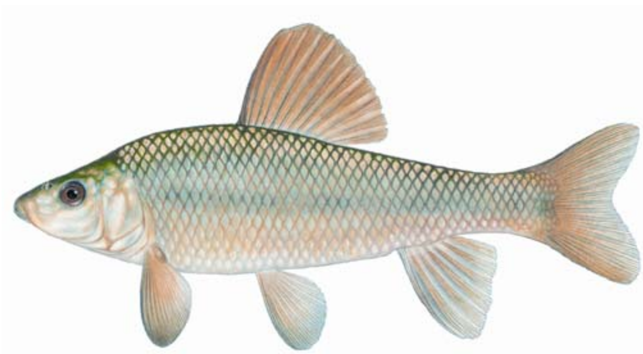
Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences
Central and Arctic Region
Canadian Science Advisory Secretariat
Science Advisory Report 2011/033

RECOVERY POTENTIAL ASSESSMENT OF LAKE CHUBSUCKER (*Erimyzon sucetta*) IN CANADA



Lake Chubsucker (Erimyzon sucetta)
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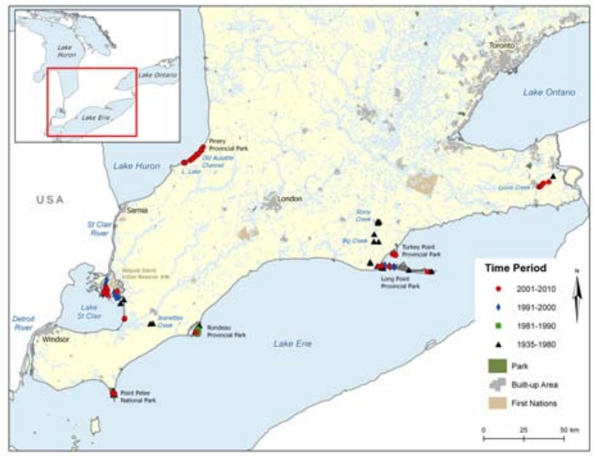

Figure 1. Distribution of Lake Chubsucker in Canada.

Context:

*The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the status of Lake Chubsucker (*Erimyzon sucetta*) in April 1994. The assessment resulted in the designation of Lake Chubsucker as Special Concern. This status was re-assessed as Threatened in November 2001. When re-examined in November 2008, Lake Chubsucker status was changed to Endangered. The reason given for this designation was that the Lake Chubsucker is "a species with a restricted geographic Canadian range with small extant populations having very specific and narrow habitat preferences, which are under continued stress. It is extremely susceptible to habitat change driven by urban, industrial and agricultural practices resulting in increased turbidity. Two populations have been lost, and of the 11 extant populations, 3 are in serious decline as a result of the continuing and increasing threats posed by agricultural, industrial and urban development that are expected to impact the remaining populations of Lakes Erie and St. Clair." Lake Chubsucker was listed on Schedule 1 of the* Species at Risk Act *(SARA) when the Act was proclaimed in June 2003. Lake Chubsucker is now listed as Endangered on Schedule 1.*

A species Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) Science to provide the information and scientific advice required to meet the various requirements of the SARA, such as the authorization to carry out activities that would otherwise violate the SARA as well as the development of recovery strategies. The scientific information also serves as advice to the Minister of DFO regarding the listing of the species under SARA and is used when analyzing the socio-economic impacts of adding the species to the list as well as during subsequent consultations, where applicable. This assessment considers the scientific data available with which to assess the recovery potential of Lake Chubsucker in Canada.

SUMMARY

- The current Lake Chubsucker distribution is limited to 11 distinct locations of the Great Lakes basin: Old Ausable Channel, L Lake, Walpole Island (dyked marshes), St. Clair National Wildlife Area (NWA), Point Pelee National Park, Rondeau Bay, Long Point Bay, Long Point NWA, Big Creek NWA (dyked marshes) and Lyons Creek.
- Three historic locations are thought be extirpated: Jeanette's Creek, the upper tributaries of Big Creek and Tea Creek.
- Adult Lake Chubsucker are generally found in clear, still, well-vegetated waters. Substrate in these systems is generally composed of gravel, sand, and silt mixed with organic debris. Recent juvenile and YOY captures from L Lake noted that individuals were found over substrate composed mainly of organic debris and vegetative cover (combination of submergent, floating, and emergent) was greater than 70%.
- To achieve ~99% probability of persistence, given a 15% chance of catastrophic decline (50%), requires ~2700 adult Lake Chubsucker and at least 1 km^2 of suitable habitat. Populations experiencing density dependence due to crowding require 1.5 times the Minimum Area for Population Viability (MAPV), or at least 1.5 km^2. Given a quasi-extinction threshold of 50 adults, the Minimum Viable Population (MVP) becomes ~16 000 adults requiring 6 km^2. Extinction risk increases exponentially when habitat is reduced below MAPV.
- In the absence of additional harm, recovery efforts, or habitat limitations, a population at 10% of MVP (270 adults) has a 95% chance of recovering within 12 years (if probability of catastrophe is 15% per generation). Increasing survival of juveniles will have the largest proportional effect on recovery time.
- The greatest threats to the survival and persistence of Lake Chubsucker in Canada are related to habitat modification and destruction, increases in turbidity and sediment loading, and exotic species. Lesser threats that may be affecting the survival of Lake Chubsucker include increases in nutrient loading, contaminants and toxic substances, and incidental harvest, although the current knowledge on the level of impact that these threats may have on Lake Chubsucker is very limited.
- Population growth of Lake Chubsucker is most sensitive to changes in juvenile survival, and is sensitive to the survival and fecundity of first time spawners. If Lake Chubsucker mature at age 2, harm to annual survival of immature individuals (hatch to age 2), survival of adults, or fecundity should not exceed 33%, 54%, or 49%, respectively. If age at maturity is 3 years, harms should not exceed 15%, 32%, or 33%, respectively. As harm approaches these levels, recovery times increase exponentially.
- There remain numerous sources of uncertainty related to Lake Chubsucker population distribution and structure, habitat preferences and to the factors limiting their existence.

