Species at Risk Act
Recovery Strategy Series

Recovery Strategy and Action Plan for the Silver Chub (*Macrhybopsis storeriana*), Great Lakes – Upper St. Lawrence populations, in Canada

Silver Chub

2025

Canada

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

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Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of a recovery strategy for species listed as extirpated, endangered, or threatened and are required to report on progress 5 years after the publication of the final document on the Species at Risk Public Registry, and every subsequent 5 years, until the recovery strategy is no longer required under SARA or the species' recovery is no longer feasible.

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

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

As stated in the preamble to SARA, success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this recovery strategy and action plan and will not be achieved by Fisheries and Oceans Canada (DFO), or any other jurisdiction, alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing this recovery strategy and action plan for the benefit of the Silver Chub and Canadian society as a whole.

Implementation of this recovery strategy and action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

This recovery strategy and action plan was prepared by A. Boyko and P. Jarvis on behalf of DFO. DFO would like to thank the following organizations for their support in the development of this recovery strategy and action plan: the Ontario Ministry of Natural Resources (OMNR) and the Ontario Ministry of the Environment, Conservation and Parks (OMECP). Additionally, the following offered their support in the review, development and/or updating of this document:

Patrick Kočovský (United States Geological Survey), Scott Reid (OMNR), Doug Watkinson (DFO), Andy Cook (OMNR), Fiona McGuiness (OMECP), and Michael Thorn (OMNR). Maps were produced by Andrew Geraghty (DFO) and Andrew Doolittle (DFO).

Executive summary

Silver Chub (*Macrhybopsis storeriana*) was listed as a species of special concern under the *Species at Risk Act* (SARA) in 2003. In 2012, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) separated the species into 2 designatable units (DU): the Great Lakes – Upper St. Lawrence populations, which was assessed as endangered, and the Saskatchewan – Nelson River populations, which was assessed as not at risk. Subsequently, the Great Lakes – Upper St. Lawrence populations was listed as endangered under SARA in 2019, while the Saskatchewan – Nelson River populations DU is not listed under SARA. The "Recovery Strategy and Action Plan for the Silver Chub (*Macrhybopsis storeriana*), Great Lakes - Upper St. Lawrence populations, in Canada" is part of a series of documents for the Great Lakes – Upper St. Lawrence populations that are linked and should be taken into consideration together, including the COSEWIC status report (COSEWIC 2012) and the recovery potential assessment (DFO 2013). Recovery of Silver Chub (Great Lakes – Upper St. Lawrence populations) has been determined to be biologically and technically feasible.

The Silver Chub is a stout minnow that has been recorded to a maximum total length of 232 mm. Its colouring is a pale grey-green dorsally, becoming silver on the sides and silvery-white ventrally. Where it is common, the Silver Chub might be an important forage base for commercial and sport fish species. In Canada, Silver Chub inhabits medium- to large-sized rivers with moderate currents, and large lakes. Great Lakes – Upper St. Lawrence populations are found in the southern tip of Lake Huron, Lake St. Clair, and Lake Erie. Currently, within the Great Lakes, Silver Chub is only encountered with regularity in the western and, to a lesser extent, central basins of Lake Erie.

The main threats facing the species are described in section 5 and include: habitat removal and alteration, nutrient loading, turbidity and sediment loading, contaminants and toxic substances and, invasive species.

The population and distribution objectives (section 6) for Silver Chub are:

- Long-term population objective: for locations where populations are sparse and/or data are lacking (that is, the Canadian portions of Lake St. Clair and the central basin of Lake Erie), the long-term objective is to ensure all extant populations demonstrate signs of reproduction and recruitment, and are stable or increasing. In the western basin of Lake Erie a more quantitative target is possible. To ensure the viability of Silver Chub for the Canadian portion of the western basin of Lake Erie, the long-term population objective is to ensure a greater than 75% chance that the median population abundance exceeds 444,000 adults (or > 2.89 fish/hectare), with a stable or increasing trajectory, over at least 3 generations (~7 years)

- Long-term distribution objective: to ensure the persistence of the species within the currently occupied watersheds (that is, Lake St. Clair, and the western and central basins of Lake Erie)

A description of the broad strategies to be taken to address threats to the species' survival and recovery, as well as research and management approaches needed to meet the population and distribution objectives, are included in section 7.

For Silver Chub, critical habitat is identified to the extent possible, using the best available information, and provides the features necessary to support the species' life-cycle functions and to achieve the species' population and distribution objectives. This recovery strategy and action plan identifies critical habitat for Silver Chub in the western basin of Lake Erie (section 8.1). It is anticipated that the protection of the species' critical habitat will be accomplished through a SARA critical habitat order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

This recovery strategy and action plan exempts from the SARA prohibitions the bycatch of Silver Chub during commercial fishing operations targeting other species.

The action plan portion of this document provides the detailed recovery planning in support of the strategic direction set out in the recovery strategy section of the document. The action plan outlines what needs to be done to achieve the population and distribution objectives, including the measures to be taken to address threats and monitor recovery of the species, as well as the required measures to protect critical habitat. Socio-economic impacts of implementing the action plan are also evaluated.

Recovery feasibility summary

The recovery of the Silver Chub (Great Lakes – Upper St. Lawrence populations) is believed to be biologically and technically feasible:

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

Yes. Reproducing populations currently exist in the western basin of Lake Erie and could provide a basis for natural expansions and potential supplementations or artificial propagation, if necessary.

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

Yes. Suitable habitat is present at several locations with extant populations (for example, western basin of Lake Erie and, to a lesser extent, in the central basin). At locations with declining populations, suitable habitat may be made available through current and proposed restoration efforts. For example, improved water quality and habitat management (through stewardship and Best Management Practices [BMPs]) could improve and expand the extent of suitable habitat.

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

Yes. Threats believed to pose a serious risk to Silver Chub, such as habitat removal and alteration, sedimentation, nutrient and contaminant loading, can be mitigated through proposed recovery techniques. Restoration and mitigation efforts are underway throughout much of the species' range. The threat posed by aquatic invasive species will be more challenging to address.

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

Yes. Techniques to reduce identified threats (for example, BMPs) and restore habitats are well known and have proven to be effective. If required, repatriations may be feasible through captive rearing or supplementation. Although there are no published studies on captive rearing for Silver Chub, these techniques have been successful for other freshwater leuciscids (for example, DeMarais and Minckley 1993).

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1 Introduction

The Great Lakes – Upper St. Lawrence populations of Silver Chub (*Macrhybopsis storeriana*; Kirtland, 1845) (hereafter referred to as Silver Chub) were listed as endangered under the *Species at Risk Act* (SARA) in 2019.

The "Recovery Strategy and Action Plan for the Silver Chub (*Macrhybopsis storeriana*), Great Lakes – Upper St. Lawrence populations, in Canada" is part of a series of documents regarding Silver Chub that should be taken into consideration together, along with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (COSEWIC 2012) and the science advisory report from the recovery potential assessment (RPA) (Fisheries and Oceans Canada [DFO] 2013). A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species; it sets objectives and identifies the main areas of activities to be undertaken. An action plan provides the detailed recovery planning that supports the strategic direction set out in the recovery strategy. Action planning for species at risk recovery is an iterative process; therefore, the implementation schedule (tables 4 to 6) in this recovery strategy and action plan may be modified in the future depending on the progression towards recovery.

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

2 COSEWIC species assessment information

Date of assessment: May 2012
Species' common name (population): Silver Chub (Great Lakes – Upper St. Lawrence populations)
Scientific name: *Macrhybopsis storeriana*
Status: Endangered
Reason(s) for designation: This small-bodied fish is native to the middle Great Lakes and has a small distribution range in Canada. Its abundance has declined substantially over the past 10 years. Moreover, the longest consecutive time series of lowest abundance has been observed over the last 5 years. The species is assessed at high risk of extirpation from several threats including habitat degradation, competition with invasive exotic species, and climate change. This species is considered at risk in several border states, including Michigan and New York.
Canadian occurrence: Ontario
Status history: The species was considered a single unit and designated special concern in April 1985. Status re-examined and confirmed in May 2001. Split into 2 populations in May 2012. The "Great Lakes - Upper St. Lawrence populations" unit was designated endangered in May 2012.

3 Species status information

Table 1. Summary of existing protection or other status designations assigned to the Silver Chub.

Jurisdiction	Authority/organization	Year(s) assessed and/or listed	Status/description	Designation level
Ontario	NatureServe	2011	S2: Imperilled	Population
Ontario	Committee on the Status of Endangered Species in Ontario (COSSARO)	2012	Threatened	Population
Ontario	Ontario's *Endangered Species Act*	2013	Threatened	Population
Canada	Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	2012	Endangered	Population
Canada	NatureServe	2015	N5: Secure	Species
Canada	*Species at Risk Act* (SARA)	2019	Endangered	Population
United States[1]	NatureServe	1996	N5: Secure	Species
International	International Union for Conservation of Nature (IUCN)	2012	Least Concern	Species
International	NatureServe	2015	G5: Secure	Species

Upon listing as an endangered species, the Silver Chub became protected wherever the species is found in Canada under section 32 of SARA:

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

Under section 73 of SARA, the competent minister may enter into an agreement or issue a permit authorizing a person to engage in an activity affecting a listed wildlife species, any part of its critical habitat or its residences as long as the activity will not jeopardize the survival or recovery of the species.

[1] Refer to NatureServe 2019 for state specific designations

4 Species information

4.1 Description

The Silver Chub (figure 1) is a stout minnow that has been recorded to a maximum total length of 232 mm (Cook, pers. comm. 2022). Species in the genus *Macrhybopsis* are characterized by the following features: a slender barbel at the end of the maxillary (corner of upper jaw), moderate-sized subterminal mouth, snout projecting beyond the mouth, and, fewer than 50 lateral line scales (Scott and Crossman 1998; Stewart and Watkinson 2004; Holm et al. 2009).

The Silver Chub is distinguished from other species in the genus by its large eyes located on the upper half of the head, a shorter snout, silvery sides without markings and a more anterior oriented dorsal fin (Pflieger 1997; Werner 2004; Page and Burr 2011). Its colouring is a pale grey-green dorsally, becoming silver on the sides and silvery white ventrally, and a faint dusky lateral band is usually present. The caudal fin is lightly pigmented, except for the lower 3 or 4 rays, which are completely white and un-pigmented (Scott and Crossman 1998).

Figure 1. Silver Chub (*Macrhybopsis storeriana*). Photo: E. Holm, Royal Ontario Museum.

The Silver Chub can be confused with large specimens of the Spottail Shiner (*Notropis hudsonius*) and species in the *Nocomis* genus. It is distinguished from the Spottail Shiner by the presence of a terminal barbel, and its snout projects further beyond the mouth than that of *Nocomis* species. Additionally, *Nocomis* species have smaller eyes than the Silver Chub and a more pigmented body that is not usually silvery (Holm et al. 2009).

The Silver Chub is the only member of the genus *Macrhybopsis* in Canada. The Great Lakes populations are lacustrine forms that are morphologically distinct from the riverine forms found throughout most of the species' range (COSEWIC 2012). Both the Great Lakes and Lake Winnipeg drainage populations are geographically isolated from the majority of other Silver Chub populations, which inhabit the Mississippi drainage. Recent work looking at genetic variation across Silver Chub populations (Assiniboine, Ohio, Missouri, Mississippi, Wabash rivers, Lake Erie) found that the Lake Erie population has four cytochrome b haplotypes[2] not found in other locations, suggesting that this population is distinct (Elbassiouny et al. 2023).

[2] A set of DNA variants along a single chromosome that tend to be inherited together.

4.2 Population abundance and distribution

Global distribution and population abundance (figure 2): The following has been adapted from COSEWIC (2012). The range of the Silver Chub extends from Lake Winnipeg and the southern Great Lakes basin south to the Gulf of Mexico. In the Great Lakes basin, the species is limited to lakes Erie and St. Clair, the extreme southern portion of Lake Huron, and possibly the Thames River. In the Lake Winnipeg drainage, it is found in southern Lake Winnipeg and in the Assiniboine and Red river drainages of Manitoba, North and South Dakota, and Minnesota. In the United States, the Silver Chub also occurs in the Mississippi River system from Minnesota, south to the Gulf of Mexico. In the northern part of its Mississippi basin range, it extends from Nebraska to New York, and, in its Gulf Coast range, extends from the Mobile Bay basin to the Lake Pontchartrain drainage. An isolated population also exists in the Brazos River drainage of Texas.

