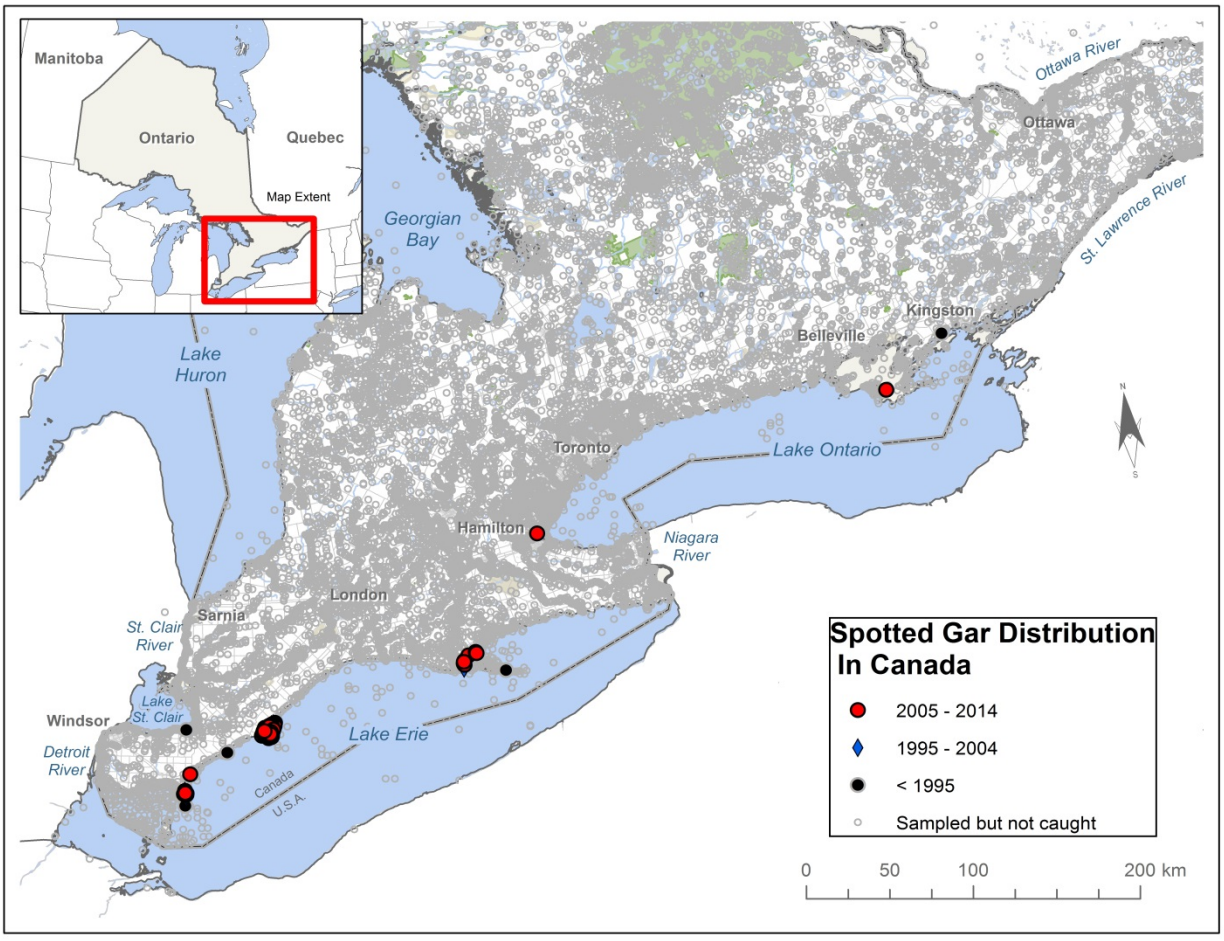

Figure 4. Distribution of Spotted Gar capture sites in Canada, including all sites where sampling has been conducted without capturing the species. Many individual captures overlap in the Lake Erie sites.

A single specimen was captured in 1962 in Lake St. Clair near the mouth of the Thames River. Subsequent sampling in the Thames River area and the Hamilton Harbour watershed has failed to confirm the presence of a population of Spotted Gar in these areas (Glass and Mandrak 2014). It is unclear whether the specimen collected in Muddy Creek, just east of Point Pelee, represents a separate population, or a single transient individual. Based on its highly disjunct nature, the upper St. Lawrence record is likely the result of an introduction. There are two records of Spotted Gar from the Sydenham River, both collected in 1975. One record was based on a metalarval fish (38 mm TL) that was subsequently determined to likely be a Longnose Gar by a larval fish expert (Darrel Snyder, Colorado State University Larval Fish Laboratory) (COSEWIC 2005). The other record lacked a voucher specimen. Subsequent sampling (most recently, boat electrofishing, hoopnetting and seining in 2002, 2003, 2010; N.E. Mandrak, unpubl. data) in the vicinity of these two original records has failed to find any additional specimens; therefore, both of the original records from the Sydenham River are deemed questionable. There have been many additional reports of Spotted Gar elsewhere in southwestern Ontario, but subsequent examinations of voucher specimens, when they were available, re-identified the specimens as Longnose Gar. If voucher specimens were not available for examination, the reports were regarded as suspect and excluded from this report.

First Nations communities are located within the distribution range of the Spotted Gar, but information from community members was not available for inclusion in the status report.

Extent of Occurrence and Area of Occupancy

Systematic sampling has been conducted at known sites of Spotted Gar populations (Figure 4), confirming the current extent of occurrence (Glass *et al.* 2011, 2012; Glass 2012). In addition, single confirmed specimens have been collected from two sites in Lake Ontario (East Lake in 2007, Hamilton Harbour in 2010); however, subsequent extensive, targeted sampling failed to detect any additional specimens in those areas (DFO, unpubl. data; Glass and Mandrak 2014). Therefore, reproducing populations in Lake Ontario have not been confirmed. In 2011, a single specimen was also collected from Muddy Creek, a tributary of Lake Erie, in close proximity to Point Pelee (DFO unpubl. data). It is unknown whether this specimen represents a separate population or a single transient individual from Point Pelee. Environmental DNA (eDNA) sampling conducted in 2012 showed positive detections of Spotted Gar in Jeanette's Creek, a tributary of the Thames River, near Lake St. Clair (Boothroyd 2013), and in Cootes Paradise, upstream of Hamilton Harbour in 2013 (Glass and Mandrak 2014). Subsequent targeted sampling using traditional methods in the spring of 2013 in the Thames River / Jeanette's Creek, and in Cootes Paradise in 2014 failed to collect any additional specimens (Glass and Mandrak 2014).

Extent of occurrence was estimated to be 20,989 km^2 before 2005, 2,462 km^2 in the period 1995 to 2004, and 13,930 km^2 in the period 2005 – 2014 (Figure 5). Area of occupancy was estimated to be 72 km^2 in the period prior to 2005, 36 km^2 in the period 1995 – 2004 and 112 km^2 in the most recent 10-year period 2005 – 2014 (Figure 6). The changes in area of occupancy and extent of occurrence are strongly influenced by the inclusion of two individuals collected before 1995 (Lake St. Clair in 1962, and upper St. Lawrence River in 1985), resulting in the largest extent of occurrence (Figure 5). Limited sampling in the 1995 – 2004 time period and no further captures in Lake St. Clair and upper St. Lawrence River resulted in a decline in calculated extent of occurrence in this time period. The capture of a single individual in East Lake (Lake Ontario) in the 2005 – 2014 time period, combined with increased sampling effort, led to an increase in the reported EOO and IAO in the most recent time period. Consequently, the changes in EOO and IAO across the three time periods reflect variable sampling effort and the inclusion (or not) of individuals from areas thought not to contain self-sustaining populations. The most recent estimates are thought to be the most accurate.

