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Information in support of a Recovery Potential Assessment of Spotted Gar (*Lepisosteus oculatus)* in Canada

L'information a l'appui de l'évaluation du potentiel de rétablissement du lépisosteus tacheté (*Lepisosteus oculatus*) au Canada

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ABSTRACT

In April 1983, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Spotted Gar (*Lepisosteus oculatus*) be designated as a species of Special Concern. This status was re-assessed and confirmed in 1994. Spotted Gar status was re-assessed as Threatened in November 2000, which was confirmed in May 2005. The reason given for this designation was that Spotted Gar "…has a very limited range in Canada where it is only known from three coastal wetlands in Lake Erie. Although its distribution is likely limited by temperature, some of the shallow vegetated habitats that it requires for all life stages are subject to the impacts of siltation, dredging, filling, and aquatic vegetation removal and harbour improvements". Subsequent to the COSEWIC designation, Spotted Gar was listed on Schedule 1 of the *Species at Risk Act* (SARA) when the Act was proclaimed in June 2003. The Recovery Potential Assessment (RPA) provides information and scientific advice needed to fulfill various requirements of SARA including permitting activities that would otherwise violate SARA prohibitions and the development of recovery strategies. This Research Document describes the current state of knowledge on the biology, ecology, distribution, population trends, habitat requirements, and threats of Spotted Gar. Mitigation measures and alternative activities related to the identified threats, that can be used to protect the species, are also presented. The information contained in the RPA and this document may be used to inform the development of recovery documents and for assessing SARA Section 73 permits.

RÉSUMÉ

En avril 1983, le Comité sur la situation des espèces en péril au Canada (COSEPAC) a recommandé que le lépisosté tacheté (*Lepisosteus oculatus*) soit désigné espèce « préoccupante ». Cette désignation a été réévaluée et confirmée en 1994. Le lépisosté tacheté a été désigné comme étant une espèce « menacée » en novembre 2000, ce qui a été confirmé en mai 2005. La raison pour cette désignation était que « L'aire de répartition de cette espèce est très limitée au Canada, où on ne la trouve que dans trois zones humides côtières du lac Érié. La température constitue un facteur de limitation de sa répartition, certains habitats peu profonds où pousse de la végétation qui sont nécessaires à cette espèce à toutes les étapes de sa vie sont touchés par l'envasement, le dragage, le remblai et l'enlèvement de la végétation aquatique ainsi que les améliorations portuaires. » À la suite de la désignation du COSEPAC, le lépisosté tacheté a été ajouté à l'annexe 1 de la *Loi sur les espèces en péril* (LEP) lorsque la loi a été promulguée en juin 2003. L'évaluation du potentiel de rétablissement (EPR) fournit l'information et l'avis scientifique nécessaires pour se conformer aux exigences de la LEP, ce qui comprend le fait de permettre des activités qui seraient normalement contraires aux interdictions prévues dans la LEP et à l'élaboration de stratégies de rétablissement. Le présent document de recherche fournit une description de l'état actuel de la biologie, de l'écologie, de la distribution, des tendances de population, des besoins en matière d'habitat et des menaces relatives au lépisosté tacheté. Les mesures d'atténuation et les activités alternatives associées aux menaces déterminées qui peuvent être utilisées dans le but de protéger l'espèce sont également présentées. L'information contenue dans l'EPR et dans le présent document peut aussi guider la préparation des documents sur le rétablissement et l'évaluation des permis de l'article 73 de la LEP.

SPECIES INFORMATION

Scientific Name – *Lepisosteus oculatus* (Winchell, 1864)
Common Name – Spotted Gar
Current COSEWIC Status (Year of Designation) – Threatened (2005)
COSEWIC Reason for Designation[1] – "This species has a very limited range in Canada where it is only known from three coastal wetlands in Lake Erie. Although its distribution is likely limited by temperature, some of the shallow vegetated habitats that it requires for all life stages are subject to the impacts of siltation, dredging, filling, and aquatic vegetation removal and harbour improvements."
SARA Schedule – 1
Range in Canada – Ontario

BACKGROUND

The Spotted Gar (*Lepisosteus oculatus*) is very elongate with a long, slender, armoured body (Holm *et al*. 2009). The armoured body is covered in non-overlapping, bony ganoid scales making it easy to distinguish from other fish species. It is described as having a relatively broad snout with sharp teeth, and a short, deep caudal peduncle, followed by a rounded, heterocercal caudal fin (COSEWIC 2005). Body colouration can range from olive-green to brown above the lateral line with dark brown spots on the snout, head, body and fins (Holm *et al*. 2009).

The total length (TL) for this species typically ranges from 200-600 mm, while maximum age is thought to be 18 years (Coker *et al*. 2001; COSEWIC 2005). In Canada, the largest specimen recorded was 865 mm (TL) and was caught in Rondeau Bay in 2008 (B. Glass, unpubl. data). TL for Spotted Gar caught in Rondeau Bay from 2002-2009 ranged from 381 to 865 mm (n=929), while Spotted Gar caught in Point Pelee National Park from 2002-2009 (n=122) ranged in length from 133-718 mm (Razavi 2006; H. Surette, unpubl. data; B. Glass, unpubl. data; DFO, unpubl. data).

Spotted Gar has a very limited distribution in Canada with only seven confirmed locations, four of which are comprised of a single record. Adult Spotted Gar prefer quiet, highly-vegetated, shallow clear waters. Spawning and nursery habitat is generally characterized by densely vegetated areas. This appears to be a requirement for spawning as eggs, once fertilized, stick to the submerged plants prior to hatching (Holm *et al*. 2009). Water temperature associated with all Canadian Spotted Gar records ranged from 11.4 to 31.3°C, with an average temperature of 22.6°C (± 0.19 standard error). Spawning generally occurs when water temperatures are between 21-26°C (Holm *et al*. 2009).

Spotted Gar, a piscivorous ambush predator, is considered a key component to complex shallow wetland ecosystems (Snedden *et al*. 1999). Spotted Gar may also feed on crayfishes and aquatic insects (Scott and Crossman 1973; COSEWIC 2005). A preliminary stomach content analysis was completed on 43 Spotted Gar captured from Rondeau Bay (TL ranged from 416-734 mm; B. Glass, unpubl. data). This study indicated that Spotted Gar diet consisted almost exclusively of fishes. Specifically, centrarchids, cyprinids and Central Mudminnow (*Umbra limi*) were the most abundant (B. Glass, University of Windsor, pers. comm.).

[1] http://www.cosewic.gc.ca/eng

Spotted Gar is one of only two native gar species found in Canada, the other being Longnose Gar (*L. osseus*). It is important to note that there is a distributional overlap between these two species. Interestingly, Longnose Gar occur in all locations where Spotted Gar have been recorded, but the opposite does not hold true; Spotted Gar are absent from many suitable wetland habitats where Longnose Gar flourish. In comparison to Spotted Gar, Longnose Gar has a longer, narrower snout. A characteristic that may lead to confusion when comparing the two species is the presence of spots along the snout, head and body of the Longnose Gar. Both species are spotted and this should not be used as a characteristic in identification. Distinguishing between the species should be based on snout length and shape.

