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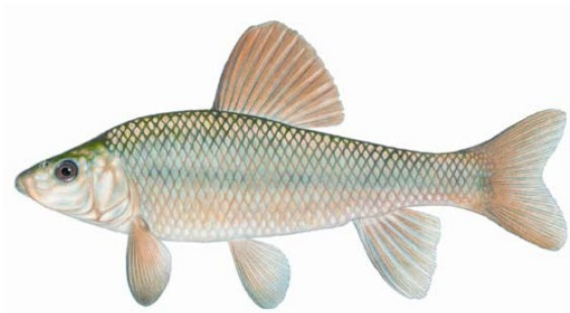
UPDATED RECOVERY POTENTIAL ASSESSMENT OF LAKE CHUBSUCKER (*ERIMYZON SUCETTA*) IN CANADA, 2011–2020



*Lake Chubsucker (*Erimyzon sucetta*)*
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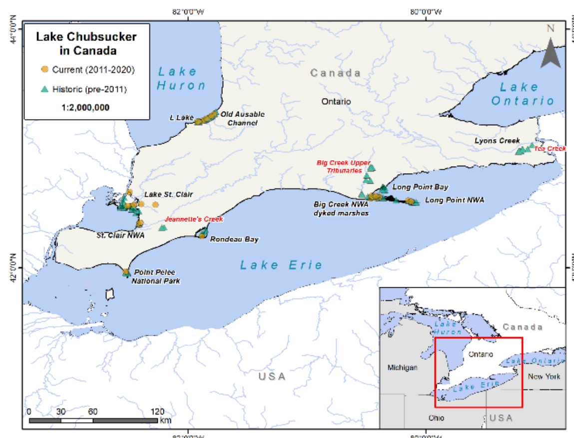

Figure 1. Distribution of Lake Chubsucker in Canada. Red font indicates areas from which the species is thought to be extirpated.

Context:

*Lake Chubsucker (*Erimyzon sucetta*) was first assessed as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1994. This status was re-assessed as Threatened in November 2001. When re-examined in November 2008, the Lake Chubsucker status was changed to Endangered. Lake Chubsucker was re-assessed by COSEWIC and the status was confirmed as Endangered in May 2021. The reason for this designation is that it has a restricted Canadian distribution, specific and narrow habitat preferences making it susceptible to cumulative impacts from aquatic invasive species (notably* Phragmites australis australis*), climate change, and agricultural practices. Three historical populations have been lost, ten are in poor condition, and one is in fair condition.*

The Lake Chubsucker was initially listed as Threatened under Schedule 1 of the Species at Risk Act *(SARA) in June 2003, and is now listed as Endangered. A Recovery Potential Assessment (RPA) was completed in March 2011. The RPA process was developed by Fisheries and Oceans Canada (DFO) to provide information and scientific advice needed to fulfill requirements of SARA, including the development of recovery strategies and authorizations to carry out activities that would otherwise violate SARA (DFO 2007). New information and methods are available since the first RPA was completed and updated information and analysis are provided herein.*

*This Science Advisory Report is from the November 16–18th, 2021 Updated Recovery Potential Assessment of Lake Chubsucker (*Erimyzon sucetta*), 2011–2020. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule](#) as they become available.*

SUMMARY

- This Recovery Potential Assessment provides updates to knowledge of Lake Chubsucker (*Erimyzon sucetta*) in Canada from 2011–2020. Information contained herein replaces previous advice.
- The current distribution of Lake Chubsucker is limited to 11 distinct areas in the Great Lakes basin: Old Ausable Channel, L Lake, Lake St. Clair, dyked marshes within the Lake St. Clair drainage, 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. The species is thought to be extirpated from three historical areas: Jeannette's Creek, the upper tributaries of Big Creek, and Tea Creek.
- Adult Lake Chubsucker are generally found in clear, shallow, still, well-vegetated waters. Substrate in these systems is generally composed of organic matter, silt, sand, and, to a lesser extent, clay and gravel. Juvenile and young-of-year (YOY) captures from L Lake were found over substrate composed mainly of organic debris, and vegetative cover (combination of submerged, floating, and emergent) was greater than 70%. Recent sampling of the St. Clair NWA East cell found all life stages associated with dense mixed stands of submerged aquatic vegetation.
- To achieve ~99% probability of persistence, given a 15% per generation chance of catastrophic population decline (50% or higher), requires ~33,600 age-1 and older Lake Chubsucker and at least 0.41 km^2 of lacustrine or 0.12 km^2 of riverine habitat. Minimum viable population (MVP) values increase as an exponential function of the annual catastrophe probability.
- In the absence of additional harm, recovery efforts, or habitat limitations, a population at 10% of MVP (3,360 age-1 and older) will have a median time-to-recovery of 15 years and a 95% chance of recovering within 39 years (if probability of catastrophe is 15% per generation).
- The greatest threats to the survival and recovery of Lake Chubsucker in Canada are related to natural system modifications associated with habitat-related effects of aquatic invasive species, dredging, drawdown of dyked wetlands, increased sediment loading from agricultural land use, and climate change. Cumulative threat effects likely impact Lake Chubsucker across its Canadian range.
- Population density and growth of Lake Chubsucker are most sensitive to changes in adult survival across all scenarios examined. As population growth rate increases, the population becomes more sensitive to changes in fecundity, YOY and juvenile survival while sensitivity to adult survival decreases.
- There remain numerous sources of uncertainty related to Lake Chubsucker: population distribution, abundance, and trajectory; recent life-history parameters for Canadian populations; habitat preferences for early life stages and over wintering; and, the threat mechanisms and extent of threat impacts.

INTRODUCTION

A meeting of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 1994 recommended that Lake Chubsucker (*Erimyzon sucetta* Lacepède 1803) be designated 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 Lake Chubsucker was re-assessed by COSEWIC in May 2021, and the status was confirmed as Endangered, with increased emphasis on the severity of threats of numerous aquatic invasive species (AIS), notably European common reed (*Phragmites australis australis*). Subsequent to the November 2001 COSEWIC designation, 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 Recovery Potential Assessment (RPA) process was 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). A RPA was completed for Lake Chubsucker in 2011 (DFO 2011). The RPA process has since been updated, and new information is available resulting from increased research and targeted sampling for Lake Chubsucker in Canada (COSEWIC 2021). Thus an update to the RPA was undertaken November 16–18, 2021, with new data from 2011 through 2020; this update replaces previous information (DFO 2011). Supporting information is found in Fung and Koops (2023) and Colm and Drake (2023).

Biology

Lake Chubsucker is a small, deep-bodied member of the sucker family (Catostomidae). It has a thick caudal peduncle, and a wide head with a blunt snout ending in a small, slightly inferior mouth (COSEWIC 2008, Holm et al. 2009). Coloration on the back and upper sides is deep olive-green to bronze, with a cross hatching pattern in adults. 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; the lateral stripe can either be continuous or broken in adults, if present. The Lake Chubsucker lacks a lateral line. It is an omnivorous benthic feeder, consuming small crustaceans, mollusks, aquatic insects, filamentous algae, and plant material (Holm et al. 2009).

Lake Chubsucker spawns between late April and June when water temperatures reach approximately 20°C. Males clear an area in the substrate or vegetation where females deposit between 3,000 and 20,000 eggs (Shireman et al. 1978, COSEWIC 2008). Eggs incubate for 6–7 days, hatching at water temperatures of 22–29°C; larvae are 5–6 mm at hatch. Lake Chubsucker matures at age 2 or 3. Otolith age assessments on 68 deceased Lake Chubsucker (91–199 mm total length) following a winterkill event in the Old Ausable Channel revealed specimens were 1–6 years (1–5 from scale age assessments; Bouvier and Mandrak 2011); the species is reported to live to a maximum of 8 years. The largest Ontario specimen on record had a total length (TL) of 280 mm. Lake Chubsucker captured by DFO in Ontario from 2011–2020 had a mean TL of 66 mm, and ranged 23–253 mm (DFO unpublished data).

A recent study evaluating population genetic structure of Lake Chubsucker from seven Ontario locations found that most specimens analyzed shared the same haplotype, with the exception of the Lyons Creek population, which had three unique haplotypes not found elsewhere in the Ontario samples (Hauser et al. 2019). This suggests Lyons Creek may contain unique genetic structure relative to other Canadian populations; however, the neutral genetic markers used in the study are not suitable for evaluating evolutionary significance, which is required to determine if the population represents a separate designatable unit (COSEWIC 2012). Further analyses including samples from across North American would help determine whether the Lyons Creek population is unique at a range-wide scale.

ASSESSMENT

Abundance

Abundance estimates are lacking for most Lake Chubsucker populations in Canada. Estimates of mean density and relative abundance have been made for Lyons Creek, L Lake and Long Point Bay based on various sampling efforts (Table 1). An additional abundance estimate was generated for the East cell of the St. Clair NWA using allometric and lake-based community density relationships.

Table 1. Estimates of abundance or density for Lake Chubsucker populations with sufficient sampling data. All sampling was conducted with seining, except for sampling in the St. Clair NWA where mini fyke nets were used (DFO 2011, DFO 2021). Note that Ind = individual.