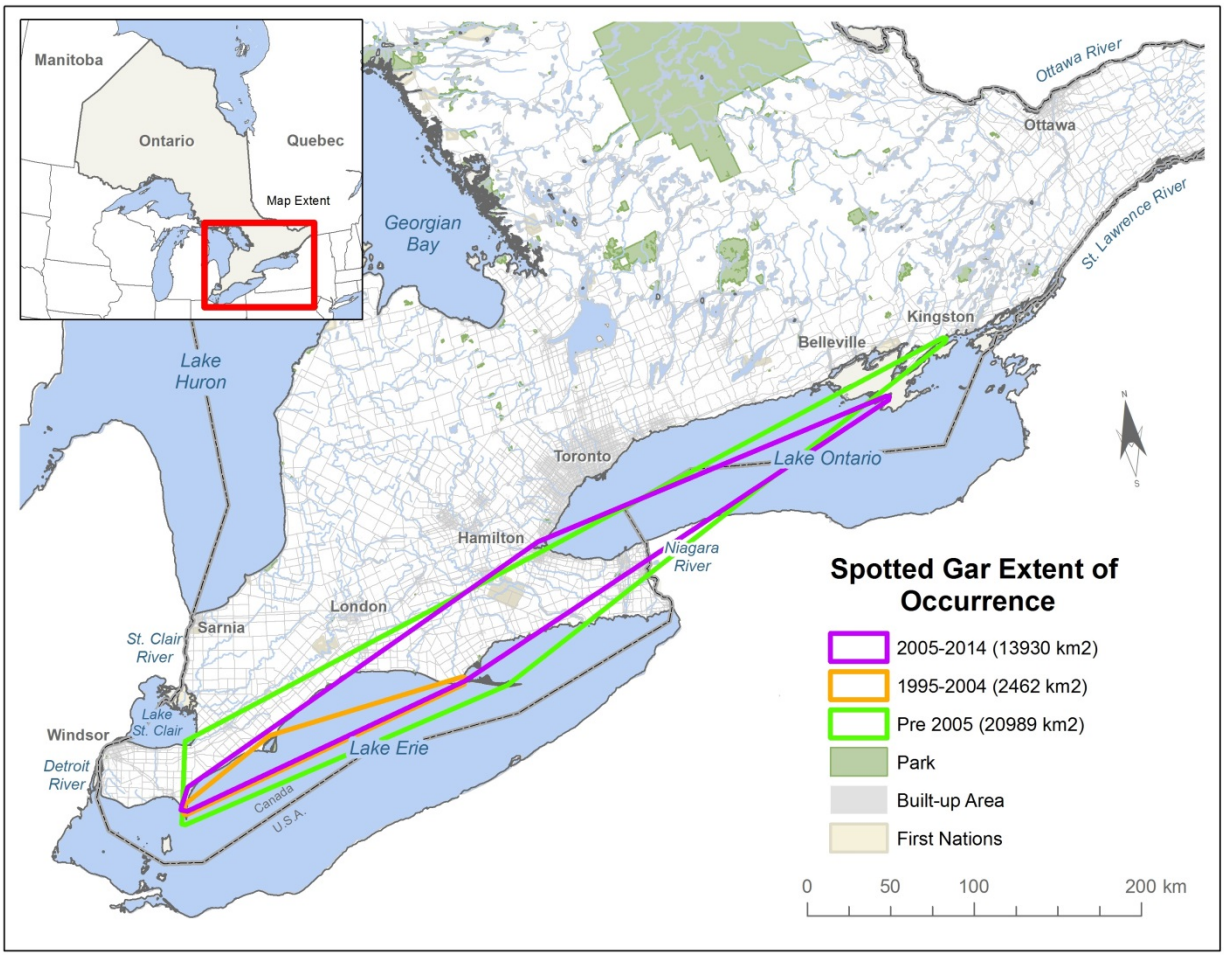

Figure 5. Extent of occurrence of Spotted Gar in Canada.

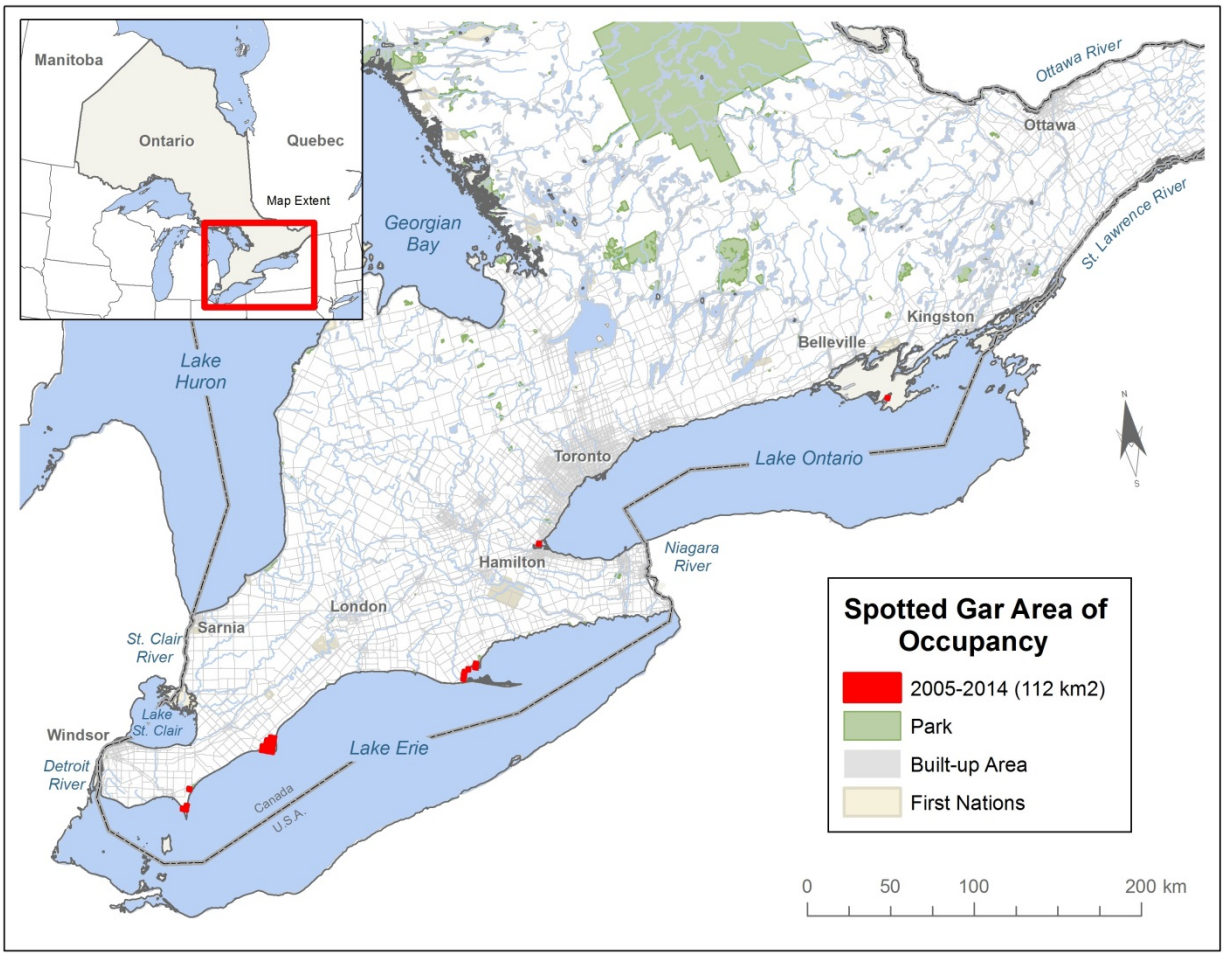

Figure 6. Area of occupancy of Spotted Gar in Canada in the time period 2005 – 2014.

Search Effort

Targeted sampling for Spotted Gar has been conducted, using techniques that have been shown to be effective in capturing this species, in all of the areas where Spotted Gar are known to occur in Canada (Glass *et al.* 2011, 2012; Glass 2012). Additional surveys have been conducted in suspected sites in Hamilton Harbour, Cootes Paradise, Thames River / Jeanette's Creek (Glass and Mandrak 2014), and East Lake (DFO unpubl. data). The majority of targeted sampling has been conducted using fine-mesh fyke nets set in shallow vegetated waters during the spring spawning season; thus, adults make up the bulk of recorded captures in Canada. Extensive non-targeted sampling has also been conducted throughout southern Ontario including that as part of the ongoing DFO Species at Risk research, Asian carp (e.g., *Hypophthalmichthys* spp.) monitoring programs (DFO unpubl. data, see Figure 4.), index monitoring and trawling of the Bay of Quinte by the Lake Ontario Management Unit (Ontario Ministry of Natural Resources and Forestry 2015). Sampling surveys using eDNA have also been conducted in the Thames River / Jeanette's Creek, Hamilton Harbour, Cootes Paradise, and the tributaries of Rondeau Bay (Glass and

Mandrak 2014). The Spotted Gar has been searched for and successfully captured in Canada through several sampling methods including fyke nets, seine nets, and boat electrofishing (see Appendix 1).

HABITAT

Habitat Requirements

Adult Spotted Gar prefer quiet, vegetated, shallow (0-5 m) clear waters of lakes and rivers (Carlander 1969; Scott and Crossman 1998; Lee *et al.* 1980; Lane *et al.* 1996a; Page and Burr 2011; Snedden *et al.* 1999; Coker *et al.* 2001; Cudmore-Vokey and Minns 2002). The adults are generally found over silt and clay (but often sand) substrates (Lane *et al.* 1996a). Snedden *et al.* (1999) described the Spotted Gar habitat in Louisiana, noting that submerged branches, fallen trees or log complexes provided diurnal resting cover, while adults in Rondeau Bay used mixed stands of submerged macrophytes as cover (Glass *et al.* 2012). The structurally complex shallow water habitat preferred by the Spotted Gar is probably related to its stealth and ambush foraging behaviour. Vegetation around which Spotted Gar were found in Oklahoma included primarily *Polygonum*, *Potamogeton*, *Myriophyllum*, and *Justicia* (Tyler and Granger 1984), while individuals in Rondeau Bay were found around mixed stands of vegetation including *Potomogeton, Ceratophyllum, Myriophyllum,* and *Vallisneria* species (Glass *et al.* 2012). Ostrand *et al.* (2004) found that Spotted Gar foraging success declined with increasing vegetation density for some prey species (e.g., Bluegill (*Lepomis macrochirus*), but not Fathead Minnow (*Pimephales promelas*)).