The non-native Florida Gar (*L. platyrhincus*) has been recorded in the Great Lakes basin in what is presumed to be the result of aquarium releases (COSEWIC 2005). Florida Gar is very similar in appearance to Spotted Gar but there is one key characteristic that can separate these two species. The Florida Gar lacks the bony translucent plates (scales) that can be found on the isthmus (between the gill openings) of Spotted Gar (Page and Burr 1991).

Primary sources of human-induced mortality and aggregate harm for Spotted Gar in Canada include habitat modification and destruction, vegetation removal, increases in nutrient loading, and increases in turbidity and sediment loadings resulting from agricultural and urban development. The presence of exotic species, such as Common Carp (*Cyprinus carpio*) and Eurasian milfoil (*Myriophyllum spicatum*) may be having a direct impact on Spotted Gar preferred habitat. Common Carp are well known to uproot submergent vegetation through foraging activities, while Eurasian milfoil can out-compete native submergent plant species and form dense vegetation mats creating unsuitable habitat for Spotted Gar. Incidental harvest through the baitfish and commercial fishing industries may also play a role in the decline of Spotted Gar, although limited information is currently available on the direct effect that these industries may have on Spotted Gar (Gislason *et al*. 2010).

A meeting of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1983 recommended that Spotted Gar be designated as a species of Special Concern. This status was re-assessed and confirmed in 1994. Spotted Gar status was re-assessed as Threatened in November 2000, which was confirmed in May 2005. The reason given for this designation was that the Spotted Gar "…has a very limited range in Canada where it is only known from three coastal wetlands in Lake Erie. Although its distribution is likely limited by temperature, some of the shallow vegetated habitats that it requires for all life stages are subject to the impacts of siltation, dredging, filling, and aquatic vegetation removal and harbour improvements". Subsequent to the COSEWIC designation, Spotted Gar was listed on Schedule 1 of the *Species at Risk Act* (SARA) when the Act was proclaimed in June 2003. A Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) to provide information and scientific advice needed to fulfill SARA requirements, including the development of recovery strategies and authorizations to carry out activities that would otherwise violate SARA (DFO 2007). This document provides background information on the Spotted Gar to inform the RPA.

CURRENT STATUS

In Canada, the current and historic distribution of Spotted Gar is limited to seven confirmed locations, four of which are comprised of a single individual (Figure 1). These locations include Lake St. Clair (single record); Point Pelee National Park; Rondeau Bay; Long Point Bay (including Big Creek Marsh, Long Point National Wildlife Area, and Long Point Inner Bay;

hereafter, referred to as Long Point Bay); Hamilton Harbour (single record), East Lake (single record; Prince Edward County); and North Channel (single record; eastern Lake Ontario). Historic records for this species exist for Lake St. Clair (1962; RMC21781), Long Point Inner Bay (1947; RMC13864), Point Pelee (1913; CMN580192), and Rondeau Bay (1947; RMC13864).

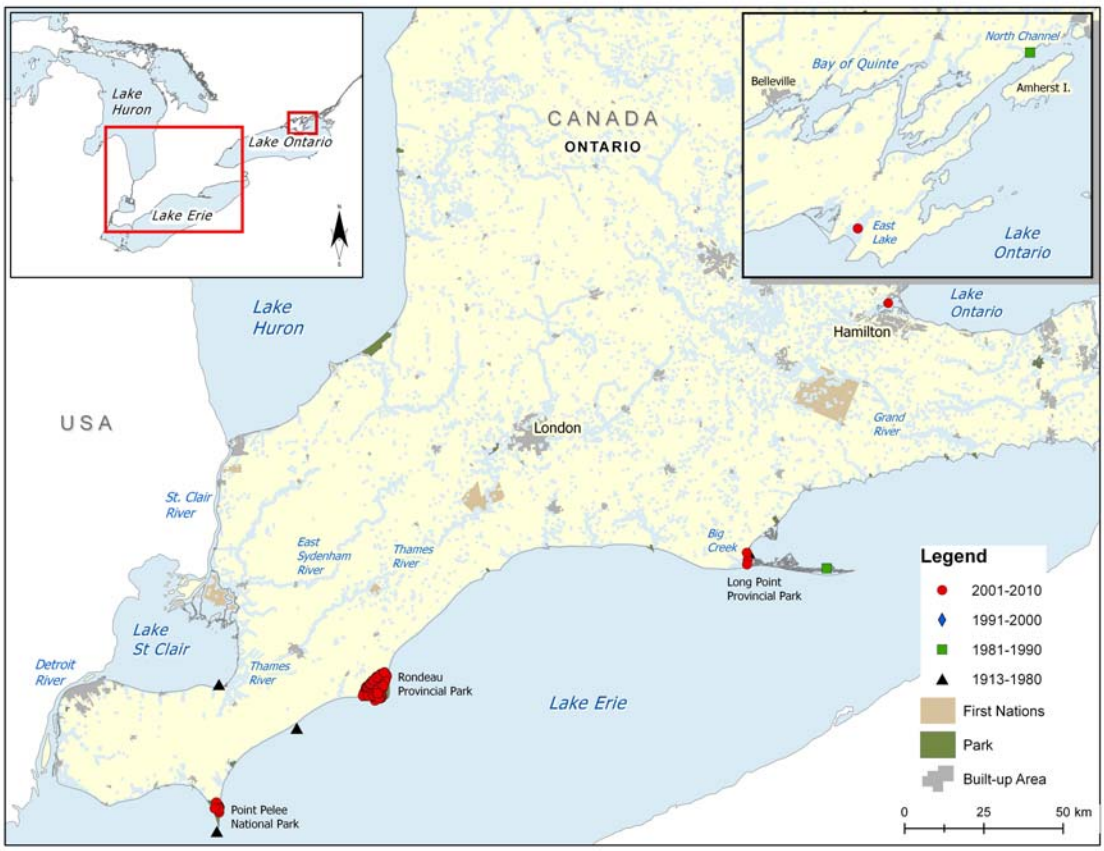

Figure 1. *Distribution of Spotted Gar in Canada.*

It is interesting to note that until 2002 there were only 19 Spotted Gar recorded in Canada, making the Spotted Gar one of the rarest fish species in Canada. Subsequent sampling from 2002 to 2010 yielded one recent record for Hamilton Harbour, 10 additional records from Long Point Bay, 122 records from Point Pelee National Park, and 930 records from Rondeau Bay (N.B. this does not take into account potential recaptures).

LAKE ST. CLAIR

A single specimen was captured from Lake St. Clair in 1962 (RMC21781). The narrative locality of this record indicated that it was captured 4 km west of the mouth of the Thames River. This voucher was questioned due to its isolated nature, and was verified to be accurate in 2004 (E. Holm, Royal Ontario Museum, pers. comm.). The south shore of Lake St. Clair has been recently sampled (2007-2008) by the Ontario Ministry of Natural Resources (OMNR) as part of their nearshore seining program. In addition, sampling was conducted in Lake St. Clair in 2002-2004 by DFO (unpubl. data), and in 2007 by Essex-Erie Conservation Authority (Nelson and Staton, in prep.). None of these studies yielded Spotted Gar captures.