Population	Estimate	Estimate Type	Sampling Years
Lyons Creek	0.0105 (±0.0156) ind/m^2	Mean population density	2010
L Lake	0.0861 (±0.1385) ind/m^2	Mean population density	2010 (June)
L Lake	0.0119 (±0.0181) ind/m^2	Mean population density	2010 (August)
Long Point Bay	0.53 ind/haul	Mean relative abundance	2012–2014
Long Point Bay	0.05 ind/haul	Mean relative abundance	2015–2018
St. Clair NWA – East cell	1302–1375 ind	Total abundance[α]	2019 (Sept)
	0.0023-0.0024 ind/m^2	Mean population density[β]	
	0.0009252 ind/m^2	Age-adjusted mean population density[γ]	

[α]Total abundance estimate based on allometric and lake-based community density relationships.

[β] Mean population density is based on the total abundance estimate divided by the habitat area of the East Cell with a depth greater than 0.3 m (57.72 ha; i.e., the habitat area likely to contribute to fish community production). Note this estimate considers all age classes.

[γ] Mean population density is based on the total abundance estimate adjusted for age 1+ Lake Chubsucker, divided by the area of the East cell (60.93 ha^2).

Distribution and Current Status

The Lake Chubsucker has a disjunct distribution in North America, being somewhat widespread in the southeastern United States (eastern Texas through Atlantic and Gulf slope drainages), and more sporadic in the Mississippi River and lower Great Lakes drainages (eastern Wisconsin through western New York, including the south side of Lake Ontario) (Page and Burr 2011). In Canada, the current and historical distribution of Lake Chubsucker is limited to 14 confirmed areas, three of which are currently considered to be extirpated. Extant areas include Old Ausable Channel (OAC), L Lake, Lake St. Clair (including Mitchell's Bay, the undyked marshes in the area, Chenail Ecarté, Little Bear Creek, Collop Drain and Prince Albert Drain), dyked marshes within the Lake St. Clair drainage, St. Clair National Wildlife Area (NWA) (St. Clair Unit – East and West cells, and Bear Creek Unit – Maxwell cell), Point Pelee National Park, Rondeau Bay, Big Creek NWA dyked marshes, Long Point Bay (including Big Creek undyked marshes, Turkey Point marshes and Long Point Inner Bay and Crown Marsh), Long Point NWA, and Lyons Creek. Areas separated by impassable barriers where dispersal is not a possibility are taken to be separate areas. Extirpated areas include upper Jeannette's Creek (a tributary of the Thames River), the upper tributaries of Big Creek (Silverthorn Creek, Lynedoch Creek, Trout Creek and Stoney Creek) and Tea Creek (a tributary of Lyons Creek).

Ausable River

It is thought that Lake Chubsucker occupied the lower Ausable River prior to its diversion in the late 1800s (ARRT 2005), but the species was extirpated following these modifications. In August 2018, two Lake Chubsucker were captured by boat electrofishing in the lower Ausable River just downstream of the dam at the OAC (Colm et al. 2019). Additional sampling is warranted to determine whether a reproducing population exists in this area.

Old Ausable Channel

Lake Chubsucker was first detected in the OAC in 1982, and subsequently in 1997 (n ≥ 2), 2001 (n = 1), 2002 (n = 13), 2004 (n = 53), 2005 (n = 39), 2009 (n = 28), 2010 (n = 1), 2012 (n = 51), and 2015 (n = 23). An additional 68 deceased individuals were obtained following a large winterkill event in 2010, which allowed for otolith and scale age assessments.

L Lake

The first known L Lake sampling event occurred in 2007 with the aid of a boat electrofisher and a seine net, yielding at least 18 individuals. L Lake was re-visited in June and August 2010 as part of a depletion survey, yielding 215 individuals from 154 seine hauls. In 2018, L Lake was sampled with a seine net and 39 individuals were captured.

Lake St. Clair

For the purposes of the population assessment, all waterbodies directly connected to Lake St. Clair, including Mitchell's Bay, undyked coastal marshes within the drainage, Chenail Ecarté, Little Bear Creek, and Collop and Prince Albert drains were grouped because movement between these localities is possible. Lake Chubsucker was first recorded from Lake St. Clair in 1949. Subsequent records are sparse and include captures from Mitchell's Bay (1952 and 1979), from St. Anne Island to the north end of Chemotogan Channel (1999, 2001 and 2002), Little Bear Creek (2013; n = 2), Prince Albert Drain (2017; n = 3), Collop Drain (2018; n = 1), Chenail Ecarté (2019; n = 50), and St. Clair River (2020; n = 2).

St. Clair National Wildlife Area

Lake Chubsucker is known from several areas of the St. Clair NWA, and all are separated from Lake St. Clair through dykes. The St. Clair Unit is made up of an East and West cell. Lake Chubsucker was first detected in the West cell in 2004 (n = 6), 2016 (n = 18), and 2019 (n = 5). It was first detected in the East cell in 2016 (n = 22), and subsequently in 2018 (n = 6) and 2019 (n = 9). Lake Chubsucker was recorded for the first time in the Bear Creek Unit (Maxwell cell) in 2016 (n = 1).

Jeannette's Creek

In Jeannette's Creek, records of Lake Chubsucker exist from 1963 and 1965, approximately 20 km upstream of the confluence with the Thames River. This area has been resampled on numerous occasions, but has not yielded any additional specimens. The habitat is now degraded (channelized and turbid) and is no longer consistent with Lake Chubsucker preferred habitat, and the 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 (n = 7), and was subsequently captured in 1968 (n ≥ 2), 1969 (n ≥ 1), 1972 (n ≥ 1), 1979 (n ≥ 1), 1983 (n ≥ 1), 1993 (n ≥ 1), 2003 (n = 25), 2016 (n = 1), and 2019 (n = 1). All Lake Chubsucker records from the park are from three ponds: Girardin Pond, Lake Pond, and Redhead Pond.

Rondeau Bay

The first record of Lake Chubsucker from Rondeau Bay dates back to 1955 (n = 14). There have been very limited known occurrences in Rondeau Bay since this date of first capture, with records from 1963 (n ≥ 3), 1983 (n ≥ 1), and 2005 (n = 1). Lake Chubsucker had not been recorded since 2005 despite extensive sampling with suitable gears, and was thought to be extirpated, but was detected again in 2020 (n = 1). All records are from within Rondeau Bay Provincial Park.

Long Point Bay

For the purposes of this population assessment, Big Creek undyked marshes, Turkey Point marshes, and Long Point Inner Bay and Crown Marsh will be collectively referred to as Long Point Bay. These localities were grouped because they are directly connected to each other and movement between them is possible. Lake Chubsucker was recorded from Long Point Inner Bay and Crown Marsh in 1951 (n = 5), 1955 (n = 2), 1994 (n ≥ 8), 1999 (n ≥ 1), 2004 (n = 1), 2009 (n ≥ 1), 2012 (n = 87), 2013 (n = 21), 2014 (n = 88), 2015 (n = 9), 2016 (n = 7), 2017 (n = 9), 2018 (n = 15), 2019 (n = 7), and 2020 (n = 2). It was recorded from the Big Creek undyked marshes in 1955 (n ≥ 5), 1979 (n = 2), 1982 (n = 4), and 2008 (n = 2), and from the Turkey Point marshes in 1985 (n = 1), 2007 (n = 22), 2009 (n ≥ 12), 2010 (n = 2), and 2011 (n = 37).

Long Point National Wildlife Area

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, some of which contain Lake Chubsucker. Ponds range from continuously connected to Lake Erie to completely landlocked. This is considered a separate area from Long Point Bay given the distance and unsuitable habitat in between. Due to its remote location, there have been very few sampling events in this area, but Lake Chubsucker was captured in 1953 (n = 1), 1975 (n ≥ 2), 2005 (n = 1), 2009 (n ≥ 1), 2016 (n = 14), and 2017 (n = 54).

Big Creek National Wildlife Area Dyked Marshes

The dyked marshes of Big Creek NWA are considered a separate area from the open wetlands of Big Creek NWA (and ultimately, from Long Point Bay) as movement between these areas is prevented by dykes. The dyked marshes were sampled for the first time in 2005, yielding 13 Lake Chubsucker. This area was not resampled again until 2016, when 165 individuals were captured (71 in the North cell and 94 in the South cell).

Big Creek Upper Tributaries

Historical Lake Chubsucker records exist for several of the tributaries in the upper reaches of the Big Creek watershed. These records include Silverthorn Creek (1972; n ≥ 1), Stoney Creek (1973; n ≥ 2) , Lynedoch Creek (1974; n ≥ 1), and Trout Creek (1979; n ≥ 2). An additional record from 1960 exists, but the precise location is unknown. Re-sampling of all historical sites in 2008 revealed that many of them are now buried agricultural drains or are dry (COSEWIC 2008). These sites no longer provide suitable habitat for Lake Chubsucker and it is thought to be extirpated from the upper tributaries of Big Creek; the conversion of natural watercourses to tiled drains has been implicated as the causative factor.