Nursery habitat consists of the top metre of water in the spring (1-2 m in fall) over sand, silt, or clay substrate. Areas of dense submergent and emergent vegetation are preferred (Simon and Wallus 1989; Lane *et al.* 1996b; Cudmore-Vokey and Minns 2002). A study of the juvenile habitat use in Rondeau Bay found water depths less than 0.5 m with moderate levels of turbidity (50 – 149 NTU) preferred in summer. Water temperature in excess of 23.5^{o}C was preferred by juvenile Spotted Gar and individuals were often found in areas with a mix of submerged and emergent vegetation (Glass and Mandrak 2014).

Spawning habitat consists of shallow water (0-1 m) with aquatic vegetation, brush or debris (Lee *et al.* 1980; Lane *et al.* 1996c; Scott and Crossman 1998) in quiet areas (Simon and Wallus 1989) such as flooded riparian areas (Snedden *et al.* 1999). Agricultural drains tributary to Rondeau Bay were also used for spawning and nursery habitat (Glass and Mandrak 2014). Laboratory experiments indicate that increasing turbidity levels negatively affect hatching success and juvenile survival (Gray *et al.* 2012).

Habitat Trends

Although long-term data on habitat trends in the localities where Spotted Gar are found in Canada are scarce, habitat modification and vegetation removal remain threats to the species, particularly in Rondeau Bay (Bouvier and Mandrak 2010). Nutrient loading and increased turbidity due to human activities is also prevalent in the habitats where Spotted Gar are found (Bouvier and Mandrak 2010) and may reduce the feeding ability of Spotted Gar, a visual predator.

An invasive plant, the European Common Reed (*Phragmites australis australis*) forms dense monotypic stands, that can virtually eliminate aquatic habitat, and it outcompetes native plant species (Gilbert and Locke 2007). The reed increased in abundance greatly in the 1990s and 2000s in Lake Erie wetlands (Wilkox *et al.* 2003; Badzinski *et al.* 2008). The European Common Reed is found in high abundance in Lake Erie wetlands and is not only reducing the native plant diversity but, in high density stands, has reduced the amount of available aquatic habitat in some areas, and foraging success of Spotted Gar on some prey species. Dense stands of European Common Reed at the mouth of agricultural drains tributary to Rondeau Bay may also impede upstream movement of Spotted Gar (D. Balint pers. comm. 2013) into drains used for spawning by adults and feeding by juveniles (Glass and Mandrak 2014).

BIOLOGY

Life Cycle and Reproduction

Spotted Gar in Canada are 3 years old at onset of maturity and approximately 515 mm in length (Glass *et al.* 2011). Love (2002) described sexual dimorphism in Spotted Gar from southern Louisiana. Females had longer bodies and snouts than males. This difference in length between the sexes was attributed to reproductive investment. Females have larger gonads than males per unit of body mass as they are extremely fecund (e.g., the number of eggs in southern US populations may exceed 10,000; Love 2004). The large snout of females may enable greater foraging success, possibly indicating that nutritional requirements are greater for females (Love 2002).

The known maximum age of Spotted Gar is 18 years and maximum length and weight are 1120 mm and 2700 g, respectively (Coker *et al.* 2001). In Canada, the known maximum age is 10 years and maximum length and weight are 761 mm (total length) and 1940 g (Glass *et al.* 2011). Studies on the growth rate of young Spotted Gar from Oklahoma suggested a growth rate of 1.7 mm (1 g) per day during July and August (Carlander 1969). Young Spotted Gar reach a length of 250 mm after the first year of life (Pflieger 1975). Females grow larger and have faster growth rates than males of the same age (Love 2002; Glass *et al.* 2011).

Increasing photoperiod and water temperatures at 15°C initiated spring spawning in Louisiana (Snedden *et al.* 1999), with the most intense spawning occurring mid-May in Oklahoma (Tyler and Granger 1984). Cudmore-Vokey and Minns (2002) reported spawning temperature to range from 21°C to 26°C. Targeted collection of spawning individuals in Rondeau Bay showed that Spotted Gar began spawning-related movements into shallow nearshore waters when temperature reached 15°C, and peaked at 21°C, during the months of May and June (Glass *et al.* 2012).

Tyler and Granger (1984) described the spawning behaviour of Spotted Gar in Oklahoma. One large female, closely accompanied by three to five much smaller males, swam slowly through densely vegetated areas. The female deposited her eggs as she jerked and thrashed in the shallows. The demersal, adhesive, oval (approximately 2.5 mm in diameter) eggs (Simon and Wallus 1989) are formed in masses held together by a clear gelatinous substance and are attached to aquatic vegetation (Scott and Crossman 1998; Coker *et al.* 2001). The eggs hatch within a week (Cudmore-Vokey and Minns 2002). Spawning was observed in Rondeau Bay in a mixed macrophyte bed containing *Myriophyllum* and *Ceratophyllum* species (Glass *et al.* 2012), as well as among emergent vegetation in an agricultural drain tributary to Rondeau Bay (Glass and Mandrak 2014).

An adhesive organ on their snout, oval-shaped pigmented eyes, and an ovoid and elongated yolk sac characterize recently hatched gars (Simon and Wallus 1989). Spotted Gar larvae are darkly pigmented sub-dermally on the dorsum (Simon and Wallus 1989). Although capable of swimming, they often remain hanging vertically, relatively inactive, attached to underwater structures by their adhesive snout. The yolk sacs are absorbed at lengths greater than 17.6 mm and the Spotted Gars then become more dispersed and begin to feed (Simon and Wallus 1989).

Physiology and Adaptability

The preferred temperature of Spotted Gar has been reported as 16°C (Coker *et al.* 2001). A tracking study conducted in Rondeau Bay found that Spotted Gar preferred the warmest water temperatures (>26°C), likely indicating the preferred summer feeding temperature (Glass *et al.* 2012).

The Spotted Gar possesses a vascularized physostomous gas bladder (i.e., open to the alimentary canal) and can breathe air (Scott and Crossman 1998). As a result of their ability to breathe air, Spotted Gar are physiologically well adapted to heavily vegetated ecosystems and can exploit seasonally hypoxic (dissolved oxygen concentrations of less than 2 mg/L) habitats that typically exclude other piscivores (Snedden *et al.* 1999).

Dispersal and Migration

A movement study in Louisiana demonstrated that Spotted Gar have low rates of movement in the winter months (15.1 m/h), followed by increased rate of movement during the spring flood pulse (40.1 m/h), at which time they move to flooded areas to spawn (Snedden *et al.* 1999). As flood waters recede, movement rates decline and individuals established distinct home ranges that they inhabited throughout the summer months (Snedden *et al.* 1999). Tracking of Spotted Gar in Rondeau Bay showed that this species migrates to shallow, nearshore areas in the spring, likely for spawning. Once spawning was finished and the summer progressed, Spotted Gar moved offshore and set up distinct home ranges in areas of abundant macrophyte growth (Glass *et al.* 2012). The distance offshore that Spotted Gar inhabited in Rondeau Bay was much greater than the distance offshore of the majority of movements by individuals in Louisiana (Snedden *et al.* 1999; Glass *et al.* 2012).

Population genetic analyses indicate a low level of connectivity and gene flow between the three Lake Erie (Canadian) populations of Spotted Gar (Glass *et al.* 2015; *see* **Population Spatial Structure and Variability).** These population genetic data suggest that considerable gene flow occurs from Point Pelee to Rondeau Bay, but that limited gene flow occurs from Rondeau Bay and Point Pelee to Long Point Bay (Glass *et al.* 2015).

Interspecific Interactions

Gars are among the most abundant piscivores in structurally complex shallow water habitats in the southern United States suggesting that they are key components of the food web (Snedden *et al.* 1999). The Spotted Gar is primarily a piscivorous ambush predator, but does consume crayfishes and aquatic insects (Carlander 1969; Tyler and Granger 1984; Scott and Crossman 1998; Snedden *et al.* 1999; Coker *et al.* 2001). Fish species consumed vary with studies and seem to indicate that Spotted Gar feed on the most vulnerable or most available prey items (Dugas *et al.*1976). Dugas *et al.* (1976) indicated that Spotted Gar in Louisiana primarily consumed small, non-game species and did not pose as much of a threat to game fishes as previously thought. Sampling of stomach contents in Rondeau Bay specimens, through gastric lavage, indicated that the most common prey items are Central Mudminnow (*Umbra limi*) and juvenile centrarchids (W.R. Glass unpubl. data). Feeding intensity varies throughout the day, with most feeding activity occurring in the early morning and, secondarily, at night (Carlander 1969; Snedden *et al.* 1999) around complex structures where prey items would be found. Laboratory studies indicate that feeding success of Spotted Gar is dependent on vegetation density, with the highest rate of capture of Bluegill occurring at low density (50 stems / m^2) and decreasing success as stem density increased (Ostrand *et al.* 2004).