POINT PELEE NATIONAL PARK

A single historic Spotted Gar record was recorded from Point Pelee National Park. Although the original record indicated that the Spotted Gar was found in “Lake Erie at Point Pelee” (as indicated in Figure 1), it is thought that this record should occur within the park where habitat is more consistent with known Spotted Gar preferred habitat. Spotted Gar was not recorded again in Point Pelee National Park until 2002. Sampling with various gear types (fyke net, bag seine, trap net, Windermere trap, and boat electrofishing) from 2002-2009 yielded 122 Spotted Gar (Razavi 2006; Surette 2006; L. Bouvier, unpubl. data, B. Glass, unpubl. data).

RONDEAU BAY

The first record of Spotted Gar in Rondeau Bay dates back to 1947 when one individual was recorded from a commercial fisherman. From 1947 to 2000, only 10 additional Spotted Gar were recorded from this area. From 2002-2005, DFO conducted targeted sampling for Spotted Gar in Rondeau Bay that resulted in the capture of 50 additional individuals (Mandrak *et al*. 2006). The success in Spotted Gar capture led to a graduate student project that began in 2007 and is currently ongoing. Through this project, 477 individuals were captured via fyke net, and an additional 69 individuals were captured via boat electrofisher. Radio tracking of marked individuals in 2007 resulted in 212 marked locations (B. Glass, University of Windsor, pers. comm.). The success of this research program leads us to believe that a healthy Spotted Gar population is present in Rondeau Bay.

LAKE ERIE

Two historic Spotted Gar records were noted from Lake Erie proper (1925; RMC0712 and 1938; RMC10498) that were captured by commercial fisherman and listed as being captured at Merlin Road and Port Crewe. It is thought that these individuals may have been caught closer to the mouth of Rondeau Bay but the catch was not processed until much later, making the narrative locality inaccurate. For this reason, these two records have been excluded from the Spotted Gar distribution map (Figure 1), and will not be discussed in terms of Population Status.

LONG POINT BAY

For the purposes of discussing Population Status, Long Point Bay will include Long Point Inner Bay, Big Creek Marsh and Long Point National Wildlife Area (NWA). A total of 14 Spotted Gar have been recorded from Long Point Bay; 11 from Long Point Inner Bay (n=1 in 1947; n=1 in 2003; n=1 in 2009; n=8 in 2010), one from the NWA (1984), and two from Big Creek Marsh (2004). The recent capture of eight Spotted Gar provides evidence that there is a reproducing population present at Long Point Bay (B. Glass, unpubl. data).

Substantial sampling has occurred throughout Long Point Bay over the last ten years with minimal success in capturing Spotted Gar. Targeted Spotted Gar sampling occurred at Long Point NWA from 2002 to 2003 (Marson *et al*. 2007); 61 sites were sampled using an electrofisher, while an additional 24 sites were sampled with fyke nets (Marson *et al*. 2007). This study yielded no Spotted Gar captures. Sampling of the Big Creek Marsh in 2003 and 2004 included boat electrofishing of 138 transects and 13 fyke net sets yielding only two Spotted Gar captures (L. Bouvier, unpubl. data). Although slightly removed from Spotted Gar area of occurrence at Long Point, Turkey Point Marsh provides highly vegetated habitat similar to Spotted Gar preferred habitat. In 2007, a total of 50 sites were sampled in the Turkey Point

Marsh area; 11 sites were seined, 30 sites were sampled with hoop nets, and 9 sites were sampled with a boat electrofisher (Nelson and Staton, in prep.). This study did not record any Spotted Gar captures. In addition, extensive targeted sampling of Spotted Gar preferred habitat was completed throughout Long Point Inner Bay in 2009, which yielded no Spotted Gar captures (B. Glass, unpubl. data).

HAMILTON HARBOUR

Although there have been reports of Spotted Gar in Hamilton Harbour in the past, these reports had not been substantiated with a voucher specimen until August 2010 when a single Spotted Gar (510 mm TL) was captured in a trapnet (OMNR, unpubl. data). This voucher specimen provides evidence that a reproducing population of Spotted Gar may exists in Hamilton Harbour. Further sampling is necessary to confirm the presence of a population as well as to determine population size.

EAST LAKE

The first, and only, Spotted Gar ever recorded from East Lake was captured by a commercial fisherman in 2007. Intensive sampling using gear known to be effective at capturing Spotted Gar was completed in East Lake in June and July 2008 to verify the presence of a reproducing population in this area (B. Glass, unpubl. data). No additional Spotted Gar were captured from this area during this targeted sampling. In addition, there has been extensive commercial hoop netting in East Lake and there is only a single recorded Spotted Gar capture, providing good evidence that a reproducing population does not currently exist for East Lake (J. Hoyle, OMNR, pers. comm.).

NORTH CHANNEL

A single Spotted Gar was captured from North Channel (north of Amherst Island, eastern Lake Ontario) in 1985, making this record the first verified record from the Lake Ontario drainage. In addition to extensive commercial fishing that is known to occur in this area, substantial sampling has been done in the area of the North Channel as part of the OMNR netting program; none of which have yielded the capture of Spotted Gar (J. Hoyle, OMNR, pers. comm.). The presence of a reproducing population is believed to be highly unlikely due to the disjunct location where this Spotted Gar was recorded, and the extensive sampling that has occurred in this area. It is speculated that this individual may be the result of an introduction.

POPULATION STATUS

To assess the Population Status of Spotted Gar populations in Canada, each population was ranked in terms of its abundance (Relative Abundance Index) and trajectory (Population Trajectory) (Table 1).

The Relative Abundance Index was assigned as Extirpated, Low, Medium, High or Unknown. Sampling parameters considered included gear used, area sampled, sampling effort, and whether the study was targeting Spotted Gar. The number of individual Spotted Gar caught during each sampling period was then considered when assigning the Relative Abundance Index. The Relative Abundance Index is a relative parameter in that the values assigned to each population are relative to the most abundant population. In the case of Spotted Gar, all populations were assigned an Abundance Index relative to the Rondeau Bay population. Catch-

data from populations sampled using different gear types were assumed to be comparable when assigning the Relative Abundance Index.

The Population Trajectory was assessed as Decreasing, Stable, Increasing, or Unknown for each population based on the best available knowledge about the current trajectory of the population. The number of individuals caught over time for each population was considered. Trends over time were classified as Increasing (an increase in abundance over time), Decreasing (a decrease in abundance over time) and Stable (no change in abundance over time). If insufficient information was available to inform the Population Trajectory, the population was listed as Unknown.

