Fisheries and Oceans Canada / Pêches et Océans Canada

Science / Sciences

Canadian Science Advisory Secretariat (CSAS)

Research Document 2013/020

Central and Arctic Region

Information in support of a Recovery Potential Assessment of Silver Chub (*Macrhybopsis storeriana*) in Ontario

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July 2013

Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044

Correct citation for this publication:

McCulloch, B.R., L.D. Bouvier, and N.E. Mandrak. 2013. Information in support of a Recovery Potential Assessment of Silver Chub (*Macrhybopsis storeriana*) in Ontario. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/020. v + 36 p.

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ABSTRACT

In April 1985, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed Silver Chub (*Macrhybopsis storeriana*) as Special Concern. The species was re-examined and the status confirmed in May 2001. In 2012, COSEWIC separated the populations into two separate designatable units: 1) the Saskatchewan - Nelson River populations; and 2) the Great Lakes - Upper St. Lawrence populations. The Saskatchewan - Nelson River populations were not considered to be at risk, while the Great Lakes-Upper St. Lawrence population was reassessed from Special Concern to Endangered in May 2012. The reason given for this designation was “This is a small bodied fish species native to the middle Great Lakes that has declined substantially in abundance over the previous three generations. The species is assessed as at a high risk of extinction from several threats including habitat degradation, exotic species interactions and climate change”. No schedule or status has yet been assigned to the Great Lakes – Upper St. Lawrence designatable unit of Silver Chub under the federal *Species at Risk Act*. The distribution of the Great Lakes-Upper St. Lawrence populations is restricted to Ontario, where it is known only from lakes Erie and St. Clair, and the extreme southern portion of Lake Huron. The Recovery Potential Assessment (RPA) provides information and scientific advice needed to fulfill various requirements of SARA including permitting activities that would otherwise violate SARA prohibitions and the development of recovery strategies. This Research Document describes the current state of knowledge of the biology, ecology, distribution, population trends, habitat requirements, and threats of Silver Chub in the Great Lakes-Upper St. Lawrence designatable unit (DU). Mitigation measures and alternative activities related to the identified threats, that can be used to protect the species, are also presented. This information may be used to inform the development of recovery documents and for assessing SARA Section 73 permits.

Information à l'appui de l'évaluation du potentiel de rétablissement du méné à grandes écailles (*Macrhybopsis storeriana*) en Ontario

RÉSUMÉ

En avril 1985, le Comité sur la situation des espèces en péril au Canada (COSEPAC) a attribué au méné à grandes écailles (*Macrhybopsis storeriana*) le statut d'espèce Préoccupante. L'espèce a fait l'objet d'une nouvelle évaluation et son statut a été confirmé en mai 2001. En 2012, le COSEPAC a divisé la population en deux unités désignables distinctes : 1) les populations de la rivière Saskatchewan et du fleuve Nelson; et 2) les populations des Grands Lacs et du haut Saint-Laurent. En mai 2012, les populations de la rivière Saskatchewan et du fleuve Nelson n'étaient pas considérées en péril, tandis que celles des Grands Lacs et du haut Saint-Laurent ont été réévaluées et sont passées de « préoccupantes » à « en voie de disparition ». Le COSEPAC a justifié ainsi cette désignation : « ce poisson de petite taille originaire des Grands Lacs centraux a connu un important déclin d'abondance au cours des trois dernières générations. On estime que l'espèce fait face à un risque élevé d'extinction émanant de plusieurs menaces telles que la dégradation de l'habitat, les interactions avec des espèces exotiques et le changement climatique. » L'unité désignable de ménés à grandes écailles des Grands Lacs et du haut Saint-Laurent ne fait partie d'aucune annexe et ne porte aucune désignation en vertu de la *Loi sur les espèces en péril* (LEP) fédérale. La répartition des populations des Grands Lacs et du haut Saint-Laurent se limite à l'Ontario, et l'espèce n'a été observée que dans les lacs Érié et Sainte-Claire ainsi que dans l'extrémité sud du lac Huron. L'évaluation du potentiel de rétablissement (EPR) fournit l'information et les avis scientifiques nécessaires pour se conformer aux exigences de la LEP, notamment l'autorisation d'activités qui seraient normalement contraires aux interdictions prévues dans la LEP et l'élaboration de stratégies de rétablissement. Le présent document de recherche fournit une description de l'état actuel des connaissances de la biologie, de l'écologie, de la répartition, des tendances démographiques, des besoins en matière d'habitat et des menaces relatives à l'unité désignable (UD) de ménés à grandes écailles des Grands Lacs et du haut Saint-Laurent. Des mesures d'atténuation et des activités alternatives associées aux menaces déterminées, qui peuvent être utilisées dans le but de protéger l'espèce, sont également présentées. Ces renseignements peuvent servir à éclairer l'élaboration de documents sur le rétablissement et à évaluer les permis délivrés en vertu de l'article 73 de la LEP.

SPECIES INFORMATION

Scientific name – *Macrhybopsis storeriana* (Kirtland, 1845)
Common name – Silver Chub
Current COSEWIC status (Year of designation) – Endangered (2012)
COSEWIC reason for designation[1] **–** This is a small-bodied fish species native to the middle Great Lakes that has declined substantially in abundance over the previous three generations. The species is assessed as at a high risk of extinction from several threats including habitat degradation, exotic species interactions, and climate change.
***Species at Risk Act* status (Schedule)**
Prior to DU separation – Special Concern (Schedule 1)
Current Great Lakes – Upper St. Lawrence DU: No Status (No Schedule)
Ontario *Endangered Species Act* status (Year of designation) – Threatened (2012)
Range of Great Lakes – Upper St. Lawrence DU – Ontario

BACKGROUND

In April 1985, COSEWIC recommended that Silver Chub (*Macrhybopsis storeriana*) be designated as Special Concern. This status was reconfirmed in May 2001. In May 2012, Silver Chub (Great Lakes-Upper St. Lawrence DU) was designated as Endangered due to its substantial decline in abundance over the previous three generations (COSEWIC 2012b). The species was assessed because it is at a high risk of extinction from several threats including habitat degradation, invasive species interactions, and climate change. Subsequent to the original COSEWIC designation, Silver Chub was listed on Schedule 3, and then moved to Schedule 1 of the federal *Species at Risk Act* (SARA). Silver Chub is currently assessed as Threatened under Ontario's *Endangered Species Act* (2007). A Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) to provide information and scientific advice needed to fulfill SARA requirements including the development of recovery strategies and authorizations to carry out activities that would otherwise violate SARA (DFO 2007). This document provides background information on Silver Chub in Ontario to inform the RPA.

SPECIES DESCRIPTION

Silver Chub is a stout minnow that reaches a maximum total length (TL) of 231 mm (Trautman 1981; Page and Burr 2011). Species in the genus *Macrhybopsis* are characterized by the following features: a barbel at the end of the maxillary (corner of upper jaw); moderate-sized subterminal mouth; and, fewer than 50 lateral line scales (Scott and Crossman 1973; Stewart and Watkinson 2004; Holm et al. 2010; Page and Burr 2011; Figure 1). 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). Colouring is a pale grey-green on the back, becoming silver on the sides and silvery white below. A faint dusky lateral band is usually present. The caudal fin is lightly pigmented except for the lower three or four rays, which are completely white and unpigmented (Scott and Crossman 1973). In trawl-captured individuals from western Lake Erie, these coloration characters are not evident [P. Kocovsky, US Geological Survey (USGS), Lake Erie Biological Station, pers. comm.].

Silver Chub can be confused with large Spottail Shiner (*Notropis hudsonius*), Gravel Chub (*Erimystax x-punctatus*), and two *Nocomis* species (*N. biguttatus*, Hornyhead Chub; and *N. micropogon*, River

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

Chub). It is distinguished from Spottail Shiner by the presence of a terminal barbel; it lacks the distinct, dark, x-shaped spots that are characteristic of Gravel Chub; and, its snout projects further beyond the mouth than that of *Nocomis* spp. Additionally, *Nocomis* spp. have smaller eyes than Silver Chub and a more pigmented body that is not usually silvery (Holm et al. 2010). Gravel Chub has been extirpated from Ontario; therefore the two species will not co-occur there. The two *Nocomis* species are river-dwelling. Therefore, the only potential overlap in distribution with Silver Chub in Ontario would be in the Detroit River, should Silver Chub use that waterbody for migration and/or spawning purposes.

Silver Chub is the only member of the genus *Macrhybopsis* in Canada, and the Great Lakes populations are lacustrine forms. It was noted that specimens from the Ohio River appeared morphologically distinct than Lake Erie populations in that specimens from the Ohio River were more streamlined in appearance, have less body depth at the dorsal origin, and their heads are less triangular (Trautman 1981). The Great Lakes populations are geographically isolated from the majority of other Silver Chub populations, which inhabit the Mississippi drainage, and could be genetically distinct.