Spotted Gar use asymmetrical movements of muscles on either side of the head to manipulate fish after capture so that the prey can be swallowed head first (Lauder and Norton 1980). This allows prey to be swallowed more successfully despite the relatively small opening of the buccal cavity and the direction of the scale rows on the prey.

The eggs of Spotted Gar were considered to be toxic to invertebrates, such as crayfish, and possibly vertebrates (Scott and Crossman 1998); however, Ostrand *et al.* (1996) found that Green Sunfish (*Lepomis cyanellus*) and Channel Catfish (*Ictalurus punctatus*) fed eggs of Spotted Gar showed no evidence of ill effects. Therefore, the ichthyotoxin of gar eggs may not act as a protective mechanism from fish predators (Ostrand *et al.* 1996). Fishes fed eggs of Spotted Gar, however, showed the least amount of weight gain compared to those fed eggs of other gar species. Crayfishes fed eggs of Spotted Gar showed lower levels of mortality (38%) than crayfishes that consumed eggs of Alligator Gar (*Atroctosteus spatula*) and Longnose Gar (Burns *et al.* 1981).

The Spotted Gar is present in Point Pelee National Park where the Longnose Gar is absent. Although Spotted Gar are present in Long Point and Rondeau bays where Longnose Gar are present, they are absent from the many suitable habitats in southwestern Ontario where Longnose Gar are abundant (N.E. Mandrak, unpubl. data). Spotted Gar are much more abundant in Rondeau Bay than Longnose Gar, while Longnose Gar are more abundant in Long Point Bay (W.R. Glass, unpubl. data). Further study is required to determine if this observation is the result of interspecific interactions or other factors.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Before 2007, fewer than 55 specimens of Spotted Gar had been collected in Canada (20 at Point Pelee, 27 in Rondeau Bay, two in Long Point Bay, two in Big Creek wetland (Long Point Bay), one in Lake St. Clair, and one in upper St. Lawrence River); therefore, it was not possible to identify population sizes and trends. Nineteen individuals were captured in Point Pelee National Park in 2002 and 2003, and 11 were large enough to be PIT-tagged (COSEWIC 2005). None of the tagged individuals were recaptured in subsequent sampling.

The fishes of Big Creek, Long Point Bay, and Rondeau Bay have been extensively sampled, primarily by seining, with few Spotted Gar captured. Prior to the first report in the Big Creek wetland in 2004, the wetland was sampled in four years (1979, 1983, 1984, 1985) by the Canadian Museum of Nature (CMN) and Wilfrid Laurier University (Royal Ontario Museum (ROM) unpubl. data). In 2003, Spotted Gar were not collected at the same Big Creek site sampled using the same effort and gear (N.E. Mandrak, unpubl. data). Long Point Bay has been sampled in 19 different years since 1928 by CMN, Ontario Ministry of Natural Resources (OMNR) and ROM (ROM unpubl. data). In 2004, it was not collected in Long Point Bay at 30 sites intensively sampled by boat electrofishing (>1000 sec/500 m site) (N.E. Mandrak unpubl. data). Before the first report in Rondeau Bay in 1955, the bay was sampled in 10 different years since 1921 by the CMN and ROM (Royal Ontario Museum unpubl. data). In the summer of 2004, intensive boat electrofishing (>1000 sec/500 m site, i.e., more than 15 minutes surveying a 500 m stretch at each site) captured eight Spotted Gar at three of eight sites sampled

Targeted sampling effort by DFO and the University of Windsor to detect Spotted Gar has greatly increased beginning in 2007 (Appendix 1). Sampling conducted in Rondeau Bay in 2007, using fine-mesh fyke nets resulted in the capture of 210 adult Spotted Gar. The species was detected in 37 of the 128 nets set. Similar success in capturing Spotted Gar in Rondeau Bay was observed in 2008 and 2009. In 2008, 173 Spotted Gar were captured in 125 fyke net sets, and 99 Spotted Gar were captured in 78 fyke net sets in 2009 (Glass 2012). Sampling in Point Pelee in 2008 using fine mesh fyke nets resulted in 93 adult individuals captured, with six recaptures in 16 fyke net sets (Glass *et al.* 2012). Targeted sampling in Long Point Bay using the same method and gear that was employed in Rondeau Bay and Point Pelee was much less successful in detecting the species. In 2010, 129 fyke net sets were conducted in Long Point Bay, including areas in the Crown Marsh and Big Creek National Wildlife Area. These net sets resulted in the capture of six individuals (Glass 2012). A survey to determine the habitat use by juvenile Spotted Gar was also undertaken in Rondeau Bay and Long Point Bay. The sampling in Rondeau Bay was conducted using Quatrefoil light traps, mamou floating trawl, and 10 m bag seine. The light traps (21 sets) and floating trawl (18 transects, 50 m in length) were unsuccessful at detecting juvenile Spotted Gar. The 10 m bag seine was successful in capturing juvenile Spotted Gar, resulting in the collection of eight juvenile individuals. The juveniles were collected at 6 of the 36 sites where single replicate seine hauls were conducted (Glass and Mandrak 2014). The juvenile survey in Long Point Bay consisted of triplicate seine hauls at 24 sites, for a total of 72 seine hauls approximately 10 to 15 m in length. The juvenile survey in Long Point Bay was unsuccessful in detecting Spotted Gar (Glass and Mandrak 2014).

Sampling was also conducted in areas where Spotted Gar had previously been reported (Appendix 1). Fine-mesh fyke nets were employed in East Lake in 2008. This sampling included 48 fyke net sets and did not detect Spotted Gar (DFO unpubl. data). Similarly, Hamilton Harbour was sampled using fyke nets in 2011. In this survey, 19 net sets were conducted at 14 sites, resulting in no captures of Spotted Gar (Glass and Mandrak 2014). Additionally, traditional sampling methods were employed in two sites where eDNA sampling resulted in positive detections of Spotted Gar: Thames River - Jeanette's Creek, and Cootes Paradise. In 2013, 36 fyke net sets were conducted in the Thames River - Jeanette's Creek in the vicinity of the positive eDNA detections reported by Boothroyd (2013) and failed to detect Spotted Gar; however, over 400 Longnose Gar were captured in this survey (DFO, unpubl. data). A positive detection based on eDNA sampling in Cootes Paradise in 2013 (Glass and Mandrak 2014) was followed by fyke net sampling during the spring of 2014. A total of 36 sets were conducted in Cootes Paradise, but resulted in no detections of Spotted Gar (Appendix 1).

Other monitoring studies have been conducted in areas known to contain Spotted Gar in the time period from 2007 to 2014. These monitoring activities have resulted in several records of Spotted Gar capture, including three individuals from Turkey Point marsh in Long Point Bay caught by OMNRF Lake Erie Management Unit staff in 2009. The records from the marsh at Turkey Point are the first from this site, and photo vouchers of these individuals were verified by the report writers (see Appendix 1 for all known sampling areas of Spotted Gar occurrence and targeted sampling in areas of suspected occurrence).

Abundance

A mark-recapture population estimate was produced for the Point Pelee site by Glass *et al.* (2012). The Spotted Gar population at Point Pelee was estimated to be 483 mature adults with 95% confidence intervals of 433 – 519 individuals. Based on the abundance estimate from Point Pelee, and by assuming similar population density and extrapolating to the size of available habitat in Rondeau Bay, the Spotted Gar population of Rondeau Bay was estimated to be 8,121 mature adults (95% C.I. 7,281 – 8,278) (Glass *et al.* 2012). The size of the Long Point Bay population has not been estimated due to the limited number of individuals captured from this site; only 21 individuals have been confirmed from Long Point Bay (DFO, unpubl. data), including the recently reported individuals from the marsh at Turkey Point.

The current status of populations in the Bay of Quinte and Lake St. Clair is unknown but, based on recent sampling (Bay of Quinte, 1988-2003; Lake St. Clair, 2002-2004) of suitable habitat (DFO, unpubl. data) and index monitoring (Bay of Quinte) by the Lake Ontario Management Unit (Ontario Ministry of Natural Resources 2015), they are presumed to be extirpated, if they were ever established at all.

The Canadian populations are separated by large distances; however, the available habitat patches in all three confirmed locations are larger than the minimum viable population area proposed by Young and Koops (2010).

Fluctuations and Trends

Because there are no long-term monitoring data for the Canadian populations and population estimates have only recently been produced, it is not possible to determine fluctuations and trends for this species in Canada. Recent findings based on population genetic structure can, however, provide some insight. The Long Point Bay population appears to be a sink, receiving immigrants from each of the other Lake Erie populations (Glass *et al.* 2015). This finding, along with the lack of juvenile captures during targeted sampling in 2014, suggests that the Long Point Bay population is not viable in the long term (Glass and Mandrak 2014). Estimates of the effective number of breeders (N_b), a statistic related to the effective population size (Waples 2005), for all but one of the genetically distinct populations in Canada are small, i.e., < ~50 (N_b = 26.9, 37.8, 50.1, 58.8, 61.4, 567.5; Glass *et al.* 2015); thus, some of these populations may be susceptible to negative effects due to inbreeding depression (Glass *et al.* 2015). The population genetic structure at the Rondeau Bay site, however, appears to be stable over time (Glass *et al.* 2015).