Lyons Creek

Lake Chubsucker is known from a 10 km stretch of Lyons Creek immediately downstream of the Welland Canal. Records exist from 2004 (n = 5), 2008 (n = 28), 2009 (n = 20), 2010 (n = 13), and 2013 (n = 5).

Tea Creek

A historical record exists for Tea Creek, a tributary of Lyons Creek, from 1958. This area has been sampled on numerous occasions since but has not yielded any additional records. The habitat in the vicinity of the historical record is no longer considered to be suitable for Lake Chubsucker and the species is thought to be extirpated from Tea Creek.

Population Assessment

To assess the population status, populations were ranked in terms of abundance (Relative Abundance Index: Extirpated, Low, Medium, High, or Unknown) and trajectory (Population Trajectory: Increasing, Decreasing, Stable, or Unknown). Populations were assessed relative to the OAC, considered to be one of the largest populations with the most consistent targeted sampling. The number of individuals caught (either per sampling event for Relative Abundance Index or over time for Population Trajectory) was considered, along with other sampling parameters (e.g., effort, gear, targeted or incidental). A certainty value was assigned based on the type of information used to assess the population (1 = quantitative analysis, 2 = catch per unit effort, 3 = expert opinion). The Relative Abundance Index and Population Trajectory were combined to yield a Population Status (Table 2). Refer to Colm and Drake (2023) for detailed methods.

Table 2. Population Status of all Lake Chubsucker populations in Canada, resulting from an analysis of both the Relative Abundance Index and Population Trajectory; certainty assigned to each Population Status (in brackets) is reflective of the lowest level of certainty associated with either initial parameter. Certainty values are assigned as 1 = quantitative analysis, 2 = catch per unit effort, 3 = expert opinion. Statuses are revised relative to original assessments in Bouvier and Mandrak (2011) due to perceived declines in L Lake and its validity as the reference population. Adapted from COSEWIC (2021).

Area	Localities	Original Population Status	Revised Population Status
Old Ausable Channel	-	Fair (2)	Fair (2)
L Lake	-	Fair (2)	Poor (2)
Ausable River*	Lower Ausable River	-	-
Lake St. Clair	Collop Drain, Prince Albert Drain, Little Bear Creek, Mitchell’s Bay, undyked marshes within the drainage, Chenail Écarté	Poor (3)	Poor (3)
Dyked marshes within Lake St. Clair drainage	-	Poor (3)	Poor (3)
St. Clair NWA	St. Clair Unit: East Cell, West Cell; Bear Creek Unit: Maxwell Cell	Poor (3)	Poor (3)
Jeanette’s Creek	Upper Jeannette’s Creek	Extirpated (2)	Extirpated (2)
Point Pelee National Park	Girardin Pond, Lake Pond, Redhead Pond	Poor (3)	Poor (3)
Rondeau Bay	Provincial Park boundaries	Poor (3)	Poor (3)
Long Point Bay	Long Point Inner Bay, Crown Marsh, Big Creek undyked marshes, Turkey Point marshes	Poor (2)	Poor (3)
Long Point NWA	coastal marshes, inland marshes	Poor (3)	Poor (3)
Big Creek (upper tributaries)	Lynedoch Creek, Silverthorn Creek, Stoney Creek, Trout Creek	Extirpated (2)	Extirpated (2)
Big Creek NWA (dyked marshes)	North Cell, South Cell	Poor (3)	Poor (3)
Lyons Creek	Lyons Creek east	Poor (2)	Poor (2)
Tea Creek	-	Extirpated (2)	Extirpated (2)

*Lake Chubsucker was detected in the lower Ausable River in 2018 (n = 2) and 2021 (n = 1). It is likely that these individuals breached the barrier at the Old Ausable Channel and there is insufficient evidence at this time to determine whether a reproducing population exists.

Habitat Requirements

Lake Chubsucker is a warmwater species, with preferred summer temperature ranging from 28–34 °C (Coker et al. 2001). Throughout the Canadian Lake Chubsucker range, it is found in clear, well vegetated, slow-moving or still waters, at depths < 2 m (COSEWIC 2021). Areas typically inhabited by Lake Chubsucker include backwaters, wetlands, ponds, floodplain lakes, and marshes (COSEWIC 2008). Turbidity is generally very low in these areas, and the substrate is commonly composed of clay, silt, and organic debris (COSEWIC 2021). The mean percent substrate composition at sites where Lake Chubsucker was found in Ontario from 2011–2020 was 40% organic matter, 31% silt, 24% sand and 11% clay. The mean percent composition of aquatic vegetation classes at sites where Lake Chubsucker was found was 66% submerged, 15% floating, and 12% emergent (DFO unpublished data). An aquatic vegetation survey of the St. Clair NWA (East and West cells) indicated that the most frequently occurring aquatic macrophyte genera included: *Nymphaea*, *Ceratophyllum*, *Elodea*, *Hydrocharis*, *Typha*, and *Lemna*. Lake Chubsucker captured during this study ranged in size from 61–215 mm TL, indicating that several life stages were using this habitat (Barnucz et al. 2021). A recent study evaluating responses of imperilled species to common environmental stressors in the Great Lakes basin found that Lake Chubsucker exhibited a strong negative (non-linear) relationship with turbidity, water velocity, and dissolved oxygen, the latter likely indicating some tolerance to low dissolved oxygen, and a strong positive (non-linear) relationship with water temperature (Rodriguez et al. 2021). There is limited information regarding habitat associations by life stage, and no information regarding over-wintering habitat.

Residence, in the context of SARA, is considered to be a dwelling-place occupied by the organism during all or part of their life cycle. Lake Chubsucker does not construct a residence during its life cycle.

In addition to having a patchy and disjunct distribution in Ontario, Lake Chubsucker faces several spatial constraints that likely prevent it from dispersing. In some cases, barriers of various kinds (e.g., dykes, low-head dams, barrier beaches) exist where movement in or out is impossible or unlikely (i.e., OAC, L Lake, St. Clair NWA, dyked marshes within the Lake St. Clair drainage, Big Creek NWA, Long Point NWA inland ponds, Point Pelee National Park). Other locations may be open and connected such that movement within or between locations is hydrologically possible (i.e., Long Point Bay, Rondeau Bay, Lyons Creek, Lake St. Clair), but distances between populations are too great and/or suitable habitat does not exist making such movements unlikely (e.g., high flow in Detroit and Niagara rivers) (COSEWIC 2021). This may have impacts on genetic structure, and likely prevents the species from relocating to suitable patches in response to deteriorating conditions or re-colonizing areas from which it has been extirpated.

Functions, Features, Attributes

A description of the functions, features, and attributes associated with the habitat of Lake Chubsucker in Canada can be found in Table 3. The habitat required for each life stage has been assigned a life-history function that corresponds to a biological requirement of Lake Chubsucker. In addition to the life-history function, a habitat feature has been assigned to each life stage. A feature is considered to be the structural component of the habitat necessary for the species. Habitat attributes have also been provided; these are measurable components describing how the habitat features support the life-history function for each life stage.

Table 3. Summary of the essential functions, features, and attributes for each life stage of Lake Chubsucker in Canada. Habitat attributes from published literature and those recorded during recent (2011–2020) Lake Chubsucker sampling events have been used to describe critical habitat. Current knowledge reflects mean habitat values at sites where young-of-year and juvenile (i.e., < 120 mm TL) and adult (i.e., > 120 mm TL) Lake Chubsucker were captured across Ontario (DFO unpublished data). Life stages are based on presumed age and size at maturity from the literature (see Fung and Koops 2023).

Life Stage	Function	Features	Attributes		
			Scientific Literature	Current Knowledge	Critical Habitat
Spawn to hatch	Spawning, cover, nursery	Areas that seasonally support aquatic vegetation	• 22–29°C (Cooper 1983); • Beds of submerged and emergent vegetation, dead grass, or filamentous algae (Goodyear et al. 1982); • Sand, silt, or gravel substrates where a nest may be cleared by male.		• Shallow waters (0–2 m) of bays, ponds, marshes, lower reaches of tributaries; • Abundant submerged aquatic vegetation; • Water temperatures of approximately 20°C from April to June.
Young-of-year, juvenile,	Feeding, cover, nursery	Areas that seasonally support aquatic vegetation	• 24–28°C (Leslie and Timmins 1997); • Slow-moving or still waters; • Shallow depths (0–2 m; Lane et al. 1996); • Heavily vegetated (> 70% cover; *Brasenia, Nymphaea, Myriophyllum, Ceratophyllum, Chara, Potamogeton, Eleocharis, Carex, Typha*) (Leslie and Timmins 1997, Barnucz et al. 2021, DFO unpublished data); • Organic substrates, or silt, sand or clay substrates (DFO unpublished data); • Low turbidity.	• Mean water temperature of 24.55°C (range: 12.07–33.70), mean conductivity of 339.29 µs/cm (21.70–741.1), mean dissolved oxygen of 6.40 mg/L (0.98–15.38), mean turbidity of 23.81 ntu (0–486.0) (mean secchi tube depth of 0.79 m [0.16–1.18]); • Mean percent composition of substrate classes: organic (40%; range: 0–100), silt (30%; 0–100), sand (24%; 0–100), clay (12%; 0–90); • Mean percent areal cover of aquatic vegetation types: submerged (68%; range: 0–100), floating (14%; 0–50), emergent (10%; 0–70); open water (11%; 0–80).	• Calm and shallow waters (0–2 m); • Abundant aquatic vegetation; • Substrates of organic debris, sand, silt, clay; • Low turbidity.