BACKGROUND

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Lake Chubsucker (*Erimyzon sucetta*) be designated as a species of Special Concern in April 1994. This status was re-assessed as Threatened in November 2001. When re-examined in November 2008, Lake Chubsucker status was changed to Endangered. Lake Chubsucker was listed on Schedule 1 of the *Species at Risk Act* (SARA) when the Act was proclaimed in June 2003. Lake Chubsucker is now listed as Endangered on Schedule 1. When COSEWIC designates an aquatic species as Threatened or Endangered and the Governor in Council decides to list it, the Minister of Fisheries and Oceans Canada (DFO) is required by the SARA to undertake a number of actions. Many of these actions require scientific information such as the current status of the population, the threats to its survival and recovery, and the feasibility of its recovery. This scientific advice is developed through a Recovery Potential Assessment (RPA). This allows for the consideration of peer-reviewed scientific analyses in subsequent SARA processes, including permitting on harm and recovery planning. This RPA focuses on Lake Chubsucker populations in Canada, and is a summary of a Canadian Science Advisory Secretariat peer-review meeting that occurred on 9 March 2011 in Burlington, Ontario. Two research documents, one providing background information on the species biology, habitat preferences, current status, threats and mitigations and alternatives (Bouvier and Mandrak 2011), and a second on allowable harm, population-based recovery targets, and habitat targets (Young and Koops 2011) provide an in-depth account of the information summarized below. Proceedings are also made available that document the activities and key discussions of the meeting (DFO 2011). Please note that the complete reference citations have been removed from the following document to minimize the length of the document. Complete references are available at Bouvier and Mandrak (2011) and Young and Koops (2011).

Species Description and Identification

Lake Chubsucker (*Erimyzon sucetta*) is a small, deep–bodied member of the sucker family (Catostomidae) (Figure 1). It has a thick caudal peduncle and a wide head with a blunt snout ending in a small, slightly inferior mouth. Coloration on the back and upper sides can range from deep olive-green to bronze, and these areas have a cross hatching pattern in adults. The lower sides are generally gold to silver, while the belly ranges from greenish-yellow to whitish-yellow. Juvenile Lake Chubsucker generally have a black stripe along the front edge of the dorsal fin and a wide, prominent black lateral stripe terminating in a dark spot at the base of the tail; while the lateral stripe can either be continuous or broken in adults, if present. A distinguishing characteristic of the Lake Chubsucker is that it lacks a lateral line.

In the literature, adult length has been noted as reaching a maximum of 410 mm total length (TL), although Canadian specimens tend to be smaller than their southern counterparts. The Ontario record for the longest recorded Lake Chubsucker measured 280 mm TL.

Lake Chubsucker is a warmwater species, with preferred temperature ranging from 28-34^{o}C. Throughout the Canadian Lake Chubsucker range, it is found in clear, well-vegetated, slow-moving or still waters. Areas typically inhabited by Lake Chubsucker include backwaters, wetlands, ponds, floodplain lakes, and marshes. Turbidity is generally very low in these areas, and the substrate is commonly composed of clay, silt, and organic debris. As an omnivorous bottom feeder, Lake Chubsucker diet is composed of small crustaceans, mollusks, aquatic insects, filamentous algae, and plant material.

Lake Chubsucker is one of 13 known sucker species currently in the Canadian Great Lakes basin. It can be differentiated from members of the genera *Carpiodes, Cycleptus*, and *Ictiobus* by the presence of dorsal fin with a short base lacking a rounded or pointed anterior lobe. Although not reliably reported from Canada, Lake Chubsucker closely resembles Creek Chubsucker (*Erimyzon oblongus*), which is present in the American tributaries of both lakes Ontario and Erie. Characteristics used to distinguish these two species include a larger eye diameter, lower lateral line scale count, higher dorsal ray count and a stouter body form for Creek Chubsucker when compared to Lake Chubsucker.

ASSESSMENT

Current Species Status

Old Ausable Channel (OAC)

It is thought that the Lake Chubsucker occupied the lower Ausable River prior to its diversion in the late 1800s. The diversion has since caused a highly turbid system, limiting the distribution of Lake Chubsucker to the protected waters of OAC. Lake Chubsucker was first detected in the OAC in 1982. Subsequent to first detection, Lake Chubsucker have been recorded from this location in 1997 (n=7), 2001 (n=1), 2002 (n=13), 2004 (n=54), 2005 (n=39), 2009 (n=28) and 2010 (n=1). It should be noted that a large Lake Chubsucker winterkill occurred in the OAC in the winter of 2010, which may explain the noticeable difference in the number of individuals caught between 2008-2009 and 2010. The majority of the fish killed were found in the southern end of the residential area (near Pinery boundary) and upstream of the dam in Pinery; however, it should be noted that dead fish were observed from the origin of the OAC to below Pinery dam. From the winterkill, 68 individuals were collected, ranging in size from 91 to 199 mm TL. Otoliths and scales of all mortalities of the winterkill were aged. Otolith-based ages ranged between 1-6 years; while scale-based ages ranged between 1-5 years; no age 0 fish were observed (Figure 2). A winterkill of this magnitude had not been observed in the OAC since 2003 and it is believed that the contributing factors included a prolonged snow cover and a thick ice pack that lead to oxygen depletion and possibly anoxic waters.