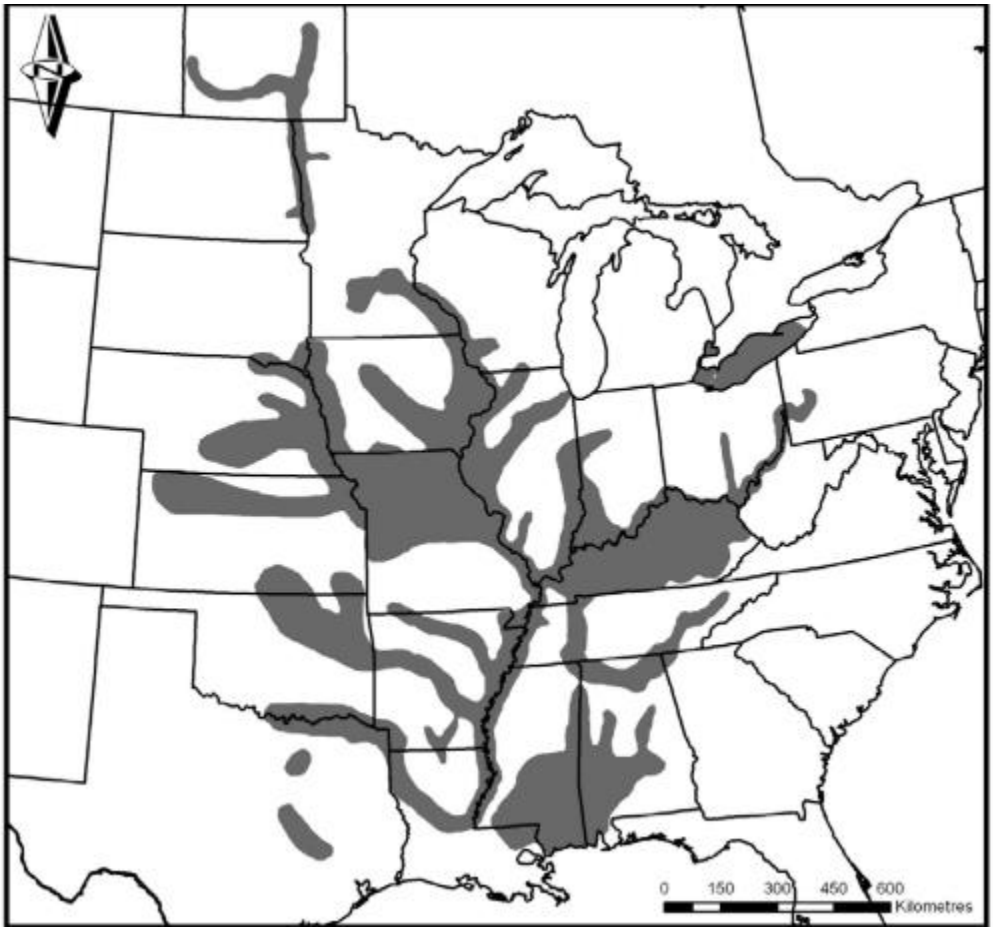

Figure 2. Global distribution of the Silver Chub (COSEWIC 2012) (used with permission).

Canadian distribution and population abundance: In Canada, the Silver Chub has been subdivided into 2 designatable units (DUs), the Great Lakes – Upper St. Lawrence populations and the Saskatchewan – Nelson River populations (see COSEWIC 2012). The separation of the Canadian populations into the 2 units was based principally on their occurrence in 2 separate Biogeographic Zones; while separation may also exist as a result of genetic and morphological factors, these possibilities remain to be explored. The contents of this recovery strategy and

action plan are restricted to the Great Lakes – Upper St. Lawrence DU, which encompasses lakes Huron, St. Clair, and Erie (figure 3).

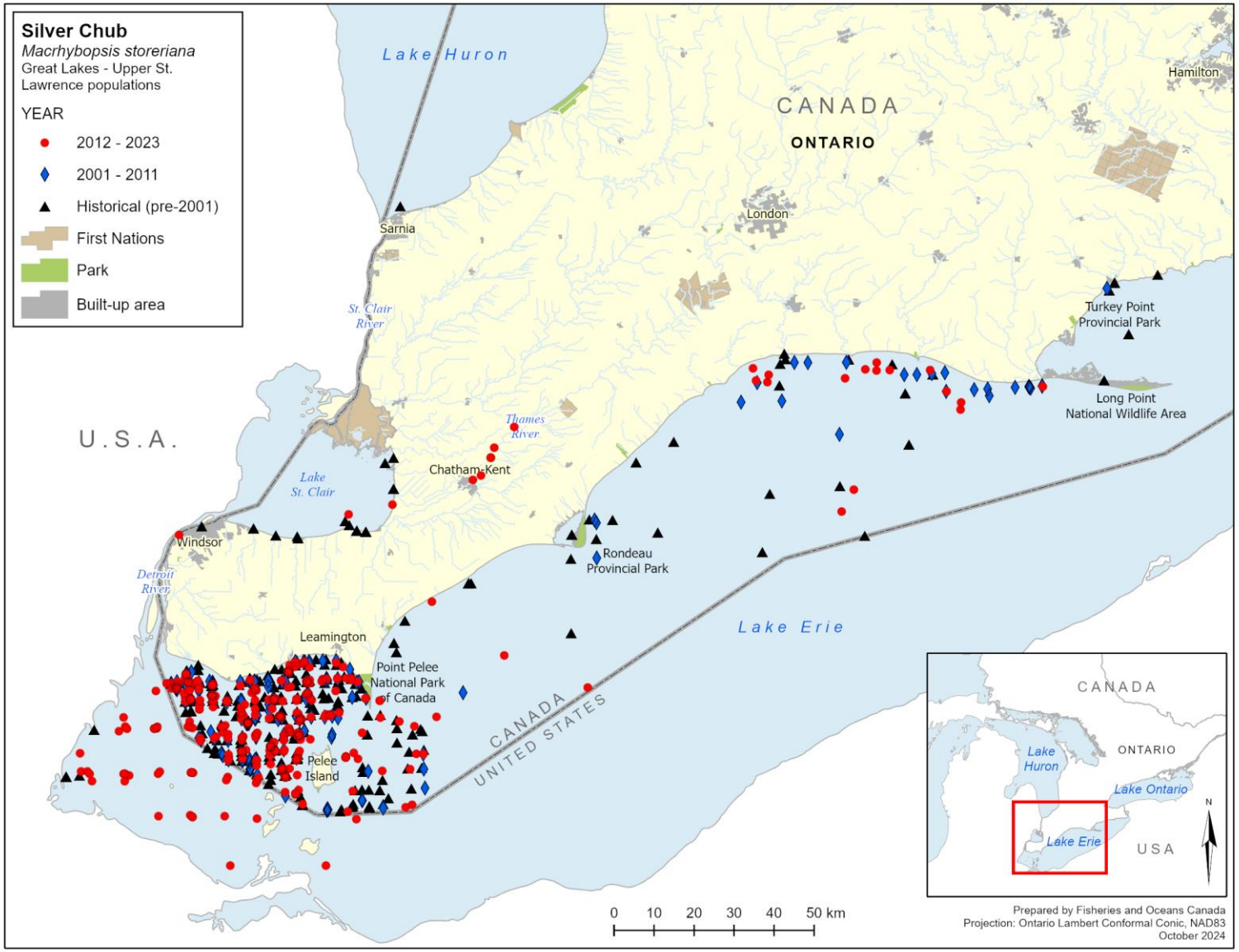

Figure 3. Distribution of Silver Chub (Great Lakes – Upper St. Lawrence populations) in Canada. Note that data shown in United States are incomplete.

In Ontario, the species has been most consistently found in the western basin of Lake Erie, with relatively high densities noted near Pelee Island and the mouth of the Detroit River (DFO, unpubl. data). A moderate number of captures have occurred in the central basin and only a very sparse historical record exists for the eastern basin (the same pattern exists in United States [U.S.] waters) (figure 3). A sizable population appears to have existed in Lake St. Clair, while only 1 location at the southern tip of Lake Huron has ever yielded Silver Chub. Historical sampling has revealed extreme fluctuations in catches in Lake St. Clair and particularly in the western basin of Lake Erie. While the pattern of extreme fluctuations has been observed in other forage species (see Lake Erie Forage Task Group 2020), the pattern may have been amplified by human-mediated ecological changes within these systems (for example, water quality degradation and invasive species).

Lake Erie – Western Basin: A dramatic decline in Silver Chub began in the early 1950s, and abundances appear to have remained relatively low through to the 1990s (COSEWIC 2012; McCulloch et al. 2013; DFO, unpubl. data). Silver Chub numbers increased considerably in the late 1990s, followed by a decline in the 2000s (van der Lee and Koops 2022). There are recent signs of an increase, as 2020 data indicate that age 1+ Silver Chub relative abundance remained high (9 fish/ha; above the 10 year mean of 1.9 fish/ha) and age-0 Silver Chub were at their greatest abundance since 1999 (Lake Erie Forage Task Group 2021). A similar pattern has been observed in U.S. waters (for example, Ohio Department of Natural Resources - Division of Wildlife [ODNR-DOW] 2019; United States Geological Survey [USGS] 2019b). van der Lee and Koops (2022) recently modelled the population trajectory of Silver Chub in the western basin of Lake Erie using bottom trawl data. Modelling suggested that the population has been increasing since 2013 at a growth rate of 1.3 to 1.8 per year and median abundance estimates ranged from 152,064 to 1,856,725 Silver Chub (these estimates differed among surveys as a result of differences in catchability and other factors) (van der Lee and Koops 2022).

Estimates of Silver Chub absolute abundance have been generated from the standardized Interagency Index Trawl Data (run by the Ontario Ministry of Natural Resources [OMNR] and ODNR-DOW), initiated in the western basin of Lake Erie in 1988 (figure 4). These data, which include both U.S. and Canadian sites, indicate that Silver Chub has undergone large fluctuations in abundance (for example, OMNR 2016; ODNR-DOW 2019). Figure 5 demonstrates the magnitude of fluctuations in catch rates for the pooled Canadian sites in the western basin of Lake Erie. Distinguishing the contributions of anthropogenic versus natural processes on the observed pattern is difficult and will require further understanding of the Silver Chub's life-history and the threats to its persistence. The USGS has a monitoring program that includes regular trawls in the western basin (including stations in Canadian waters); these surveys have also returned small catches of Silver Chub in the early 2000s (USGS 2019b; DFO, unpubl. data). The longest known continuous trawl survey in Lake Erie is the USGS Lake Erie Biological Station's East Harbor (Ohio) sampling program (1961 to 2011). The consecutive 5-yr period with lowest average catch per effort in the USGS East Harbor data series was 1973 to 1977 (USGS Lake Erie Biological Station 2016).

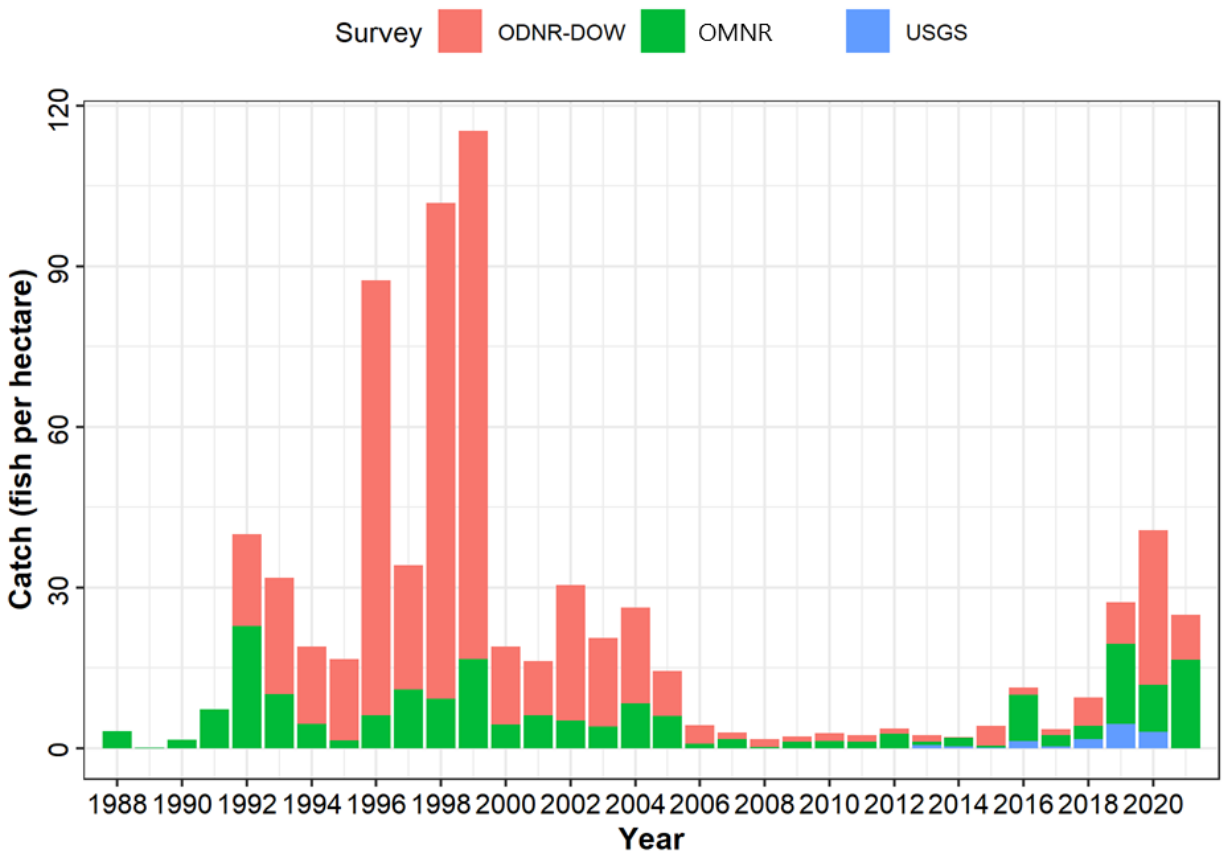

Figure 4. Silver Chub collections in the Interagency Index Trawling in the western basin of Lake Erie, 1988 to 2021 (United States and Canadian sides).