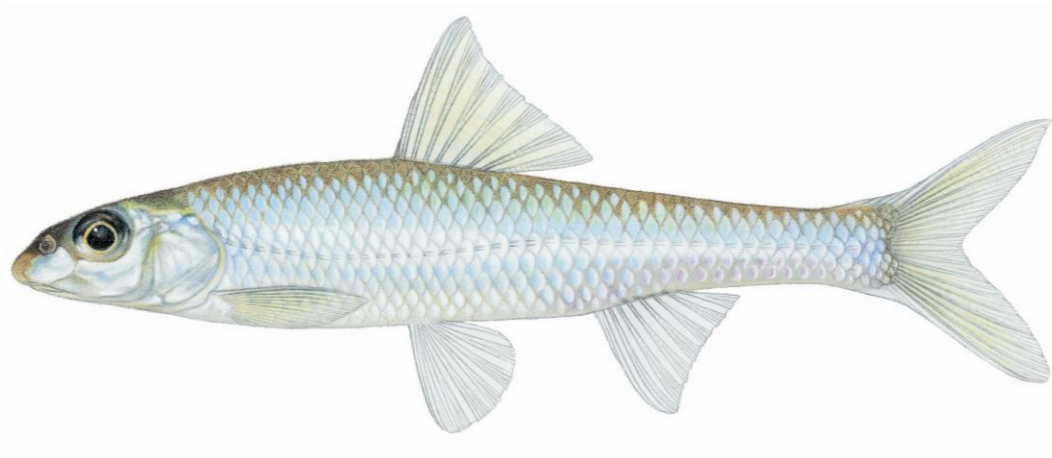


Figure 1. Silver Chub, Macrhybopsis storeriana*. Illustration by Joe Tomelleri, reproduced with permission.*

GROWTH RATE

Figure 2 shows length-frequency data for 73 Silver Chub captured in the western basin of Lake Erie in June and fall (September and October) of 2012 [P. Kocovsky, US Geological Survey (USGS), Lake Erie Biological Station, unpubl. data]. Of the 73 Silver Chub captured, 22 voucher specimens, collected during the June sampling surveys, were used for age interpretation. A single Age 1 fish and a single Age 3 were collected, 104 mm and 155 mm TL, respectively (Figure 3). TL ranged from 115 to 174 mm TL for Age 2 fish.

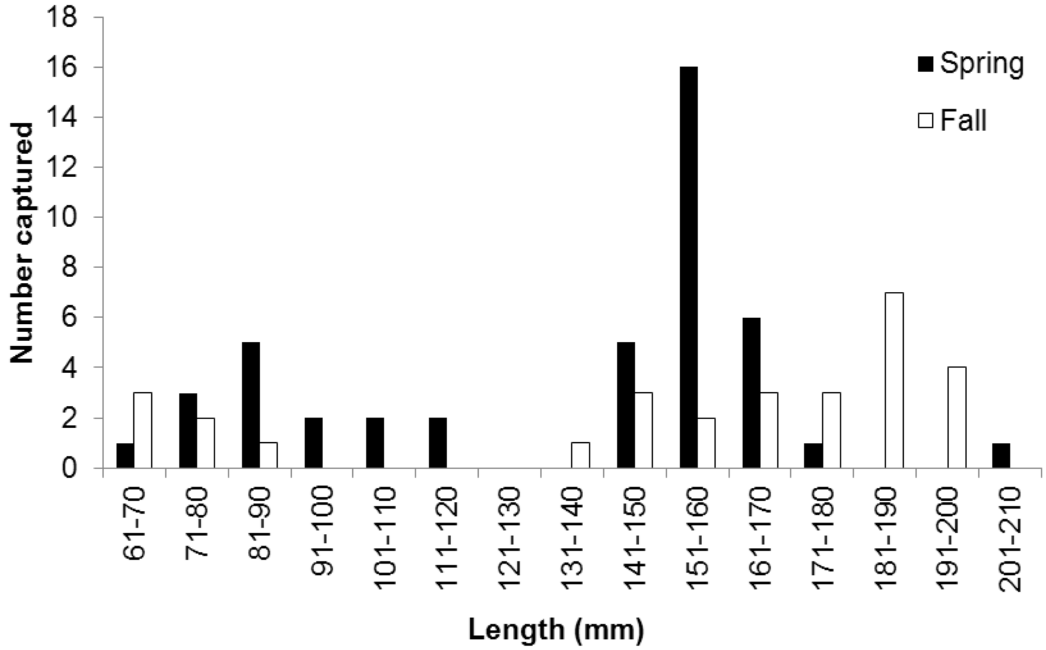


Figure 2. Length-frequency histogram for 73 Silver Chub collected in the western basin of Lake Erie in June (black bars), and September and October (white bars) 2012 (P. Kocovsky, USGS, unpubl. data).

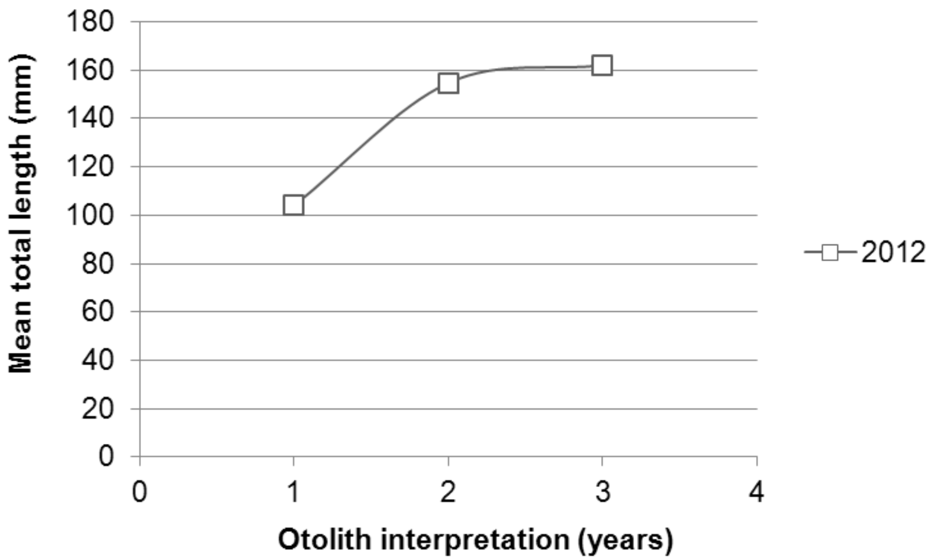


Figure 3. Results of otolith interpretation of 22 Silver Chub captured in June 2012 from the western basin of Lake Erie (P. Kocovsky, USGS, unpubl. data)

A collection of 110 Silver Chub caught in the western basin of Lake Erie in 2000 were aged using scales (Figure 4; N. Mandrak, DFO, unpubl. data). The specimens ranged in age from 1-4, and the mean growth rate was similar to that reported by Kinney (1954), prior to their disappearance from Lake Erie.

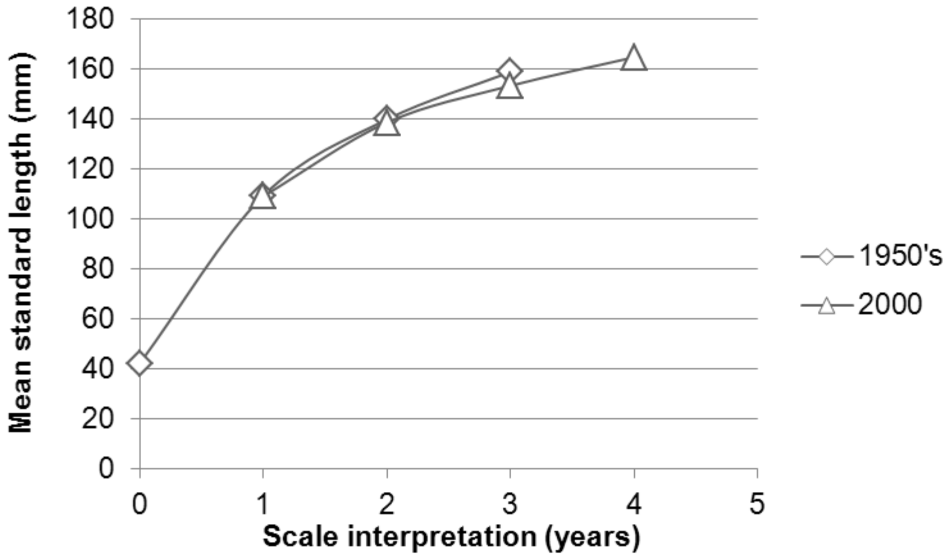


Figure 4. Growth of 110 Silver Chub collected in Lake Erie in 2000 and compared to Kinney (1954). (N. Mandrak, DFO, unpubl. data).

DIET

Silver Chub is a bottom feeder that uses both taste and sight to obtain its food. External taste buds are located on the head and pectoral fins. It feeds on a variety of items depending on age and available food. In the Mississippi and Richmond rivers of Wisconsin, diet consisted of aquatic insect larvae, Hemiptera, Coleoptera, crustaceans, and molluscs (Becker 1983). Historically, in Lake Erie, young fed on small crustaceans (copepods, *Daphnia*, ostracods, and *Gammarus*) and insect larvae (midges, caddisflies, and mayflies), while older individuals fed primarily on the mayfly nymph, *Hexagenia*, when available (Scott and Crossman 1973). Examination of 12 stomachs from large (188–228 mm TL) female Silver Chub captured in Lake Erie on 9 June 1997 [Royal Ontario Museum (ROM) Catalogue Number 70921] indicated that the most common food item was the mayfly nymph, *Hexagenia limbata,* (present in eight of 12 stomachs). Other items included fish eggs of approximately 1.0–1.4 mm in diameter (three of 12); Zebra Mussel, *Dreissena polymorpha,* (two of 12); *Cypria,* an ostracod (one of 12); one *Oecetis* (a caddisfly) (one of 12); and possibly, a small fish (one of 12). Etnier and Starnes (1993) noted that Silver Chub moves into reservoirs in Tennessee where the introduced clam *Corbicula* is abundant. A study of 110 Silver Chub collected in Lake Erie in 2000, found that 86% of the stomachs contained dreissenid mussels, 22% sphaeriids, 15% Coleoptera, 10% *Hexagenia*, and less than 10% contained a variety of other insects (N. Mandrak, DFO, unpubl. data). Although these data suggest that Silver Chub preferred feeding on dreissenid mussels rather than the mayfly nymph as suggested by Kinney (1954), it should be noted that samples studied by Kinney (1954) were collected between February and May. Therefore, post-dreissenid invasion, Silver Chub may switch prey items, depending on seasonal availability, and mayfly nymphs may be more predominant in their diet in early spring, when nymphs emerge and swim to the surface (Boyko and Staton 2010). A gut content analysis was completed on Silver Chub captured in the fall of 2010 (P. Kocovsky, USGS, unpubl. data; Figure 5). Over 90% of the fish Age 1 or older consumed dreissenid mussels. *Hexagenia* mayflies and eggs of *Daphnia* were also present in moderate numbers. While the presence of dreissenid mussels and *Daphnia* eggs was also associated with Age 0 fish, these younger fish fed more heavily on cladocerans, copepods, and ostracods.