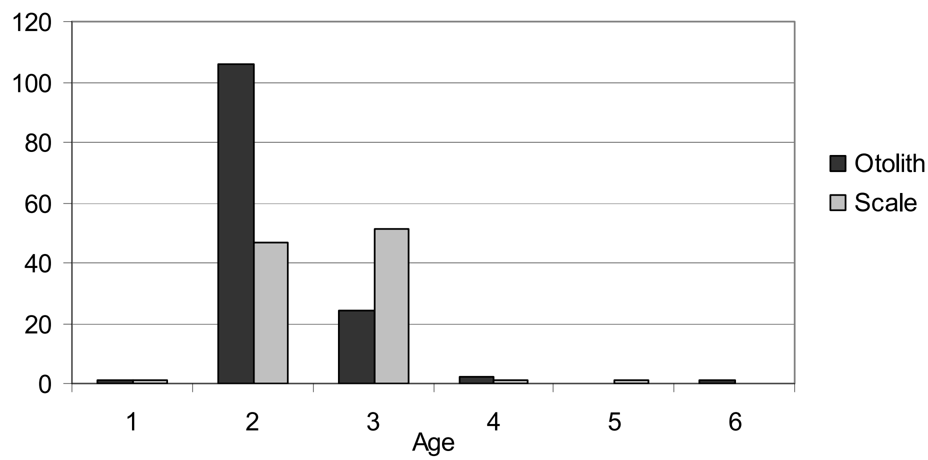

Figure 2. *Age frequency distribution resulting from otolith and scale analysis of fish collected from the Old Ausable Channel after the winterkill of 2010.*

L Lake

L Lake is an oxbow lake located approximately 3.5 km WSW of the OAC. The first known L Lake sampling event occurred in 2007 with the aid of a boat electrofisher and a seine net. A total of 29 individuals were captured during a 7-day sampling event. Subsequently, L Lake was re-visited in June and August 2010 as part of a depletion survey and a total of 215 individuals were recorded. The length of these individuals ranged from 12 to 143 mm TL. Results of the depletion survey indicated a mean population density of 0.0861 (± 0.1385) and 0.0119 (± 0.0181) individuals/m^2 based on data from June and August sampling events, respectively.

Lake St. Clair

For the purposes of the Lake Chubsucker population assessment, all waterbodies directly connected to Lake St. Clair, including Mitchell's Bay and the undyked waters of Walpole Island, where movement between subpopulation is possible, were grouped. Lake Chubsucker was first recorded from Lake St. Clair in 1949. Subsequent records are sparse and include successful captures in 1952 and 1979 in Mitchell's Bay, and records scattered from St. Anne Island to the north end of Chemotogan Channel from 1999, 2001 and 2002. Extensive sampling completed in the spring, summer and fall in Mitchell's Bay in 2003 and 2004, using fyke netting and boat electrofishing failed to collect any individuals.

Walpole Island Dyked Marshes

The Walpole Island marshes Lake Chubsucker records were separated from the Lake St. Clair as the marshes are separated by dykes and movement between these locations is thought to be very unlikely. Lake Chubsucker records exist for the dyked wetlands of Walpole Island for 1999 and 2001. 39 individuals were recorded over a one-day sampling period in 1999, while 125 individuals were recorded over a four-day sampling event in 2001 by the Royal Ontario Museum (ROM). The dyked marshes have not been sampled since 2001.

St. Clair National Wildlife Area (NWA)

The St. Clair NWA is located approximately 8.5 km south of Mitchell's Bay. The NWA is separated from Lake St. Clair by use of dykes and fish movement between these two systems is very unlikely. Extensive sampling was completed in the St. Clair NWA in 2003 and 2004 by boat electrofishing and fyke netting. Although Lake Chubsucker did not appear in the 2003 sampling, six individuals (ranging in size from 66-255 mm) were recorded in 2004. The St. Clair NWA is composed of an eastern and a western cell. All individuals were recorded from the western cell, although limited sampling has occurred in the eastern cell.

Jeanette's Creek

Jeanette's Creek is a tributary of the Thames River. Historically, two records of Lake Chubsucker exist for Jeanette's Creek (1963 and 1965) and were recorded approximately 20 km upstream of the confluence with the Thames River. This area has been re-sampled on numerous occasions in recent years and has not yielded the capture of any additional Lake Chubsucker. The site of initial capture has more recently been described as very turbid, channelized, and forming part of an agricultural drain. This type of habitat is no longer consistent with Lake Chubsucker preferred habitat, and this species is thought to be extirpated from this area.

Point Pelee National Park

Lake Chubsucker was first recorded from Point Pelee National Park (PPNP) in 1949. Since this first collection, Lake Chubsucker has been recorded from PPNP in 1968, 1972, 1979, 1983, 1993, and 2003. All Lake Chubsucker records from the park are restricted to three ponds; Lakepond, Redhead Pond, and Girardin Pond. However, it should be noted that the most recent verified record from Lakepond is from 1972 despite extensive sampling in 2002 and 2003, leading park staff to believe that Lake Chubsucker may no longer be present in Lakepond. The loss of Lake Chubsucker from Lakepond would indicate that there is an overall decline in the Lake Chubsucker area of occupancy at Point Pelee National Park. A total of 30 individuals were collected from Redhead and Girardin ponds in 2003 ranging from 46-247 mm TL in size, suggesting that a reproducing population is likely present.

Rondeau Bay

The first record of Lake Chubsucker from Rondeau Bay dates back to 1955 when 14 individuals were captured. There have been very limited known occurrences in Rondeau Bay since this date of first capture, with records from 1963, 1983, and 2005. The inner marshes of Rondeau Bay have been sampled on numerous occasions with the aid of seine nets, fine-mesh hoopnets and electrofishing in 2005 and 2007-2009. All records, both historic and current, occur within the Rondeau Bay Provincial Park boundaries.