Rescue Effect

The populations of Spotted Gar in Canada are disjunct and separated by large distances of unsuitable habitat, so movement between populations is likely a rare occurrence. Population genetic analyses, using microsatellite DNA allele frequencies, suggest that there is limited gene flow among the Canadian populations (Glass *et al.* 2015; see **Population Spatial Structure and Variability).** Point Pelee shows considerable genetic isolation from the other populations due to its physical separation from the rest of Lake Erie (Glass *et al.* 2015). Periodic breaches to the barrier beach at Point Pelee (Surette 2006) allow export of individuals to the other areas of Lake Erie (Glass *et al.* 2015). Population genetic analyses also suggest that the Canadian populations of Spotted Gar are distinct from populations in the southern United States (Glass *et al.* 2015); thus, immigration from potential source populations in the southern core of the species' range is likely not occurring. The closest populations outside Canada are also at risk. The species is listed as Endangered in Ohio and Pennsylvania, and Special Concern in Michigan; thus, these populations are not likely to provide large numbers of potential migrants. Therefore, a rescue effect is unlikely.

THREATS AND LIMITING FACTORS

Given that Canada constitutes the northern range limit of the Spotted Gar (Figure 3), temperature, specifically low water temperatures, likely limits the distribution of Spotted Gar in Canada. Its Canadian distribution, however, may expand under some climate warming scenarios (Mandrak 1989, see also below).

Several threats to the Spotted Gar in Canada are present throughout the species' Canadian range. The greatest threats to Spotted Gar in Canada are related to natural system modifications including pollution from agricultural and municipal sources, loss of wetland habitat, vegetation removal, and invasive species. Threats to the persistence and recovery of Spotted Gar in Canada are discussed below, in order of perceived impact to the species (Table 1) as described in Bouvier and Mandrak (2010). The International Union for the Conservation of Nature (IUCN) Threats Assessment Calculator returned a calculated threat assessment of "Medium to High" (Appendix 2), with pollution and drain cleaning related to agriculture representing the greatest threats to the species.

Table 1. Threat status for Spotted Gar populations in Canada. Information from Bouvier and Mandrak (2010). Threat categorization is the result of analysis of threat likelihood and threat impact, based on expert opinion during the recovery potential assessment process.

	Point Pelee	Rondeau Bay	Long Point Bay
Habitat modification	High*	High	Low
Aquatic vegetation removal			
Mechanical	Low	High	Low
Chemical		High	Low
Turbidity and sediment loading	Low	High	High
Nutrient loading	Low	High	High
Exotic species	Medium	Medium	Medium
Incidental harvest	Low	Low	Low

*Habitat modification has occurred historically in Point Pelee; however, further modification is not presently taking place.

Invasive Species and Natural System Modification

Loss of the preferred habitat of Spotted Gar is one of the greatest threats to the species in Canada. Spotted Gar inhabit shallow, vegetated waters, particularly areas with mixed stands of macrophytes (Glass *et al.* 2012). These vegetated areas are used for feeding and cover, although excessive density of vegetation has been shown to reduce the feeding efficiency of Spotted Gar in laboratory trials with some prey species (Ostrand *et al.* 2004). Shallow wetland areas with emergent vegetation are also used for spawning by this species (Scott and Crossman 1998). Loss of habitat for Spotted Gar has resulted from a combination of invasive species, native vegetation replacement and removal, and human disturbance.

Invasive aquatic macrophytes have a negative effect on the shallow wetland habitat that Spotted Gar use in Canada. The invasive European Common Reed forms dense monotypic stands and it outcompetes native plant species (Gilbert and Locke 2007). The European Common Reed is found in high abundance in Lake Erie wetlands and the establishment of the European Common Reed in Long Point Bay and Rondeau Bay has drastically altered and reduced the amount of potential nearshore habitat available for Spotted Gar (Gilbert and Locke 2007; Badzinski *et al.* 2008). Badzinski *et al.* (2008) demonstrated that the abundance and distribution of the European Common Reed has increased dramatically in Long Point Bay compared to a survey conducted in 1999. Specifically, the area of coverage in the Big Creek marsh has increased from 3 ha in 1999 to 76 ha in 2006, an annual increase of 48% (Badzinski *et al.* 2008). Observations in the Crown Marsh area of Long Point Bay mirrored those from the Big Creek marsh, where coverage by the European Common Reed increased from 8 ha in 1999 to 48 ha in 2006, an annual increase of 27.8% (Badzinski *et al.* 2008). Dense stands of the European Common Reed at the mouth of agricultural drains tributary to Rondeau Bay may also impede upstream movement of Spotted Gar (D. Balint, pers. comm. 2013) into drains used for spawning by adults and feeding by juveniles (Glass and Mandrak 2014).

Another invasive macrophyte that is abundant in areas where Spotted Gar is found in Canada is Eurasian Water-milfoil (*Myriophyllum spicatum*). This species may form dense, single species mats and outcompete native aquatic vegetation causing a loss of native plant diversity and abundance (Boylen *et al.* 1999). Eurasian Water-milfoil is highly abundant in Rondeau Bay, dominating the submerged macrophyte community in the western and central to northern sections of the bay (Gilbert *et al.* 2007). These dense stands also create pockets of stagnant water at the surface, which leads to increased water temperature and a decrease in dissolved oxygen concentration (Lyons 1989). Spotted Gar were shown to prefer macrophytes in mixed species beds (Glass *et al.* 2012); thus, the proliferation of monotypic beds of Eurasian Milfoil may lead to a decrease in the quantity and quality of habitat available for Spotted Gar. A similar conclusion was made for the co-distributed Warmouth (*Lepomis gulosus*, COSEWIC 2015). Common Carp (*Cyprinus carpio*) is an invasive fish species that is prevalent throughout the Canadian range of Spotted Gar. Common Carp, which was intentionally stocked into Lake Erie starting in 1922 (Corkum 2010), has been shown to cause severe impacts to wetland habitat through its feeding behaviour, which uproots aquatic vegetation and increases turbidity levels (Lougheed *et al.* 1998, 2004). It was determined that the feeding behaviour of Common Carp resulted in re-suspension of bottom sediments was a primary cause of increased eutrophication in Point Pelee (Mayer *et al.* 1999). This loss of aquatic vegetation and increase in turbidity and eutrophication may negatively affect Spotted Gar. The Grass Carp (*Ctenopharyngodon idella*) is an invasive herbivore that is known to have significant negative impacts on aquatic vegetation (Wittmann *et al.* 2014) and has been found to likely be reproducing in the Sandusky River which flows into Sandusky Bay on the American side of Lake Erie (Chapman *et al.* 2013). If this species expands into Canadian waters it has the potential to have a significant impact on the habitat of Spotted Gar.

Rondeau Bay has undergone dramatic loss of wetland habitat, particularly along the western shore, where habitat has been lost due to ditching, diking, infilling, and hardening of shoreline for agricultural and residential purposes (Gilbert *et al.* 2007). Historically, wetlands bordered the entirety of Rondeau Bay in a single contiguous system (Gilbert and Locke 2007). This wetland habitat on the northwest shore was reduced to scattered patches totalling approximately 740 ha by the 1980s, further reduced to just 107 ha by 2006 (Gilbert and Locke 2007).

Similar loss of wetland habitat has occurred in the Point Pelee area, with an estimated loss of 60% of the wetland habitat connecting Point Pelee with Hillman Marsh (Dobbie *et al.* 2006). This habitat loss was due to the diking and draining of wetlands for agricultural use in the late 1800s to mid-1900s (Dobbie *et al.* 2006) and has resulted in a decline in the available habitat for Spotted Gar in this area.

Native Vegetation Removal

Removal of native aquatic vegetation for transportation, recreation, and residential purposes is a threat to Spotted Gar in Canada. Spotted Gar relies on aquatic vegetation for cover, feeding, and spawning habitat, and removal of this vegetation represents a direct loss of suitable habitat for the species. Removal of vegetation by chemical methods may also increase biological oxygen demand (Gilbert *et al.* 2007), potentially reducing the amount of forage species available in the community.

Both large- and small-scale vegetation removal has occurred in Rondeau Bay. These vegetation removals have been implemented to increase ease of recreational navigation in the bay (Gilbert *et al.* 2007). Ongoing vegetation removals through physical and chemical means are common in Rondeau Bay (Gilbert *et al.* 2007).

Mechanical vegetation removal has also occurred at Point Pelee and Long Point Bay. There has been no known chemical vegetation removal at Point Pelee and the practice has become infrequent at Long Point Bay, where mechanical removal is the preferred method of macrophyte control.