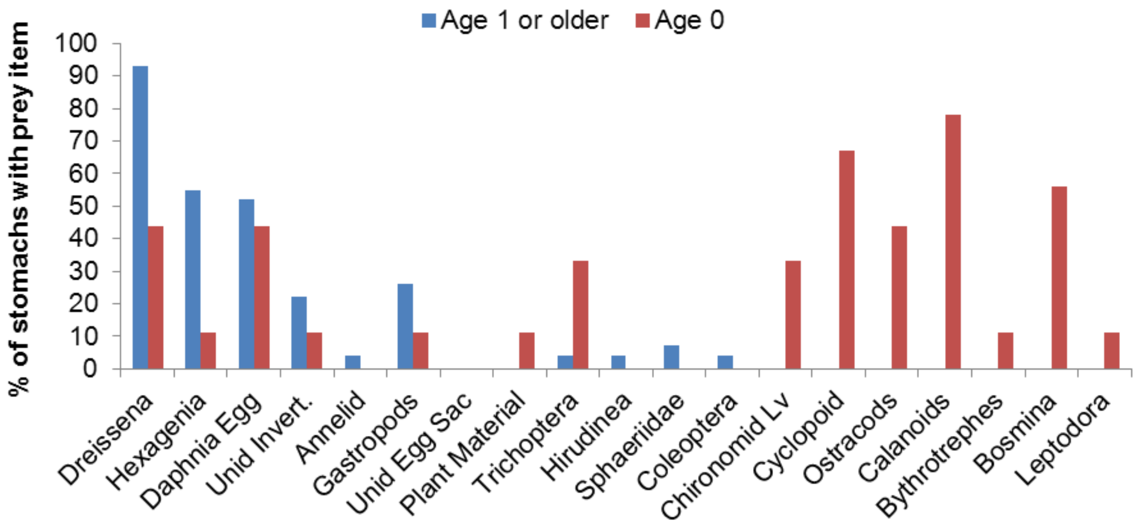


Figure 5. Prey items from Silver Chub captured in the western basin on Lake Erie (U.S. waters), fall 2010 (P. Kocovsky, USGS, unpubl. data).

GENETICS

Genetic studies have not been conducted on Silver Chub; therefore, little is known on the genetic variability of the species. However, the Great Lakes populations differ morphologically, and may be genetically distinct from the riverine forms found throughout most of its range in the United States. These populations are also isolated from most other Silver Chub populations, which occur in the Mississippi River drainage (COSEWIC 2012b). A genetic study should be conducted to compare the Great Lakes populations with those in the Mississippi River and Lake Winnipeg watershed.

DISTRIBUTION

The distribution of Silver Chub extends from Lake Winnipeg and the southern Great Lakes basin south to the mouth of the Mississippi River (Gilbert 1980; Werner 2004). It occurs in the Mississippi River system from Minnesota south to the Gulf of Mexico. In the northern part of its range in the Mississippi basin, it extends from Nebraska to New York [where it was last taken in 1928 (Werner 2004)]; and, in its Gulf Coast range, it extends from the Mobile Bay basin to the Lake Pontchartrain drainage. There is also an isolated population in the Brazos River drainage of Texas. Silver Chub has not been collected in the Kansas River since 1980 (Miller and Gress 2010) and it is a species of concern in the Missouri National Recreational River in Nebraska and South Dakota (Berry and Young 2004).

Less than 5% of the species' global distribution is currently found in Canada. In the Great Lakes basin, Silver Chub is limited to Lake Erie, Lake St. Clair, and the extreme southern portion of Lake Huron (Figure 6). In the Lake Winnipeg drainage, it is found in southern Lake Winnipeg and in the Assiniboine and Red River drainages of Manitoba, North Dakota, and Minnesota.

CURRENT STATUS

In Ontario, Silver Chub was historically collected along most of the north shore of Lake Erie and the south and east shores of Lake St. Clair (Figure 6). Most of the records for Lake Erie were collected prior to 1960 and since 1990; whereas, the Lake St. Clair records were collected in the 1970s and 1980s. Since 1980, Silver Chub has been collected primarily in the western and central basins of Lake Erie, with a few occurrences in Lake St. Clair, and a single occurrence in Lake Huron. The increase in records from the western basin of Lake Erie in the 1990s is likely a reflection of the species' recovery since the 1980s. However, the spatial extent of records has decreased in the last 10 years based on ongoing standardized sampling, leading to a 64% decline in both Extent of Occurrence (EO) (7639.42 km² for 2001-2010 records) and the Index of Area of Occupancy (IAO) (296 km², if only Canadian portion of grids are included; 2001-2010 records) (COSEWIC 2012b).

LAKE ERIE – WESTERN BASIN

The Canadian portion of the western basin of Lake Erie is bounded on the east by Point Pelee on the north shore. Most of the collections of Silver Chub in Lake Erie have come from the western basin (Figure 6); although catches have fluctuated greatly (see "Fluctuations and Trends" section).

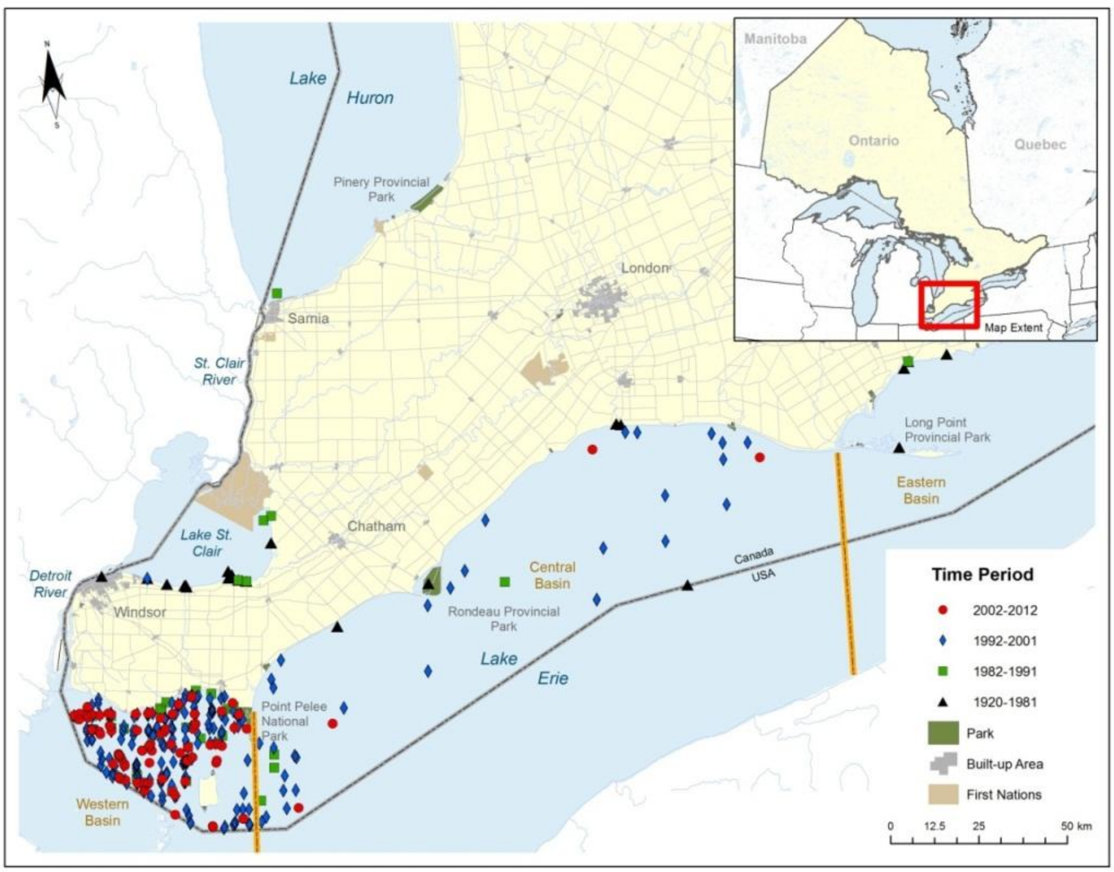


Figure 6. Distribution of Silver Chub in Ontario waters (Great Lakes – Upper St. Lawrence designatable unit).

In 2012, a total of 70 bottom trawls (37 were in Canadian waters) were conducted by the USGS in late spring (June 18-19) and fall (September 14-17, and October 9 and 11) (P. Kocovsky, USGS, unpubl.

data) (Figure 7). In June, three of 19 trawls in Canadian waters produced 49 Silver Chub for a catch rate of 8.70 fish/hectare. Forty-five Silver Chub (29 and 16) were captured from two sites south of Willow Beach and Ambassador Beach. In the fall, 13 Silver Chub, including six young-of-the-year (YOY), were captured from five of the 18 trawls for a catch rate of 2.33 fish/hectare. The combined catch rate in Canadian waters for 2012 was 5.53 fish/hectare, which is similar to recent sampling efforts.