Life Stage	Function	Features	Attributes		
			Scientific Literature	Current Knowledge	Critical Habitat
Adult	Feeding, cover	Areas that seasonally support aquatic vegetation	• warm waters, 28–34°C (Coker et al. 2001, Rodriguez et al. 2021); • Clear, low velocity, heavily vegetated waters (backwaters, drainage ditches, floodplain lakes, marshes, oxbows, sloughs, wetlands) (COSEWIC 2008, Bouvier and Mandrak 2011, Rodriguez et al. 2021).	• Mean water temperature of 22.33°C (range: 14.5–28.07), mean conductivity of 356.12 µs/cm (232.40–474.30), mean dissolved oxygen of 5.75 mg/L (0.99–11.22), mean turbidity of 5.30 ntu (0.11– 22.33) (mean secchi tube depth of 0.84 m (0.52–1.15)); • Mean percent composition of substrate classes: silt (38%; range: 0–80), organic (37%; 0–100), sand (24%; 0–100), clay (4%; 0–40); • Mean percent areal cover of aquatic vegetation types: submerged (54%; range: 0–100), emergent (19%; 0–100), floating (14%; 0–60); open water (15%; 0–85); • Mean depth of 0.886 m (range: 0.18–4.4 m).	Same as above

Threats

A wide variety of threats negatively impact Lake Chubsucker across its range. Knowledge of threat impacts on Lake Chubsucker populations is limited, as there is a paucity of threat-specific cause and effect information in the literature. The occurrence of pristine, highly vegetated systems in Ontario where Lake Chubsucker thrive is very limited, and the cumulative effects of aquatic invasive species (AIS), various watercourse modifications, pollution inputs, and climate change are likely to continue to degrade these areas.

Natural Systems Modifications

A variety of anthropogenic habitat modifications likely threaten the survival and recovery of Lake Chubsucker across its Canadian range. Siltation of watercourses through increased surface water flow has been attributed to the decline of Lake Chubsucker throughout its range by reducing the conditions that promote the growth of aquatic macrophytes. This is most pertinent to Lake Chubsucker populations directly adjacent to agricultural lands where flow-through effects lead to direct sediment inputs, and less so in dyked wetlands where surface flows are modulated. Shoreline hardening and modifications to increase bank stability and protect against property loss (i.e., through installation of rock, metal, or other hard retaining structures) have occurred in parts of the Lake Chubsucker range in Canada, principally for boating channels and other shoreline infrastructure. This may modify water currents and sediment transport and lead to changes in the composition and availability of substrate, which may reduce the availability of macrophyte cover and food. Dredging is also conducted in parts of the Lake Chubsucker range, mainly in canals and channels used for boating, for agricultural drain maintenance, and for removal of AIS and habitat restoration. Where dredging occurs in proximity to Lake Chubsucker, it may physically disturb individuals and may modify Lake Chubsucker habitat through changes to food supply, sedimentation, structure/cover, and macrophyte composition and availability.

Water-level drawdowns and other manipulations have occurred in several areas inhabited by Lake Chubsucker and the principal impact is reduced habitat availability for this already habitat-limited species. Several populations of Lake Chubsucker exist in dyked wetlands in lakes St. Clair and Erie drainages, and increasingly, water-level drawdowns to promote hemi-marsh conditions have been proposed and implemented in these areas. The short-term consequences of water-level drawdown will be contingent on the amount and quality of refuge habitat available to Lake Chubsucker during drawdown conditions, but will result in density-dependent effects (e.g., increased predation risk, reduced food supply through competition, increased risk of disease transfer due to crowding, reduced dissolved oxygen through consumption) and density-independent effects (e.g., increased temperatures, decreased dissolved oxygen from temperature effects, loss of habitat structure, fragmentation, stranding mortality) to Lake Chubsucker (DFO 2021). Lake Chubsucker is also susceptible to water-level manipulations through the management of the Welland Canal as part of the St. Lawrence Seaway. Water is pumped continuously into the headwaters of Lyons Creek as overflow water from the Welland Canal. If pumping was interrupted, immediate dewatering of the portion of Lyons Creek supporting Lake Chubsucker would be very likely. Lastly, water-level fluctuations are common in the OAC resulting from a combination of historical and recurring human interference. The system receives only limited hydrologic inputs of water from groundwater and runoff, there are a series of undersized culverts and aging water-control structures that restrict what little flow exists, and beaver dams are often removed leading to a near de-watering of the northern portion of the system most preferred by Lake Chubsucker. All of these influences result in wetted habitat that is reduced in both quantity and quality.

Aquatic invasive species are implicated in the current and future decline of Lake Chubsucker through generalized food web changes and the loss or modification of preferred habitat.

Common Carp (*Cyprinus carpio*) is a known ecosystem engineer and is found throughout the Canadian range of Lake Chubsucker. It uproots aquatic vegetation that Lake Chubsucker requires for feeding, cover, and reproduction, and this also leads to increased turbidity, which can further decrease macrophyte abundance and diversity. Grass Carp (*Ctenopharyngodon idella*), a species of increasing abundance in Lake Erie, feeds almost exclusively on aquatic vegetation, which will similarly negatively affect habitat required by all life stages of Lake Chubsucker. The establishment and spread of invasive plants, notably European common reed and Eurasian Watermilfoil (*Myriophyllum spicatum*) within coastal and inland wetlands is also likely to impact Lake Chubsucker. European common reed has led to substantial reductions of wetted area and a presumed reduction of preferred habitat features in many localities inhabited by Lake Chubsucker, and Eurasian watermilfoil likely competes with native plants that Lake Chubsucker relies on, which may be especially problematic if it reaches higher densities than stands of native macrophytes. A better understanding of the ecological effects of both of these invasive plants on Lake Chubsucker (e.g., spawning success, food supply, provision of cover) is required. A final consideration is that, in some cases, the effects of controlling AIS, especially activities to reduce the density of European common reed and Eurasian watermilfoil (e.g., spraying of chemical control agents, burning, cutting, dredging) may negatively affect Lake Chubsucker in the short term through direct impacts (e.g., mortality, distress to individuals) or through changes to habitat condition.

Pollution

Lake Chubsucker is considered a pollution-intolerant species, and although there have been no direct studies evaluating the impacts of pollutants on it, pollutants are likely to negatively affect growth and reproduction, whether directly (i.e., neurological or endocrine disruption) or indirectly (i.e., impacts to macrophyte growth or invertebrate communities). Lake Chubsucker is found in areas with high agricultural land use where runoff is likely to contain heavy loads of nutrients, which may impact primary productivity, water clarity, and dissolved oxygen, as well as pesticides, herbicides and metals through the field application of biosolids from both agriculture and human waste, that may have harmful effects on Lake Chubsucker and its food source. A handful of Lake Chubsucker populations may be impacted by industrial effluents (e.g., those downstream of the St. Clair River), or exposure to industrial compounds from historical sources, notably polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), zinc, and DDT and its derivatives (i.e., in Point Pelee National Park, Lyons Creek). Bioaccumulation of these compounds within benthic organisms has been documented (Milani et al. 2013), which may lead to contaminant effects for Lake Chubsucker given that these organisms constitute a key prey resource. Microplastic waste from industrial and urban sources has been found in surface waters and sediments of the lower Great Lakes, and is likely to settle out in low-energy environments, such as those inhabited by Lake Chubsucker. Little is known about the impacts of microplastic waste on freshwater fishes at this time. Lastly, some populations of Lake Chubsucker may be exposed to pollution from urban sources, notably aging septic beds in areas with residential or recreational properties near the shoreline. Septic leaching can result in increased nitrogen and possibly phosphorus loading, leading to algal blooms and other primary production, which can result in heightened periods of consumption and decay during late summer and early fall. Additionally, application of road salts for winter de-icing has been shown to impair growth and development of salmonid eggs and larvae (Hintz and Relyea 2017, 2019), and impact survival, feeding, and growth of leuciscid minnows (Corsi et al. 2010, Hintz et al. 2017). Further research is needed on impacts of these pollutants on Lake Chubsucker.