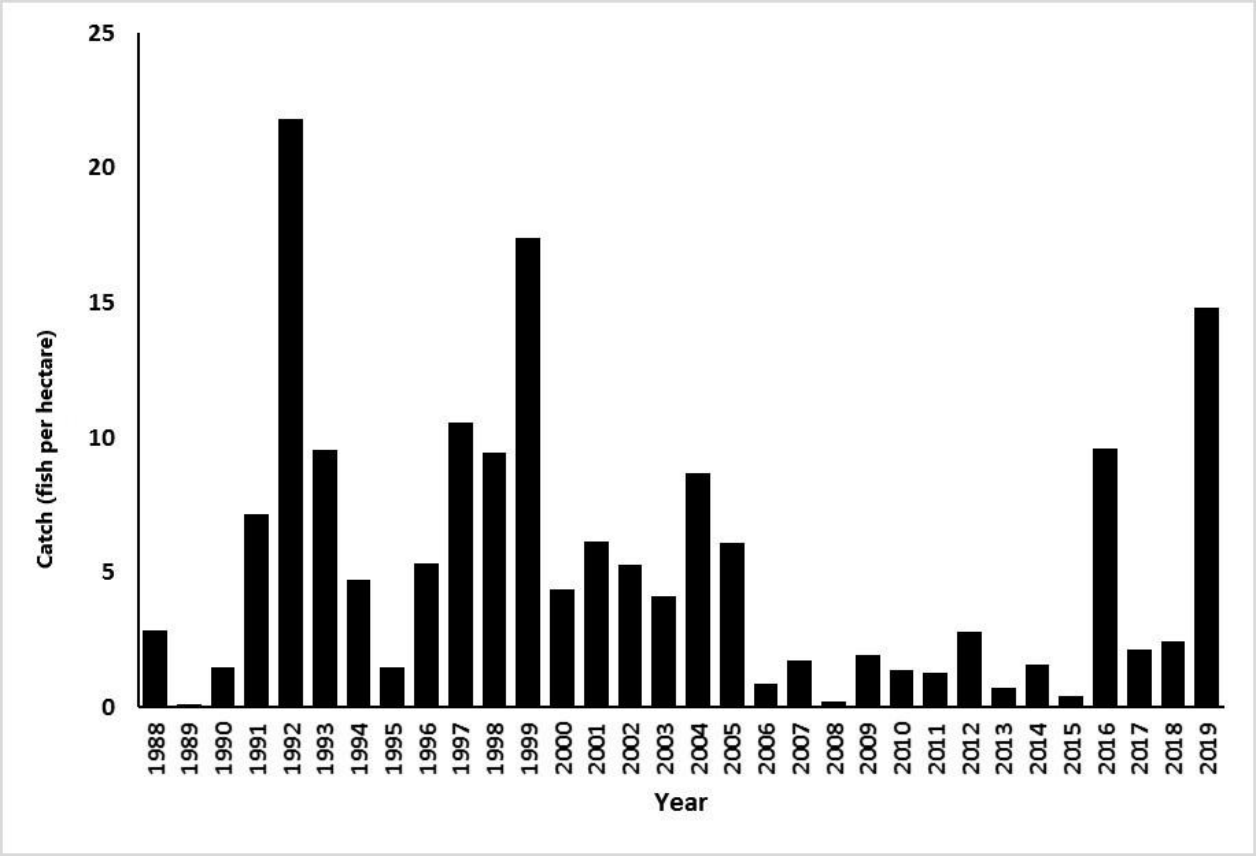

Figure 5. Canadian Silver Chub relative abundance estimates (fish per hectare) generated from the Interagency Index Trawling in the western basin of Lake Erie (from OMNR 2016, 2019a).

Silver Chub is also regularly captured in the annual Partnership Gill Net Index Survey run by the OMNR and the Ontario Commercial Fisheries' Association, initiated in Lake Erie in 1989. Gill net data from the western basin (OMNR 2016, 2019a, unpubl. data) show a similar trend in Silver Chub abundances as demonstrated from trawl data; recent gill net data demonstrate an increase in Silver Chub numbers. In 2021, the species was captured at record numbers (406 Silver Chub detected) (OMNR, unpubl. data).

Lake Erie – Central and Eastern Basins: In the central basin, Silver Chub has a wide distribution but is found in relatively low numbers and detections have been sparse. For example, only 56 Silver Chub have been captured between 2001 to 2015 via gill net through the central basin partnership surveys (OMNR, unpubl. data) and a single Silver Chub was captured between 2016 and 2021 via bottom trawl surveys (Belore, pers. comm. 2021). Although recent gill net data (2017 to 2021) show relatively high numbers, with 39 Silver Chub detected from the central basin (including 14 in 2021) (OMNR, unpubl. data), overall catches remain low compared to the western basin.

In the eastern basin of Lake Erie, Silver Chub has not been caught since a single individual was recorded in 2001 (OMNR, unpubl. data).

Despite the recent relatively higher numbers in the central basin, large numbers of Silver Chub have never been recorded in the central and eastern basins of Lake Erie, even during periods of high abundance in the western basin, which suggests habitat conditions are unsuitable or less suitable for this species than the western basin.

Lake St. Clair: Historically, Silver Chub has been captured along the southern and eastern shore of Lake St. Clair, with relatively high catches occurring in the late 1970s and early 1980s (DFO, unpubl. data). However, sampling that has occurred between 1995 and 2022, has resulted in only 2 Silver Chub detections; 1 individual was collected (north of the Thames River) during beach seining in 2014 (DFO, unpubl. data) and another was captured by the OMNR via gill net during fish community assessment sampling (OMNR, unpubl. data). The population dynamics of Silver Chub in Lake St. Clair are not well understood because of the absence of a consistent sampling program (an annual lake-wide trawling program ended in 1984, and data now come from fyke net surveys conducted approximately every five years); nonetheless, available evidence points to a population decline.

In 2015, trawling surveys in the lower Thames River upstream of Chatham (an area that has not been sampled extensively) yielded 1 specimen (DFO, unpubl. data), the first record of this species in the river. In 2018, another individual was captured via gill net, near the 2015 location, in an OMNR gear comparison study (OMNR 2019a). An additional 6 specimens were captured between 2023 and 2024, via angling, at locations both upstream and downstream of the previous records (DFO, unpubl. data). However, it is unclear whether these individuals are migrants from Lake St. Clair or if a separate population exists in the Thames River.

In 2022, an angler captured a single Silver Chub from the Canadian side of the Detroit River, near the Ambassador Bridge (DFO, unpubl. data). This is the first confirmed record for the species in the Detroit River on the Canadian side. It is unclear whether a population exists in the Detroit River or whether the specimen is a migrant from Lake St. Clair or Lake Erie.

Lake Huron: Silver Chub was collected from the southern end of Lake Huron, near Sarnia, in 1983, when 2 specimens were caught in a commercial trapnet (McCulloch et al. 2013). No other records of this species exist for Lake Huron.

The apparent decline of Silver Chub in the western basin of Lake Erie (and likely in Lake St. Clair) was the principal reason for the change in the 2012 COSEWIC designation from special concern to endangered. Young and Koops (2013) calculated a 20% average annual decline (from 2000 to 2012) of Silver Chub in the western basin of Lake Erie. The rate of decline has decreased over time, suggesting that the population may be stabilizing, and modelling conducted by van der Lee and Koops (2022) indicates that Silver Chub abundance in the western basin has been increasing since 2013.

Further details on sampling history can be found in the RPA documents (DFO 2013; McCulloch et al. 2013), the COSEWIC status report (COSEWIC 2012), and van der Lee and Koops (2022).

Population assessment: Using data and information available at the time, the status of Silver Chub populations in Ontario was assessed by McCulloch et al. (2013) (table 2)[3]. Results of this assessment indicated that the Silver Chub populations in Lake Erie and Lake St. Clair had a status of poor. However, recent data from the western basin as well as modelling conducted by van der Lee and Koops (2022) suggest that the population status, for the western basin at least, has improved since the publication of the RPA and may no longer be considered poor (see figures 6 and 7, for example).

[3] Populations were ranked with respect to relative abundance and trajectory, which were then combined to determine the population status. A certainty level was also assigned to the population status, which reflected the lowest level of certainty associated with either relative abundance or trajectory. Refer to McCulloch et al. (2013) for further details on the methodology.

It is unknown whether the population status of the remaining locations has improved since 2013. The Thames River population is not included in the status table as the species was only discovered at this location in 2015, after the completion of the RPA. It is unclear at this time whether a separate population exists in the Thames River or if the specimens found in 2015, 2018, and 2023 originated in Lake St. Clair.

Table 2. Population status and associated certainty of individual Silver Chub populations in Ontario (McCulloch et al. 2013)[4].

Population	Population status	Certainty
Lake St. Clair	Poor	Catch per unit effort (CPUE) or standardized sampling
Lake Erie – western basin	Poor	CPUE or standardized sampling
Lake Erie – central basin	Poor	CPUE or standardized sampling
Lake Erie – eastern basin	Poor	CPUE or standardized sampling
Lake Huron	Unknown	Expert opinion

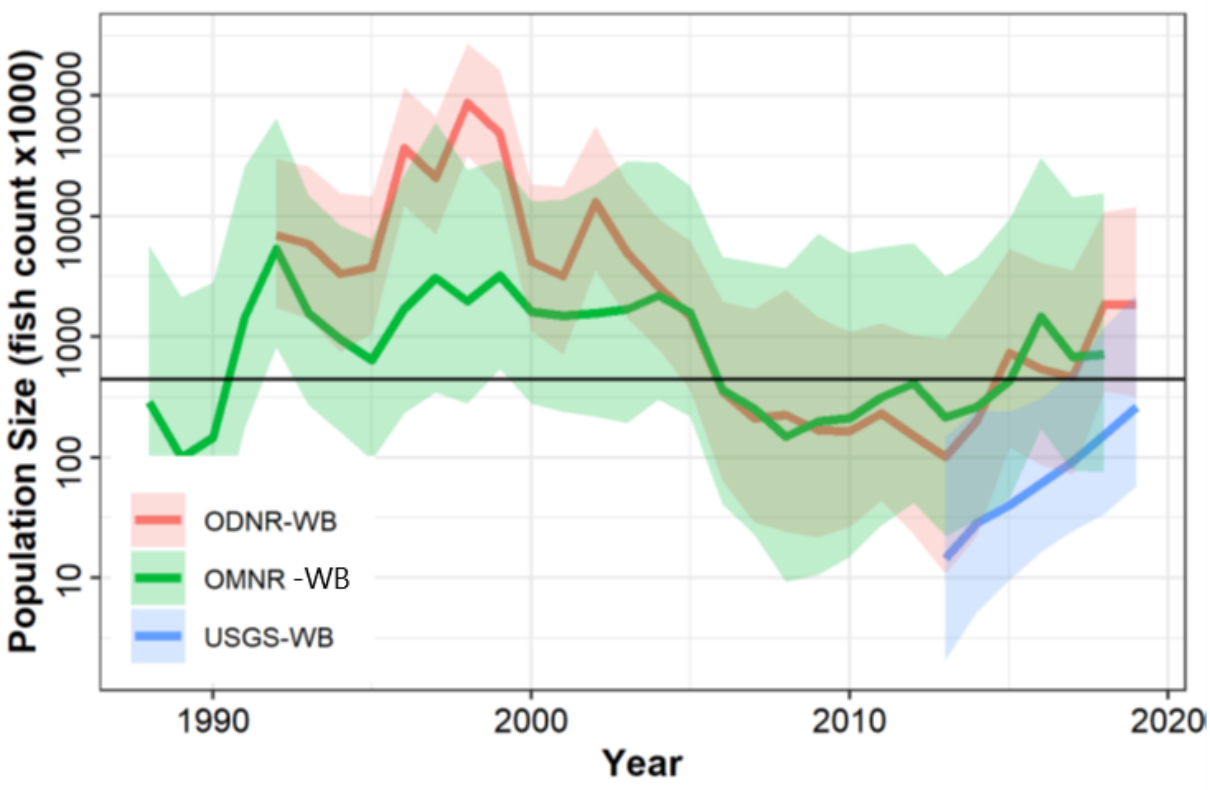

Figure 6. Estimated Silver Chub population size through time in the western basin of Lake Erie, by agency. The horizontal line represents the estimated minimum viable population given a 15%/generation catastrophe rate and 1% chance of extinction over 100 years, and a quasi-extinction threshold of 50 adults (Young and Koops 2013). Figure from van der Lee and Koops

[4] Table adapted from DFO 2013.