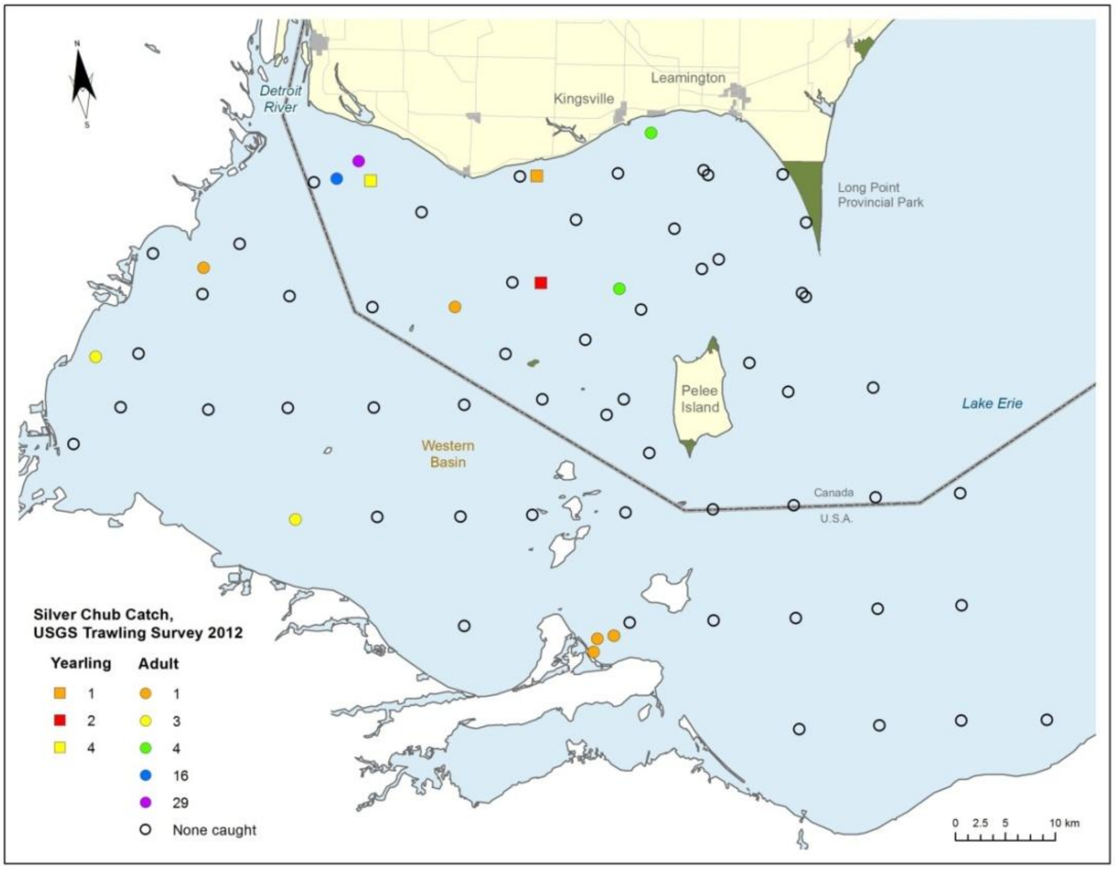


Figure 7. Location of bottom trawls and numbers of Silver Chub captured in the western basin of Lake Erie in 2012 (P. Kocovsky, USGS, unpubl. data).

In 2011 and 2012, nearshore electrofishing and trapnetting was conducted by a University of Toledo graduate student and the Ohio Environmental Protection Agency. A total of 143 sites were sampled by electrofishing (68 day and 75 night events). This sampling covered over 66 kilometres of nearshore habitat. No Silver Chub was captured. In six trapnet nights with approximate soak times of 14 hours, three Silver Chub were captured at one site on May 25, 2011. All Silver Chub captured were determined to be age 3.

The standardized Interagency Trawl Index Data, collected by the Ontario Ministry of Natural Resources (OMNR) and Ohio Division of Wildlife (ODW) is completed annually in the western basin of Lake Erie to provide fishery harvest and effort information, as well as gain baseline stock assessment data for important sport, commercial and forage fish (ODW 2012). A total of 74 bottom trawls were completed in 2012, yielding the capture of 37 Silver Chub from 12 sites (Figure 8).

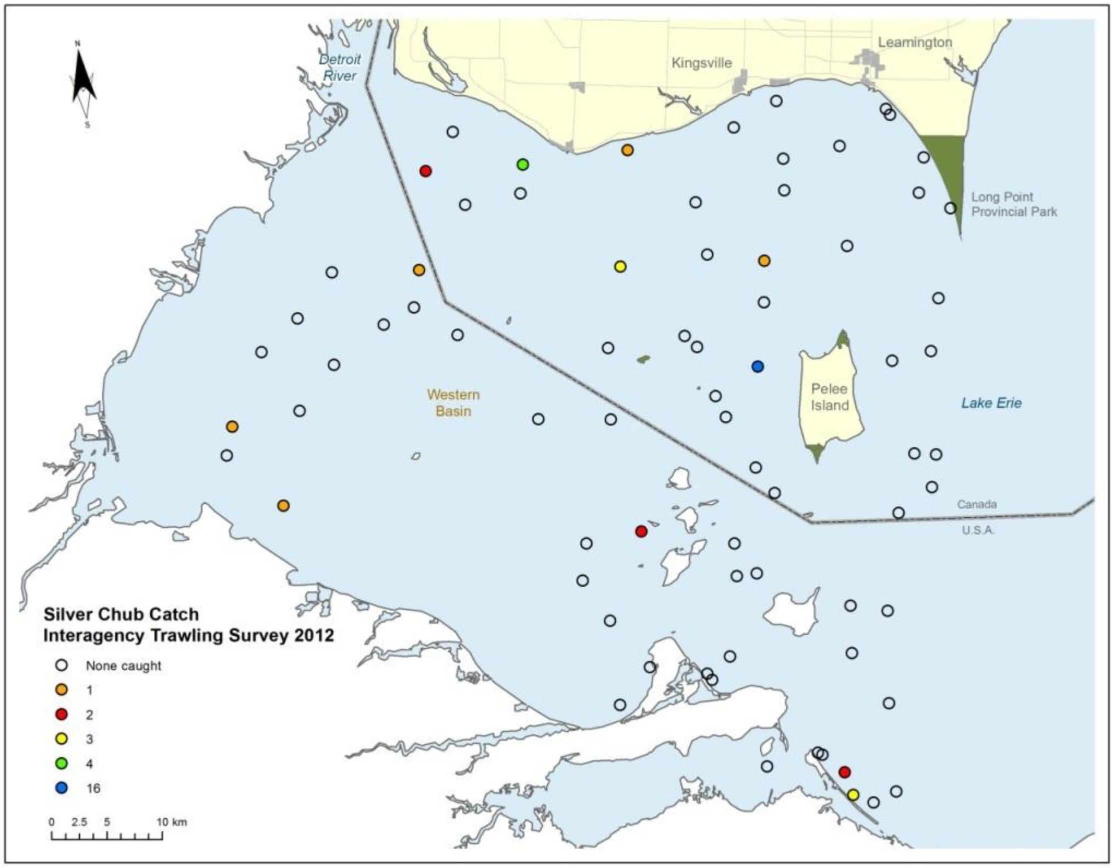


Figure 8. Number of Silver Chub caught in the 2012 Interagency trawling survey (ODW 2013; Ontario Ministry of Natural Resources 2013a).

The most recent data from the Partnership Index Gill Net Index Program (OMNR and commercial fishing agencies) show a slight decrease in the mean catch per gear in 2012 [0.14 fish/multi-mesh gang (mmg)]; four fish total; Figure 9). This follows five consecutive years where values were below 1 fish/mmg. It should be noted that gillnetting is not the effective means of capturing Silver Chub as the mesh size configuration has been selected to minimize the capture of smaller forage species.

Silver Chub have also been recorded during the 2004 yearling Walleye (*Sander vitreus*) gillnet survey. A total of 235 Silver Chub were recorded from surveys conducted from July 12 to October 27, 2004 (M. Belore, OMNR, unpubl. data). During this survey all nets were fished on the bottom overnight. Silver Chub was most often caught in mesh sizes 51 mm and smaller (M. Belore, OMNR, unpubl. data). This survey has not been repeated since 2004.