Table 1. *Relative Abundance Index and Population Trajectory of each Spotted Gar population in Canada. Certainty has been associated with the Relative Abundance Index and Population Trajectory rankings and is listed as: 1=quantitative analysis; 2=CPUE or standardized sampling; 3=expert opinion.*

Population	Relative Abundance Index	Certainty	Population Trajectory	Certainty
Lake St. Clair	Extirpated	2	-	3
Point Pelee	Medium	2	Stable	2
Rondeau Bay	High	1	Stable	1
Long Point Bay	Low	2	Unknown	2
Hamilton Harbour	Unknown	3	Unknown	3
East Lake	Unknown	2	Unknown	2
North Channel	Unknown	3	Unknown	3

The Relative Abundance Index and Population Trajectory values were then combined in the Population Status matrix (Table 2) to determine the Population Status for each population. Population Status was subsequently ranked as Poor, Fair, Good, Unknown or Not applicable (Table 3).

Table 2. *The Population Status Matrix combines the Relative Abundance Index and Population Trajectory rankings to establish the Population Status for each Spotted Gar population in Canada. The resulting Population Status has been categorized as Extirpated, Poor, Fair, Good, or Unknown.*

		Population Trajectory			
		Increasing	**Stable**	**Decreasing**	**Unknown**
Relative Abundance Index	**Low**	Poor	Poor	Poor	Poor
	Medium	Fair	Fair	Poor	Poor
	High	Good	Good	Fair	Fair
	Unknown	Unknown	Unknown	Unknown	Unknown
	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated

Table 3. *Population Status of all Spotted Gar populations in Canada, resulting from an analysis of both the Relative Abundance Index and Population Trajectory. Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Relative Abundance Index, or Population Trajectory).*

Population	Population Status	Certainty
Lake St. Clair	Extirpated	3
Point Pelee	Fair	2
Rondeau Bay	Good	1
Long Point Bay	Poor	2
Hamilton Harbour	Unknown	3
East Lake	Unknown	2
North Channel	Unknown	3

HABITAT REQUIREMENTS

SPAWNING AND NURSERY

Spotted Gar are spring spawners, spawning in May and June when water temperature is between 21 and 26°C (Holm *et al*. 2009). Shoreward movement to spawning grounds was observed in Rondeau Bay when water temperature approached 18°C (B. Glass, pers. obs.). Spawning occurs in shallow (0-1 m water depth), heavily vegetated wetlands, marshes or flooded riparian areas (Goodyear *et al*. 1982; Snedden *et al*. 1999; Cudmore-Vokey and Minns 2002). Spotted Gar were observed spawning in Rondeau Bay over vegetation beds comprised of milfoil (*Myriophyllum* sp.) and curly pondweed (*Potamogeton crispus*) (B. Glass, pers. comm.). Spawning generally involves several males and a single, larger, female (Holm *et al*. 2009). Sperm and eggs are deposited over weed beds and the adhesive eggs become fixed to the submergent macrophytes and debris where they remain until hatch (approximately one to two weeks) (Alfaro *et al*. 2008; Holm *et al*. 2009). Nursery habitat is characterized by dense submergent and emergent vegetation (Simon and Wallus 1989).

YOUNG-OF-THE-YEAR (YOY) & JUVENILE

Young-of-the-year (YOY) remain in the spawning area until their yolk sac is fully absorbed, which occurs at approximately 17 mm TL or greater (Staton *et al*. 2010). Once absorbed, the YOY disperse and began to feed (Simon and Wallus 1989). Limited data on both YOY and juvenile Spotted Gar habitat requirements necessitate the inference of these requirements from other, well-studied, life stages.

ADULT

Spotted Gar are generally found in quiet backwaters, or wetland areas. All adult Spotted Gar in Canada were caught in shallow water with water depth ranging between 0.23 and 2.6 m, with the exception of the Spotted Gar caught in the North Channel (eastern Lake Ontario) that was caught in water 7.5 m deep. Dense vegetation appears to be a mandatory component of adult Spotted Gar preferred habitat. Preferred substrate appears to be a mixture of silt, clay and sand (Lane *et al*. 1996). Water temperature at Canadian capture sites ranged from 11.4 to 31.3°C with the average being 22.6°C (± 0.19).

Preliminary results from a Spotted Gar tracking study that occurred in Rondeau Bay in 2007 indicated that of 212 tracking locations marked, 192 (or 92%) had macrophytes present, and that complex macrophytes dominated the samples. Collection sites were mainly composed of Eurasian milfoil, hornwort (*Ceratophyllum* spp.), stonewort (*Chara* spp.), various pondweed species (*Potamogeton* spp.) and water celery (*Vallisneria* spp.) (B. Glass, unpubl. data). Other commonly recorded species include water lily (*Nuphar* spp.), cattails (*Typha* spp.), and Canadian waterweed (*Elodea canadensis*). This dense vegetation requirement is thought to be related to the foraging behaviour of the Spotted Gar in that the structurally complex habitat provides camouflage to the ambush predator and reduces the visibility of its potential prey (Coen *et al*. 1981; Ostrand *et al*. 2004).

An extensive movement and dispersal study was completed on Spotted Gar in the lower Atchafalaya River basin (Louisiana, USA) (Snedden *et al*. 1999). In this study, which focused on habitat use and home range behaviour of 37 Spotted Gar, they observed that large home ranges were established in spring (265.1 ha), while home range size was substantially decreased in the summer (10.5 ha) and fall-winter (6.2 ha). Snedden *et al*. (1999) also noted that Spotted Gar median movement rates were highest in the spring (130.1 m/d) (movements/day) and were reduced considerably in the summer (34.6 m/d) and fall-winter (35.8 m/d). Seasonal differences in home range size and movement rate were attributed to Spotted Gar migration to nearshore spawning grounds in the spring (Snedden *et al*. 1999).

RESIDENCE

Residence is defined in SARA as a, “dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating”. Residence is interpreted by DFO as being constructed by the organism. In the context of the above narrative description of habitat requirements during YOY, juvenile and adult life stages, Spotted Gar do not construct residences during their life cycle.

THREATS

A wide variety of threats negatively impact Spotted Gar across its range. Our knowledge of threat impacts on Spotted Gar populations is limited to general documentation, as there is a paucity of threat-specific cause and effect information in the literature. The greatest threats to the survival and persistence of Spotted Gar in Canada are related to habitat modification and destruction, aquatic vegetation removal, increases in nutrient loading, and increases in turbidity and sediment loadings resulting from agricultural and urban development. The presence of pristine, highly-vegetated systems in southwestern Ontario, where Spotted Gar thrive, is very limited. Locations where Spotted Gar currently exist are widely separated, potentially isolating these populations, and limiting the possibility of migration between locations. Lesser threats that may be affecting the survival of Spotted Gar include the introduction of exotic species, and incidental harvest through the baitfish and commercial fishing industries, although the current knowledge on the level of impact that these threats may have on Spotted Gar is very limited.

It is important to note that these threats may not always act independently on Spotted Gar populations; rather, one threat may directly affect another, or the interaction between two threats may introduce an interaction effect on Spotted Gar populations. It is quite difficult to quantify these interactions; therefore, each threat is discussed independently.

HABITAT MODIFICATIONS

Physical loss of Spotted Gar habitat can occur through habitat modifications, resulting from urban, agricultural and shoreline development. Modifications can result in shoreline hardening, wetland drainage and infilling, dock, marina and break wall construction, and the creation of artificial dykes, groynes, and jetties. These modifications are altering or destroying the quiet, densely-vegetated nearshore areas that are vital to all Spotted Gar life stages. In addition, these modifications may lead to increased siltation compounding the direct effects of modifications on Spotted Gar survival.