Long Point Bay

For the purposes of this population status assessment, Big Creek undyked marshes, Turkey Point marshes, and Long Point Inner Bay were grouped together and will be referred to as Long Point Bay. These areas were grouped because they are directly connected to each other and movement between these areas is possible. Lake Chubsucker has been recorded from Long Point Inner Bay in 1955, 1982, 1994, 1999, and 2004. Additional records from the undyked marshes of Big Creek exist from 1979, 1982 and more recently, from 2008 when two individuals were recorded from a site approximately 2 km upstream of where the mouth of the Big Creek flows into Long Point Inner Bay. A total of 22 individuals were captured from Turkey Point in 2007 and an additional two individuals were captured in 2010.

Long Point NWA

Long Point NWA is located on the eastern portion of the large spit forming the southern boundary of Long Point Bay. This portion of the spit is characterized by several small ponds, and should be considered a separate location from Long Point Inner Bay as movement between these locations is unlikely. Due to its remote location, there have been very few sampling events in this area. From these limited sampling activities, Lake Chubsucker was captured in 1952, 1975, and 2005 (represented by a single individual).

Big Creek Upper Tributaries

Historic Lake Chubsucker records exist for several of the tributaries in the upper reaches of the lower Big Creek watershed (1960, 1972, 1973, 1974, and 1979). All voucher specimens were verified to be Lake Chubsucker. Sites where these records originated include Silverthorn Creek, Stoney Creek, Lynedock Creek, and Trout Creek. Re-sampling of all historic sites in 2008 revealed that many of the historic sites were now buried agricultural drains or are dry. These sites no longer provide suitable habitat for Lake Chubsucker and this species is thought to be extirpated from the upper tributaries of Big Creek.

Big Creek NWA Dyked Marshes

The dyked marshes of Big Creek NWA should be considered a separate location from the open wetlands of Big Creek NWA and ultimately, a separate location from Long Point Inner Bay as movement between these areas is prevented by the presence of dykes. The dyked marshes were sampled exclusively in 2005 with the aid of a seine net, and resulted in the capture of seven individuals. It is believed that no additional sampling has occurred in this area prior to or subsequent to 2005.

Lyons Creek

Lyons Creek is a tributary of the Niagara River. It is generally considered to be composed of highly degraded habitat and poor water quality with the exception of a clear segment approximately 2 km long that receives overflow water from the Welland Canal. Approximately half of the Lake Chubsucker records collected since 2004 were located in this clear segment of Lyons Creek. The remaining records are from the 8 km section of Lyons Creek immediately downstream. A total of five, 28, 20, and 13 Lake Chubsucker were captured from Lyons Creek in 2004, 2008, 2009 and 2010, respectively. Sampling events of Lyons Creek in 2010 were also used in the preliminary depletion study described above. Unfortunately, only three of the sites sampled fulfilled the requirements necessary to complete the population estimate analysis. Results indicated that the mean population density was 0.0105 (± 0.0156) individuals/m^2.

Tea Creek

Tea Creek is a small tributary to Lyons Creek. A single historic record exists for Tea Creek from 1958. This location has been sampled on numerous occasions since 1958 and has not yielded any additional records. The habitat in the vicinity of the historic record at present is considered to be not suitable for Lake Chubsucker and this species is thought to be extirpated from Tea Creek.

Population Status

To assess the Population Status of Lake Chubsucker populations in Canada, each population was ranked in terms of its abundance (Relative Abundance Index) and trajectory (Population Trajectory). The level of certainty was associated with each assignment (1=quantitative analysis; 2=CPUE or standardized sampling; 3=expert opinion). The Relative Abundance Index and Population Trajectory values were combined in the Population Status matrix to determine the Population Status for each population. Each Population Status was subsequently ranked as Poor, Fair, Good, Unknown or Extirpated (Table 1). The Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter. Refer to Bouvier and Mandrak (2011) for the complete methodology on Population Status assessment.

Table 1. *Population Status of all Lake Chubsucker populations in Canada, resulting from an analysis of both the Relative Abundance Index and Population Trajectory. Certainty (1=quantitative analysis; 2=CPUE or standardized sampling; 3=expert opinion) 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
Old Ausable Channel	Fair	2
L Lake	Fair*	2
Lake St. Clair	Poor	3
Walpole Island (dyked marshes)	Poor	3
St. Clair NWA	Poor	3
Jeanette's Creek	Extirpated	2
Point Pelee National Park	Poor	3
Rondeau Bay	Poor	3
Long Point Bay	Poor	3
Long Point NWA	Poor	3
Big Creek (upper tributaries)	Extirpated	2
Big Creek NWA (dyked marshes)	Poor	3
Lyons Creek	Poor	2
Tea Creek	Extirpated	2

* L Lake is considered to be the healthiest Lake Chubsucker population. Please see Sources of Uncertainty for additional information related to the population status classification.

Habitat Requirements

Spawning and Nursery

In Ontario, Lake Chubsucker are thought to be spring spawners, spawning between late April and June, when temperatures reach approximately 20°C. Spawning habitat consists of shallow waters of bays, the lower reaches of tributaries, or ponds and marshes with aquatic vegetation beds, dead grass, or filamentous algae. Spawning behaviour includes males clearing an area in the sand, silt, or often gravel, which is then used by the female to deposit between 3000 and 20 000 eggs (number of eggs is thought to be size-dependent). The eggs subsequently hatch when water temperature reaches between 22 and 29°C. Nursery habitat has been described as water 2 m in depth composed of submergent and emergent vegetation over a substrate of silt, sand, or clay.