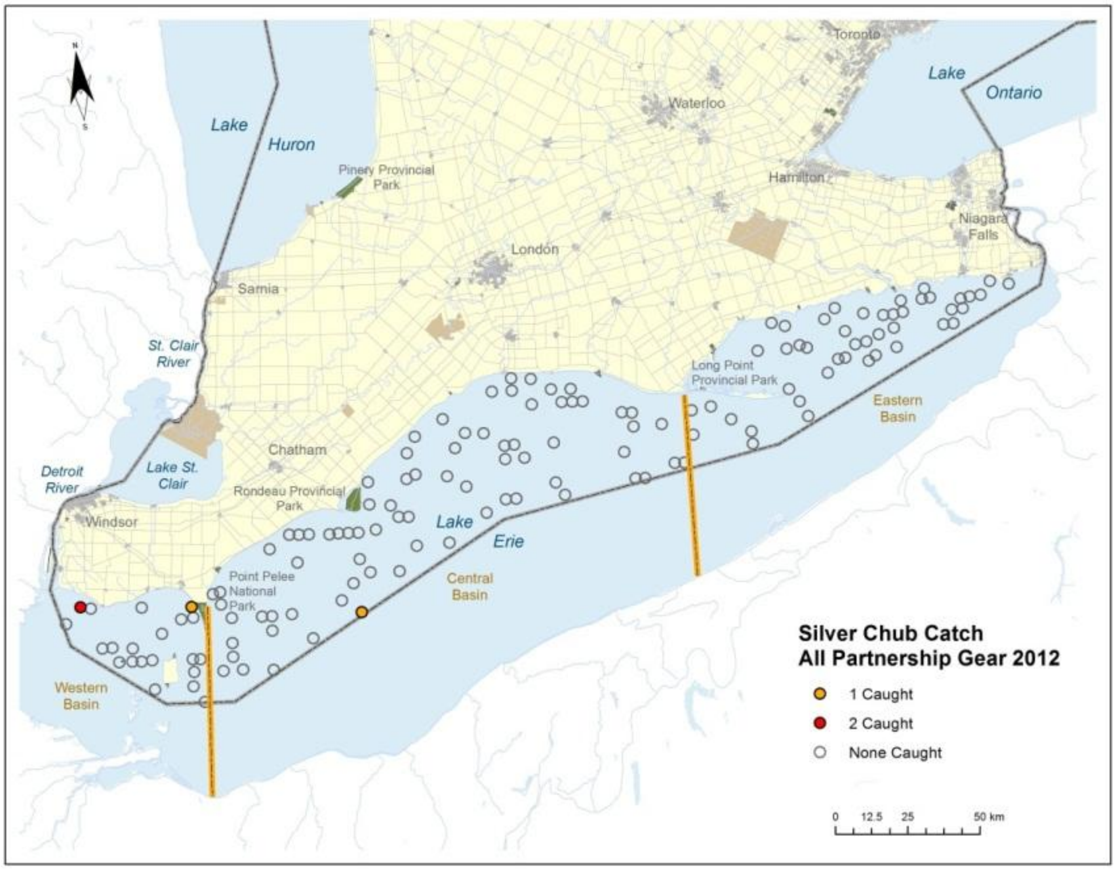


Figure 9. Number of Silver Chub caught in the 2012 Partnership gill net index (OMNR LEMU).

Using a hierarchical multi-scale classification of nearshore aquatic habitats of the western basin of Lake Erie, and a combination of data from shallow-water electrofishing surveys, and bottom trawl surveys, McKenna and Castiglione (2010) predicted Silver Chub abundance (Figure 10). Twenty-two geo-referenced habitat variables were used in the analysis. Habitat variables included in the classification were benthic 3-D structure (% of rock, boulder, and submerged aquatic vegetation), benthic substratum, coastline geomorphology, coastline protection, coastline sediment, coefficient of variation of water temperature, density of rivers entering the basin (rivers/km), direction to nearest delta-type wetland (degrees), direction to nearest protected-type wetland (degrees), direction to nearest open-type wetland (degrees), distance to mouth of nearest river of Strahler 4 or larger (m), distance to nearest delta-type wetland (m), distance to nearest open-type wetland (m), distance to nearest protected-type wetland (m), effective fetch (m), ice cover duration (days), mean water temperature (°C), Secchi depth (m), sinuosity of coastline [straight-line distance : coastline distance (m/m)], slope of submerged bottom [change in depth (m/m)], submerged aquatic vegetation (% cover), and water depth (m) (McKenna and Catiglione 2010).

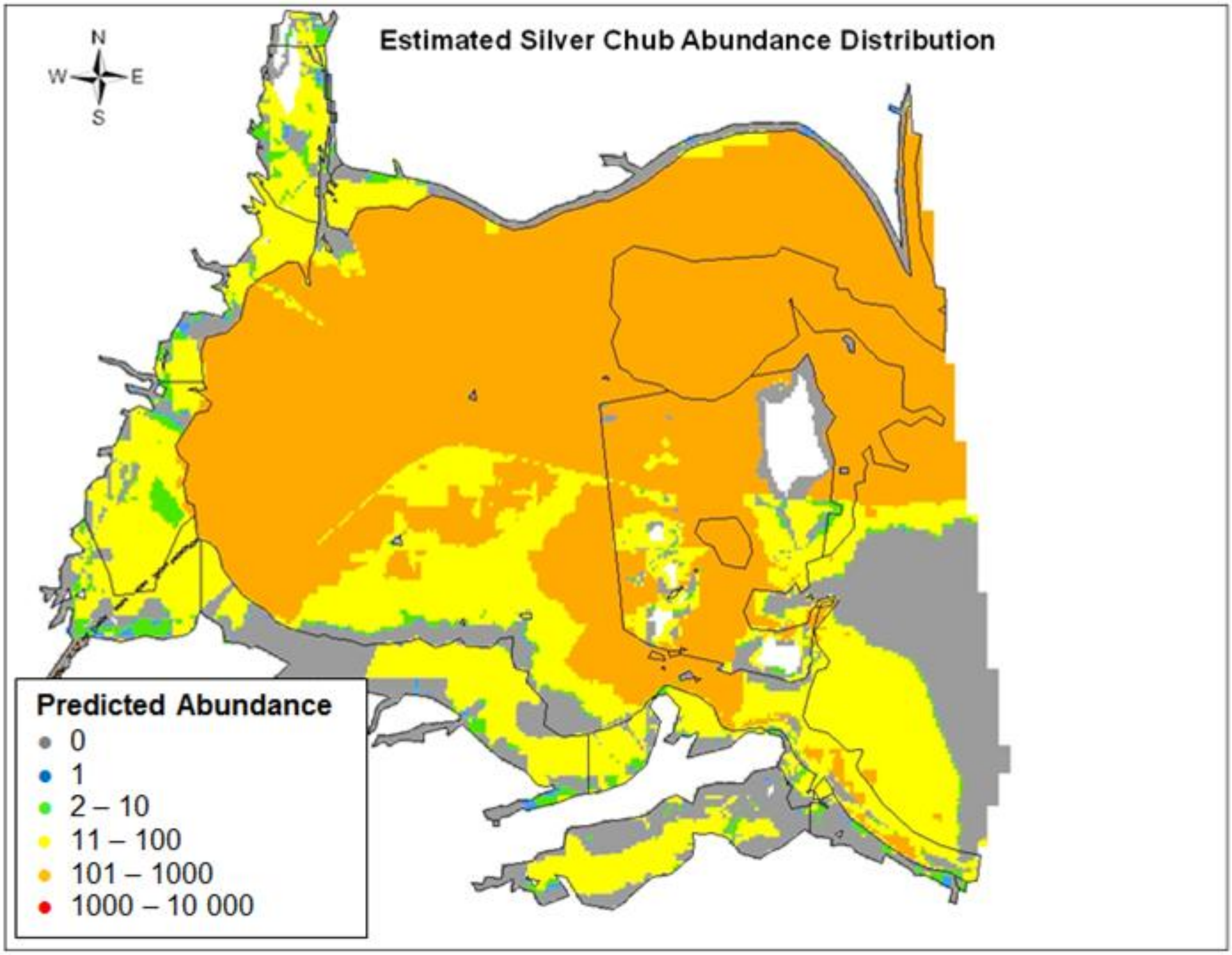


Figure 10. Estimated Silver Chub abundance distribution for the western basin of Lake Erie (J. McKenna, USGS, unpubl. data). Map produced from procedures used in McKenna and Castiglione (2010).

LAKE ERIE – CENTRAL BASIN

The Canadian portion of the central basin of Lake Erie is bounded on the west by Point Pelee, and by Long Point on the east (Figure 6). Despite considerable sampling effort, catch rates from the Partnership Index Gill Net Index Program remained low for 2012 (0.03; one Silver Chub recorded) (Ontario Ministry of Natural Resources 2013a; Figure 9).

LAKE ERIE – EASTERN BASIN

The Canadian portion of the eastern basin of Lake Erie is bounded on the west by Long Point (Figure 6). A single Silver Chub was recorded from the eastern basin of Lake Erie in 2001 by the Partnership Index Gill Net Index Program. Silver Chub have not been since this 2001 capture.

LAKE ST. CLAIR

Recent sampling has failed to collect Silver Chub in Lake St. Clair. The Michigan Department of Natural Resources conducted annual bottom trawl surveys in Lake St. Clair (including the Canadian side) between 1996 and 2001 and did not catch any Silver Chub (Thomas and Haas 2004), despite using mesh sizes effective at detecting Silver Chub. The trawl dimensions were 76 mm, 38 mm, and 32 mm graded, stretched-measure mesh from gape to cod end. A 9-mm stretched-mesh liner was sewn in the cod end (Thomas and Haas 2004). Several cyprinid species with smaller maximum sizes than Silver Chub [e.g., Spottail Shiner, Emerald Shiner (*Notropis atherinoides*), and Mimic Shiner (*Notropis volucellus*)], as well as other small benthic species [e.g., Logperch (*Percina caprodes*), Johnny Darter (*Etheostoma nigrum*)], were captured.

The OMNR have completed several beach seine surveys of Lake St. Claire at eight sites in 1990-1996, 2005, 2007-2012 (with an additional nine sites in 2007 sampled by a combination of seining and boat electrofishing). These surveys resulted in the capture of 21 Silver Chub from three sites in 1990, and one additional individual in 1994. Silver Chub have not been recorded from Lake St. Clair since 1994.

LAKE HURON

Silver Chub was collected at one location in 1983 at the extreme southern end of the lake near Sarnia, Ontario. Two individuals were taken by commercial trapnet at an estimated depth of 8 m (S. Taylor, OMNR, Lake Huron Fisheries Assessment Unit). It is not known how many others were captured or the effort expended (E. Holm, ROM, pers. comm. 2013).

FLUCTUATIONS AND TRENDS

Lake Erie

In Lake Erie, a dramatic decline in the Silver Chub began in the late 1940s. In 1973, the last known record of Silver Chub was recorded in 1960 (NMC60-0476A) leading Scott and Crossman (1973) to state, “the present status of the species in Lake Erie is in doubt but obviously it is rare”. However, Silver Chub began appearing in Ontario Ministry of Natural Resources (OMNR) midwater trawls and bottom gillnets in 1967 (S. Nepszy, pers. comm. 2000, cited in Mandrak and Holm 2001).