Climate Change

Climate change is expected to modify habitat resources that Lake Chubsucker relies on to carry out its life history. However, the magnitude and direction of habitat change is difficult to predict due to the potential for synergistic and antagonistic habitat effects. Lake Chubsucker is considered one of the more vulnerable species to impacts from climate change (Doka et al. 2006, Brinker et al. 2018). Being a coastal wetland/shallow water species, it is more susceptible to fluctuations in water level and temperature that are expected to become more frequent and severe. As a late spring/early summer spawner, the variable onset of spring and more variable spring conditions overall relative to historical conditions are likely to impact spawning success and recruitment. Lake Chubsucker has a restricted distribution; there are relatively few populations, many of which are far apart for a species with limited dispersal capabilities. If populations are lost, it is unlikely they can be rescued. The presence of barriers, especially anthropogenic ones, also contributes to Lake Chubsucker's vulnerability to climate change as barriers will prevent or deter it from relocating if conditions become unfavourable. Lastly, although the species may be tolerant of warming temperatures (Rodriguez et al. 2021), it has historically experienced relatively low variability in seasonal temperatures across its range in Ontario, which may make it poorly adapted to predicted future changes (Doka et al. 2006, Brinker et al. 2018).

Invasive and Other Problematic Species and Genes

Although direct evidence of impacts from invasive and other problematic species on Lake Chubsucker is limited, several species are likely to negatively affect it. Round Goby (*Neogobius melanostomus*), a small benthic invader now widely established in many waterways inhabited by Lake Chubsucker, has been implicated in the decline of other small-bodied native species, which was assumed to be the result of direct competition for food and habitat resources, and predation on eggs and larvae (Poos et al. 2009). Similarly, Rudd (*Scardinius erythrophthalmus*), another invader of European origin, has shared habitat preferences and an omnivorous feeding strategy that make predation and competition with Lake Chubsucker likely. The establishment and ongoing range expansion of Round Goby and Rudd is also likely to cause generalized food web changes in areas where Lake Chubsucker occurs. Although illegal stocking of predatory sport fishes has not been documented in areas inhabited by Lake Chubsucker, it has resulted in changes to the composition and productivity of native fish communities in many parts of North America. If introduced, predatory fishes may lead to the decline of Lake Chubsucker, which will have the greatest impact when Lake Chubsucker is ecologically naïve to the predator. Lastly, centrarchids have become more widespread and locally abundant across Ontario, likely resulting from cumulative impacts of human-mediated dispersal, climate change, and their adaptability to habitat changes from AIS or anthropogenic land uses (Jackson and Mandrak 2002, Finigan et al. 2018). Increased abundance of centrarchids would increase predation pressure and competition (particularly from younger age classes) on Lake Chubsucker.

Cumulative Threat Effects

The interaction between multiple threats has not been evaluated, but given the limited habitat area available to Lake Chubsucker within which multiple threats occur, it is highly likely that cumulative threat impacts on Lake Chubsucker are occurring across its range.

Threat Assessment

A threat assessment was completed for Lake Chubsucker following guidelines provided in DFO (2014). Each threat was ranked in terms of the threat Likelihood of Occurrence, threat Level of Impact, and Causal Certainty. The Likelihood of Occurrence and Level of Impact for each population were subsequently combined in a Threat Risk Matrix resulting in the population-level threat assessment. Terms used to describe threat categories are described in Table 4. Threats were then rolled-up to create a species-level threat assessment, presented in Table 5. Refer to Colm and Drake (2023) for detailed methods.

Table 4. Terms and definitions used to describe population-level threat occurrence (PTO), threat frequency (PTF) and threat extent (PTE) reproduced from DFO (2014).

Term	Definition
Population-Level Threat Occurrence (PTO)	
Historical (H)	A threat that is known to have occurred in the past and negatively impacted the population.
Current (C)	A threat that is ongoing, and is currently negatively impacting the population.
Anticipatory (A)	A threat that is anticipated to occur in the future, and will negatively impact the population.
Population-Level Threat Frequency (PTF)	
Single (S)	The threat occurs once.
Recurrent (R)	The threat occurs periodically, or repeatedly.
Continuous (C)	The threat occurs without interruption.
Population- Level Threat Extent (PTE)	
Extensive (E)	71–100% of the population is affected by the threat.
Broad (B)	31–70% of the population is affected by the threat.
Narrow (NA)	11–30% of the population is affected by the threat.
Restricted (R)	1–10% of the population is affected by the threat.

Table 5. Species-level Threat Assessment of all Lake Chubsucker populations in Canada, resulting from a roll-up of the Population-level Threat Assessment (Colm and Drake 2023). The species-level Threat Assessment retains the highest level of risk for any population. The number in brackets refers to the highest Causal Certainty associated with the Threat Impact (1 = Very High; 2 = High; 3 = Medium; 4 = Low; 5 = Very Low). All categories of Threat Occurrence (H = Historical; C = Current; A = Anticipatory) and Threat Frequency (S = Single; R = Recurrent; C = Continuous) are retained, and the species-level Threat Extent (E = Extensive; B = Broad; NA = Narrow; R = Restricted) is the mode of the population-level Threat Extent.

		Species-level Threat Risk	Species-level Threat Occurrence	Species-level Threat Frequency	Species-level Threat Extent
Natural Systems Modifications	Agriculture	High (3)	H/C/A	R/C	B
	Shoreline development and hardening	High (4)	H/C/A	S/R	R
	Dredging	High (3)	H/C/A	S/R	B
	Drawdown of dyked wetlands and other water level manipulations	High (1)	H/C/A	S/R/C	R/E
	Aquatic Invasive Species	High (4)	H/C/A	C	B
Pollution	Agriculture	High (3)	H/C/A	R/C	B
	Industrial activity	Medium (4)	H/C/A	R/C	R
	Urbanization	High (4)	H/C/A	R	R
Climate Change	Climate Change	High (3)	H/C/A	C	B

		Species-level Threat Risk	Species-level Threat Occurrence	Species-level Threat Frequency	Species-level Threat Extent
Invasive and other Problematic Species and Genes	Competition/Predation	Low (4)	H/C/A	C	N
	Illegal Stocking	Low (5)	A	S	B

Recovery Modelling

Recovery potential modelling was completed in three main steps. Firstly, information on vital rates was compiled to build projection matrices that incorporate stochasticity and density-dependence acting on the first year of life. The impact of anthropogenic harm to populations was then quantified with the use of elasticity and simulation analyses. Lastly, estimates of recovery targets for abundance and habitat were made with estimation of the minimum viable population (MVP) and the minimum area for population viability (MAPV). Refer to Fung and Koops (2023) for complete methods.

Allowable Harm

The impact of harm to Lake Chubsucker populations was analyzed with deterministic elasticity analysis on the population growth rate and on life-stage densities, and via the use of population simulations. This combination of methods allows for the impact of changes to vital rates on a population's growth rate to be evaluated under situations of permanent changes (elasticity) and transient/periodic harm (simulations).

Overall, Lake Chubsucker populations are most sensitive to changes in adult survival. Population growth rate was sensitive to changes in early life history, decreasing with age; however, impacts are more likely to affect an entire life stage rather than a specific age, thus, when age classes are combined, the adult life stage is most sensitive to perturbations overall. When the population is stable or in decline, adult survival exerts the strongest influence on population growth rate; when the population is growing or booming, the influence of juvenile and YOY survival becomes stronger, although still not stronger than adult survival. When the influence of density is considered, increases to both adult and juvenile survival rate will lead to an increase in density, but density is more sensitive to adult survival than juvenile survival. Likewise, adult densities are more sensitive than juvenile densities to perturbations in survival rate. For example, reduction in the adult survival rate by ~13% would cause the adult population to decline by 25% from its initial carrying capacity. This is similar to results from the annual harm simulations, where harm of ~12% to adult survival leads to a 25% decline in adult abundance. Adult abundance is less sensitive to YOY and juvenile survival where a ~20% decrease in either rate would lead to a 25% decline. Simulation results evaluating impacts of transient or periodic perturbations similarly found the adult stage to be most sensitive. When harm is applied to adults, the population trajectories exhibit greater negative slopes and reach a lower population level than when harm is applied to YOY or juvenile stages. Relationships between specific anthropogenic activities and changes in vital rates have not yet been established for Lake Chubsucker, but elasticity analyses may be useful for guiding decisions based on known (or estimated) population size and expected level of harm.

Recovery Targets

Abundance (Minimum Viable Population)

The concept of demographic sustainability was used to identify potential recovery targets for Lake Chubsucker using the concept of a minimum viable population (MVP) size. MVP was estimated using simulation analysis which incorporated environmental stochasticity and density-dependence. Simulations ran over a 100 year timeframe incorporating different frequencies and severities of catastrophic events to account for uncertainties in nature, and used a quasi-extinction threshold of 25 adult females, below which a population is likely unviable.

The number of adult female Lake Chubsucker required for a 99% persistence probability over 100 years is ~1,800 for a 5% generational catastrophe rate, ~4,000 for a 10% rate and ~8,500 for a 15% rate (Table 6). The stable stage distribution for Lake Chubsucker is 99.95% YOY, 0.025% juveniles (age 1) and 0.025% adults (age 2–8). Given this stable stage distribution and a 99% chance of persistence, Lake Chubsucker adult and juvenile MVP is ~7,200 for a 5% generational catastrophe rate, ~15,800 for a 10% rate and ~33,600 for a 15% rate (Table 6). The frequency of catastrophes has a strong impact on the required population size for sustainability, and the relationship is depicted in Figure 2.