Rondeau Bay has undergone extensive modifications over the past few decades. Much of the wetland habitat found along the western shoreline has been lost due to ditching, diking, infilling and hardening of shoreline for both agricultural and residential purposes (Gilbert *et al*. 2007). There remains a very small percentage of natural forest cover (~3.3%) throughout the watershed as numerous fields are cropped to the edge of the bay (Gilbert and Locke 2007). It is estimated that approximately 70% of the western shoreline has been reclaimed for agricultural or residential use (Gilbert and Locke 2007). Expanding land for farming or habitation has come at the expense of nearshore wetlands (Gilbert and Locke 2007). Historically, wetlands bordered the entire shore of Rondeau Bay and appeared as a large contiguous system (Gilbert and Locke 2007). The first wetland assessment of Rondeau Bay was conducted in the early 1980s and, by this time, the wetland complex on the northwest shore had been reduced to isolated patches totalling approximately 740 ha, with a further reduction in 2006 to approximately 107 ha (Gilbert *et al*. 2007).

A similar situation exists in the Point Pelee area where it is estimated that close to 60% of the historic wetlands that once connected Point Pelee to Hillman Marsh were drained and diked during late 1800s to mid-1900s for agricultural purposes (Dobbie *et al*. 2006). This loss of historic wetlands has undoubtedly decreased the amount of preferred habitat available for the Spotted Gar population at Point Pelee.

A distinct challenge presents itself when considering the effect of habitat modifications on the Long Point Bay population as the three areas being considered (Long Point Inner Bay, Long Point NWA and Big Creek Marshes) are very diverse, facing varying pressures from habitat modifications. Both Long Point NWA and Big Creek Marshes would face very little impacts from habitat modifications as both of these areas are National Wildlife Areas, which are afforded protections and are managed by Canadian Wildlife Service, Environment Canada. Long Point Inner Bay (near Port Rowan) would face slightly increased pressures from habitat modifications from the construction and maintenance of marinas and shoreline development.

VEGETATION REMOVAL

A habitat modification that requires specific attention is the removal of aquatic vegetation. Due to the importance of aquatic vegetation on Spotted Gar survival, an in-depth discussion on this specific habitat modification is warranted. Spotted Gar is highly dependent on heavily vegetated, shallow nearshore areas for many of its life processes. Spotted Gar is known to use these areas throughout its life cycle as spawning and nursery grounds, as well as foraging habitat. Destruction and removal of aquatic vegetation in the nearshore area of lakes and wetland systems may have detrimental effects on the associated Spotted Gar population. In addition to the implications of vegetation removal, the physical act of removing aquatic vegetation, whether it is mechanical or chemical, may also have negative impacts on Spotted Gar. Chemical removal generally involves the application of the herbicide “Reward” [Diquat; S. Durst, Ministry

of the Environment (MoE), pers. comm.] that may also be detrimental to Spotted Gar. It has been noted that the mechanical option is preferred to chemical treatment for both habitat and aesthetic reasons, as the mechanical option reduces the oxygen demand from decaying vegetation (Gilbert *et al*. 2007).

Historic large-scale and recent small-scale vegetation removal operations have been recorded for Rondeau Bay. Primarily, these removals have occurred because the presence of submerged aquatic macrophytes can become a nuisance to recreational activities when it reaches high densities (Gilbert *et al*. 2007). In Rondeau Bay, a total of eight chemical and two mechanical vegetation removal referrals have been received by DFO Fish Habitat Management (FHM) since 2002 (N.B. one referral may include more than one removal area) (D. Ming, DFO-FHM, pers. comm.). It should be noted that unauthorized vegetation removals have also been noted to occur in Rondeau Bay over the same time period. Limited mechanical vegetation removal occurs at both Long Point Bay (within the area of Spotted Gar occurrence) and Point Pelee National Park (P. Gagnon, Long Point Conservation Authority, pers. comm.; V. M^{c}Kay, Parks Canada Agency, pers. comm.). There has been no known chemical vegetation removal at Point Pelee National Park (V. M^{c}Kay, Parks Canada Agency, pers. comm.). A total of nine permits have been authorized for the application of the herbicide “Reward” near the area of Spotted Gar occurrence in Long Point Bay from 2002-2005 (S. Durst, MoE, pers. comm.). The total area treated under these permits was 0.448 ha (S. Durst, MoE, pers. comm.). The MoE has not received any permit applications for herbicidal treatment in this area since 2005 (S. Durst, MoE, pers. comm.).

TURBIDITY AND SEDIMENT LOADING

Increases in sediment loading and turbidity may be detrimental to Spotted Gar survival and recovery. Increases in sediment loading can be attributed to poor agricultural and land management practices, improper drain maintenance practices, dredging activities and the removal of riparian vegetation (Staton *et al*. 2010). Negative effects of increased turbidity on Spotted Gar may include direct impacts on respiration rates and vision, leading to a decrease in prey capture rates. It may also lead to indirect impacts on Spotted Gar preferred habitat through decreased water clarity, impeding light penetration, decreasing macrophyte growth, resulting in a loss of Spotted Gar habitat. Increased sedimentation may also lead to increased silt on substrates and submergent vegetation, smothering eggs.

Siltation has been highlighted as an ongoing problem in Rondeau Bay where the presence of tile drainage has lead to increased siltation, particularly relevant during storm events (Gilbert *et al*. 2007). It has been suggested that a reduction in sediment inputs from point and non-point sources would greatly contribute to the restoration of Rondeau Bay (Gilbert *et al*. 2007).

At Point Pelee National Park, altered sediment transport along the Lake Erie shoreline has increased erosion of the barrier beach, leading to increases in breaching events (Dobbie *et al*. 2006; Surette 2006). This has resulted in water quality declines, including increases in turbidity levels in the park (V. M^{c}Kay, Parks Canada Agency, pers. comm.).

An evident turbidity plume has been noted in Long Point Inner Bay originating from the mouth of Big Creek (B. Glass, University of Windsor, pers. comm.). Although turbidity values are currently not available for this area, the extent of the turbidity plume does encompass the area of occurrence for Spotted Gar, and may be negatively impacting Spotted Gar habitat.

NUTRIENT LOADING

Degradation of Spotted Gar preferred habitat may also result from increases in nutrient (nitrates and phosphorus) loading. Increased nutrient loading can be the result of fertilizer releases into the waterbody, loading from sewage treatment plants, and nutrient runoff from manure piles. These increased nutrient levels can subsequently lead to the development of algal blooms and, consequently, to decreased levels of dissolved oxygen once the blooms begin to senesce (EERT 2008). Since Spotted Gar is a facultative air breather, the direct effects of decreased dissolved oxygen would have a greater effect on its prey. Decreases in the amount of available prey would, therefore, have a cascading effect on the Spotted Gar population. Nutrient loading has been listed as a primary threat to Long Point Bay, Point Pelee National Park, and Rondeau Bay, which are all areas currently occupied by Spotted Gar (EERT 2008).