The standardized Interagency Trawl Index Data exhibit a steady rise from 3.6 fish/hectare in 1988 to 25.9 fish/hectare in 1994 (ODW 2013; Ontario Ministry of Natural Resources 2013a; Figure 11). Numbers increased dramatically to 106 fish/hectare in 1996 and 125 fish/hectare in 1999, and then declined precipitously to less than seven fish/hectare since 2005. There had been a decline of 71% for 10 years, but an increase of 26% over the next 5 years. Surveys completed in 2012 yielded 1.76 fish/hectare (ODW 2013; Ontario Ministry of Natural Resources 2013aa).

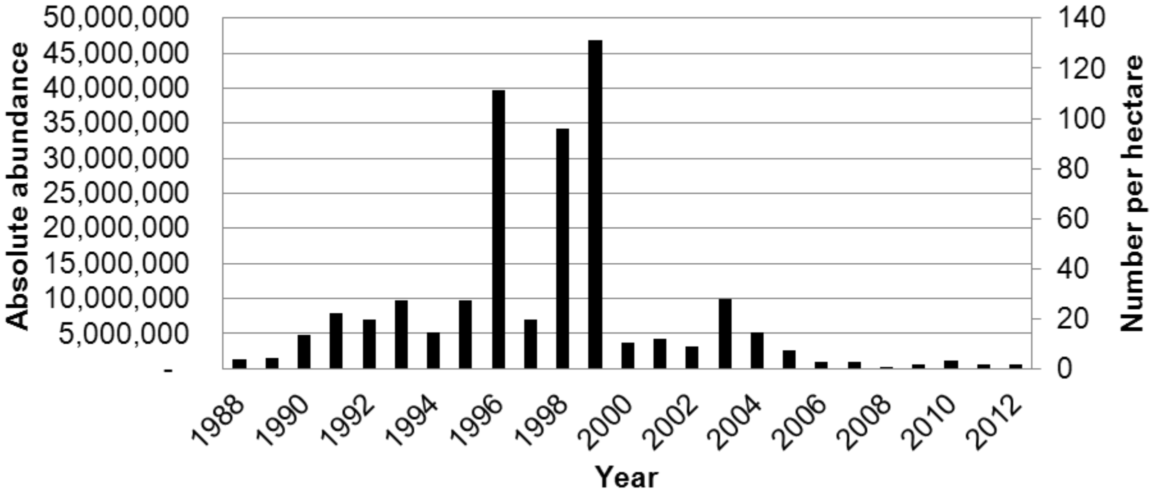
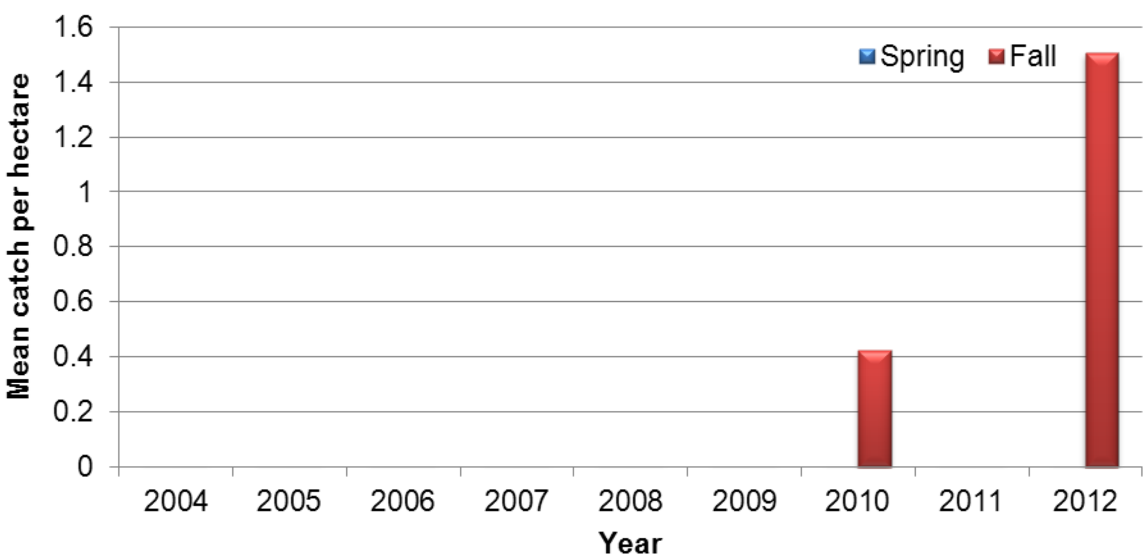


Figure 11. Silver Chub collections in the Interagency Trawling Program in the western basin of Lake Erie, 1988–2012 (ODW 2013; Ontario Ministry of Natural Resources 2013a).

Additional trawling of the western basin occurred from 2004-2012 (P. Kocovsky, USGS, unpubl. data; Figure 12). Relatively few Age 0 individuals have been recorded from this program with the greatest Age 0 catch rate observed in 2012 with a mean Silver Chub catch per hectare of 1.50 (Figure 12a). A greater catch rate was observed for adult Silver Chub, with higher catch rates recorded during spring sampling for all years, with the exception of 2006 (Figure 12b).

(a) Age 0 Silver Chub



(b) Adult Silver Chub

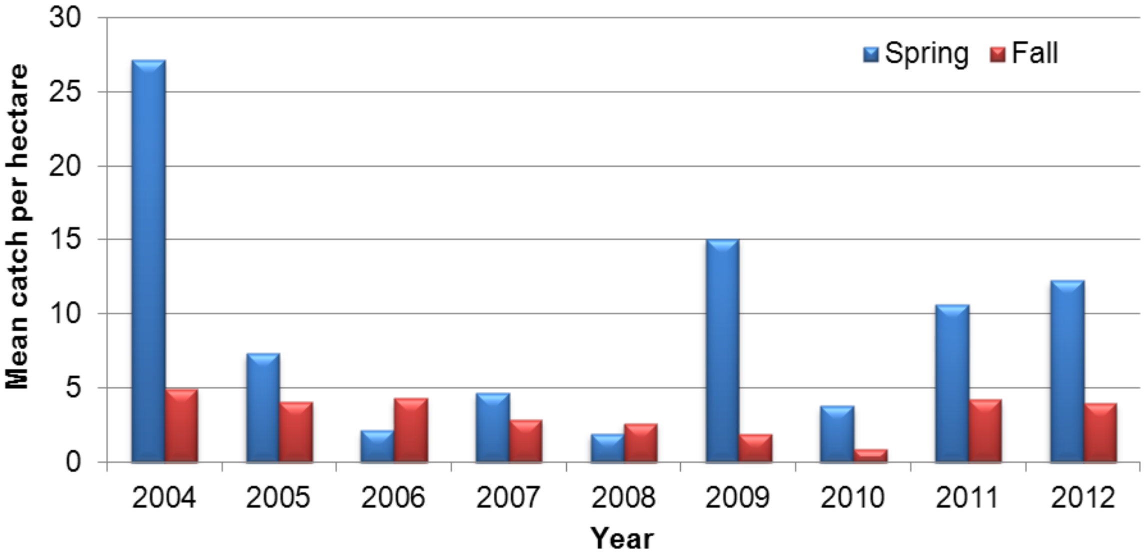
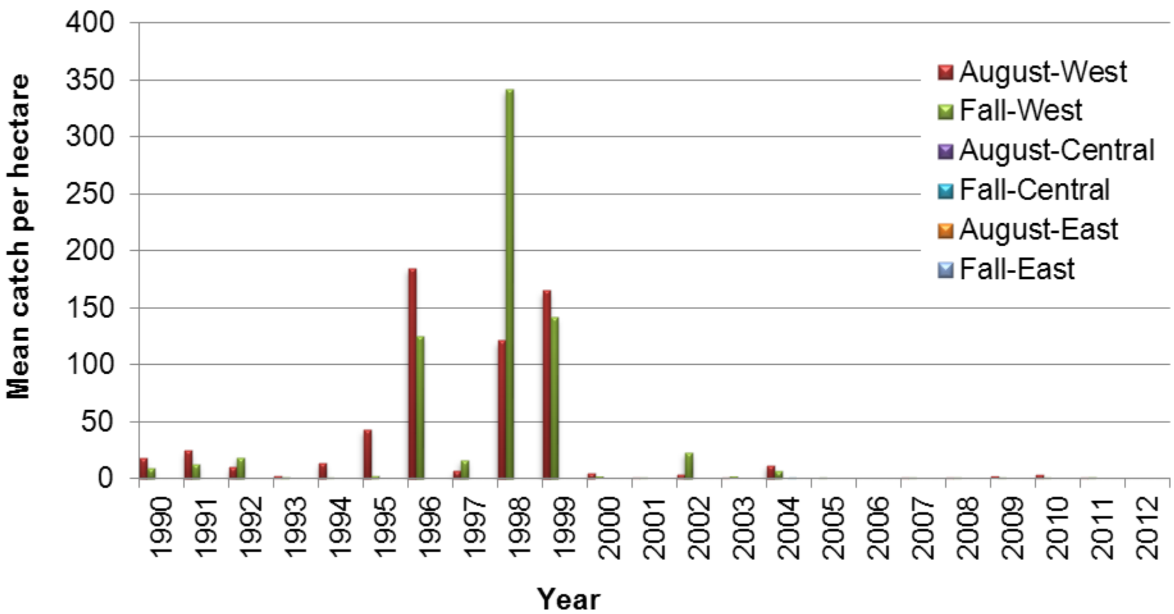


Figure 12. (a) Age 0 and (b) adult Silver Chub captured from the western basin of Lake Erie in the spring and fall from 2004 to 2012 (P. Kocovsky, USGS, unpubl. data).