Pollution

Increases in nutrient loading (nitrogen and phosphorus) due to agricultural and municipal runoff can have serious negative effects on the habitat of Spotted Gar in Canada. This increase in nutrient loading can lead to algal blooms, which then cause a decrease in dissolved oxygen content when the algae die and begin to decompose (Gilbert *et al.* 2007). Although the Spotted Gar is capable of withstanding low dissolved oxygen levels due to its ability to breathe atmospheric oxygen, a decrease in dissolved oxygen can have negative consequences on the overall aquatic community, and lessen the availability of forage species on which the Spotted Gar rely. Nutrient loading is a primary threat that is recognized for all three of the locations where Spotted Gar is found in Canada (Essex-Erie Recovery Team 2008).

Water samples taken from Rondeau Bay tributaries in 2005 and 2006 showed elevated levels of phosphorus compared to provincial water quality guidelines (Gilbert *et al.* 2007). These increased nutrient levels were recorded at all sites sampled in 2005, and all but one of the tributaries sampled in 2006 (Gilbert *et al.* 2007). These nutrient inputs are thought to be the primary cause of algal blooms in Rondeau Bay (Gilbert *et al.* 2007). In 2005, a large algal bloom which covered 70% of Rondeau Bay, with a thickness up to 1 m, resulted in decreased dissolved oxygen concentrations throughout the bay (Gilbert *et al.* 2007). When the algal bloom died off during the winter months, large areas of the northern and eastern shorelines were covered in a thick layer of organic material that resulted in anoxic conditions (Gilbert *et al.* 2007).

Increased sediment loading is another result of municipal and agricultural runoff. Increased turbidity levels have been shown to affect hatching success of Spotted Gar in laboratory trials (Gray *et al.* 2012). Increased turbidity levels and siltation attributed to poor agricultural and land use practices have been reported for each of the sites of Spotted Gar occurrence in Canada. Siltation is an ongoing problem in Rondeau Bay, particularly during storm events (Gilbert *et al.* 2007). Turbidity levels are also elevated in the spring, coinciding with spring runoff and rain events (W.R. Glass, pers. obs.) and tend to decline over the course of the summer as macrophyte coverage increases. Altered sediment transport in Lake Erie has led to erosion of the barrier beach at Point Pelee, resulting in more frequent breach events (Dobbie *et al.* 2006; Surette 2006) and decreased water quality in the marsh (V. Mackay, pers. comm. in Bouvier and Mandrak 2010). Long Point Bay experiences a visible sediment plume in the area of the mouth of Big Creek and silt accumulation is evident on the aquatic vegetation in this area (W.R. Glass, pers. obs.). This sediment plume increases in size and density after rainfall events and during spring runoff.

Human Intrusion and Disturbance

Although several research studies have been conducted on this species in Canada, there is likely little overall harm caused by research and handling. Studies are designed to minimize harm and permits must be issued through the federal *Species at Risk Act*, provincial *Endangered Species Act*, and Parks Canada or provincial parks sampling permits are required to collect this species in Canadian waters. Permits typically stipulate that all individuals must be released unharmed.

Residential and Commercial Development

Part of the habitat and surrounding area is protected at each of the sites where Spotted Gar is found in Canada. At Point Pelee, the marsh falls within Point Pelee National Park but a large portion of the surrounding area outside the park has been diked and drained for agricultural use. At Long Point Bay, a portion of the area in which Spotted Gar is found is protected by the Big Creek National Wildlife Area and Long Point Provincial Park, although other portions of the bay, particularly the northwest shore, are subject to development of marinas and residences. Rondeau Bay is partially protected by Rondeau Provincial Park but a large portion of the western shoreline has been subjected to agricultural and residential development. Only a small portion (approximately 3.3%) of the natural tree cover in the Rondeau Bay watershed remains (Gilbert and Locke 2007). Residential development in the watershed can lead to hardening of shorelines, removal of native shoreline vegetation, increased nutrient inputs from lawn and garden chemicals, and increased pressure for aquatic vegetation removal to facilitate access to waterfront properties. Agricultural development often leads to increased nutrient runoff and increased erosion and siltation.

Biological Resource Use

It is illegal in Canada to intentionally capture Spotted Gar through recreational angling and any incidental captures must be immediately released unharmed. Although there is a large recreational fishery in both Rondeau Bay and Long Point Bay, incidental capture of Spotted Gar is unlikely due to the species' bony snout making hook penetration difficult. Incidental harvest in the Long Point Bay commercial fishery is a potential threat. A single Spotted Gar was confirmed captured in the commercial fishery in 2009 (Gislason *et al.* 2010) and another was found illegally for sale at a live food fish market in Toronto, Ontario (Glass 2012). The magnitude of the threat that incidental capture poses is uncertain, but likely very low. In the 2009 study of commercial fishing in Long Point Bay, a total of 368 hoop net sets were documented with just a single individual Spotted Gar captured (Gislason *et al.* 2010).

Climate Change and Severe Weather

Under climate change, impacts such as increases in water and air temperature, decreases in water levels, shortening of the duration of ice cover, increases in the frequency of extreme weather events, emergence of diseases, and shifts in predator-prey dynamics may negatively impact native fishes (Lemmen and Warren 2004). Based on an evaluation of the effects of climate change on the habitat of coastal wetland fishes in the Great Lakes, Doka *et al.* (2006) concluded that Spotted Gar populations in such habitats were highly vulnerable to climate change due to loss of wetland habitat caused by decreasing water levels, which also tend to promote expansion of invasive plants such as the European Common Reed in Lake Erie wetlands (Wilkox *et al.* 2003).

Number of Locations

The most serious plausible threat to Spotted Gar that could rapidly affect all individuals at a location is habitat loss as a result of rapid spread of invasive European Common Reed. Known populations of European Common Reed exist in three Lake Erie wetlands: Point Pelee, Rondeau Bay, Long Point Bay. Individual specimens have been collected in East Lake and Hamilton Harbour of Lake Ontario, and Muddy Creek of the Lake Erie watershed; however, subsequent sampling failed to confirm populations at these sites. Given the distance between these populations and the spatial and temporal scale of the European Common Reed threat, each population should be considered to occupy a separate location. Therefore, there would be three (Point Pelee, Rondeau Bay, Long Point Bay) to six (if the three sites with single records of Spotted Gar are included) locations.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

The Spotted Gar was assessed as Special Concern in 1983 by COSEWIC and this status was reconfirmed in 1994. The status was re- examined and assessed as Threatened in 2000 (COSEWIC 2014). It is currently listed as a Threatened wildlife species on Schedule 1 of the Canadian *Species at Risk Act* (SARA), which makes it an offence to kill, harm, capture, take, possess, collect, buy, sell or trade a Spotted Gar, as well as damage or destroy its residence. Spotted Gar is also listed as Threatened under the Ontario *Endangered Species Act* (2007), which prohibits the killing, harming, harassing, or taking of a living member of the species. The provincial *Act* also prohibits damage or destruction of the species' habitat.

The collection of freshwater fishes for scientific research purposes is regulated by the *Fish and Wildlife Conservation Act* and requires a scientific collector's permit to be issued by the Ontario Ministry of Natural Resources and Forestry. Permits for scientific collection are also required under the federal SARA and the provincial *Endangered Species Act*. The federal *Fisheries Act* previously provided protection to all fishes and their habitat in Canada. Recent changes have limited protection to fishes that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery. Distributional overlap does exist between Spotted Gar and several recreational and commercial fishes; thus, the habitat used by Spotted Gar should receive protection under the revised *Fisheries Act*.

Populations found in Long Point Provincial Park, Big Creek National Wildlife Area, Rondeau Provincial Park, and Point Pelee National Park are partially protected by their occurrence in these protected areas.

Non-Legal Status and Ranks

Spotted Gar is considered secure (S5) or apparently secure (S4) in much of its range, particularly in the southern United States (Texas, Louisiana, Mississippi, Alabama, Tennessee, Missouri, Oklahoma, Arkansas, Indiana, and Kentucky, Table 2). At the margins of its United States distribution, however, including the Great Lakes basin, it is ranked S2S3 (Michigan, Illinois), S1S2 (Kansas), and S1 (Pennsylvania, Ohio, and Georgia) (NatureServe 2014).

Table 2. Global, National and Subnational (State and Provincial) ranks and status for Spotted Gar (*Lepisosteus oculatus*) (NatureServe 2014).

Global	US National	Canadian National*	Subnational	
			US States	Ontario
G5*	N5*; Not found in TESS (USFWS database of Threatened and Endangered Species)	N1*; COSEWIC= Threatened	SX* = NM S1*= PA, OH S1S2*= KS S2S3*= IL, MI, GA S4* = OK, AR, IN, KY S5*= TX, LA, MS, AL, TN, MO SNR = FL	S1*; OMNR Status=Threatened

*G/S ranks: 1=critically imperilled; 2=imperilled; 3=vulnerable to extirpation or extinction; 4=apparently secure; 5=demonstrably widespread, abundant and secure; X = extirpated; NR = unranked, not yet assessed.