Nutrient samples taken from Rondeau Bay tributaries during two sampling periods (June and August) in 2005 and 2006 were compared to the Provincial Water Quality Guidelines (total phosphorus should not exceed 0.03 mg•L-1; MOE 1994). Samples from all tributaries in 2005, and all tributaries but one in 2006 exceeded the guideline (Gilbert *et al*. 2007). These elevated nutrient levels are thought to be the primary cause of prolific algal blooms that are a common occurrence in Rondeau Bay (Gilbert *et al*. 2007). An algal bloom, reaching thicknesses of approximately 1 m, covering 70% (3169 ha) of the surface of Rondeau Bay was recorded in 2005 (Gilbert *et al*. 2007). This bloom began along the western and northern shoreline (in the tributary mouths and protected embayments), and slowly migrated to the exposed open water where it anchored to the dense submerge vegetation (Gilbert *et al*. 2007). The bloom substantially altered the dissolved oxygen concentrations, which dropped to 5 $mg \cdot L^{-1}$ (Gilbert *et al*. 2007). The bloom senesced in the winter months and resulted in the deposit of a thick organic material over the northern and eastern shorelines that smothered habitat and created anoxic zones (Gilbert *et al*. 2007).

A study at Point Pelee National Park (Sanctuary Pond) was completed in 1994 to determine the cause of elevated nutrient concentrations leading to prolific algal growth (Mayer *et al*. 1999). It was determined that organic matter decomposition was an important mechanism leading to high concentrations of nutrients, and that resuspension of bottom sediment, primarily by Common Carp foraging behaviour, were most likely responsible for the hypereutrophic conditions (Mayer *et al*. 1999). Although Spotted Gar has yet to be recorded from Sanctuary Pond, Common Carp are present throughout Point Pelee National Park and may be affecting Spotted Gar preferred habitat by creating a hypereutrophic environment leading to increased algal growth.

EXOTIC SPECIES

The introduction of exotic species, both fishes and aquatic macrophytes, to known Spotted Gar locations may have detrimental effects on the local Spotted Gar population.

Common Carp

The feeding behaviour of Common Carp is known to have serious negative impacts on aquatic systems by uprooting aquatic vegetation and increasing turbidity levels (Lougheed *et al*. 1998; Lougheed *et al*. 2004). This feeding behaviour, known to cause significant alterations to native wetland habitats, may have significant effects on Spotted Gar, which is dependent on aquatic vegetation for many of its life processes. In addition, Common Carp has been shown to be the cause of bottom sediment resuspension, increasing nutrient levels, leading to hypereutrophic conditions (Mayer *et al*. 1999).

Eurasian milfoil

It is also well known that exotic aquatic macrophytes can drastically alter the aquatic vegetation complex by outcompeting native plants. One such plant, Eurasian milfoil, is known to grow into dense vegetation mats, blocking sunlight to submergent macrophytes, increasing phosphorous and nitrogen inputs, increasing pH and temperature, and creating a potentially unsuitable environment for Spotted Gar and many other fishes (OFAH 2009).

Eurasian milfoil may be particularly relevant to Spotted Gar at Point Pelee National Park and Rondeau Bay where the macrophyte has flourished. It is not known when the species became established, making it difficult to draw a causal relationship between the presence of Eurasian milfoil and Spotted Gar abundance. The submerged macrophyte community on the western and central to northern sections of Rondeau Bay tend to be dominated by Eurasian milfoil and coontail (*Ceratophyllum demersum*), which can reach high densities and biomass between 500 and 1300 $g \cdot m^{-2}$ dry weight (Gilbert *et al*. 2007).

Round Goby

Round Goby was accidentally introduced into the St. Clair River in the mid-1980s, and has since flourished throughout the Great Lakes. The introduction and establishment of Round Goby may also be negatively impacting Spotted Gar populations. The direct impact of Round Goby on Spotted Gar is currently unknown, although one can speculate that the presence of Round Goby may cause a shift in the fish assemblage and, ultimately, the abundance of Spotted Gar prey. Round Goby has also been shown to prey on Lake Trout eggs (*Salvelinus namaycush*), as well as speculated to feed on eggs and fry of sculpins (Cottidae), darters (Percidae) and Logperch (*Percina caprodes*) (Marsden and Jude 1995; Fuller *et al*. 2010). Although, the effect of gar eggs acting as an ichthyotoxin is debatable (Ostrand *et al*. 1996), if this is shown to be true, this toxin may act as a deterrent to Round Goby feeding on Spotted Gar eggs. To date, there has been no evidence in the literature of Round Goby feeding on Spotted Gar eggs.

Florida Gar

A closely related species that may represent an additional threat to Spotted Gar is the Florida Gar. Although Florida Gar is not currently established in Canada, it has been collected in the Great Lakes basin (likely the result of an aquarium release), and may act as a competitor to Spotted Gar if ever it were to become established. Florida Gar may represent an additional threat to Spotted Gar through hybridization, leading to nonviable hybrid offspring with reduced reproductive fitness and contributing to the loss of unique genetic diversity (Epifanio and Nielsen 2001). All four extant *Lepisosteus* spp. share similar reproductive modes (external fertilization) and overlap substantially in their ranges facilitating hybridization. Herrington *et al*. (2008) conducted a research experiment in which he housed Longnose, Alligator and Spotted Gar in the same aquarium, witnessed a spawning event and tested the offspring for their parental lineage. Morphological and genetic results indicated that the offspring were Alligator Gar and Longnose Gar hybrids, providing evidence for gar hybridization (Herrington *et al.* 2008). There are currently no known studies testing the probability of Spotted Gar and Florida Gar hybridization.

INCIDENTAL HARVEST

Baitfish industry

The use of Spotted Gar as a baitfish is illegal in Ontario (OMNR 2010). Baitfish harvesting does occur within the distribution of Spotted Gar and it may be caught incidentally. There are two typical commercial baitfish harvest methods used in the baitfish industry. The first consists of a lacustrine nearshore baitfish harvest, which generally targets Emerald Shiner (*Notropis*

atherinoides) habitat consisting of clear and sandy-bottom areas. This type of habitat is inconsistent with Spotted Gar preferred habitat and, therefore, the threat of incidental harvest from this method is thought to be negligible (A. Drake, University of Toronto, pers. comm.). The second type is the inland baitfish harvest industry. This type of baitfish harvest generally occurs in rivers and streams at road crossings that provide easy access to the waterway. This type of harvest also occurs in areas not typically associated with preferred Spotted Gar habitat. Therefore, the probability of incidental capture via both commercial baitfish harvest methods is considered to be very low (A. Drake, University of Toronto, pers. comm.).