A similar pattern, but with lower mean values, for yearling (Figure 13a) and adult Silver Chub (Figure 13b) was exhibited by additional trawling in the Ohio waters of the western basin in August and September to October (Fall) each year between 1990 and 2012 (ODW 2013). Trawling in the Ohio waters confirmed very low adult numbers in the west-central basin (OH District 2) and virtually no individuals in the east-central basin (OH District 3) (Figure 13b). The mean trend across basins is a 99% decline over the last five and 10 years. YOY data for the same trawls indicated large catches in 1996, 1998, and 1999, but virtually no catches since then.

(a) Yearling Silver Chub



(b) Adult Silver Chub

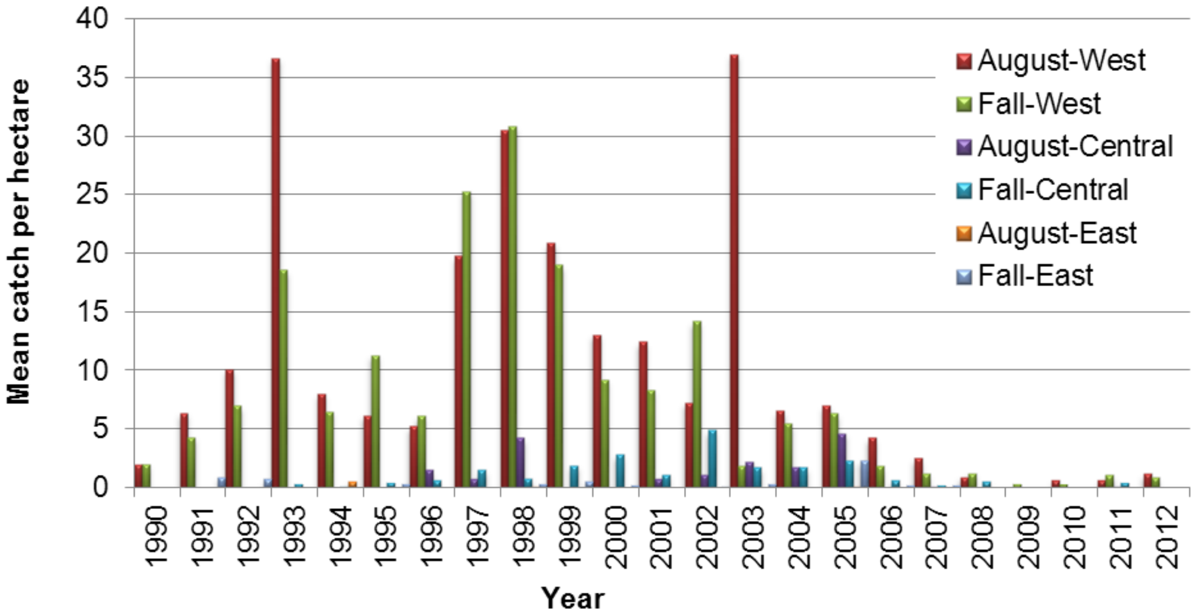


Figure 13. (a) Yearling and (b) adult Silver Chub captured by the Lake Erie Ohio Division of Wildlife trawling program,1990–2012 (ODW 2013).

Data from the Partnership Index Gill Net Index Program are available for Canadian populations in the western of Lake Erie from 1990 to 2012, and for the central, and eastern basins from 1989 to 2012 (Ontario Ministry of Natural Resources 2013a; Figure 14). In the western basin, the mean catch per gear increased from 1.1 fish/mmg in 1990 to 13.86 fish/mmg in 1993, dropping again until 1999 with a second peak of 8.41 fish/mmg. Mean catch of Silver Chub subsequently decreased to less than 1 fish/mmg in 2007 and has remained at this low level since 2007. The 2012 mean Silver Chub catch for the western basin of Lake Erie was 0.14 fish/mmg.

Mean Silver Chub catch per gear data from the central basin has never reached levels greater than 0.89 fish/mmg (Ontario Ministry of Natural Resources 2013a). This small peak occurred in 2003 (Figure 14). A single Silver Chub was caught in the eastern basin of Lake Erie in 2001. The western basin and the central basin have experienced a 93 and 96% decline in Silver Chub catch over the last 10 years, respectively.

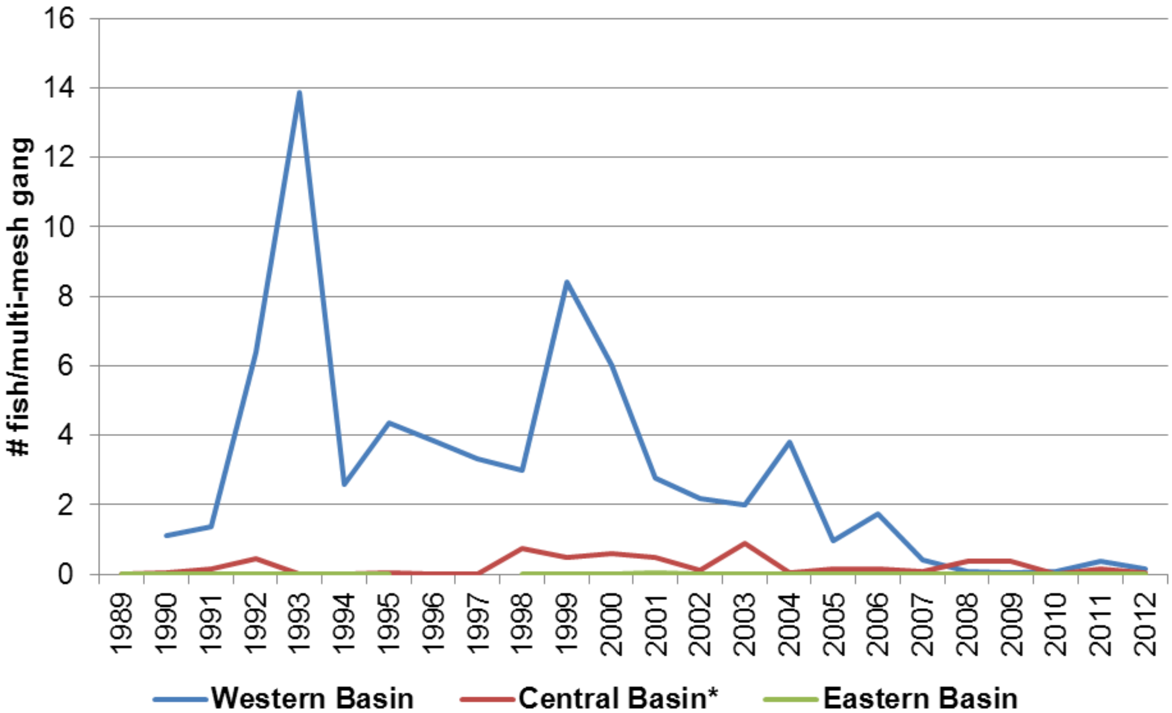


*Figure 14. Mean annual catch by gear from Partnership Index Gill Net Index Program for standard bottom sampling in Lake Erie from 1989 to 2012 (*combination of west-central, east-central, and Pennsylvania Ridge data) (Ontario Ministry of Natural Resources 2013a).*

Lake St. Clair

Silver Chub has been collected in Lake St. Clair only since 1968. By 1975, abundance began to increase in the lake based on OMNR index trawling data for the period 1968–1984 (Figure 15). Dramatic increases were recorded between 1981 and 1984 (approximately 60–200 individuals per trawl-hour), the last years of the index trawling program (S. Nepszy, OMNR, pers. comm. 2000, as cited in COSEWIC 2001). An OMNR beach seine study conducted in Lake St. Clair in 1979 to 1981 and 1990 to 1996 documented high numbers of Silver Chub in 1979 and moderate numbers in 1980, 1981, and 1990. During 1991 to 1996, only a single individual was recorded in 1994. OMNR beach seine surveys in 2005, 2007-2012, and trawling in 2010 failed to capture any Silver Chub.

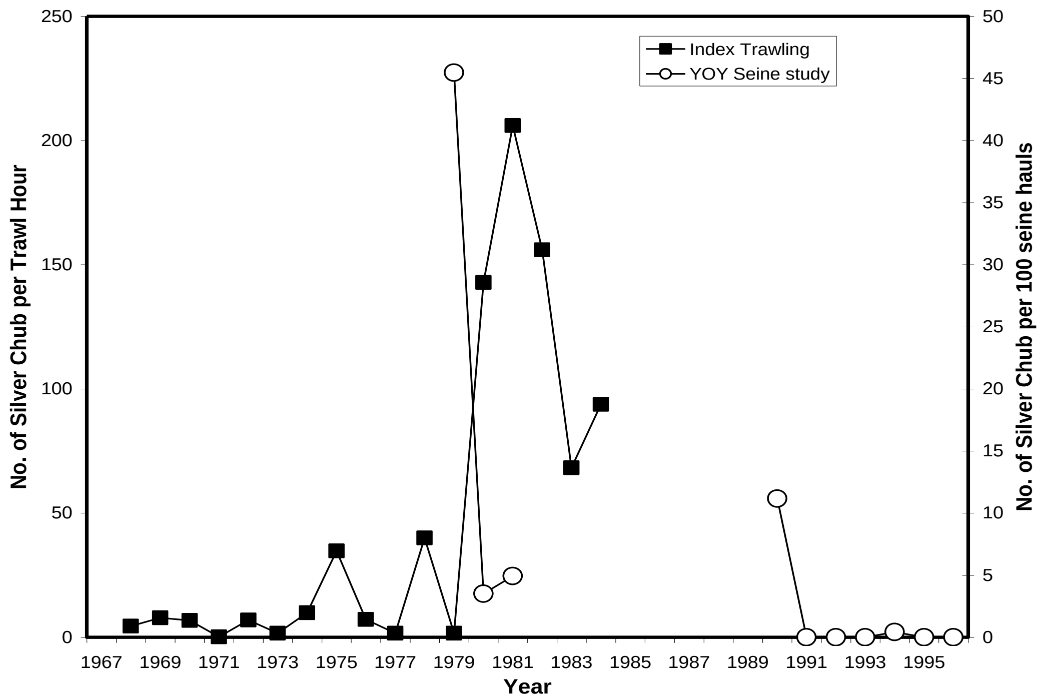


Figure 15. Silver Chub captures in OMNR trawling and young of the year seining in Lake St. Clair, 1968–1996 (reproduced from COSEWIC 2012b).