Table 6. The minimum viable population (MVP) and minimum area for population viability (MAPV) under six catastrophe rates and for two probabilities of quasi-extinction. Bolded numbers represent a plausible scenario, and indicate the values presented in the summary bullets.

Risk of Extinction	Catastrophe Rate per Generation	MVP			MAPV (km^2)	
		Adult Females	All Adults	Age-1 and Older	Lacustrine	Riverine
5%	5%	597	1,194	2,349	0.029	0.008
	10%	1,214	2,428	4,777	0.059	0.017
	15%	2,334	4,668	9,184	0.11	0.032
	20%	4,324	8,648	17,015	0.21	0.06
	25%	9,505	19,010	37,402	0.46	0.13
	30%	23,817	47,634	93,720	1.15	0.33
1%	5%	1,837	3,674	7,229	0.089	0.026
	10%	4,009	8,018	15,775	0.19	0.056
	15%	**8,532**	**17,064**	**33,573**	**0.41**	**0.12**
	20%	16,995	33,990	66,875	0.82	0.24
	25%	45,681	91,362	17,9755	2.21	0.64
	30%	139,329	278,658	548,260	6.74	1.94

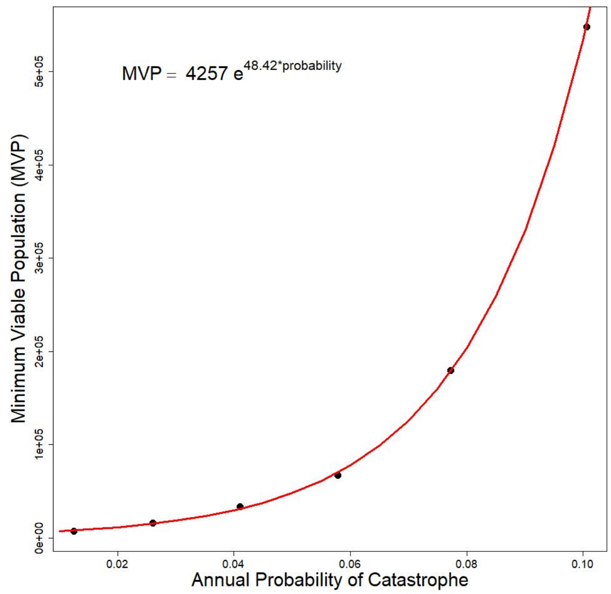

Figure 2. The minimum viable population (MVP) as an exponential function of the annual probability of catastrophe. The points represents the MVP values for generational catastrophe rates ranging from 5% to 30% at 5% intervals, expressed as annual probabilities.

Habitat (Minimum Area for Population Viability)

The minimum area for population viability (MAPV) is the quantity of habitat required to support a population of MVP size, and is estimated as the MVP divided by mean population density. Three mean population density estimates were available, two from the L Lake population (representing different sampling periods) and one from Lyons Creek. A density estimate was also available from the St. Clair NWA East cell based on an allometric and community density derived abundance estimate (DFO 2021). Allometric relationships for lacustrine and riverine habitats were used to estimate mean population density for other populations.

Given an MVP of ~ 33,600 age-1 and older individuals (with a 15% generational catastrophe rate and 1% extinction risk), the MAPV estimated from the three density estimates was 0.39, 2.82, and 3.2 km^2, respectively, and 36.3 km^2 from the St. Clair NWA East cell. When population density is estimated using allometric relationships, the required MAPV is ~0.41 km^2 for lacustrine habitats and ~0.12 km^2 for riverine habitats (Table 6). A comparison of the allometry-based MAPV with the amount of habitat estimated to be available to various Lake Chubsucker populations is listed in Table 7. These are coarse estimates based on an area of occupancy approach and do not necessarily include all of the habitat that contributes to life-history processes. Additionally, population-specific habitat requirements are not known, and therefore, not accounted for.

Table 7. The amount of available habitat (km²) for each Lake Chubsucker population and whether it meets the demand for the minimum area for population viability (MAPV). Available habitat was coarsely estimated and may not include all habitat area that contributes to life-history processes. NA indicates reasonable habitat size estimates were not available. Some areas include dyked wetland cells that may not meet MAPV requirements if movement between cells is not possible.

Population	Available Habitat (km^2)	Habitat Type	MAPV Achieved
Old Ausable Channel	0.61	Lacustrine	Yes
L Lake	0.136	Lacustrine	No
Lake St. Clair	NA	Lacustrine	-
Dyked marshes within the Lake St. Clair drainage	NA	Lacustrine	-
St. Clair NWA *(East and West cells)*	3.52	Lacustrine	Yes
Point Pelee National Park *(Redhead, Girardin, Lake ponds)*	1.44	Lacustrine	Yes
Rondeau Bay	9.43	Lacustrine	Yes
Long Point Bay	59.62	Lacustrine	Yes
Long Point NWA	81.34	Lacustrine	Yes
Big Creek NWA	0.53	Lacustrine	Yes
Lyons Creek	0.418	Riverine	Yes

Recovery Time

As population abundance is unknown for most Lake Chubsucker populations in Ontario, time to recovery was estimated with simulations that began with an initial population size set at 10% of the MVP. Simulations incorporated stochasticity, density-dependence, and catastrophes in the same manner as MVP simulations. Recovery simulations resulted in a distribution of recovery times, but the median time to recovery was 15 years and 95% percent of populations reached recovery in 39 years or less.

Mitigations and Alternatives

Threats to Lake Chubsucker survival and recovery can be reduced by implementing mitigation measures to reduce or eliminate potential harmful effects resulting from works, undertakings or activities (w/u/a) associated with projects in Lake Chubsucker habitat. In the last eight years, a variety of w/u/a have occurred in Lake Chubsucker habitat including: dredging/excavation, aquatic vegetation removal, culverts, and shoreline protection. A review has been completed summarizing the types of projects that have been undertaken in habitat known to be occupied by Lake Chubsucker (see Colm and Drake 2023 for details). A total of 77 projects were identified, eight of which were authorized under the *Fisheries Act*. Most projects were deemed low risk to fishes and fish habitat and were addressed through letters of advice with standard mitigations. Without appropriate mitigations, projects or activities occurring adjacent or close to these areas could have impacted Lake Chubsucker (e.g., through increased turbidity, sedimentation, direct mortality or other physiological impacts). The most frequent project type was dredging/excavation. Based on the assumption that historical and anticipated development pressures are likely to be similar, it is likely that similar types of projects will occur in or near Lake Chubsucker habitat in the future.

Numerous threats affecting Lake Chubsucker populations in Canada are related to habitat loss or degradation (Table 8). The DFO Fish and Fish Habitat Protection Program (FFHPP) has developed guidance on mitigation measures for 18 Pathways of Effects for the protection of aquatic species at risk in the Ontario and Prairie Region (formerly part of Central and Arctic Region) (Coker et al. 2010). This guidance should be referred to when considering mitigation and alternative strategies for habitat-related threats. Additional advice developed for mitigating threats specifically for Lake Chubsucker, or in specific locations where it occurs, and advice for non-habitat related threats is presented below.

Table 8. Summary of works, undertakings and activities that have occurred during the period of November 2013 to June 2021 in areas known to be occupied by Lake Chubsucker. Threats known to be associated with these types of works, undertakings, and activities are indicated with a checkmark. The number of works, undertakings, and activities associated with each Lake Chubsucker population, as determined from the project assessment analysis, has been provided. Applicable Pathways of Effects are indicated for each threat associated with a work, undertaking, or activity: 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.

Work/Undertaking/Activity	**Threats** (associated with work/undertaking/activity)				**Projects per Watercourse** (number of works/undertakings/activities between November 2013 - June 2021)										
	Natural Systems Modifications	Pollution	Invasive and Other Problematic Species and Genes	Climate Change and Severe Weather	Old Ausable Channel	L Lake	Lake St. Clair	Dyked marshes within the Lake St. Clair drainage	St. Clair NWA	Point Pelee National Park	Rondeau Bay	Long Point Bay	Long Point NWA	Big Creek NWA Dyked marshes	Lyons Creek
Applicable pathways of effects for threat mitigation and project alternatives	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 15, 18	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12 ,13, 14, 15, 16,18	-	-	-	-	-	-	-	-	-	-	-	-	-
Water crossings (bridges, culverts, open cut crossings)	✓	✓	-	-	-	-	4	-	3	-	-	4	-	-	2
Shoreline, streambank work (stabilization, infilling, retaining walls, riparian vegetation management)	✓	✓	-	-	1	-	3	-	1	-	-	7	-	-	-
Instream works (channel maintenance, restoration, modifications, realignments, dredging, aquatic vegetation removal)	✓	✓	-	-	-	1	15	-	8	2	3	9	-	-	1
Water management (stormwater management, water withdrawal)	✓	✓	-	-	-	-	1	-	1	-	-	-	-	-	-