Habitat Protection and Ownership

In Canada, the Spotted Gar occurs in publicly owned waters, and co-occurs with several commercial and recreational fishery species. The habitat of these commercial and recreational fishery species is protected by the federal *Fisheries Act*. In addition, Spotted Gar is found in Point Pelee National Park, Rondeau Provincial Park, and Long Point Bay, which has both a provincial park and a national wildlife area. Therefore, its habitat receives additional protection afforded to national wildlife areas through the *Canada Wildlife Act*, and national and provincial parks through the *Canada National Parks Act* and Ontario *Provincial Parks Act*. The Spotted Gar is listed as Threatened in Schedule 1 of the federal SARA and therefore its critical habitat is protected (see Staton *et al.* 2012). The habitat of Spotted Gar is protected under the general habitat provisions of Ontario's *Endangered Species Act*.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Andrew Doolittle and Lynn Bouvier assisted with the preparation of the maps and calculation of area of occupancy and extent of occurrence. Kurt Oldenburg, OMNRF and Jan Ciborowski, University of Windsor, provided unpublished data and voucher photographs for identification. Lynn Bouvier gathered and provided information on sampling effort.

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The following people were contacted and a response was received: Rich Russel (Canadian Wildlife Service); Lynn Bouvier and Shelly Dunn (Fisheries and Oceans Canada); Patrick Nantel (Parks Canada); Vivian Brownell, Scott Reid, Tom McDougall, and Kurt Oldenburg (Ontario Ministry of Natural Resources and Forestry); Martina Furrer (Natural Heritage Information Centre); and Jan Ciborowski (University of Windsor).

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William R. Glass is a post-doctoral fellow with Fisheries and Oceans Canada in Burlington, Ontario. His research interests are the conservation of fish species at risk in Canada and the adaptations of range edge populations. Bill has extensively studied the Spotted Gar in Canada and has conducted research on the age and growth, home range and habitat use, and the population genetic structure of Spotted Gar in Canada.

Nicholas E. Mandrak is an associate professor in Biological Sciences at the University of Toronto Scarborough in Toronto, Ontario. His research interests are the biodiversity, biogeography and conservation of Canadian freshwater fishes. Nick has co-authored 36 COSEWIC reports and the ROM Field Guide to Ontario Fishes.

COLLECTIONS EXAMINED

E. Holm, ROM, verified identifications of specimens from Lake St. Clair and Bay of Quint**e**. W. Glass verified identifications of voucher photos from Long Point Bay (Turkey Point marsh, Big Creek marsh) provided by Ontario MNRF and University of Windsor and also performed much of the field sampling conducted in each of the three Canadian locations. N.E. Mandrak confirmed the identification of the Hamilton Harbour and Muddy Creek specimens.

Appendix 1. Summary of sampling effort conducted in areas where Spotted Gar is present and targeted sampling for Spotted Gar in areas where the species potentially exists. Gray cells indicate sampling effort that did not detect Spotted Gar.

Sampling effort for the Spotted Gar from 1913-2014.

Waterbody	n	Year	Sampling Effort	Reference
Point Pelee	1	1913 - 1982	-15 different years in this time period -mostly completed by seine	CMN, ROM, Point Pelee National Park (PPNP) staff [see Surette (2006) for complete details]
Point Pelee	0	1983	-hoop net set (<24 h x 39 sets)	G. Mouland, unpubl. data (received from J. Keitel, PPNP)
Point Pelee	0	1989	-seine net (5 days) -creel survey (unknown effort)	E. Holm and D. Boehm (ROM, unpubl. data) K. Janoki and G. Mouland (Surette 2006)
Point Pelee	0	1992	-creel survey (unknown effort)	T. Linke (Surette 2006)
Point Pelee	0	1993	-trap net (48 h set x 3 sites x 2 events) -seine (10 m x 5 hauls)	Dibble *et al.* (1995)
Point Pelee	0	1997	-seine (2 days) -plastic trap (5 days) -boat electrofisher (4.3 h)	E. Holm, D. Boehm and M. Ciuk (ROM, unpubl. data)
Point Pelee	0	2002	-boat electrofisher (4 sites)	N. Mandrak, unpubl. data
Point Pelee	0	2002	-hoop net (24 h sets x 5 sites) -trap net (24 h sets x 3 sites)	N. Mandrak, unpubl. data
Point Pelee	19	2002 – 2003	-seine (55 events) -minnow trap (80 events) -Windermere trap (80 events) -trap net (28 events) -hoop net (342 events)	Surette (2006)
Point Pelee	0	2003	-boat electrofisher (100 m x 18 sites) -fyke net (24 h set x 8 sites)	L. Bouvier, unpubl. data
Point Pelee	1	2004	-boat electrofisher (100 m x 18 sites x 2 events) -fyke net (24 h set x 8 sites x 2 events)	L. Bouvier, unpubl. data
Point Pelee	9	2005	-3 paired fyke nets (2 large and 1 small x 2 sites)	Razavi (2006)
Point Pelee	93	2009	-fyke net (24 h set x 16 sets)	Glass *et al.* (2015)
Long Point Bay	1	1928 -2003	- 18 years in this time period, unknown effort	OMNRF, ROM & CMN (ROM unpubl. data)
Big Creek Marsh	0	1979	-unknown effort	Canadian Museum of Nature & Wilfrid Laurier University (ROM unpubl. data)
Big Creek Marsh	1	1983 - 1985	-unknown effort	Canadian Museum of Nature & Wilfrid Laurier University (ROM unpubl. data)
Big Creek Marsh	0	2003	-boat electrofisher (50 m x 15 sites x 2 events) -fyke net (24 h sets x 4 sites x 2 events)	L. Bouvier, unpubl. data
Long Point Bay	1	2003	-boat electrofisher (50 m x 18 sites x 2 events) -fyke net (24 h sets x 4 sites x 2 events)	L. Bouvier, unpubl. data
Long Point Bay	0	2004	-boat electrofisher (50 m x 18 sites x 2 events) -fyke net (24 h sets x 4 sites x 2 events)	L. Bouvier, unpubl. data

Waterbody	n	Year	Sampling Effort	Reference
Long Point Bay	0	2004	-boat electrofisher [<1000 s (1 pass) x 47 sites; >1000 s (2 passes) x 10 sites)]	DFO, unpubl. data
Big Creek Marsh	2	2004	-boat electrofisher (50 m x 15 sites x 2 events) -fyke net (24 h set x 4 sites x 2 events)	L. Bouvier, unpubl. data
Big Creek Marsh	0	2005	-seine (2 hauls x 1 site)	DFO, unpubl. data
Long Point Bay	0	2005	-hoop net (24 h sets x 24 sites)	DFO, unpubl. data
Big Creek Marsh	0	2005	-hoop net (24 h set x 26 sites)	DFO, unpubl. data
Long Point Bay	0	2007	-hoop net (24 h sets x 58 sites) -seine (1 haul x 2 sites; 2 hauls x 9 sites; 3 hauls x 3 sites; 4 hauls x 1 site)	DFO, unpubl. data
Long Point Bay	0	2007	-seine (33 sites)	K. Oldenburg, OMNRF Lake Erie Management Unit (LEMU), unpubl. data
Long Point Bay	0	2007	-boat electrofisher (524-3860 s x 9 sites)	DFO, unpubl. data
Big Creek Marsh	0	2008	-boat electrofisher (422-843 s x 10 sites) -boat seine (1 haul x 3 sites; 3 hauls x 6 sites; 4 hauls x 1 site) -bag seine (3 hauls x 1 site)	DFO, unpubl. data
Crown Marsh	0	2008	-minnow traps (24 h x 9 sites) -seine (3 sites)	K. Oldenburg, OMNRF LEMU, unpubl. data
Turkey Point	2	2009	-minnow trap (24 h x 12 sites) -fyke net (22 sites)	K. Oldenburg, OMNRF LEMU, unpubl. data
Long Point Bay	1	2009	-hoop net (24 h set x 368 events)	Gislason *et al.* (2010)
Turkey Point	1	2009	-electrofisher (8 sites)	K. Oldenburg, OMNRF LEMU, unpubl. data
Long Point Bay	8	2010	-fyke net (24 h set x 129 sets)	Glass *et al.* (2015)
Big Creek	0	2011	-unknown effort	J. Wilson, LPCA, unpubl. data
Turkey Point	0	2011	-unknown effort	J. Wilson, LPCA, unpubl. data
Long Point Bay	3	2012	-hoop net (24 h set x 47 sites)	DFO, unpubl. data
Long Point Bay	0	2012	-bag seine (5 hauls x 60 sites x 2 events)	DFO, unpubl. data
Long Point Bay	0	2013	-bag seine (5 hauls X 34 sites)	DFO, unpubl. data
Long Point Bay	0	2013	-bag seine (3 hauls X 1 site) -boat electrofisher (1000 m x 2 sites; 800 m x 1 site; 400 m x 6 sites; 200 m x 2 sites) -trammel net (0.5-0.75 h x 3 sites)	DFO, unpubl. data
Long Point Bay	0	2013	-bag seine (5 hauls x 60 sites x 2 events)	DFO, unpubl. data
Long Point Bay	0	2013	-mini fyke net (24 h sets X 18 sites)	DFO, unpubl. data
Long Point Bay	0	2014	-bag seine (40 sites x 5 hauls)	DFO, unpubl. data
Big Creek	1	2014	-fyke net (6 overnight sets)	J. Ciborowski, University of Windsor, unpubl. data
Long Point Bay	0	2014	-bag seine (24 sites x 3 hauls per site)	Glass and Mandrak (2014)
Rondeau Bay	6	1921 – 1999	-unknown effort	CMN & ROM (ROM, unpubl. data)
Rondeau Bay	7	2002	-boat electrofisher (10 sites)	DFO, unpubl. data