(2022). ODNR – Ohio Department of Natural Resources, OMNR – Ontario Ministry of Natural Resources, USGS – United States Geological Survey, WB – western basin.

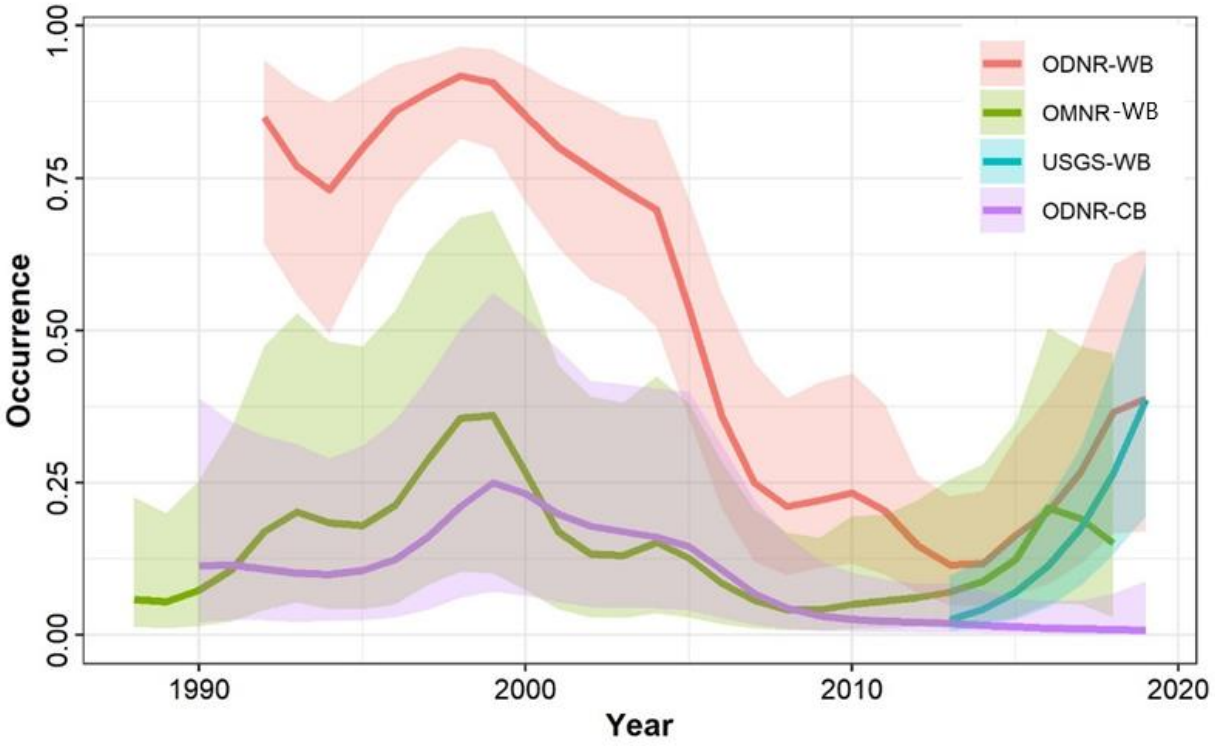

Figure 7. Estimated trend through time occurrence (proportion of trawl with Silver Chub caught) of Silver Chub in bottom trawl research surveys in the western and central basins (ODNR only) of Lake Erie, by agency. Figure from van der Lee and Koops (2022). ODNR – Ohio Department of Natural Resources, OMNR – Ontario Ministry of Natural Resources, USGS – United States Geological Survey, WB – western basin, CB – central basin.

4.3 Needs of the Silver Chub

Studies specific to the biological requirements of the Silver Chub are rare, hence, defining the needs of the species relies largely on surveys that have recorded both the Silver Chub and habitat characteristics at the point of capture.

Spawn to hatch: The Silver Chub spawns in spring or early summer (May to July) at water temperatures of 19 to 23°C (Mandrak and Holm 2001); however, there is some uncertainty regarding where the species spawns and its spawning habitat requirements (Kočovský, pers. comm. 2020). Scott and Crossman (1998) stated that the species likely spawns in open water (although it was not specified, given that Silver Chub is a benthic species, it is presumed they meant the open lake areas, rather than mid-water column), while Kinney (1954) observed that, in Lake Erie, the species moved nearshore in late spring, presumably to spawn. Goodyear et al. (1982) suggested that Silver Chub historically spawned over clean gravel substrates in tributaries of Lake Erie. McKenna et al. (2023) examined potential spawning locations for Silver Chub in Lake Erie and results suggested the Maumee and Portage rivers in Ohio as potential locations. Brown et al. (In Press) collected fertilized Silver Chub eggs in surface-deployed ichthyoplankton nets in the Maumee River, confirming it as a spawning location. Although this

work does not rule out spawning in nearshore areas or in open waters of Lake Erie, it corroborates previous findings in the Mississippi River (for example, Larson et al. 2016; Camacho et al. 2019) that Silver Chub is a pelagophil (that is, non-adhesive eggs are scattered in open waters).

Larval stage and young-of-the-year (YOY): Two larval Silver Chub have been captured in the western basin of Lake Erie; both were captured in ichthyoplankton nets near the surface of the water, which suggests that the larvae are pelagic (McKenna et al. 2023). There is no additional information available on the habitat needs of larval Silver Chub.

Adult: In Canada, Silver Chub inhabits medium- to large-sized rivers with moderate currents, and large lakes at depths of 2.3 to 24 m (McCulloch et al. 2013). Modelling conducted on the western basin of Lake Erie suggests that waters between 2 and 9 m deep provide suitable habitat (McKenna Jr. and Kočovský 2020). Preferred substrate is typically sand or gravel (Trautman 1981), but the species is also sometimes associated with silt (in backwater habitats) (Kinney 1954) and hard substrates such as rubble, boulder, or bedrock (Kinney 1954; Trautman 1981; Robison and Buchanan 1988). In the western basin of Lake Erie, most Silver Chub have been captured over soft or 'muck' substrates (Kočovský, pers. comm. 2022). Robison and Buchanan (1988) stated that the species appears to be tolerant of siltation and turbidity; however, in Ohio, it reached greatest abundance over substrates of clean gravel and sand, and appeared to be susceptible to many types of pollutants (Trautman 1981). In Manitoba, the species is found in the Assiniboine and Red rivers, which can be very turbid as a result of clay soils. In the Arkansas River, Silver Chub was found over sand substrate during the day but moved to shore (0.5 to 1 m) to feed at night (Robison and Buchanan 1988). The Silver Chub is not typically associated with aquatic macrophytes (Mandrak and Holm 2001).

Kinney (1954) stated that the Silver Chub seems to require a growth period of six to seven months with water temperatures above 7.2 to 10°C, and at least 3 of those months above 21°C. Further information on the life cycle and habitat requirements of Silver Chub can be found in the RPA documents (DFO 2013; McCulloch et al. 2013) and the COSEWIC status report (COSEWIC 2012).

The Silver Chub is a bottom feeder that feeds on small crustaceans, insect larvae (primarily *Hexagenia* spp.), and dreissenid mussels (collectively, Zebra Mussel [*Dreissena polymorpha*] and Quagga Mussel [*D. bugensis*]). Studies have demonstrated that in Lake Erie, *Hexagenia* spp. typically makes up the majority of the Silver Chub diet (for example, Kinney 1954; COSEWIC 2012; Kočovský 2019); however, dreissenid mussels have also become a major food source (for example, COSEWIC 2012; Kočovský 2019), and have likely replaced other molluscs including Gastropoda and Sphaeriidae, in Silver Chub diets (Kočovský 2019). Kočovský (2019) also reported that although dreissenids are consumed, stable isotope analysis demonstrated that little energy is derived from dreissenids and that most of the energy assimilated by Silver Chub was from *Hexagenia* sp., Sphaeriidae, and Chironomidae.

Limiting factors: Silver Chub may be limited by the abundance of predators and prey (for example, *Hexagenia* spp.), in addition to key physical/chemical characteristics of its environment (for example, temperature, dissolved oxygen). Shifting predator-prey dynamics involving Yellow Perch (*Perca flavescens*) and Walleye (*Sander vitreus*) may have the potential to supress Silver Chub abundance through competition and possibly predation (COSEWIC 2012). Due to limited understanding of the species, further limiting factors may exist but are currently unknown.

5 Threats

5.1 Threat assessment

McCulloch et al. (2013) assessed threats to Silver Chub populations in Ontario. Known and suspected threats, which were ranked with respect to threat likelihood and threat impact for each population, were then combined to produce an overall threat status (table 3). A certainty level was also assigned to the overall threat status, which reflected the lowest level of certainty associated with either threat likelihood or threat impact. Lake Huron, the eastern basin of Lake Erie, and the Thames River were excluded as it is unknown if Silver Chub populations are present at these locations. See McCulloch et al. (2013) and DFO (2013) for further details. Additional information is provided in the subsequent threat summaries.

Table 3. Summary of threats and threat status to Silver Chub populations in Ontario[5].

Threats	Threat status in Lake St. Clair	Threat status in Lake Erie western basin	Threat status in Lake Erie central basin
Habitat removal and alteration	High (3)	High (3)	High (3)
Nutrient loading	High (3)	High (3)	High (3)
Turbidity and sediment loading	Low (3)	Low (3)	Low (3)
Contaminants and toxic substances	High (3)	High (3)	Medium (3)
Invasive species	High (3)	High (3)	High (3)
Incidental harvest	Low (2)	Low (2)	Low (2)

5.2 Description of threats

Habitat removal and alteration: The alteration of natural coastal processes through the hardening of shorelines and other activities (such as sand and gravel mining) has been identified as a potential threat for fish species at risk, including Silver Chub (Essex-Erie Recovery Team 2008). The extent to which this alteration impacts Silver Chub is currently unknown as the species is believed to frequently inhabit offshore, open water areas.

The development of offshore wind power in Lake Erie represents a potential threat to Silver Chub (see McCulloch et al. 2013). Potential impacts to fish communities include localized physical disruptions during the construction process that may result in increased sedimentation and turbidity and re-suspension of contaminated sediment, degradation or loss of benthic habitat from wind turbine placement, and continuous emission of noise and vibrations. A review of the potential effects of offshore wind power development on fish communities concluded that noise had the greatest impact on fishes, primarily during the construction phase, and, to a lesser extent, during long-term operations (Nienhuis and Dunlop 2011). Currently, a moratorium on offshore wind projects exists in Ontario, while construction is set to begin on a project in Ohio

[5] The number in brackets refers to the level of certainty associated with each threat: 1=causative studies; 2=correlative studies; and, 3=expert opinion; table adapted from DFO 2013.

waters of Lake Erie. The extent to which offshore wind power development could impact Silver Chub populations is currently unknown.

Nutrient loading: Historical nutrient loading from anthropogenic activities is a well-documented issue in Lake Erie (for example, Environment and Climate Change Canada [ECCC] and the United States Environmental Protection Agency [U.S. EPA] 2017). Silver Chub was thought to be possibly extirpated from Lake Erie by the 1960s (Scott and Crossman 1998), likely as a result of eutrophication and associated low oxygen levels that negatively impacted water quality and the invertebrate food supply for the species (Mandrak and Holm 2001). Historical eutrophication of Lake Erie contributed to the collapse of *Hexagenia* spp. populations (for example, Schloesser et al. 2000), a significant prey item for Silver Chub. The only sustained recovery of *Hexagenia* spp. in the Great Lakes has been observed in the western basin of Lake Erie (ECCC and U.S. EPA 2009), while conditions for *Hexagenia* spp. population growth remain more uncertain in the central and eastern basins (Krieger et al. 2007). Although substantial efforts, beginning in the 1970s, to reduce phosphorus loadings had been successful, the lake has undergone re-eutrophication in recent years (see Watson et al. 2016), which has motivated the development of reduced phosphorus loading targets (ECCC and U.S. EPA 2015). The Maumee River watershed in Ohio is the largest contributor of nutrients to Lake Erie; it is estimated that nutrient input from the Maumee River contributes up to 80% of the nutrients that result in the lake's algal blooms (Baker et al. 2014; Van Brenk 2016). During the period of re-eutrophication, dissolved reactive phosphorus input from the Maumee River increased by 169% (Baker et al. 2014). From 2010 to 2022, phosphorous loads from Canadian sources ranged from 16 to 22% of the total load entering the lake (ECCC 2023).