Young-of-the-Year (YOY) and Juvenile

YOY preferred habitat has been described as shallow areas (0 to 2 m) containing heavy aquatic vegetation and substrates of silt, sand, and clay. Lake Chubsucker YOY were captured from Long Point Inner Bay, and a habitat description of the capture location was provided. This area was described as a heavily vegetated drainage ditch with water temperature between 24 and 28°C. During the same study, additional YOY individuals were captured from Walpole Island in approximately 10 cm of water under a layer of leaves in a roadside ditch. YOY captured from L Lake in June 2010 (n=28) were captured when water temperatures were between 22 and 25°C and dissolved oxygen ranged between 6.93 and 9.07 mg/L. The substrate at all sampling locations was described as 100% organic. Vegetative cover (combination of submergent, floating and emergent) was greater than 70%, with dominant species of watershield (*Brasenia schreberi*), water lily (*Nymphaea* sp.), milfoil (*Myriophyllum sibiricum*) or chara (*Chara* spp.).

In addition to YOY, age 1+ individuals were also recorded from Long Point, and were found in marshes associated with hairgrass (*Eleocharis* sp.), sedges (*Carex* sp.) and cattails (*Typha* sp.). Juveniles captured from L Lake in June 2010 were captured when water temperatures ranged from 21 to 24°C and dissolved oxygen was between 5.39 and 13.71 mg/L. Similarly to the YOY habitat description for L Lake, all individuals were captured from sites composed of 100% organic substrate. Vegetative cover at sites where juveniles were found was greater than 75%, with the dominant vegetation type at all sites being listed as chara.

Adult

Adult Lake Chubsucker are generally found in clear, still, well-vegetated waters, such as those provided by backwaters, drainage ditches, floodplain lakes, marshes, oxbows, sloughs, or wetlands. Substrate in these systems is generally composed of gravel, sand, and silt mixed with organic debris. In Ontario, adult Lake Chubsucker are commonly found in heavily vegetated systems with very low turbidity. Based on all known Lake Chubsucker records in Ontario where water depth was available, Lake Chubsucker appear to occupy areas with water depth ranging from 0.38 to 2 m; although, it should be considered that the upper bound of this range may reflect sampling restrictions. Lake Chubsucker sampling from L Lake in 2010 indicated that Lake Chubsucker were found in areas where the substrate was classified as being greater than 90% organic. It appears that throughout the range of Lake Chubsucker in Ontario, protected coastal wetlands and dyked marshes play a crucial role in the maintenance of preferred Lake Chubsucker habitat and subsequently, are of paramount importance for this species.

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, Lake Chubsucker do not construct residences during their life cycle.

Recovery Targets

Recovery Targets and Times

Demographic sustainability was used as a criterion to set recovery targets for Lake Chubsucker. Demographic sustainability is related to the concept of a minimum viable population (MVP; Shaffer 1981), and was defined as the minimum adult population size that results in a desired probability of persistence over 100 years (approximately 28 generations). MVP targets were chosen to optimize the benefit of reduced extinction risk and the cost of increased recovery effort, and resulted in a persistence probability of approximately 99% over 100 years. Assuming that the chance of catastrophic decline was 10%, 15% or 44% per generation, simulations indicated that MVPs for a Canadian population of Lake Chubsucker are 800, 2730, or >10 million adults respectively. The highest rate of catastrophe was simulated to explore the possibility of frequent winterkill scenarios. Populations were considered extinct at less than 2 adults (one male and one female). If the quasi-extinction threshold is defined as 20 adults, and the chance of catastrophe is 15% per generation, MVP increases from 2730 to 16 800 adults. Thus, if the true extinction threshold is greater than 2 adults, larger recovery targets should be considered.

Under current estimated conditions (i.e. assuming a population growth rate of 1.4), and in the absence of recovery efforts or additional harm, a Lake Chubsucker population was predicted to increase from ~270 adults to the MVP target of 2730 adults in approximately 12 years (assuming a 15% per generation probability of catastrophe). Simulated recovery strategies decreased recovery times as much as 3 years. The most effective simulated strategy was an improvement to survival of immature individuals ($s_{1,2}$). Conversely, the time to recovery increased exponentially as harm was added to vital rates (Figure 3)

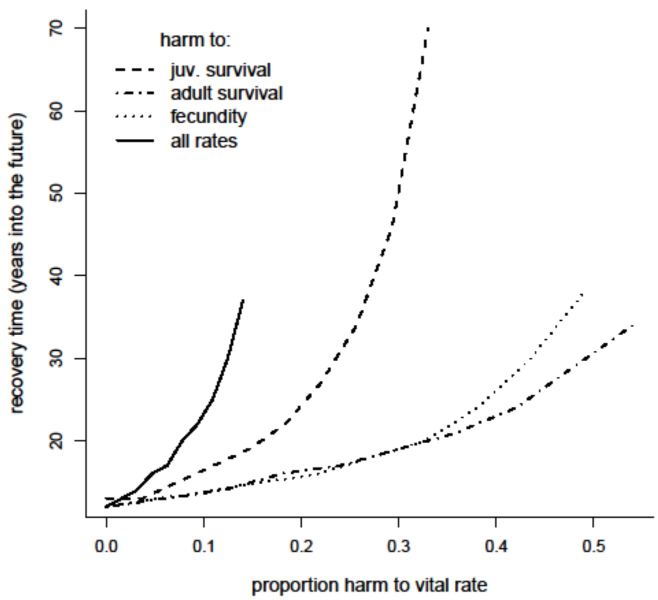

Figure 3. *Predicted change in the time to 95% chance of recovery of a Lake Chubsucker population as a function of increased harm (by proportion of vital rate) to: fecundity (f_n), early survival ($s_{1,2}$), adult survival ($s_{2..8}$), or all rates. Zero harm indicates status quo conditions. 15% per generation probability of catastrophe assumed.*

Minimum Area for Population Viability

Minimum area for population viability (MAPV) is a quantification of the amount of habitat required to support a viable population. Variables included in the MAPV assessment include

MVP values and area required per individual (API values). API values were estimated from an allometry for lake environments from freshwater fishes. With a target MVP of 2730 adults, under a 0.15 probability of catastrophe per generation, the MAPV is 1 km2 of suitable habitat. If the extinction threshold is assumed to be 50 adults, the MVP increases to nearly 45 000 adults requiring ~16 km^2. If available habitat does not meet the MAPV requirements, probability of extinction over 100 years increases exponentially, and recovery is likewise delayed (Figure 4). Habitat exceeding at least 1.5 x MAPV was sufficient to reduce simulated extinction risk to the level observed in the absence of habitat restrictions and density dependence.