Work/Undertaking/Activity	Threats (associated with work/undertaking/activity)				Projects per Watercourse (number of works/undertakings/activities between November 2013 - June 2021)										
	Natural Systems Modifications	Pollution	Invasive and Other Problematic Species and Genes	Climate Change and Severe Weather	Old Ausable Channel	L Lake	Lake St. Clair	Dyked marshes within the Lake St. Clair drainage	St. Clair NWA	Point Pelee National Park	Rondeau Bay	Long Point Bay	Long Point NWA	Big Creek NWA Dyked marshes	Lyons Creek
Applicable pathways of effects for threat mitigation and project alternatives	1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 15, 18	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12 ,13, 14, 15, 16,18	-	-	-	-	-	-	-	-	-	-	-	-	-
Structures in water (boat launches, docks, effluent outfalls, water intakes, dams)	✓	✓	-	-	2	-	1	-	-	1	-	6	-	-	-
Invasive species introductions (accidental and intentional)	✓	-	✓	-	-	-	-	-	-	-	-	-	-	-	-

Drawdown of Dyked Wetlands

Following a proposed water-level drawdown in the St. Clair NWA (East cell of the St. Clair Unit), DFO (2021) evaluated the impacts on Lake Chubsucker across various drawdown increments and provided several potential mitigation strategies for this system. This advice is likely applicable to other dyked wetlands; however, the impacts to Lake Chubsucker from drawdown would depend on the habitat availability (and other biotic and abiotic factors) under baseline conditions in those systems.

Mitigation

- Create deep water habitat in advance of water-level drawdowns (i.e., dredge deep sections to reduce the net loss of deep water habitat during drawdown conditions).
- Dredge channels strategically to maintain connectivity between habitat patches (based on bathymetry of the system). This will maximize access to deep water habitat and minimize the risk of stranding.
- Removal of predators to reduce density-dependent effects.
- Reduce the drawdown increment to maximize both the total wetted area and area of deep water habitat to serve as refuge.

Dredging (Pond Creation/ Restoration)

As part of management actions for European common reed, open-water ponds were created and/or restored in Long Point Crown Marsh. Their ability to support fish species at risk, including Lake Chubsucker, and a healthy wetland fish community overall was evaluated (DFO 2017a). Several mitigations were recommended that can be applied to future pond restoration projects within Long Point Bay.

Mitigation

- Maintain a permanent channel (i.e., sufficiently deep for low water events) to ensure fishes can enter and exit the ponds as needed based on seasonal influences. This will help promote the survival of fishes and prevent the ponds from functioning as ecological traps. In the case of Lake Chubsucker where ponds may not individually meet the MAPV, channels connecting ponds to each other and/or to the Inner Bay will ensure the total habitat space accessible to the species meets the MAPV target.
- Ponds should be constructed with a gradient with the greatest depth at the mouth of the connecting channel so fishes can exit the ponds during low water periods.
- Maintenance works in created ponds should be limited so that submerged aquatic vegetation has the ability to recolonize quickly and provide functional habitat.

Dredging (Drain Maintenance)

Different scenarios for conducting agricultural drain maintenance in Little Bear Creek were evaluated in terms of their predicted effect on at-risk fishes in the system (including Lake Chubsucker) and their habitat (DFO 2017b). An aquatic vegetation survey, bathymetry survey, and fluvial geomorphology survey were completed to model changes in habitat availability under the different scenarios, and mitigation measures were proposed.

Mitigation

- Dredging activities should be conducted in the centre bottom of the channel only, leaving edges intact. This preserves slow-moving, vegetated habitat preferred by Lake Chubsucker and can help maintain longitudinal connectivity between suitable habitat patches.

- If cross-sectional dredging is required, decreasing the depth of bottom dredging to < 1.425 m is recommended as this will promote macrophyte regeneration within 1–2 years.

Invasive and Other Problematic Species and Genes

Several aquatic invasive taxa threaten Lake Chubsucker directly (through competition/ predation) and indirectly (through habitat modifications).

Mitigation

- Develop public awareness campaigns and encourage the use of existing invasive species reporting systems (e.g., Ontario Invading Species Awareness Program hotline, EDDMapS)
- 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 result in the loss of preferred Lake Chubsucker habitat.
- Conduct early detection surveillance or monitoring for invasive species that may negatively affect Lake Chubsucker populations directly, or negatively affect Lake Chubsucker preferred habitat.
- Develop a response plan to address potential risks, impacts, and proposed actions if monitoring detects the arrival or establishment of an exotic species.

Alternatives

- Unauthorized introductions
  - None
- Authorized introductions
  - Do not stock non-native species in areas inhabited by Lake Chubsucker.
  - Do not enhance habitat for non-native species in areas inhabited by Lake Chubsucker.
  - Follow the National Code on Introductions and Transfers of Aquatic Organisms for all aquatic organism introductions (DFO 2017c).

Sources of Uncertainty

Sources of uncertainty have been organized into research themes based on Drake et al. (2021) to create consistency across RPAs and to aid in planning and prioritization of research objectives.

Population Ecology

Abundance and Distribution

Abundance estimates are lacking for most Lake Chubsucker populations. In some cases where estimates were attempted (i.e., through depletion and mark-recapture studies in Lyons Creek and L Lake, respectively), too few individuals were captured to provide an estimate. For similar data-limited species, allometric relationships are often used to estimate abundance but no such relationships exist for wetland communities, which would be best suited to Lake Chubsucker in Canada. Recent sampling has confirmed that Lake Chubsucker is still extant at 11 historical areas and targeted exploratory sampling has failed to find new populations; however, incidental sampling has detected it in new localities (e.g., Ausable River, Collop Drain, Prince Albert Drain, etc.) suggesting the species distribution in Ontario is not fully understood. Long-term, standardized monitoring would allow for better estimates of population abundance, trajectory, and changes in distribution through time.

Life-history

The life-history characteristics of Lake Chubsucker are not well described in the literature, and there is a paucity of recent information from wild Canadian populations. Information on age and growth was based on a small sample size and was supplemented with age estimates that were derived from length intervals rather than length distributions; this introduces potential error to estimates of mortality and other vital rates. Fecundity estimates came from an experimental pond stocking study in the U.S.A. and may not be representative of wild Canadian populations. Additionally, much of the life-history data was decades old, and it may not be representative of current conditions. Additional studies (e.g., measuring survival through tagging studies) and use of new technologies (e.g., portable ultrasound equipment for measuring fecundity) may be able to fill life-history data gaps.

Genetics

Progress has been made on evaluating population genetics of Lake Chubsucker in Canada; however, uncertainties remain regarding how the genetics of Canadian populations fit into the genetic structure of the species across its North American range. Collection of tissues from U.S.A. populations would help contextualize the Canadian populations. Additionally, genetic studies thus far have used neutral genetic markers that are not suitable for exploring evolutionary significance of unique haplotypes (e.g., Lyons Creek), so identifying appropriate markers for future analyses would be useful for resolving the most appropriate unit/level for species management.

Habitat

Associations by Life Stage

There remain gaps in knowledge on the seasonal habitat requirements by life stage for Lake Chubsucker in Canada. In particular, little is known of Lake Chubsucker over-wintering habitat and the availability of suitable refuges in dyked wetlands and other closed systems over-winter. In addition, comprehensive surveys of Lake Chubsucker habitat availability have not been conducted.

Threats

Mechanism of Impact

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 have been no direct studies evaluating physiological tolerances (e.g., to temperature, dissolved oxygen, pollutants, sedimentation) of Lake Chubsucker at different life stages. Understanding neurological or endocrinological effects of herbicide (e.g., glyphosate) applications may be especially prudent. Increased knowledge on physiological effects and tolerances would provide an opportunity to mitigate the effects of water quality, pollution, and climate change-related threats.

Probability, Extent and Magnitude of Impact

There are many uncertainties related to the probability, extent, and magnitude of impacts from various threats, and in particular, the response of Lake Chubsucker populations to habitat modifications. The impacts on population vital rates from anthropogenic activities like dredging, shoreline hardening, and siltation of watercourses are unknown. The frequency of catastrophic events from anthropogenic (or natural) disturbances is also unknown. Lastly, there are a number of uncertainties regarding potentially negative biotic interactions with AIS, illegally introduced sport fishes, or native species expanding in range or abundance. In these cases, the mechanisms of impact are often known (i.e., habitat- or food web-related changes, competition, predation), but the extent to which these species will affect the survival and recovery of Lake Chubsucker, fish community production, and habitat quantity and quality is unknown.

Recovery

Threat Mitigation

There are several threats to Lake Chubsucker for which mitigations have been proposed, but the effectiveness of these mitigations remain poorly understood. Management activities like water-level drawdowns and invasive species control have been proposed and/or undertaken in Lake Chubsucker habitat. The long-term benefits, if realized, are expected to outweigh short-term consequences, but an evaluation of long-term monitoring data (i.e., before-after-control-impact study) would help confirm this. There is also uncertainty around the effectiveness of standard mitigations and offset measures typically prescribed for development projects in Lake Chubsucker habitat.