Commercial fishing

Commercial fishing of Spotted Gar is prohibited in Canada, although incidental catch through this industry is a possibility. A study was conducted in 2009 at Long Point Bay on the effects of commercial fishing on aquatic species at risk (Gislason *et al.* 2010). In this study, 368 hoop net lifts were monitored for aquatic species at risk, and a single Spotted Gar was recorded (0.0027 catch per lift) (Gislason *et al*. 2010). This study provides evidence that the hoop net commercial fishery at Long Point Bay is a minimal threat to Spotted Gar in this area. However, the effect of the draw-seine commercial fishing industry on Spotted Gar at Long Point requires further investigation. Commercial fishing is known to occur at two additional extant Spotted Gar locations (Rondeau Bay and East Lake); however, the impact of these commercial fishing operations is currently unknown.

CLIMATE CHANGE

Through discussion on the effects of climate change on Canadian fish populations, impacts such as increases in water and air temperatures, changes (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 have been highlighted, all of which may negatively impact native fishes (Lemmen and Warren 2004). Doka *et al*. (2006) completed an assessment on the projected impacts of climate change on wetland fish assemblages by ranking fish species vulnerability to climate change. A vulnerability matrix was calculated and was based on species status, thermal and habitat associations (Doka *et al*. 2006). Results indicated that of the 99 fish species assessed, Spotted Gar was ranked as the 5th most vulnerable species. Climate change will have wide-reaching direct and indirect effects on fish species that rely on wetland areas for their survival. Since the effects of climate change on Spotted Gar are speculative, it is difficult to determine the likelihood and impact of this threat on each Spotted Gar population; therefore, the threat of climate change is not included in the following population-specific Threat Status analysis.

THREAT STATUS

To assess the Threat Status of Spotted Gar populations in Canada, each threat was ranked in terms of the Threat Likelihood and Threat Impact on a population basis (Table 4, 5). The Threat Likelihood was assigned as Known, Likely, Unlikely, or Unknown, and the Threat Impact was assigned as High, Medium, Low, or Unknown. Threat Impact categorization is location specific, in that impact categorization was assigned on a location-by-location basis. If no information was available on the Threat Impact at a specific location, a precautionary approach was used - the highest level of impact from all sites was applied. The Threat Likelihood and Threat Impact for each population were subsequently combined in the Threat Status Matrix (Table 6) resulting in the final Threat Status for each location (Table 7). Certainty has been classified for Threat Impact and is based on: 1= causative studies; 2=correlative studies; and, 3=expert opinion.

Table 4. *Definition of terms used to describe Threat Likelihood and Threat Impact.*

Term	Definition
Threat Likelihood	
Known (K)	This threat has been recorded to occur at site X.
Likely (L)	There is a > 50% chance of this threat occurring at site X.
Unlikely (U)	There is a <50% chance of this threat occurring at site X.
Unknown (UK)	There are no data or prior knowledge of this threat occurring at site X.
Threat Impact	
High (H)	If threat was to occur, it would jeopardize the survival or recovery of this population.
Medium (M)	If threat was to occur, it would likely jeopardize the survival or recovery of this population.
Low (L)	If threat was to occur, it would be unlikely to jeopardize the survival or recovery of this population.
Unknown (UK)	There is no prior knowledge, literature or data to guide the assessment of the impact if it were to occur.

Table 5. *Threat Likelihood and Threat Impact of each Spotted Gar population in Canada. The Threat Likelihood was assigned as Known (K), Likely (L), Unlikely (U), or Unknown (UK), and the Threat Impact was assigned as High (H), Medium (M), Low (L), or Unknown (UK). Certainty is associated with Threat Impact (TI) and is based on the best available data (1= causative studies; 2=correlative studies; and 3=expert opinion). References (Ref) are provided. Gray cells indicate that the threat is not applicable to the population due to the nature of the aquatic system where the population is located.*

	Lake Erie Drainage											
	Point Pelee				Rondeau Bay				Long Point			
Threat	**TLH**	**TI**	**C**	**Ref**	**TLH**	**TI**	**C**	**Ref**	**TLH**	**TI**	**C**	**Ref**
Habitat modifications	K	H	3	h	K	H	3	i,l	K	L	3	d
Aquatic vegetation removal												
Mechanical	K	L	3	h	K	H	3	k,i,l	K	L	3	d,n,o
Chemical				h	K	H	3	k,i,l	U	L	3	d,n,o
Turbidity and sediment loading	K	L	3	b,g,h	K	H	3	i,l	K	H	3	d,l,o
Nutrient loading	K	L	3	b,g,h,m	K	H	3	i,l	K	H	3	d
Exotic species	K	M	3	b,g,h,m	K	M	3	i,j,l	K	M	3	d,j
Incidental harvest	U	L	3	h	K	L	3	a,l	K	L	2	d,e,o

	Lake St. Clair drainage				Lake Ontario Drainage							
	Lake St. Clair				Hamilton Harbour				East Lake			
Threat	**TLH**	**TI**	**C**	**Ref**	**TLH**	**TI**	**C**	**Ref**	**TLH**	**TI**	**C**	**Ref**
Habitat modifications	K	H	3	c	K	L	3	q	U	L	3	f
Aquatic vegetation removal												
Mechanical	K	UK	3	o				n	L	L	3	f,o
Chemical	U	L	3	p				n				f
Turbidity and sediment loading	K	H	3	c,o	K	M	3	q	U	UK	3	f,o
Nutrient loading	K	L	3	c,o	K	L	3	q	U	UK	3	f,o
Exotic species	K	M	3	c,j	K	M	3	q	K	M	3	f,o
Incidental harvest	U	L	3	o				r	K	L	3	f

a – S. Dunn, DFO, pers. comm.
b – Dobbie *et al*. (2006)
c – EERT (2008)
d – P. Gagnon, Long Point Conservation Authority, pers. comm.
e – Gislason *et al*. (2010)
f – D. Bucholtz, Sandbanks Provincial Park, pers. comm.
g – H. Surette, unpubl. data
h – V. M^{c}Kay, Parks Canada Agency, pers. comm.
i – B. Glass, University of Windsor, pers. comm.
j – DFO, unpubl. data
k – D. Ming, DFO, pers. comm.
l – Gilbert *et al*. (2007)
m – Mayer *et al*. (1999)
n – S. Durst, MoE, pers. comm.
o – Spotted Gar Recovery Potential Assessment Meeting Participants (23 June 2010, Burlington, Ontario)
p – M. Nelson, Essex Region Conservation Authority, pers. comm.
q – Bowlby *et al*. (2009)
r – Holmes and Whilans (1984)

Table 6. *The Threat Status Matrix combines the Threat Likelihood and Threat Impact rankings to establish the Threat Status for each Spotted Gar population in Canada. The resulting Threat Status has been categorized as Poor, Fair, Good, or Unknown.*

		Threat Impact			
		Low (L)	**Medium (M)**	**High (H)**	**Unknown (UK)**
Threat Likelihood	**Known (K)**	Low	Medium	High	Unknown
	Likely (L)	Low	Medium	High	Unknown
	Unlikely (U)	Low	Low	Medium	Unknown
	Unknown (UK)	Unknown	Unknown	Unknown	Unknown

Table 7. *Threat Status for all Spotted Gar populations, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets refers to the level of certainty assigned to each Threat Status, which relates to the level of certainty associated with Threat Impact. Certainty has been classified as: 1= causative studies; 2=correlative studies; and 3=expert opinion. Gray cells indicate that the threat is not applicable to the population due to the nature of the aquatic system where the population is located. Clear cells do not necessarily represent a lack of a relationship between a population and a threat; rather, they indicate that either the Threat Likelihood or Threat Impact was Unknown.*

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

N.B. The Threat Status represents a combination of the current Threat Impact and Threat Likelihood at a location. It does not reflect the potential impact a threat might have on a population if it was allowed to occur in the future.