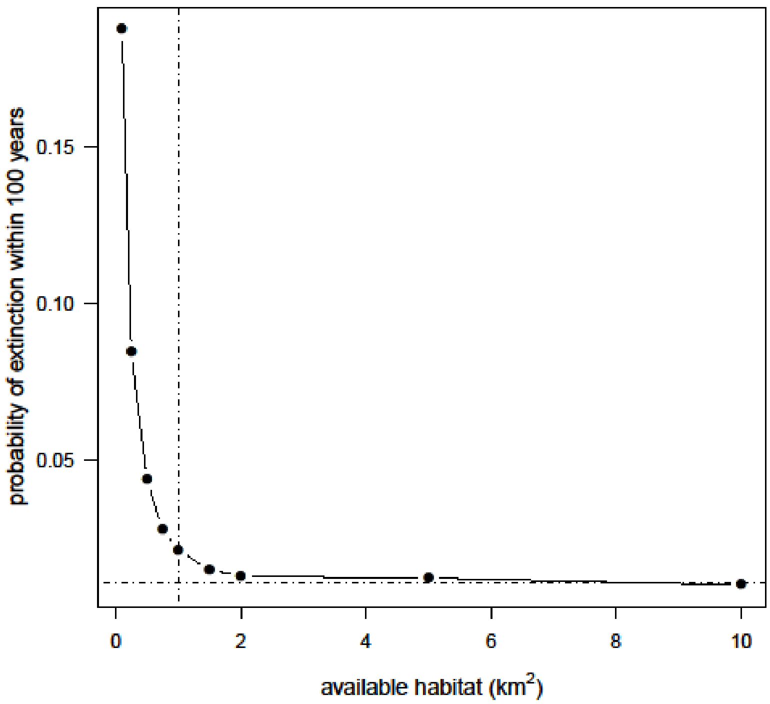

Figure 4. *Probability of extinction within 100 years of 10 simulated Lake Chubsucker populations at minimum viable population (MVP) size, and experiencing habitat based density dependence, as a function of available habitat area. Simulations assume a 15% per generation chance of catastrophe. Dashed reference lines show Minimum Area for Population Viability (MAPV, vertical) and the probability of extinction in the absence of habitat restrictions (0.011, horizontal).*

Threats to Survival and Recovery

A wide variety of threats negatively impact Lake Chubsucker across its range. Our knowledge of threat impacts on Lake Chubsucker 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 Lake Chubsucker in Canada are related to habitat modification and destruction, increases in turbidity and sediment loading resulting from agricultural practices, and increases in nutrient loading. The presence of pristine, highly vegetated systems in Ontario, where Lake Chubsucker thrive, is very limited. Lesser threats that may be affecting the survival of Lake Chubsucker include the introduction of exotic species and incidental harvest, although the current knowledge on the level of impact that these threats may have on Lake Chubsucker is very limited.

A distinct challenge presents itself when considering the effect of the various threats on Lake Chubsucker of Long Point Bay as the areas being considered (Long Point Inner Bay, Long Point NWA, Turkey Point marshes, and Big Creek marshes) are very diverse, facing varying pressures from different threats. Therefore, for the purposes of the threat assessment, these four areas will be discussed independently.

It is important to note the threats discussed below may not always act independently on Lake Chubsucker populations; rather, one threat may directly affect another, or the interaction between two threats may introduce an interaction effect on Lake Chubsucker populations. It is quite difficult to quantify these interactions; therefore, each threat is discussed independently. Refer to Bouvier and Mandrak (2011) for a detailed description of each threat and how it may be negatively affecting Lake Chubsucker populations.

Threat Status

To assess the Threat Status of Lake Chubsucker populations, each threat was ranked in terms of the Threat Likelihood and Threat Impact on a population basis (see Bouvier and Mandrak 2011 for complete details on classification approach). Threat Impact categorization was location specific, in that impact categorization was assigned on a location-by-location basis. If no information was available on the Threat Impact at a specific location, a precautionary approach was used - the highest level of impact from all sites was applied. The Threat Likelihood and Threat Impact for each population were subsequently combined in the Threat Status Matrix resulting in the final Threat Status for each location (Table 2). Certainty has been classified for Threat Impact and is based on: 1= causative studies; 2=correlative studies; and, 3=expert opinion.

Table 2. *Threat Level for all Lake Chubsucker 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 Level, 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. 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, or that information to aid in the threat classification was not available.*

	Old Ausable Channel	L Lake	Lake St. Clair	Walpole Island (dyked marshes)
Habitat modifications	High (3)	Medium (3)	Medium (3)	
Turbidity and sediment loading	Low (3)	Medium (3)	Medium (3)	
Nutrient loading	High (3)	Low (3)	Low (3)	
Contaminants and toxic substances	Unknown (3)	Unknown (3)	Low (3)	
Exotic species	Medium (3)	Medium (3)	Medium (3)	
Incidental harvest	Low (3)	Low (3)	Low (3)	Low (3)

Table 2. (continued)