Turbidity and sediment loading: The impacts of high sediment loads and associated turbidity on the Silver Chub are not fully understood. Sediment loadings and turbidity affect aquatic environments in many ways (for example, through reduced water clarity and increased siltation of substrates) and may have a role in the selective transport of pollutants. Although Silver Chub has been captured in turbid rivers, the species has been observed to move to cleaner water with gravel substrates when pools became excessively silted (Trautman 1981). Robison and Buchanan (1988) reported that the species was most abundant over clean, silt-free, substrates of sand and gravel. Silver Chub may be more tolerant of high levels of suspended solids (that is, high turbidity) than it is to high levels of sediment deposition, given that the species has been caught in the turbid Assiniboine and Red rivers (where Secchi[6] depths of 10 to 30 cm [indicative of highly turbid waters] are not uncommon) at sites with little to no siltation. Furthermore, data from trawl and gillnet surveys conducted in the western basin of Lake Erie have demonstrated a positive relationship with turbidity and Silver Chub catch rates (Cook, pers. comm. 2020), while areas where the species has been caught in the central basin are often more turbid due to wave action and/or river discharge. It is not known if the species has a preference for turbid waters or if there are other habitat features present in these areas that are driving the species' distribution in Lake Erie.

Contaminants and toxic substances: Concentrations of legacy contaminants in the Great Lakes have begun to decline (for example, ECCC and U.S. EPA 2009; Mahmood et al. 2013). The western basin of Lake Erie tends to have a relatively high contaminant load. Samples from the western basin have indicated the highest levels of most compounds (for example, organochlorines, polycyclic aromatic hydrocarbons [PAHs]) and the highest observed mercury

[6] A measure of water transparency obtained by lowering a Secchi disk (typically a white or black and white patterned disk) into the water column and recording the depth at which the disk is no longer visible from the surface.

levels across the Great Lakes have occurred in the western basin of Lake Erie (ECCC and U.S. EPA 2009). A relatively new suite of potential contaminants (for example, flame-retardants, plasticizers, pharmaceuticals) is of an increasing concern to aquatic ecosystems as the long-term effect of these substances is either unknown or poorly characterized. Susceptibility of the Silver Chub to specific forms of contamination is unknown; an increased catch rate of the species was observed following temporary pollution abatement (Krumholz and Minckley 1964). Additionally, Gewurtz et al. (2000) demonstrated that dreissenid mussels and *Hexagenia* spp. played a large role in transferring PAHs and polychlorinated biphenyls to upper trophic levels. Given this, it is possible that Silver Chub may be susceptible to biomagnification of contaminants.

Invasive species: A variety of invasive species may be currently impacting Silver Chub populations as invasive species have had a dramatic effect on many aquatic species at risk and continue to alter ecosystems and ecosystem processes. Krieger et al. (2007) suggested that predation by the Round Goby (*Neogobius melanostomus*) may be limiting the abundance of *Hexagenia* spp. in Lake Erie, indicating that competitive interactions between Round Goby and Silver Chub may be occurring. Trawl surveys in the western basin are frequently dominated by juvenile White Perch (*Morone americana*), a species that preys on benthic invertebrates, including *Hexagenia* spp. (A. Cook, OMNR, unpubl. data, cited in COSEWIC 2012). It is possible that Silver Chub may at times benefit in some ways from the presence of invasive species; for example, it has been hypothesized that the Zebra Mussel may be indirectly enhancing the availability of an important prey item for Silver Chub by diverting plankton to the substrate in the form of feces or pseudofeces, providing a food source for *Hexagenia* spp. (for example, Schloesser et al. 2000; Freeman et al. 2011). However, the overall impacts on Silver Chub are unknown and given the known negative impacts many invasive species have had on native fishes (for example, French and Jude 2001; Janssen and Jude 2001), impacts on Silver Chub are suspected.

Given that Silver Chub is likely a pelagophil, a new potential threat exists in the form of Grass Carp (*Ctenopharyngodon idella*) control, as Grass Carp is also a pelagophil. In the Sandusky River, Grass Carp management includes the use of a seasonal barrier (AECOM 2021) to prevent Grass Carp from reaching its spawning grounds (Kočovský et al. 2021). Should the same/similar control efforts be used in the Maumee River, where Grass Carp is known to spawn (USGS 2019a), they risk disrupting spawning of Silver Chub as well.

Incidental harvest: Incidental harvest as a result of commercial fishing for food fishes has been described as a potential threat to the Silver Chub (Mandrak and Holm 2001); however, the minimum mesh size of commercial gill nets in Lake Erie is 57 mm, and 99% of Silver Chub were caught in mesh sizes less than 57 mm during OMNR surveys (Belore, pers. comm. 2008). Therefore, incidental catch from commercial operations in Ontario is not likely to present a serious threat to Silver Chub.

Silver Chub is not a legal baitfish in Ontario (OMNR 2019b); however, baitfish harvesting activities (commercial and angler baitfish harvesting) that indirectly harvest Silver Chub have the potential to negatively impact population abundance. The extent to which Silver Chub is caught as bycatch during angler baitfish harvesting in Ontario is unknown. In contrast, the possibility of the bycatch of non-target species, including species at risk, during commercial harvests for live bait fisheries has been investigated (Drake and Mandrak 2014b). This research indicated that the potential bycatch of non-target species is dependent on the harvest effort and strategy (gear type, site selection, sampling efficiency, etc.) applied within habitats where the species is present. Silver Chub is not predicted to occur as bait harvest bycatch due to its rarity in Lake

Erie and its predominantly offshore distribution. Another study by Drake and Mandrak (2014a) investigated the presence of imperilled fishes within samples taken from baitfish dealers across southern Ontario in 2007 and 2008 (a cumulative total of 16,886 fishes). No Silver Chub were detected in these samples (only 1 imperilled species, River Redhorse [*Moxostoma carinatum*], was detected), which may suggest that the species is not frequently captured within baitfish harvests. Overall the potential for incidental catch of Silver Chub during baitfish harvesting is believed to be extremely low.

Climate change: Climate change is expected to have significant effects on aquatic communities through several mechanisms, including: increases in water and air temperatures, decreases in dissolved oxygen, changes in water levels, shortened duration of ice cover, increases in the frequency of extreme weather events, emergence of diseases, increased toxicity of pollutants, and, shifts in predator-prey dynamics (for example, Lemmen and Warren 2004; Ficke et al. 2007), all of which may negatively impact Canadian fish populations. Drought has been implicated in Silver Chub recruitment failure in Kansas rivers (Perkin et al. 2019); similar drought conditions in the Thames River could represent a threat to the species if recruitment is occurring in this river. In the Great Lakes, water temperature might limit the northern range of Silver Chub (for example, Kinney 1954). Hence, climate change may have an impact on the species' range through shifts in water temperature, allowing the species to expand its range. Also, the relationship between Silver Chub, Round Goby, *Hexagenia* spp., and dreissenid mussels in the context of climate change has not been sufficiently studied. It is difficult to determine the likelihood and impact of this threat on each Silver Chub population; therefore, this threat was not included in the aforementioned population-specific threat level assessment (table 3).

Recovery

6 Population and distribution objectives

Population and distribution objectives establish, to the extent possible, the number of individuals and/or populations, and their geographic distribution, that is necessary for the recovery of the species. The population and distribution objectives[7] for Silver Chub are:

Long-term population objective: for locations where populations are sparse and/or data are lacking (that is, the Canadian portions of Lake St. Clair and the central basin of Lake Erie), the long-term objective is to ensure all extant populations demonstrate signs of reproduction and recruitment, and are stable or increasing. In the western basin of Lake Erie a more quantitative target is possible; although densities prior to 1988 are unknown, a long-term target can be set using the minimum viable population size (MVP) as a guide. Population modelling conducted by Young and Koops (2013) estimated that the MVP for Silver Chub is 444 000 adults, given a 15% chance of a catastrophic event occurring per generation. To ensure the viability of Silver Chub for the Canadian portion of the western basin of Lake Erie, the long-term population objective is to ensure a greater than 75% chance that the median population abundance exceeds 440 000 adults (or > 2.89 fish/hectare), with a stable or increasing trajectory, over at least 3 generations (~7 years).

[7] Note: Population and distribution objectives apply only to the Canadian portions of lakes Erie and St. Clair.

Long-term distribution objective: to ensure the persistence of the species within the currently occupied watersheds (that is, Lake St. Clair, and the western and central basins of Lake Erie).

Lake Huron was not included in the population and distribution objectives as only two specimens have ever been captured and it is unclear whether there is an established population present. The Thames River was not included at this time as it is not known whether an established population is present or whether the individuals captured are strays from Lake St. Clair. The eastern basin of Lake Erie was not included given the rarity of historical and contemporary catches, despite regular index sampling by provincial agencies and the possibility that those captured are strays from the central basin. Should new information become available (for example, evidence that populations are established), the population and distribution objectives will be revisited.

It is important to note that the setting of population and distribution objectives and the identification of critical habitat are science-based exercises and that socio-economic factors were not considered in their development.

7 Broad strategies and general approaches to meet objectives

7.1 Actions already completed

Single and multi-species recovery strategies and management plans have been drafted previously for a variety of fish species, the distributions of which partly overlap with that of Silver Chub. These include, but are not limited to, the Northern Madtom (*Noturus stigmosus*) and Pugnose Shiner (*N. anogenus*). The implementation of recovery actions within these watersheds is ongoing and may indirectly benefit Silver Chub. The Essex-Erie recovery strategy (Essex-Erie Recovery Team 2008) is an ecosystem-based recovery strategy that includes Silver Chub. Other ecosystem-based recovery strategies that may be applicable to the conservation of Silver Chub are the Thames River recovery strategy (Thames River Recovery Team 2005) and the Sydenham River action plan (DFO 2018); both of these watersheds contribute a significant amount of sediment and nutrients to Lake St. Clair, where Silver Chub is known to occur.

Conservation authorities (for example, Essex Region, Lower Thames Valley, Kettle Creek, Catfish Creek, and Long Point Region) continue to play a vital role in stewardship and public education programs that have resulted in increased awareness of species at risk and improvements to habitat and water quality within several of the major tributaries to Lake St. Clair and Lake Erie.

Although Silver Chub is not a legal baitfish in Ontario (see 2019 Fishing Ontario: Recreational Fishing Regulations Summary), incidental harvest of this species is possible. A baitfish field guide has been made available by DFO that identifies the baitfish species of Ontario (Cudmore and Mandrak 2018). The baitfish field guide, which includes Silver Chub, has been made available to commercial bait harvesters, anglers, and the general public via OMNR and ServiceOntario offices. Additionally, a baitfish field guide application has been developed for Android and iOS devices.

Research examining the genetic structure of Silver Chub populations using mitochondrial DNA determined that Lake Erie has four cytochrome-B haplotypes not found in other areas, and only

1 Lake Erie specimen had a haplotype shared with another areas (Mississippi), suggesting that the Lake Erie population is genetically distinct. This research also revealed that Silver Chub in the Mississippi have the largest number of different haplotypes (Elbassiouny et al. 2023).

7.2 Strategic direction for recovery and implementation schedule

Successful recovery of this species is dependent on the actions of many different jurisdictions, industries, non-governmental organizations, Indigenous partners, and Canadians in general. It requires the commitment and cooperation of the constituencies that will be involved in implementing the directions and measures set out in this recovery strategy and action plan.

This recovery strategy and action plan provides a description of the measures that provide the best chance of achieving the population and distribution objectives for Silver Chub, including measures to be taken to address threats to the species and monitor its recovery. These measures will guide not only activities to be undertaken by DFO, but those for which other jurisdictions, organizations and individuals have a role to play. As new information becomes available, these measures and the priority of these measures may change. DFO strongly encourages all Canadians to participate in the conservation of Silver Chub by undertaking measures outlined in this recovery strategy and action plan.

Table 4 identifies the measures to be undertaken by DFO to support the recovery of Silver Chub. Table 5 identifies the measures to be undertaken collaboratively between DFO and its partners, other agencies, organizations or individuals. Implementation of these measures will be dependent on a collaborative approach, in which DFO is a partner in recovery efforts, but cannot implement the measures alone. As all Canadians are invited to join in supporting and implementing this recovery strategy and action plan, table 6 identifies the remaining measures that represent opportunities for other jurisdictions, organizations, or individuals to lead for the recovery of the species. If your organization is interested in participating in one of these measures, please contact the Species at Risk - Ontario and Prairie office.