The Threat Status results were used to assess the overall effect each threat may have on Canadian Spotted Gar populations as a whole. Each threat was categorized in terms of both Spatial and Temporal Extent (Table 8). Spatial Extent was categorized as Widespread [threat is likely to affect a majority of Spotted Gar populations (i.e., threat affecting three or more populations)] or Local [threat is likely to not affect a majority of Spotted Gar populations (i.e., threat affecting less than three populations)]. Temporal Extent was categorized as Chronic (threat that is likely to have a long-lasting, or re-occurring affect on a population) or Ephemeral (threat that is likely to have a short-lived, or non-recurring affect on a population).

Table 8. *Overall effect of threats on Spotted Gar populations. Spatial Extent was categorized as Widespread or Local, while Temporal Extent was categorized as Chronic or Ephemeral (see text for description of categorization).*

Threat	Spatial Extent	Temporal Extent
Habitat modifications	Widespread	Chronic
Aquatic vegetation removal		
Mechanical	Local	Ephemeral/Chronic*
Chemical	Local	Ephemeral/Chronic *
Turbidity and sediment loading	Widespread	Chronic
Nutrient loading	Local	Chronic
Exotic species	Widespread	Chronic
Incidental harvest	Local	Ephemeral

*Temporal Extent is indicative of single removal event, subsequent or repetitive aquatic vegetation removal events would be categorized as Chronic.

MITIGATIONS AND ALTERNATIVES

Numerous threats affecting Spotted Gar populations are related to habitat loss or degradation. Habitat-related threats to Spotted Gar have been linked to the Pathways of Effects developed by DFO FHM (Table 9). DFO FHM has developed guidance on generic mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in the Ontario Great Lakes Area (Coker *et al*. 2010). This guidance should be referred to when considering mitigation and alternative strategies. Additional mitigation and alternative measures, specific to the Spotted Gar, related to the introduction of exotic species and incidental harvest through commercial fishing and the baitfish industry are listed below.

Table 9. *Threats to Spotted Gar populations in Ontario and the Pathways of Effect associated with each threat. 1 - Vegetation clearing; 2 – Grading; 3 – Excavation; 4 – Use of explosives; 5 – Use of industrial equipment; 6 – Cleaning or maintenance of bridges or other structures; 7 – Riparian planting; 8 – Streamside livestock grazing; 9 – Marine seismic surveys; 10 – Placement of material or structures in water; 11 – Dredging; 12 – Water extraction; 13 – Organic debris management; 14 – Wastewater management; 15 – Addition or removal of aquatic vegetation; 16 – Change in timing, duration and frequency of flow; 17 – Fish passage issues; 18 – Structure removal; 19 – Placement of marine finfish aquaculture site.*

Threat	Pathways
Habitat loss and degradation	1, 2, 3, 4, 5, 7, 8, 10, 11, 13, 14, 15, 16, 18
Aquatic vegetation removal	10, 11, 15
Turbidity and sediment loading	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18
Nutrient loading	1, 4, 7, 8, 11, 12, 13, 14, 15, 16

EXOTIC SPECIES

As discussed in the **THREATS** section, Common Carp, Eurasian milfoil, Florida Gar and Round Goby introduction and establishment could have negative effects on Spotted Gar populations.

Mitigation

- Removal/control of non-native species from areas known to be inhabited by Spotted Gar.
- Establish “Safe Harbours” in areas known to have suitable Spotted Gar habitat. Safe Harbours work to minimize the impact or prevent the introduction of exotic species through best management practices.
- Watershed monitoring for early detection of exotic species that may negatively affect Spotted Gar populations, or negatively affect Spotted Gar preferred habitat. If exotics are detected, implement a rapid response plan to eradicate or control the newly discovered species.
- Introduction of a public awareness campaign.

Alternatives

- Unauthorized introductions
    - There are no alternatives for unauthorized introduction because unauthorized introductions should not occur.
- Authorized introductions
    - Do not carry out introduction where Spotted Gar is known to exist.

INCIDENTAL HARVEST

As discussed in the **THREATS** section, incidental harvest through commercial fishing or the baitfish industry was recognized as a potential threat.

Mitigation

- Provide information and education to commercial fishermen, bait harvesters and recreational anglers on Spotted Gar, and request the voluntary avoidance of occupied Spotted Gar areas.
- Immediate release of Spotted Gar if incidentally caught.
- Introduction of timing windows so commercial and recreational fishing does not occur during Spotted Gar spawning season.

Alternatives

- Prohibition on the commercial and recreational fishing industry in areas where Spotted Gar is known to exist.

SOURCES OF UNCERTAINTY

Despite concerted efforts to increase our knowledge of Spotted Gar in Canada, there are still areas of uncertainty related to population structure, Spotted Gar life history, and to the factors that are limiting their existence.

Only a single record exists for four locations where Spotted Gar have been caught (Lake St. Clair, Hamilton Harbour, East Lake and North Channel), suggesting that our knowledge on its current distribution is incomplete. Increased sampling effort in these areas is needed to

determine if reproducing populations exist and, if so, the size of the current populations. Although eight individuals have recently been captured at Long Point Bay, there remains some uncertainty as to whether or not a reproducing population exists for this location. Further investigation at Long Point Bay is required to confirm the presence of a reproducing population. Spotted Gar populations that were assigned low certainty in the population status analysis should be considered priority when considering additional field sampling. These baseline data are required to monitor trends in Spotted Gar distribution and abundance as well as the success of any recovery measures. There is a need to assess genetic variation across all Spotted Gar populations in Canada to determine population structure and the level of connectivity between populations.

There is a need to identify habitat requirements for each life stage. Areas of particular uncertainty are related to the juvenile life stage. Very little information is available regarding the preferred habitat of juvenile Spotted Gar necessitating the inference of these requirements from other life stages. There is a need to determine the seasonal habitat requirements for adult Spotted Gar, and whether or not these needs vary by season.

Numerous threats have been identified for Spotted Gar populations in Canada, although the direct impact that these threats might have is currently unknown. There is a need for more causative studies to evaluate the impact of each threat on each extant Spotted Gar population with greater certainty. In the literature, the threat impacts are generally discussed at a broad level (i.e., fish assemblage level). It is important to further our knowledge on threat likelihood and impact at the species level. The effect of vegetation control is currently unknown for Spotted Gar. There is a need to investigate the effects of vegetation removal through both mechanical and chemical removal and what effects chemical application might have on the reproduction and development of Spotted Gar. There is a need to determine threshold levels for water quality parameters, and to identify point sources of nutrient and sediment inputs and their relative effects on Spotted Gar survival.

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