	St. Clair NWA	Point Pelee National Park	Rondeau Bay	Big Creek (undyked marshes)
Habitat modifications	Medium (3)	High (3)	Medium (3)	High (3)
Turbidity and sediment loading	Low (3)	High (3)	High (3)	High (3)
Nutrient loading	Low (3)	Medium (3)	Medium (3)	Medium (3)
Contaminants and toxic substances	Low (3)	Low (3)	Low (3)	Low (3)
Exotic species	Medium (3)	Medium (3)	Medium (3)	High (3)
Incidental harvest	Low (3)	Low (3)	Low (3)	Low (3)

	Turkey Point	Long Point Inner Bay	Long Point NWA	Big Creek (dyked marshes)
Habitat modifications	Medium (3)	High (3)	High (3)	High (3)
Turbidity and sediment loading	High (3)	Medium (3)	Medium (3)	Low (3)
Nutrient loading	Low (3)	Low (3)	Low (3)	Low (3)
Contaminants and toxic substances	Low (3)	Low (3)	Low (3)	Low (3)
Exotic species	High (3)	High (3)	High (3)	Low (3)
Incidental harvest	Low (3)	Low (3)	Low (3)	Low (3)

	Lyons Creek
Habitat modifications	High (3)
Turbidity and sediment loading	High (3)
Nutrient loading	Medium (3)
Contaminants and toxic substances	Medium (3)
Exotic species	Low (3)
Incidental harvest	Low (3)

Allowable Harm

Allowable harm was assessed in a demographic framework following Vélez-Espino and Koops (2009). The assessment involves perturbation analyses of population projection matrices, and includes a stochastic element. Outputs of the analyses include calculation of a population growth rate and its sensitivity to changes in vital rates. See Young and Koops (2011) for complete details of the model and results. Based on the mean vital rates of the Lake Chubsucker, we estimate the population growth rate of this species to be λ = 1.4. Modelling indicated that population growth of Lake Chubsucker is most sensitive to perturbations of early life survival ($s_{1,2}$). In addition, the population is more sensitive to changes in survival and fecundity of newly mature adults, while changes in older adult rates are less important (Figure 5). Uncertainty in sensitivity is driven primarily by uncertainty in the estimate of age-0 survival. Maximum allowable harm should be limited to 33% to juvenile survival (simultaneous harm to ages 0 and 1), 54% to adult survival (ages 2-8) or 49% to fecundity of all ages. If human activities are such that harm exceeds just one of these thresholds, the future survival of individual populations is likely to be compromised.

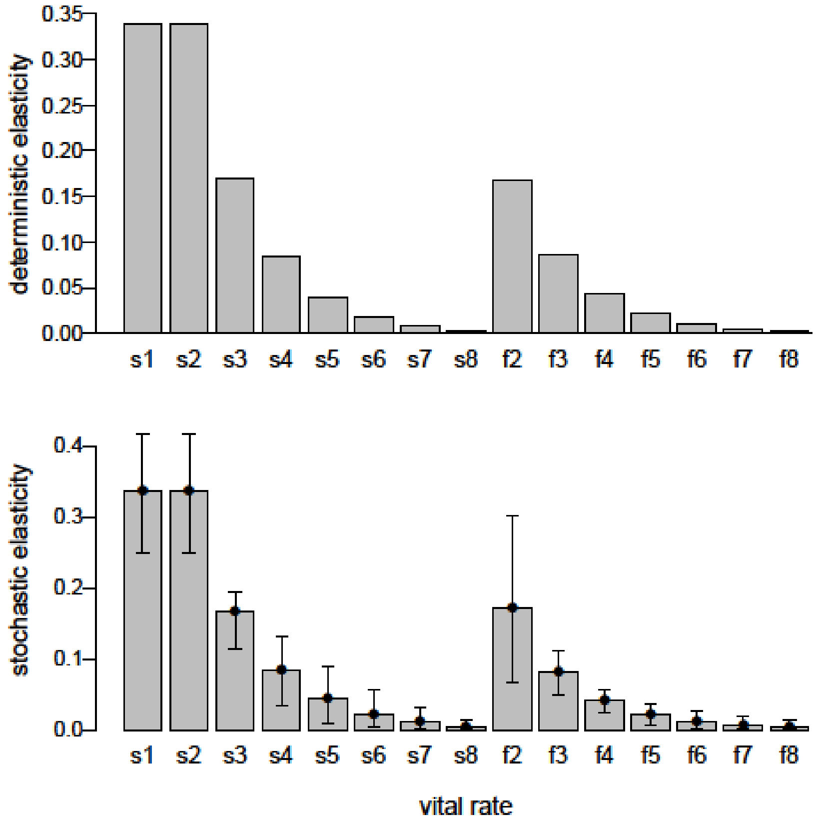

Figure 5 . *Results of the deterministic and stochastic perturbation analysis showing elasticities (ε_v) of the vital rates: annual survival probability of age j-1 to age j (s_i) and fertility (f_i). Stochastic results include associated bootstrapped 95% confidence interval.*

Summary of Science Advice on Allowable Harm

- When population trajectory is declining there is no scope for allowable harm
- When population trajectory is unknown the scope for allowable harm can only be assessed once population data are collected
- Scientific research to advance the knowledge of population data should be allowed
- In the absence of population abundance estimates, no harm should be allowed to survival of juveniles (<2 years) or to first time spawners (age 2)
- Modelling indicates that minimal additional cumulative harm is allowable on survival and reproduction of older adults (age 3+)
- If population abundance estimates exceed MVP, cumulative allowable harm may be allowed to the level identified in the AH modelling

Mitigations and Alternatives

Numerous threats affecting Lake Chubsucker populations are related to habitat loss or degradation. Habitat-related threats to Lake Chubsucker have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (FHM) (Table 3). 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 Lake Chubsucker, related to exotic species and incidental harvest are listed below.