Reintroductions

Reintroductions of Lake Chubsucker into historically occupied locations were proposed as a potential recovery measure pending feasibility assessments. Key knowledge gaps remain around habitat associations by life stage, suitability of habitat in receiving locations, compatibility of source and receiving populations/ecosystems, and resilience of source populations.

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SOURCES OF INFORMATION

This Science Advisory Report is from the November 16–18th, 2021 regional advisory meeting on the Updated Recovery Potential Assessment of Lake Chubsucker (*Erimyzon sucetta*), 2011–2020. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

ARRT (Ausable River Recovery Team). 2005. Recovery strategy for species at risk in the Ausable River: An ecosystem approach, 2005-2010. Draft Recovery Strategy submitted to RENEW Secretariat. 129 p.

Barnucz, J., Colm, J.E., and Drake, D.A.R. 2021. Fish Community Inventory of Dyked Wetlands in the St. Clair National Wildlife Area, Ontario, 2018 and 2019. Can. Data Rep. Fish. Aquat. Sci. 1324: vii + 34 p.

Bouvier, L.D., and Mandrak, N.E. 2011. Information in support of a Recovery Potential Assessment of Lake Chubsucker (*Erimyzon sucetta*) in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/048.

Brinker, S.R., Garvey, M., and Jones, C.D. 2018. Climate change vulnerability assessment of species in the Ontario Great Lakes Basin. Ontario Ministry of Natural Resources and Forestry, Peterborough, ON. Climate Change Research Report CCRR-48: 85 p. + Appendix

Coker, G.A., Portt, C.B., and Minns, C.K. 2001. Morphological and ecological characteristics of Canadian freshwater fishes. Can. Manuscr. Rep. Fish. Aquat. Sci. 2554: iv + 89 p.

Coker, G.A., Ming, D.L., and Mandrak, N.E. 2010. Mitigation guide for the protection of fishes and fish habitat to accompany the species at risk recovery potential assessments conducted by Fisheries and Oceans Canada (DFO) in Central and Arctic Region. Version 1.0. Can. Manuscr. Rep. Fish. Aquat. Sci. 2904: vi + 40 p.

Colm, J.E. and Drake, D.A.R. 2023. Information in support of an updated Recovery Potential Assessment of Lake Chubsucker (*Erimyzon sucetta*) in Canada, 2011–2020. DFO Can. Sci. Advis. Sec. Res. Doc. 2023/012. v + 61 p.

Colm, J., Marson, D. and Cudmore, B. 2019. Results of Fisheries and Oceans Canada's 2018 Asian Carp Early Detection Field Surveillance Program. Can. Manscr. Rep. Fish. Aquat. Sci. 3168-1: vi + 69 p.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2008. COSEWIC assessment and update status report on the Lake Chubsucker, *Erimyzon sucetta*, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. vi + 29 p.

COSEWIC. 2012. COSEWIC guidelines for recognizing designatable units [online]. (accessed September 4, 2020).

COSEWIC. 2021. COSEWIC assessment and status report on the Lake Chubsucker Erimyzon sucetta in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. xi + 49 p.

Cooper, E. L. 1983. Fishes of Pennsylvania and the northeastern United States. The Pennsylvania University Press, University Park, PA. vii + 243 p.

Corsi, S.R., Graczyk, D.J., Geis, S.W., Booth, N.L., and Richards, K.D. 2010. A fresh look at road salt: aquatic toxicity and water-quality impacts on local, regional, and national scales. Environ. Sci. Technol. 44: 7376–7382.

DFO. 2007. Revised protocol for conducting recovery potential assessments. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/039.

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

DFO. 2014. Guidance on Assessing Threats, Ecological Risk and Ecological Impacts for Species at Risk. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2014/013. (*Erratum*: June 2016).

DFO. 2017a. Evaluation of habitat restoration activities for species at risk fishes within Crown Marsh (Long Point Bay). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/056.

DFO. 2017b. Assessment of the impacts of an agricultural drain maintenance project on aquatic species at risk in Little Bear Creek, Ontario. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/046.

DFO. 2017c. National code on introductions and transfers of aquatic organisms. Fisheries and Oceans Canada, Ottawa, ON. DFO/2017-1997. 41 p.

DFO. 2021. Ecological Impact of Water-Level Drawdown on Lake Chubsucker (Erimyzon Sucetta) in the St. Clair National Wildlife Area. DFO Can. Sci. Advis. Sec. Sci. Resp. 2021/012.

Doka, S., Bakelaar, C., and Bouvier, L.D. 2006. Chapter 6. Coastal wetland fish community assessment of climate change in the lower Great Lakes. *In* Great Lakes Coastal Wetland Communities: Vulnerability to Climate Change and Response to Adaptation Strategies. Edited by J.I.L. Mortsch, A. Hebb, and S. Doka. Environment Canada and Fisheries and Oceans Canada, Toronto, ON. pp. 101–128.

Drake, D.A.R., Lamothe, K.A., Thiessen, K.E., Morris, T.J., Koops, M.A., Pratt, T.C., Reid, S.M., Jackson, D.A., and Mandrak, N.E. 2021. Fifteen years of Canada's Species at Risk Act: Evaluating research progress for aquatic species in the Great Lakes – St. Lawrence River basin. Can. J. Fish. Aquat. Sci. 78: 1205–1218.

Finigan, P.A., Mandrak, N.E., and Tufts, B.L. 2018. Large-scale changes in the littoral fish communities of lakes in southeastern Ontario, Canada. Can. J. Zool. 96: 753–759.

Fung, S.R. and Koops, M.A. 2023. Updated Recovery Potential Modelling of Lake Chubsucker (*Erimyzon sucetta*) in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2023/011. iv + 25 p.

Goodyear, C.S., Edsall, T.A., Ormsby Dempsey, D.M., Moss, G.D., and Polanski, P.E. 1982. Atlas of the spawning and nursery areas of Great Lakes fishes. Volume 13: Reproductive characteristics of Great Lakes fishes. U.S. Fish and Wildlife Service. Washington, DC. FWS/OBS-82/52. 144 p.

Hauser, F.E., Fontenelle, J.P, Elbassiouny, A.A., Mandrak, N.E., and Lovejoy, N.R. 2019. Genetic structure of endangered lake chubsucker Erimyzon sucetta in Canada reveals a differentiated population in a precarious habitat. J. of Fish Biol. 95: 1500–1505.

Hintz, W.D., and Relyea, R.A. 2017. Impacts of road deicing salts on the early-life growth and development of a stream salmonid: salt type matters. Environ. Poll. 223: 409–415.

Hintz, W.D., and Relyea, R.A. 2019. A review of the species, community, and ecosystem impacts of road salt salinisation in fresh waters. Freshw. Biol. 64: 1081–1097.

Hintz, W.D., Mattes, B.M., Schuler, M.S., Jones, D.K., Stoler, A.B., Lind, L.A., and Relyea, R.A. 2017. Salinization triggers a trophic cascade in experimental freshwater communities with varying food-chain length. Ecol. App. 27: 833–844.

Holm, E., Mandrak, N.E., and Burridge, M. 2009. The ROM field guide to freshwater fishes of Ontario. Royal Ontario Museum, Toronto, ON. 464 p.

Lane, J.A., Portt, C.B., and Minns, C.K. 1996. Nursery habitat characteristics of Great Lakes fishes. Can. Manuscr. Rep. Fish. Aquat. Sci. 2338: v + 42 p.

Leslie, J.K., and Timmins, C.A. 1997. Early life history of fishes in Long Point Inner Bay, Lake Erie. Can. Tech. Rep. Fish. Aquat. Sci. 2150: iii + 18 p.

Jackson, D.A., and Mandrak, N.E. 2002. Changing fish biodiversity: predicting the loss of cyprinid biodiversity due to global climate change. *In* Fisheries in a changing climate 32. Edited by N.A. McGinn. American Fisheries Society, Bethesda, MD. pp. 89–98.

Milani, D., Grapentine, L.C., and Fletcher, R. 2013. Sediment contamination in Lyons Creek East, a tributary of the Niagara River: part I. Assessment of benthic macroinvertebrates. Arch. Environ. Contam. Tox. 64 : 65–85.

Page, L. M., and Burr, B.M. 2011. Peterson Field Guide to Freshwater Fishes of North America North of Mexico. Houghton Mifflin Company, Boston, MA. 688 p.

Poos, M. S., Dextrase, A., Schwalb, A.N., and Ackerman, J. 2009. Secondary invasion of the round goby into high diversity Great Lakes tributaries and species at risk hotspots: Potential new concerns for endangered freshwater species. Biol. Inv. 12: 1269–1284.

Rodriguez, M.A., Marselli, G., and Mandrak, N.E. 2021. Responses of vulnerable fishes to environmental stressors in the Canadian Great Lakes basin. Can. J. Fish. Aquat. Sci. 78: 1278–1292.

Shireman, J.V., Stetler, R.L., and Colle, D.E. 1978. Possible use of Lake Chubsucker as a baitfish. Prog. Fish Cult. 30: 33–34.

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