Federal funding programs for species at risk that may provide opportunities to obtain funding to carry out some of the outlined activities include the Habitat Stewardship Program for Species at Risk, Aboriginal Fund for Species at Risk, and the Canada Nature Fund for Aquatic Species at Risk.

The measures included in this recovery strategy and action plan to be implemented by DFO will be subject to the availability of funding and other required resources. As indicated in the tables below, partnerships with specific organizations will provide expertise and capacity to carry out some of the listed recovery measures. However, the identification of partners is intended to be advice to other jurisdictions and organizations and carrying out these actions will be subject to each group’s priorities and budgetary constraints.

Table 4. Measures to be undertaken by Fisheries and Oceans Canada for the Silver Chub (Great Lakes – Upper St. Lawrence populations).

#	Recovery measures	Approach	Broad strategy	Priority[8]	Threats or concern addressed	Status/ timeline[9]
1	Work with ecosystem- or single species-based recovery teams to share knowledge, combine resources, implement recovery actions and ensure a coordinated approach to recovery.	Coordination of activities	Management and coordination	High	All threats	Ongoing
2	Work with municipal planning authorities so that they consider the protection of critical habitat for the Silver Chub within official plans. Recommend consideration of the Silver Chub's needs when developing projects at the design stage and when issuing permits.	Coordination of activities	Management and coordination	High	All threats	Ongoing
3	Establish a cooperative relationship with neighbouring United States jurisdictions responsible for Silver Chub management to allow for effective information sharing.	Strengthening international collaboration	International collaboration	Medium	All threats	Ongoing

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

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

[9] Timeline reflects the amount of time required for the measure to be completed from the time the recovery strategy and action plan is published as final on the Species at Risk Public Registry.

Table 5. Measures to be undertaken collaboratively between Fisheries and Oceans Canada and its partners for the Silver Chub (Great Lakes – Upper St. Lawrence populations).

#	Recovery measures	Approach	Broad strategy	Priority[10]	Threats or concern addressed	Status/ timeline[11]	Lead and partner(s)
4	Work with relevant organizations (for example, conservation authorities, Ontario Ministry of Natural Resources [OMNR], Indigenous groups) to share knowledge, combine resources, implement recovery actions and ensure a coordinated approach to recovery.	Coordination of activities	Management and coordination	High	All	Ongoing	Fisheries and Oceans Canada (DFO), Michigan Department of Natural Resources (MDNR), Ohio Department of Natural Resources (ODNR), OMNR, Ontario Ministry of Environment, Conservation and Parks (OMECP), United States Geological Survey (USGS), conservation authorities, environmental non-governmental organizations

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

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

[11] Timeline reflects the amount of time required for the measure to be completed from the time the recovery strategy and action plan is published as final on the Species at Risk Public Registry.

#	Recovery measures	Approach	Broad strategy	Priority[10]	Threats or concern addressed	Status/ timeline[11]	Lead and partner(s)
5	Ensure the continued monitoring of Silver Chub during trawling and gillnetting surveys undertaken by each agency in Lake Erie.	Population and habitat assessment	Inventory and monitoring	High	Knowledge Gaps	Ongoing	DFO, MDNR, ODNR, OMNR, USGS, United States Fish and Wildlife Service (USFWS)
6	Conduct targeted surveys (and/or target Silver Chub in pre-existing surveys) at historical Silver Chub locations (for example, Lake Huron, Lake St. Clair).	Population and habitat assessment	Inventory and monitoring	High	Knowledge Gaps	New/3 to 4 years	DFO, OMNR, OMECP
7	Conduct targeted surveys (and/or target Silver Chub in pre-existing surveys) for undetected populations in high probability areas (for example, Detroit and Thames rivers).	Population and habitat assessment	Inventory and monitoring	Medium	Knowledge Gaps	New/3 to 4 years	DFO, OMNR, OMECP
8	Identify thresholds of tolerance to environmental stressors (for example, sedimentation of substrate) to determine what constitutes destruction of Silver Chub critical habitat.	Threat evaluation	Research	High	Turbidity and sediment loading, contaminants and toxic substances, nutrient loading	New/4 to 5 years	DFO, academia

#	Recovery measures	Approach	Broad strategy	Priority[10]	Threats or concern addressed	Status/ timeline[11]	Lead and partner(s)
9	Investigate the impact of invasive species (for example, Round Goby) interactions (for example, competition) with Silver Chub.	Threat evaluation	Research	High	Invasive species	New/4 to 5 years	DFO, academia
10	Determine the life history of the Silver Chub (for example, lifespan, fecundity, growth).	Life history studies	Research	Medium	Knowledge gaps	New/4 to 5 years	DFO, OMNR, OMECP, USGS
11	Determine Silver Chub interactions with other species (for example, predation, competition).	Life history studies	Research	Medium	Knowledge gaps	New/4 to 5 years	DFO, OMNR, OMECP, USGS
12	Determine the catchability of Silver Chub, to allow for more accurate abundance estimates.	Population and habitat assessment	Research	Medium	Knowledge gaps	New/4 to 5 years	DFO, OMNR, OMNECP, USGS, USFWS
13	Support invasive species public awareness initiatives.	Increase public awareness and support	Stewardship and outreach	Low	Invasive species	Ongoing	DFO, OMNR

#	Recovery measures	Approach	Broad strategy	Priority[10]	Threats or concern addressed	Status/ timeline[11]	Lead and partner(s)
14	Promote stewardship among landowners and First Nations abutting the habitat of Silver Chub and/or with the potential to directly or indirectly affect the habitat of Silver Chub.	Increase public awareness and support	Stewardship and outreach	High	All threats	Ongoing	DFO, MECP, MNR, conservation authorities

Table 6. Measures that represent opportunities for other jurisdictions, organizations or individuals to lead for the Silver Chub (Great Lakes – Upper St. Lawrence populations).

#	Recovery measures	Approach	Broad strategy	Priority[12]	Threats or concern addressed	Potential jurisdictions or organizations
15	Assess genetic structure within Silver Chub populations via the nuclear genome to determine whether there are distinct sub-populations in Lake Erie.	Genetic structure assessments - Silver Chub populations	Research	Medium	Knowledge gaps	Ohio Department of Natural Resources (ODNR); Ontario Ministry of Natural Resources (OMNR); Ontario Ministry of Environment, Conservation and Parks (OMECP); United States Geological Survey (USGS); University of Toronto
16	Conduct targeted surveys (and/or target Silver Chub in pre-existing surveys) for undetected populations in high probability areas in American tributaries to Lake Erie (for example, Maumee River).	Population and habitat assessment	Inventory and monitoring	Medium	Knowledge gaps	Michigan Department of Natural Resources, ODNR, United States Fish and Wildlife Service, USGS

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

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

#	Recovery measures	Approach	Broad strategy	Priority[12]	Threats or concern addressed	Potential jurisdictions or organizations
17	Implement local stewardship programs to improve habitat conditions and reduce threats within critical habitat and other occupied habitats. Priorities and mitigation approaches to be informed through threat evaluation research.	Habitat improvement	Stewardship and outreach	High	All threats	Conservation authorities, environmental non-governmental organizations (ENGOs)
18	Increase public awareness about potential impacts of invasive species on the ecosystem, including Silver Chub. Discourage the emptying of bait buckets.	Increase public awareness and support	Stewardship and outreach	Medium	Invasive species	OMNR, conservation authorities, ENGOs

7.3 Narrative to support the recovery planning and implementation tables

Management and coordination

Coordination of activities (measures: 1, 2, 4): Many of the threats affecting Silver Chub populations are similar to those that affect other aquatic species. Therefore, efforts to remediate these threats should be done in close connection with others working to recover aquatic species at risk. For example, the requirements of Silver Chub are incorporated into the Essex-Erie recovery strategy. As well as species-specific considerations, the Essex-Erie recovery strategy employs basin-wide strategies to improve environmental conditions, such as water quality, benefiting Silver Chub and other species. In addition, the implementation of Silver Chub recovery actions will be coordinated with recovery approaches for other aquatic species at risk with distributions that overlap that of the Silver Chub (see section 7.1).

International collaboration

Strengthening international collaboration (measure: 3): As the Silver Chub is found in watercourses that are under shared jurisdiction, strategic partnering with various entities in the U.S. is imperative. The USGS and the U.S. Fish and Wildlife Service (USFWS) collect Silver Chub regularly in monitoring and research trawls in the western basin of Lake Erie, and the ODNR run the annual Interagency Index Trawl in cooperation with the OMNR. Additionally, the Michigan Department of Natural Resources (MDNR) has their own fisheries assessment program that includes Silver Chub.

Inventory and monitoring

Population and habitat assessment (measures: 5 to 7, 16): A key first step in Silver Chub recovery planning is to determine the current distribution and abundance of the species. Although there is no species-specific monitoring program for Silver Chub in Ontario, the Interagency Index Trawl conducted by the OMNR and the ODNR to assess forage fish populations, as well as the Partnership Gill Net Index Program conducted by the OMNR and commercial fishing agencies are standardized programs that detect Silver Chub regularly on the Canadian side of Lake Erie, providing long-term data. Additional surveys that occur annually on the U.S. side, which regularly catch Silver Chub, include bottom trawls conducted every June and September by the USGS, and invasive species sampling conducted in June by the USFWS. To allow for quantitative tracking of changes in population abundance and demographics and analyses of habitat use and availability, as well as changes in these parameters over time, it is essential that the agencies involved in these programs continue to identify and record Silver Chub in their catches. The intent is not to develop a stand-alone monitoring program but to harmonize population and habitat data needs with existing monitoring programs.

Ultimately, a thorough understanding of all extant populations is necessary to refine the identification of critical habitat and to inform effective recovery actions.

Research

Threat evaluation (measures: 8, 9): A variety of potential threats to Silver Chub populations were identified in the COSEWIC report (COSEWIC 2012) and the RPA (McCulloch et al. 2013)

(table 3). For example, the impacts of altered coastal processes and invasive species, such as the Round Goby, on the Silver Chub are unknown. Further needs include identifying how threats affect individuals and populations (for example, through vital rates). Examining responses of vital rates to threats will assist with defining thresholds, if they exist, for water quality parameters (for example, nutrients, turbidity) and determining physiological parameter limits including temperature, pH, dissolved oxygen, and contaminant tolerance. The status, certainty and cumulative effects of these threats should be confirmed throughout the species' distribution to ensure that appropriate and defensible recovery actions are undertaken.

Life-history studies (measures: 10, 11): Much of the life-history information for Silver Chub is decades old; an improved understanding of the Silver Chub's life history is required to refine critical habitat descriptions, protect critical habitat, inform modelling efforts designed to develop quantifiable recovery targets, and allow for clear focus of recovery planning and actions. Some key information gaps include the location of spawning grounds (although the work of Brown et. al. [In Press] provides new information on spawning locations, as described in McKenna et al. [2023] there are other spawning areas that should be investigated), age-specific habitat requirements (refer to section 8.2 Schedule of studies to identify critical habitat for research needs related to habitat requirements for Silver Chub), stage-dependent survival rates, and fecundity estimates. Investigations into the timing and location of spawning in the western basin of Lake Erie have been initiated; research examining the microchemistry of Silver Chub otoliths to estimate daily ages of juveniles has been ongoing since 2016 (McKenna et al. 2023; Brown et al. In Press). If feasible, samples collected during annual OMNR index surveys of the western basin of Lake Erie should be kept for studies on the biology, reproduction, and life history of the Silver Chub. Data collected from index surveys and monitoring will help to inform research activities with respect to spatial and temporal considerations (for example, spawning times and locations).

Population and habitat assessment (measure: 12): Although there are standardized lake-wide monitoring programs in Lake Erie (for example, Interagency Index Trawl) that collect valuable Silver Chub data and provide catch per unit effort information, having estimates of catchability of the species would allow for more accurate estimates of abundance; future efforts should focus on determining the catchability of Silver Chub.

Genetic structure assessments (measure: 15): While an assessment of the genetic structure across the Silver Chub's geographic range using mitochondrial DNA was completed (Elbassiouny et al. 2023) (refer to section 7.1 Activities already completed for details), further work looking at the nuclear genome should be completed to determine whether there are distinct sub-populations in Lake Erie. This will ensure that appropriate management actions are taken to conserve and recover the species.

Stewardship and outreach

Increase public awareness and support, habitat improvement (measures: 13, 14, 17, 18): Public participation in the recovery process for Silver Chub is essential, as potential threats to its populations may result from diffuse non-point source inputs relating to the general agricultural and urban activities within these watersheds. Recovery cannot occur without the full participation of local citizens and landowners, highlighting the need for an effective public awareness program. Silver Chub should be considered in existing communication and outreach programs both for ecosystem-based recovery and for other aquatic species at risk to raise awareness of the need to protect freshwater fishes and ensure the health of freshwater ecosystems.