Waterbody	n	Year	Sampling Effort	Reference
Rondeau Bay	4	2004	-boat electrofisher (>1000 s/500 m site x 10 sites) -hoop net (24 h set x 28 sites)	DFO, unpubl. data
Rondeau Bay	7	2005	-hoop net (24 h set x 24 sites)	DFO, unpubl. data
Rondeau Bay	0	2005	-bag seine (1 haul x 3 sites; 2 hauls x 5 sites; 3 hauls x 14 sites) -boat seine (1 haul x 5 sites)	DFO, unpubl. data
Rondeau Bay	210	2007	-fyke net (24 h set x 128 sets)	Glass *et al.* (2011)
Rondeau Bay	173	2008	-fyke net (24 h set x 126 sets)	Glass *et al.* (2015)
Rondeau Bay	99	2009	-fyke net (24 h set x 78 sets) -electrofishing (effort not recorded)	Glass *et al.* (2015)
Rondeau Bay	0	2009	-fyke net (unknown effort)	M. Belore, OMNR, LEMU, unpubl. data
Rondeau Bay and tributary drains	45	2013	-hoop net (24 h sets x 21 sites)	Glass and Mandrak (2014)
Rondeau Bay and tributary drains	9	2013	-bag seine (1 haul x 36 sites) -quatrefoil light trap (24 h sets x 21 sites) -pelagic trawl (100 m x 1 pass x 14 sites; 100 m x 3 passes x 1 site)	Glass and Mandrak (2014)
Rondeau Bay	8	2013	-mini fyke net (24 h sets x 14 sites) -boat electrofisher (4 x 100 m x 11 sites)	DFO, unpubl. data
Mill Creek (tributary of Rondeau Bay)	0	2013	-fyke net (4 sites)	J. Ciborowski, University of Windsor, unpubl. data
Rondeau Bay	0	2014	-trap net (24 h sets x 4) -fyke net (24 h sets x 4) -gill net (24 h sets x 7) -boat electrofishing (600 s x 22 sites)	DFO, unpubl. data
East Lake	0	2008	-fyke net (24 h sets x 48)	W. Glass unpubl. data
Hamilton Harbour	0	2011	-fyke net (24 h sets x 19)	Glass and Mandrak (2014)
Cootes Paradise	0	2014	-fyke net (24 h sets x 36)	Glass and Mandrak (2014)
Thames River / Jeanette's Creek	0	2013	-fyke net (24 h set x 37)	DFO unpubl. data

Appendix 2. The International Union for the Conservation of Nature Threats Assessment Calculator.

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Spotted Gar (*Lepisosteus oculatus*)
Element ID	**Elcode**
Date (Ctrl + ";" for today's date):	
Assessor(s):	teleconference 22 May 2015, Dwayne Lepitzki, Nick Mandrak, Scott Reid, Isabelle Duclos, Doug Watkinson
References:	draft COSEWIC status report

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	low range
A	Very High	0	0
B	High	0	0
C	Medium	2	0
D	Low	2	4
Calculated Overall Threat Impact:		High	Medium

Assigned Overall Threat Impact:	
Impact Adjustment Reasons:	
Overall Threat Comments	Overall high meaning 10-70% decline; however, suspected to be on the lower end of this range.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	There is currently a subdivision in the corner of Rondeau but no evidence of increase. Discussion in the past about removal of vegetation. Eighty individuals may be affected. Species can move though, ongoing. Most of development has already occurred. No projections for growth. Cottages but no plans for development of new cottages. This threat has occurred in the past. Negligible in the future.
1.2	Commercial & industrial areas						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism & recreation areas	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Removal of native vegetation for recreational navigation in the bay for boating lanes. Cut out boating channels 10m wide by the length of the bay. Towards the lower end of the scope. Use of herbicide as well as mechanical removal of vegetation.
2	Agriculture & aquaculture	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs)	Habitat modification and destruction, including removal of aquatic vegetation and loss of wetland habitat - Increased turbidity and nutrient loading due to agriculture and development
2.1	Annual & perennial non-timber crops	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs)	Areas for spawning but proportion of spawning that occurs in agricultural drains is unknown at this time. Possibility of increase in drainage infrastructure, but likely upstream and therefore little impact to Spotted Gar. Drain clearing is accounted for under this threat since its part of agricultural practices. Site fidelity is unknown and therefore difficult to quantify this threat. Less density dependence and decreased mortality but insufficient data to support year class failure.
2.2	Wood & pulp plantations						not applicable
2.3	Livestock farming & ranching						not applicable
2.4	Marine & freshwater aquaculture						not applicable
3	Energy production & mining						
3.1	Oil & gas drilling						not applicable
3.2	Mining & quarrying						not applicable
3.3	Renewable energy						not applicable
4	Transportation & service corridors						
4.1	Roads & railroads						not applicable
4.2	Utility & service lines						not applicable
4.3	Shipping lanes						Rondeau Bay has some boating but no ships. Accounted for under threat 1.3
4.4	Flight paths						not applicable
5	Biological resource use		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						not applicable
5.2	Gathering terrestrial plants						not applicable
5.3	Logging & wood harvesting						not applicable
5.4	Fishing & harvesting aquatic resources		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Ongoing threat from recreational fishery causing decline in recruitment via bycatch and incidental harvest. However, not intensive.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities						Recreational boating not directly impacting population size
6.2	War, civil unrest & military exercises						not applicable
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Incidental harm during scientific research minimal. Less than 1%
7	Natural system modifications	D	Low	Restricted - Small (1-30%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression						not applicable
7.2	Dams & water management/use						not applicable
7.3	Other ecosystem modifications	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	Some native aquatic vegetation removal is a problem at Rondeau Bay
8	Invasive & other problematic species & genes		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
8.1	Invasive non-native/alien species						Invasive species, such as Eurasian Milfoil (*Myriophyllum spicatum*), European Common Reed (*Phragmites australis australis*), and Grass Carp (*Ctenopharyngodon idella*) are important threats. *Phragmites* is a threat at Rondeau Bay, but not spreading at the same rate as Long Point Bay. It can get into areas greater than 2m depth. Phragmites will affect all of the spawning beds (10% of total population directly impacted). Impact on spawning beds would have an effect on the entire future population. Phragmites converts aquatic habitat into semi-aquatic habitat. Common Carp feeding behaviour known to have serious negative impacts by uprooting aquatic vegetation and increasing turbidity levels; however, threat from this is negligible to Spotted Gar. This threat has occurred mostly in the past due to introduction 100yrs ago. Milfoil outcompetes native plants that it preferred vegetation to the Gar as well as altering the pH and dissolved oxygen at Rondeau Bay which decreases water levels also. But the threat impact is in the past as well.
8.2	Problematic native species						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.3	Introduced genetic material		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Aquarium releases - Florida Gar as well as US traded aquarium specimens of Spotted Gar (locally adapted) could hybridize with Spotted Gar occurring very infrequently; however, long term impact is high.
9	Pollution	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
9.1	Household sewage & urban waste water		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Loading from household sewage treatment plant is ongoing but nutrients are likely from agricultural runoff (9.3). Septic systems in Rondeau affecting water quality. Nutrient loading is causing algal blooms in Lake Erie.
9.2	Industrial & military effluents						not applicable
9.3	Agricultural & forestry effluents	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Agricultural runoff and drainage affecting the quality of water and nutrient loading. Sediment loading from drains is also prevalent, but uncertain impact. This threat is historical. Although Gar can occur at low oxygen levels, their prey do not and therefore nutrient loading affects Gar indirectly. No supporting data. Gar are persisting despite exposure to this threat over several years; however, blooms did not occur at 100% coverage.
9.4	Garbage & solid waste						not applicable
9.5	Air-borne pollutants						not applicable
9.6	Excess energy						not applicable
10	Geological events						
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides						not applicable
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration						Variability in water level changes; decreasing. Climate change contributing to lowering water levels which facilitates *Phragmites* encroachment which further alters aquatic habitat to semi-aquatic. Phragmites accounted for in 7.3 for aquatic habitat conversion. However climate change affecting lower water levels accounted for here (11.1) since this relates to changes in available suitable habitat due to changes in water level as a result of climate change.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.2	Droughts						Prediction of lowered water levels from increased evaporation as a result of increased temperatures. Unknown anticipated decline from drought. Changes in precipitation and temperature changes or droughts are all interrelated and accounted for in 11.1.
11.3	Temperature extremes						not applicable
11.4	Storms & flooding						not applicable

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).