Table 3. *Threats to Lake Chubsucker populations in Canada 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 modifications	1, 2, 3, 4, 5, 7, 8, 10, 11, 13, 14, 15, 16, 18
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
Contaminants and toxic substances	1, 4, 5 ,6 ,7 ,11 ,12 ,13 ,14, 15, 16 ,18

Exotic species

Common Carp and non-native aquatic vegetation introduction and establishment could have negative effects on Lake Chubsucker populations.

Mitigation

- Physically remove non-native species from areas known to be inhabited by Lake Chubsucker. It should be noted that special consideration is required if an aquatic vegetation removal/control program is implemented as this may also result in the loss of preferred Lake Chubsucker habitat.
- Monitor watersheds for exotic species that may negatively affect Lake Chubsucker populations directly, or negatively affect Lake Chubsucker preferred habitat.
- Develop a plan to address potential risks, impacts, and proposed actions if monitoring detects the arrival or establishment of an exotic species.
- Introduce a public awareness campaign and encourage the use of existing exotic species reporting systems.

Alternatives

- Unauthorized
  - None.
- Authorized
  - Use only native species.
  - Follow the National Code on Introductions and Transfers of Aquatic Organisms for all aquatic organism introductions (DFO 2003).

Incidental Harvest

Incidental harvest of Lake Chubsucker through the baitfish industry was recognized as a potentially low risk threat.

Mitigation

- Provide information and education to bait harvesters on Lake Chubsucker to raise awareness, and request the voluntary avoidance of occupied Lake Chubsucker areas.
- Immediate release of Lake Chubsucker if incidentally caught, as defined under the Ontario Recreational Fishing Regulations (OMNR 2011).

- Education through mandatory training on species at risk for baitfish harvesters.

Alternatives

- Prohibit the harvest of baitfish in areas where Lake Chubsucker are known to exist.

Sources of Uncertainty

Despite concerted efforts to increase our knowledge of Lake Chubsucker in Canada, there are still areas of uncertainty related to population distribution and structure, habitat preferences and to the factors that are limiting their existence.

Many of the locations where Lake Chubsucker are known to exist are represented by a few individuals caught over a limited number of sampling events. Sites, such as the dyked marshes of Walpole Island, St. Clair NWA, Rondeau Bay, Long Point NWA, and the dyked marshes of Big Creek NWA, should be sampled with increased sampling effort to determine if reproducing populations do exist and, if so, the size of the populations. Lake Chubsucker 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 Lake Chubsucker distribution and abundance as well as the success of any recovery measures. A preliminary depletion study was undertaken in 2010 at L Lake and Lyons Creek to determine the feasibility of obtaining population size estimates of extant populations. This type of work should be refined and continued in an attempt to better understand Lake Chubsucker population size. Extant populations should be re-visited to establish baseline information, and to eventually aid in the determination of long-term population trends. There is also uncertainty related to the population trajectory of the L Lake Chubsucker population. Although it is believed that this is the healthiest known Lake Chubsucker population in Canada, the population trajectory is currently based on two sampling events; and therefore, was ranked as 'Unknown', which resulted in an overall population status ranking of 'Fair'. Additional sampling events at this location over time would increase our knowledge on the population trajectory which may result in a higher population status ranking.

Additional exploratory sampling should be completed in areas determined to be composed of suitable Lake Chubsucker habitat, in an attempt to discover undetected populations. Sites that would be good candidates for exploratory surveys would include old oxbow lakes of the lower Ausable River in the vicinity of L Lake and the OAC, as well as tributaries of the Niagara River.

There is a need to identify seasonal habitat requirements for each life stage. Although it is currently assumed that individuals from all Lake Chubsucker life stages occupy the same functional habitat, this assumption should be verified through sampling. This may also allow us to gain a better understanding of preferred habitat of juvenile Lake Chubsucker.

Numerous threats have been identified for Lake Chubsucker 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 Lake Chubsucker 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. Lake Chubsucker is considered to be a pollution-intolerant species, although there is a lack of evidence on the direct or indirect effects of toxic substances on Lake Chubsucker populations. There is a need to determine Lake Chubsucker threshold levels for water quality parameters (e.g., nutrients, dissolved oxygen), as well as a need to identify point and non-point sources of nutrient and sediment inputs and their relative effects on Lake Chubsucker survival. There is a need to do conduct research to determine temperature tolerances for Lake Chubsucker for the various life stages. Further research on the Lake Chubsucker tolerance may provide insight on the causes of Lake Chubsucker extirpation from Tea Creek and Jeanette's Creek, and whether other populations should be flagged as being highly vulnerable to extirpation. Knowledge on temperature and dissolved oxygen tolerance levels for this species may also help to explain which factors are contributing to the large Lake Chubsucker winterkill that occurred in the OAC in 2010. Temperature tolerance information may also provide insight on Lake Chubsucker over-wintering grounds. Increased knowledge on tolerances would provide an opportunity to mitigate the effects of the threat at each highlighted site. Although incidental harvest is listed as a potential threat to Lake Chubsucker, the level of occurrence is currently unknown. Research is needed to determine the level to which Lake Chubsucker are incidentally caught.

Many of the variables required to inform the population modelling efforts are currently unknown, or are only known for non-Canadian populations. Uncertainty in parameter estimates has resulted in large uncertainty in the population growth rates. Studies should focus on acquiring additional information on size-specific fecundity of Canadian populations, annual survival rates of immature individuals, and age at maturity. Estimates of population growth rates and true extinction thresholds are also needed. Finally, the frequency and magnitude of catastrophic events such as winterkill are unknown.

SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat regional advisory meeting of March 9, 2011 on Recovery Potential Assessment (RPA) of Lake Chubsucker. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1919-5079 (Print)
ISSN 1919-5087 (Online)

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO. 2011. Recovery Potential Assessment of Lake Chubsucker (*Erimyzon sucetta*) in Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/033.