Stewardship and outreach activities targeting the following initiatives would support the maintenance or improvement of water quality in Silver Chub habitats: maintaining riparian buffer strips, restricting livestock access to streams, preventing untreated or under-treated sewage or manure run-off into waterways, and, minimizing chemical and fertilizer applications to lands adjacent to waterways. Phosphorus inputs to Lake Erie have been reduced, but localized concerns persist as they do for a variety of contaminants (see ECCC and U.S. EPA 2009). Best management practices (BMPs) represent a good tool to provide clear direction for improved methods of operation for those industries that may impact water quality. To be effective, BMPs should target primary threats affecting currently occupied habitat and, in particular, critical habitat. Once threats have been evaluated for extant populations, the results will inform local stewardship programs for threat mitigation.

Success can be achieved through increasing awareness of these stewardship activities and through providing financial assistance to local landowners. Improvements to watershed water quality require the involvement of local residents, businesses and organizations. The earlier into the recovery process that the community is involved, the greater the likelihood of sustained and growing support for recovery actions. Therefore, it is important to involve the public in the action planning and implementation of recovery.

8 Critical habitat

8.1 Identification of Silver Chub critical habitat

8.1.1 General description of Silver Chub critical habitat

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

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

For the Silver Chub, critical habitat is identified to the extent possible, using the best available information, and provides the features and attributes necessary to support the species' life-cycle functions.

This recovery strategy and action plan identifies the features of critical habitat for Silver Chub as near shore areas and open waters of large lakes and their connecting channels at depths of 2.3 to 24 m, over silt, or clean sand and gravel substrates.

The areas within which critical habitat can be found for Silver Chub as the Canadian portion of the western basin of Lake Erie, from the outlet at the Detroit River to the eastern limits of the basin adjacent to Point Pelee.

Note that permanent anthropogenic structures within the delineated area are specifically excluded.

It is unknown if the critical habitat identified in this recovery strategy and action plan is sufficient to achieve the species' population and distribution objectives. The schedule of studies (section 8.2) outlines the research required to acquire more detailed information about the critical habitat identified to achieve the species' population and distribution objectives.

8.1.2 Information and methods used to identify critical habitat

Using the best available information at the time this recovery strategy and action plan was developed (surveys conducted up until 2023), critical habitat has been identified using a bounding box in the western basin of Lake Erie. This means that critical habitat is not comprised of the entire area within the identified boundaries but only those areas within the identified geographical boundaries where the described biophysical feature and the function it supports occur, as described in table 8.

Within the western basin (that is, the bounding box), aquatic features of critical habitat for Silver Chub include areas from 2.3 to 24 m deep with silt, or clean sand and gravel substrates.

8.1.3 Identification of critical habitat

Geographic information

For Silver Chub, the area within which critical habitat is identified is the Canadian portion of the western basin of Lake Erie, from the outlet at the Detroit River to the eastern limits of the basin adjacent to Point Pelee (figure 8). These boundaries are supported by the large number of records throughout the Canadian side of the basin, as well as by modelling that suggests there are extensive areas of the western basin that could support Silver Chub (McKenna and Castiglione 2014; McKenna Jr. and Kočovský 2020).

Areas of critical habitat identified at these locations may overlap with critical habitat identified for other co-occurring species at risk (for example, Channel Darter [*Percina copelandi*] [Lake Erie populations]); however, the specific habitat requirements within these areas may vary by species.

Table 7 provides the geographic coordinates that delineate the boundaries within which critical habitat is found for Silver Chub; these points are indicated on figure 8.

Table 7. Coordinates[13] delineating the boundaries within which critical habitat is found for the Silver Chub (Great Lakes – Upper St. Lawrence populations).

Location	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8
Lake Erie – Western Basin	41.989733, -82.4987279	42.035260, -82.613485	42.054466, -83.116042	42.053517, -83.145528	42.040981, -83.149678	41.863583, -83.069111	41.676556, -82.679714	41.676556, -82.510750

[13] All coordinates obtained using map datum NAD 83

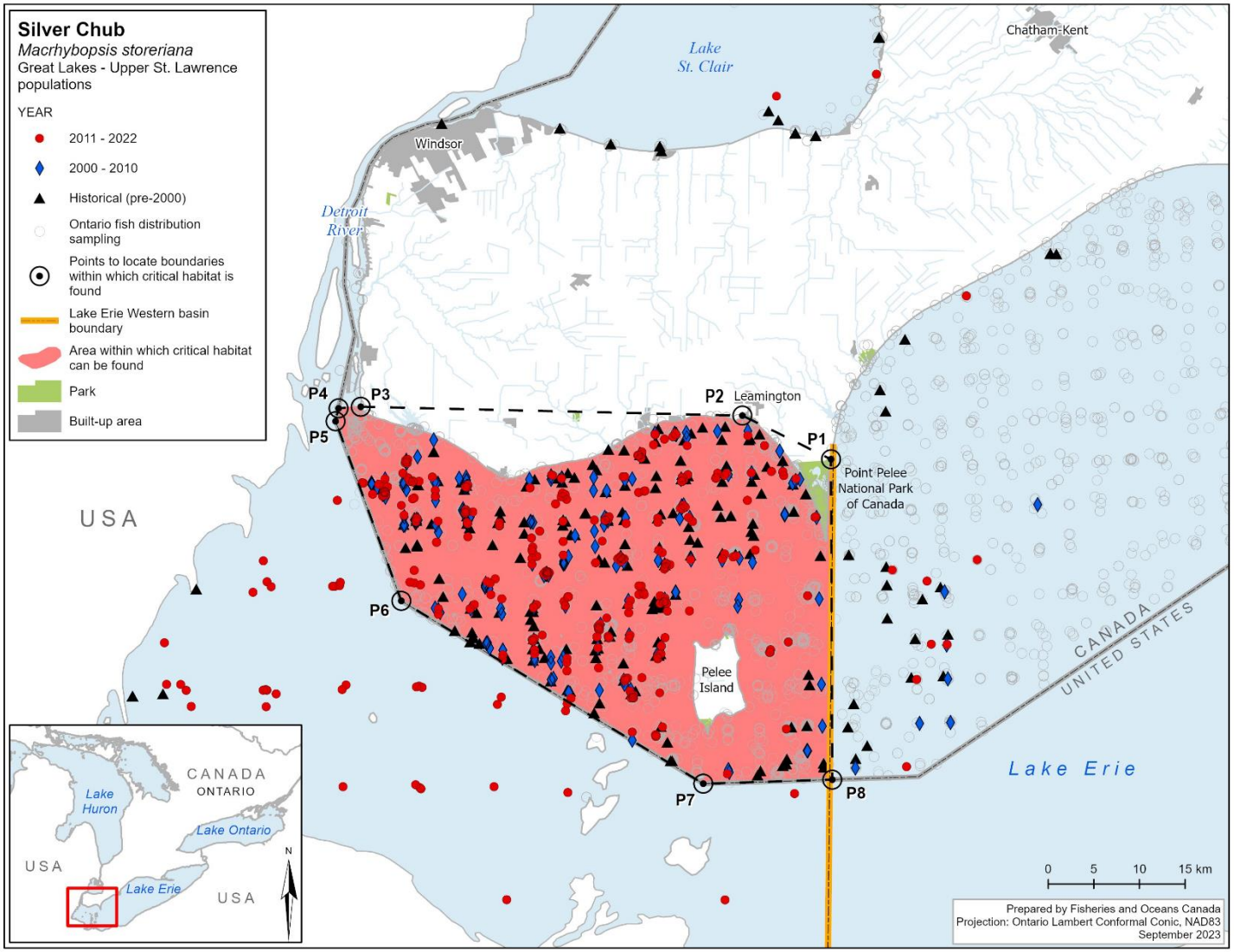

Figure 8. Bounding box within which critical habitat for Silver Chub can be found in the western basin of Lake Erie. Note that critical habitat is not comprised of all areas within the bounding box, but only those areas within the identified geographical boundaries where the described biophysical feature and the function it supports occur, as described in table 8.

Biophysical functions, features and attributes

Table 8 summarizes the best available knowledge of the functions, features, and attributes for each life stage of the Silver Chub (refer to section 4.3 Needs of the Silver Chub for full references). Note that not all attributes in table 8 must be present for a feature to be identified as critical habitat. If the features as described in table 8 are present and capable of supporting the associated function(s), the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table. A relatively wide range of features and attributes have been reported for this species and further information will be required to refine the description of critical habitat (for example, it is unclear where spawning occurs).

Table 8. General summary of the biophysical functions, features, and attributes of critical habitat necessary for the recovery of Silver Chub (Great Lakes – Upper St. Lawrence populations).

Life stage	Function[14]	Features[15]	Attributes[16]
Spawning (spawning likely occurs late May through to July)	Spawning	Nearshore and open water of large lakes, tributaries	• Water temperatures between 19 and 23°C in spring to early summer
Egg to juvenile	Nursery, feeding, cover	Nearshore and open water of large lakes, tributaries	• Depths of 2.3 to 24 m in Lake Erie • Silt, clean sand and gravel substrates • Dissolved oxygen levels sufficient to support Silver Chub • Adequate food supply (primarily aquatic invertebrates) • Water temperatures of at least 7.2 to 10°C for six to seven months and at least 21°C for 3 of those months (to support normal growth and reproduction)

[14] Function: functions are life-cycle processes of the listed species, which take place in critical habitat (for example, spawning, nursery, rearing, feeding and migration).

[15] Feature: features are the essential biophysical components of critical habitat that support the life-cycle function(s). Features may change over time and usually consist of more than one part, or attribute. A change or disruption to the feature or any of its attributes may affect the habitat's ability to support the life-cycle functions.

[16] Attribute: attributes are measurable properties or characteristics of a feature. Attributes describe how the identified features support the identified functions necessary for the species' life processes.

Life stage	Function[14]	Features[15]	Attributes[16]
Adult (from age 1 to onset of sexual maturity)	Feeding, cover	Large lakes and connecting rivers	• Depths of 2.3 to 24 m in Lake Erie • Silt, clean sand and gravel substrates • Dissolved oxygen levels sufficient to support Silver Chub • Adequate food supply (primarily aquatic invertebrates) • Water temperatures of at least 7.2 to 10°C for six to seven months and at least 21°C for 3 of those months (to support normal growth and reproduction)

Note that permanent anthropogenic structures that may be present within the delineated areas (for example, marinas, navigation channels, marine dredgeate disposal areas) are specifically excluded; it is understood that maintenance or replacement of these features may be required at times[17].

Studies to refine knowledge on the essential features and attributes for various life stages of the Silver Chub are described in section 8.2 (Schedule of studies to identify critical habitat).

Summary of critical habitat relative to population and distribution objectives

This is an area that, based on current best available information, the Minister of Fisheries and Oceans considers necessary to partially achieve the population and distribution objectives required for the survival/recovery of the Silver Chub. Additional critical habitat may be identified in future updates to the recovery strategy and action plan.

8.2 Schedule of studies to identify critical habitat

Further research is required to identify/refine critical habitat necessary to support the species' population and distribution objectives and protect critical habitat from destruction. The activities listed in table 9 are not exhaustive and it is likely that the process of investigating these actions will lead to the discovery of further knowledge gaps that need to be addressed.

[17] Depending on the type of maintenance or replacement, DFO should be notified before work is conducted to obtain guidance on best practices to minimize impacts to fish and fish habitat and to determine whether an application for a permit should be submitted.

Table 9. Schedule of studies to identify critical habitat for the Silver Chub (Great Lakes – Upper St. Lawrence populations).

Description of study	Rationale	Timeline[18]
Determine the seasonal habitat requirements, including species movement and migration, of all Silver Chub life stages (especially spawning locations and their habitat characteristics).	This would support the refinement/identification of features and attributes of critical habitat and identification of unique conditions that might be required for particular life stages.	3 to 5 years
Describe response curves of vital rates to threats, which will help to determine the physiological thresholds, if they exist, of the Silver Chub with respect to various water-quality parameters (for example, turbidity, water temperature, contaminants, dissolved oxygen).	Will help to refine features and attributes of critical habitat.	7 to 9 years
Continually review population and distribution objectives based on most recent data collected, with a particular focus on areas lacking data (for example, the southern tip of Lake Huron, Lake St. Clair, Thames River). Determine amount, configuration and description of critical habitat required to achieve these objectives if adequate information exists.	Revision of recovery targets may be required to ensure that they are achievable and defensible; will allow further refinement of critical habitat description (spatial and biophysical attributes).	Ongoing

[18] Timeline reflects the amount of time required for the study to be completed from the time the recovery strategy and action plan is published as final on the Species at Risk Public Registry. Timelines are subject to change in response to demands on resources and/or personnel and as new priorities arise.

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

The following examples of activities likely to result in the destruction[19] of critical habitat (table 10) are based on known human activities that are likely to occur in and around critical habitat and would result in the destruction of a part of critical habitat if unmitigated. The list of activities is neither exhaustive nor exclusive and has been guided by the threats described in section 5 (Threats). The absence of a specific human activity from this table does not preclude or restrict the Department's ability to regulate that activity under the SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition, and does not mean the activity will inevitably result in destruction of critical habitat. Every proposed activity must be assessed on a case-by-case basis and site-specific mitigation will be applied where it is available and reliable. Where information is available, thresholds and limits have been developed for critical habitat attributes to better inform management and regulatory decision making. However, in many cases, knowledge of a species and its critical habitat's thresholds of tolerance to disturbance from human activities is lacking and must be acquired.

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

Table 10. Examples of activities likely to result in the destruction of critical habitat for the Silver Chub (Great Lakes – Upper St. Lawrence populations).

Threat	Activity	Effect- pathway	Function affected	Feature affected	Attribute affected
Turbidity and sediment loading	Work in or around water with improper sediment and erosion control (for example, installation of wind turbines, bridges, pipelines, and culverts; overland runoff from ploughed fields; runoff from urban and residential development; use of industrial equipment; cleaning or maintenance of bridges or other structures without proper mitigation). Unfettered livestock access to waterbodies.	Improper sediment and erosion control or mitigation can cause increased turbidity and sediment deposition, the alteration preferred substrates, and impairment of feeding and reproductive functions. Unfettered livestock access to waterbodies can cause damage to shorelines, banks and watercourse bottoms, which can result in increased erosion and sedimentation, affecting turbidity and water temperatures.	Spawning, feeding, nursery	Nearshore and open water of large lakes Large lakes and connecting rivers	• Sand and gravel substrates • Dissolved oxygen levels sufficient to support Silver Chub and prey • Adequate food supply
Nutrient loading	Over-application of fertilizer and improper nutrient management (for example, organic debris management, wastewater management, animal waste, septic systems and municipal sewage).	Improper nutrient management can cause nutrient loading of nearby waterbodies. Elevated nutrient levels (phosphorus and nitrogen) can cause increased turbidity, harmful algal blooms, altered water temperatures, and reduced dissolved oxygen (DO) levels.	Spawning, feeding, nursery	Nearshore and open water of large lakes Large lakes and connecting rivers	• Dissolved oxygen levels sufficient to support Silver Chub and prey

Threat	Activity	Effect- pathway	Function affected	Feature affected	Attribute affected
Contaminants and toxic substances	Over-application or misuse of herbicides and pesticides. Release of urban runoff and municipal and industrial pollution into habitat (including municipal wastewater effluents). Introduction of high levels of chloride through activities such as excessive salting of roads in winter.	Introduction of toxic compounds (for example, mercury, polycyclic aromatic hydrocarbons, pharmaceuticals) into habitat used by this species can change water chemistry affecting the habitat and prey availability.	Spawning, feeding, nursery	Nearshore and open water of large lakes Large lakes and connecting rivers	• Adequate food supply
Habitat removal and alteration	Dredging, grading, and excavation Placement of material or structures in water (for example, wind turbines, pilings, bridge construction, infilling, partial infills).	Changes in bathymetry, shoreline and channel morphology caused by dredging and nearshore grading and excavation can alter preferred substrates, change water depths, and change flow patterns, potentially affecting turbidity, nutrient levels and water temperatures. Placing material or structures in water can reduce habitat availability (for example, the footprint of the infill or structure is lost). Placing of fill can cover preferred substrates.	Spawning, feeding, nursery	Nearshore and open water of large lakes Large lakes and connecting rivers	• Sand and gravel substrates • Adequate food supply • Water temperatures between 19 and 23˚C (reproduction) • Water temperatures of at least 7.2 to 10°C for six to seven months and at least 21°C for 3 of those months (to sustain normal growth and permit reproduction)

In the future, threshold values for some stressors may be informed through further research. For some of the above activities, BMPs may be sufficient to mitigate threats to the species and its habitat. However, in other cases, it is not known if BMPs are adequate to protect critical habitat and further research is required.

8.4 Proposed measures to protect critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a final recovery strategy or action plan that is included in the Species at Risk Public Registry.

Once the final recovery strategy is included in the Species at Risk Public Registry, the critical habitat for the Silver Chub will be protected through a SARA critical habitat order made under subsections 58(4) and 58(5), which will invoke the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

9 Evaluation of socio-economic costs and benefits of the action plan

SARA requires the competent minister to undertake an evaluation of the socio-economic impacts of the action plan component of the recovery document[20]. The evaluation includes the socio-economic costs of the action plan and the benefits to be derived from its implementation (SARA paragraph 49(1)(e)). This evaluation addresses only the incremental impacts of 'new' recovery measures outlined in this action plan (that is, measures that have not yet been implemented), recognizing that not all aspects of its implementation are under the jurisdiction of the federal government. This evaluation does not address any 'underway' measures (that is, measures that were initiated or implemented prior to the development of the action plan but have not yet been completed) as they are not considered as incremental costs to the government and other stakeholders (for example, research studies to identify critical habitat). In addition, the analysis does not address the costs associated with social and cultural loss of access to the species by Indigenous peoples and Canadians.

The protection and recovery of species at risk can result in both benefits and costs. The preamble to SARA recognizes that "wildlife, in all its forms, has value in and of itself and is valued by Canadians for aesthetic, cultural, spiritual, recreational, educational, historical, economic, medical, ecological and scientific reasons". Self-sustaining and healthy ecosystems with their various elements in place, including species at risk, contribute positively to the livelihoods and the quality of life of all Canadians. Actions taken to preserve a species, such as habitat protection and restoration, are also valued.

An estimate of the costs and benefits associated with this action plan are described below.

This evaluation does not address the socio-economic impacts of protecting critical habitat for the Silver Chub. Under SARA, DFO must ensure that critical habitat identified in a recovery strategy or action plan is legally protected within 180 days of the final posting of the recovery strategy or action plan. Where a SARA critical habitat order will be used for critical habitat

[20] The "action plan component of the recovery document" will simply be referred to as "action plan" from this point forward.

protection, the development of the order will follow a regulatory process in compliance with the Cabinet Directive on Regulation, including an analysis of any potential incremental impacts of the SARA critical habitat order that will be included in the regulatory impact analysis statement. As a consequence, no additional analysis of critical habitat protection has been undertaken for the assessment of costs and benefits of this action plan.

Policy baseline

The policy baseline consists of the protection under SARA for Silver Chub. The species was listed under the SARA as endangered in 2019. The species is afforded additional protections under Ontario's *Endangered Species Act*, 2007 where it has been listed as Threatened. Further protections may be afforded to Silver Chub and its habitat under other provincial legislation[21].

The policy baseline also includes any recovery actions that were implemented prior to and after Silver Chub was listed under SARA and discussed in section 7.1 of this document. These recovery actions included various projects funded by the federal government and Province of Ontario. This socio-economic evaluation does not address past recovery efforts as they are not considered incremental costs.

Socio-economic costs

The recovery measures in this plan are grouped under 5 broad strategies: management and coordination, international collaboration, inventory and monitoring, research, and stewardship and outreach. Costs would be incurred by the lead agencies to implement the measures listed in the recovery strategy and action plan, and by partners who choose to participate in the recovery measures. Some measures are ongoing, whereas others occur once or twice. The present value of the costs of implementing the recovery measures in this plan are anticipated to be approximately $331,000 over a five-year period[22]. Implementation of the actions is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations. Costs would be incurred by the federal government to implement the activities listed in the recovery strategy and action plan. In-kind costs, such as volunteer time, providing expertise and equipment, would be incurred as a result of implementing activities listed in the recovery strategy and action plan. Costs (including in-kind support) could be incurred by the Province of Ontario and conservation authorities.

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

Socio-economic benefits

Some of the benefits of recovery actions required to return and maintain self-sustaining populations of Silver Chub outlined in this recovery strategy and action plan are difficult to

[21] Examples of other provincial legislation that provide habitat protection include, but may not be limited to, considerations under section 2.1.7 of the Provincial Policy Statement (2020) under Ontario's *Planning Act*, which prohibits development and site alteration in habitat of endangered and threatened species, except in accordance with provincial and federal requirements, as well as protection under the *Lakes and Rivers Improvement Act* in Ontario.
[22] The present value of the total incremental costs of the action plan was estimated with a discount rate of 7% over the five-year period.

quantify but would generally be positive. If implemented, stewardship programs to improve habitat conditions and reduce threats within critical habitat could help to improve riverine habitat and lead to healthier watersheds through improved water quality.

Some unquantifiable non-market benefits would be enjoyed by the Canadian public as a result of implementing the recovery actions contained in the action plan. Economic research shows that Canadians have a willingness to contribute to the costs of recovery actions that lead to improvements for species at risk.

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

Distributional impacts

Governments and conservation authorities will incur the majority of costs of implementing the action plan.

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

10 Measuring progress

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. A successful recovery program will achieve the overall aim of recovering populations to a state where they are stable or increasing and demonstrably secure with low risk from known threats. Progress towards meeting these objectives will be reported on in the report on the progress of recovery strategy implementation, 5 years after the publication of the final document on the Species at Risk Public Registry, and every subsequent 5 years.

Reporting on implementation of the action plan (under section 55 of SARA) will be done by providing information on the costs incurred to implement the action plan. Reporting on the ecological and socio-economic impacts of the action plan (under section 55 of SARA) will be done by assessing the results of monitoring the recovery of the species and its long-term viability, and by assessing the implementation of the action plan.

Performance indicators[23]:

1. The continued presence of Silver Chub within its current known distribution within the western and central basins of Lake Erie by 2029
2. Population status (relative abundance and trajectory) in Lake St. Clair known by 2034
3. Evidence of continued reproduction and recruitment in Lake Erie (central and western basins) by 2029
4. Silver Chub spawning locations identified in the western basin of Lake Erie by 2029

[23] Note: Performance indicators apply only to the Canadian portions of lakes Erie and St. Clair.

5. Determination of reproduction and recruitment in the Thames River by 2029
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11 Activities permitted by the recovery strategy

SARA states that “subsections 32(1) and (2), section 33 and subsections 36(1), 58(1), 60(1) and 61(1) do not apply to a person who is engaging in activities that are permitted by a recovery strategy, an action plan or a management plan and who is also authorized under an Act of Parliament to engage in that activity, including a regulation made under section 53, 59 or 71.” [subsection 83(4)]

The following activity is permitted by this recovery strategy and action plan:

Activity 1: Bycatch of Silver Chub during commercial fishing in the Canadian portion of Lake Erie.

Silver Chub is not a target species for commercial fishing; however, it may be captured incidentally. Commercial fishing is regulated by the Province of Ontario through the Ontario Fishery Regulations, 2007, of the *Fisheries Act*. In a study completed by the OMNR in 2004, 99% of Silver Chub captured were recorded from gill nets less than 57 mm (minimum mesh size for targeting Yellow Perch) (Belore, pers. comm. 2008), indicating that the rate of bycatch from the commercial fishing industry is a minimal threat to Silver Chub. The implementation of mesh size configurations to minimize the capture of small Yellow Perch (to allow spawning at least once before capture) is also successful in reducing the capture of Silver Chub.

Under subsection 83(4) of SARA, this recovery strategy and action plan allows commercial harvesters to engage in the activities of commercial fishing that incidentally kill, harm, harass, capture or take Silver Chub, subject to the following conditions:

1. The fishing activities are conducted under licenses issued under the Ontario Fishery Regulations, 2007

2. All Silver Chub caught are to be released immediately and returned to the place from where taken in a manner that causes them the least harm

For activities not listed above that are likely to interact with the Silver Chub in a manner prohibited by SARA, permits under section 73 and 74 may be sought by contacting the regional DFO office.

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Appendix A: record of cooperation and consultation

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

Name	Affiliation
Andy Cook	Ontario Ministry of Natural Resources
Andrew Drake	Fisheries and Oceans Canada
Bill Glass	Fisheries and Oceans Canada
Patrick M. Kočovský	United States Geological Survey
Fiona McGuinness	Ontario Ministry of Environment, Conservation, and Parks
Tom Pratt	Fisheries and Oceans Canada
Scott Reid	Ontario Ministry of Natural Resources
Michael Thorn	Ontario Ministry of Natural Resources
Doug Watkinson	Fisheries and Oceans Canada

In addition, consultation on the draft recovery strategy and action plan occurred through letters sent via email to Indigenous communities. Additional stakeholder, Indigenous, and public input were sought through the publication of the proposed document on the Species at Risk Public Registry for a 60-day public comment period. Comments received informed the final document.