POPULATION STATUS

To assess the population status of Silver Chub in Ontario, each population was ranked in terms of its abundance (Relative Abundance Index) and trajectory (Population Trajectory) (Table 1). The Relative Abundance Index was assigned as Extirpated, Low, Medium, High, or Unknown. Sampling parameters, such as gear used, area sampled, sampling effort, and whether the study targeted Silver Chub, were considered. The number of individual Silver Chub caught during each sampling period was also considered when assigning the Relative Abundance Index. The Relative Abundance Index is a relative parameter in that the values assigned to each population are relative to the most abundant population. The Population Trajectory was assessed as Decreasing, Stable, Increasing, or Unknown for each population based on the best available information about the current trajectory of the population. The number of individuals caught over time for each population was considered. Trends over time were classified as Increasing (an increase in abundance over time), Decreasing (a decrease in abundance over time), and Stable (no change in abundance over time). If insufficient information was available to identify the trajectory, the Population Trajectory was listed as Unknown. Certainty has been associated with the Relative Abundance Index and Population Trajectory rankings and is listed as: 1=quantitative analysis; 2=catch per unit effort (CPUE) or standardized sampling; 3=expert opinion (Table 1).

The Relative Abundance Index and Population Trajectory values were then combined in the Population Status matrix (Table 2) to determine the Population Status for each population. Each Population Status is subsequently ranked as Poor, Fair, Good, Unknown or Not applicable (Table 3). Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Relative Abundance Index, or Population Trajectory).

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

Population	Relative Abundance Index	Certainty	Population Trajectory	Certainty
Lake St. Clair	Low	2	Unknown	2
Lake Erie – western basin	Medium	2	Decreasing	2
Lake Erie – central basin	Low	2	Decreasing	2
Lake Erie – eastern basin	Low	2	Unknown	2
Lake Huron	Unknown	3	Unknown	3

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

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

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

Population	Population Status	Certainty
Lake St. Clair	Poor	2
Lake Erie – western basin	Poor	2
Lake Erie – central basin	Poor	2
Lake Erie – eastern basin	Poor	2
Lake Huron	Unknown	3

HABITAT REQUIREMENTS

SPAWNING

Scott and Crossman (1973) and NatureServe (2013) stated that Silver Chub likely spawns in open water; however, Kinney (1954) observed that the species moved nearshore presumably to spawn in Lake Erie. Goodyear et al. (1982) suggested that Silver Chub historically spawned over clean gravel substrates in tributaries of Lake Erie. In Ohio, Silver Chub spawns in late May or early June, possibly in open water, when water temperature reaches 21°C (Werner 2004).

In Canada, spawning occurs in spring or early summer (May to July) at temperatures of 19–23°C (Holm et al. 2010). Fecundity can be as high as 12 311 eggs (Coad 1995); however, egg counts from five individuals captured in June 2012 (Table 4) were much lower (P. Kocovsky, USGS, unpubl. data).

Table 4. Egg counts from five Silver Chub captured in June 2012 (P. Kocovsky, USGS, unpubl. data)

Length (mm)	Weight (g)	Egg Count
150	41.9	1078
158	41.9	557
162	46.5	1143
170	48.6	762
174	60.4	1968

LARVAL AND JUVENILE

There is very limited information available on habitat preferences of larval and juvenile Silver Chub. In September 2012, six YOY Silver Chub were captured using bottom trawls at three locations (P. Kocovsky, USGS, unpubl. data). Water depth ranged between 7.6 and 9.8 m. Sheaffer and Nickum (1986) found larval and juvenile Silver Chub in equal numbers in surface and bottom sampling and their abundance was higher in backwaters than the main channel of the upper Mississippi River.

ADULT

Water temperature

Water temperature might limit the northern extent of the range of Silver Chub. Kinney (1954) stated that it requires water temperatures of 7.2–10°C for six to seven months and 21°C for three months to sustain normal growth and permit reproduction. In the western basin of Lake Erie in 2012, Silver Chub was captured in water temperatures ranging from 14°C in October to 22.9°C in June (P. Kocovsky, USGS, unpubl. data). In the partnership gill net surveys, Silver Chub was caught when bottom temperatures ranged from 9.6 to 23.9°C (Ontario Ministry of Natural Resources 2013a). In the western basin interagency bottom trawls, Silver Chub was caught at bottom temperatures from 17.1 to 25.9°C (Ontario Ministry of Natural Resources 2013a).

Water depth

In Ontario, Silver Chub is found in large lakes but may also occur in connecting rivers (i.e., St. Clair and Detroit rivers). In 1995, Silver Chub was captured at depths of 7.6 to 12 m in Lake Erie (Schwier et al. 1995a, b) but it has been reported from as deep as 20 m (Kinney 1954). In the partnership gill net surveys, Silver Chub have been caught between 4 and 24 m (average depth for presence = 10.5 m), primarily in nets fished on bottom. In the western basin interagency bottom trawls, Silver Chub was caught at depths from 2.3 to 13.7 m (ODW 2012; Ontario Ministry of Natural Resources 2013a). In 2012 in the western basin of Lake Erie, Silver Chub was caught at depths from 3.1 to 10.4 m, with nearly 40% of the fish caught at 5.8 m. (P. Kocovsky, USGS, unpubl. data).

Silver Chub CPUE across various depths was explored to determine the relationship between depth and Silver Chub presence and abundance (Figure 16). Data were borrowed from the interagency bottom trawling conducted in August and early September from 1987 to 2012. CPUE was highest for trawls at depths of 6.1-7.0 m, followed by 2.1-3.0 m. There is substantial variation in the catch data; therefore, Silver Chub depth preference cannot be determined.

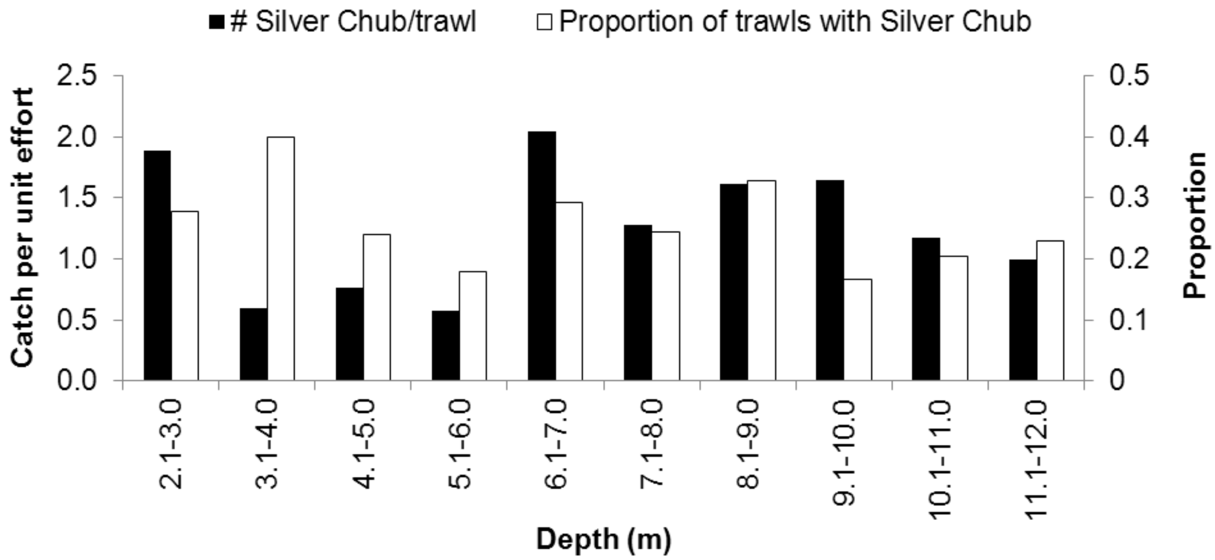


Figure 16. CPUE of Silver Chub at depth from the Canadian waters of the western basin of Lake Erie between 1987 and 2012 (ODW 2013, Ontario Ministry of Natural Resources 2013a). The proportion of trawls where Silver Chub was detected is also plotted.

Turbidity

In the western basin of Lake Erie in 2012, Silver Chub was captured where Secchi depths, when measured, ranged from 0.25 to 2 m. Nearly 40% of the fish were captured where Secchi depth was 0.25 m (P. Kocovsky, USGS, unpubl. data). In Manitoba, the species is captured in Lake Winnipeg and the Red River, both of which are turbid waterbodies (Stewart and Watkinson 2004). Robison and Buchanan (1992) stated that Silver Chub was “quite tolerant of silty turbid streams” and was also common in some reservoirs in Oklahoma. Piller et al. (2004) found Silver Chub abundance significantly increased in the Pearl River following human-caused disturbances that increased the proportion of mobile substrate in the system.

Silver Chub CPUE was also explored across various Secchi depths to determine possible relationship between Silver Chub abundance and turbidity (Figure 17). Data were taken from the interagency bottom trawling conducted in August and early September of each year. While CPUE was highest for trawls at Secchi depths of 2.6 to 3.0 m, Silver Chub was captured in a low proportion of the trawls, with large numbers at a few sites influencing the CPUE. When Secchi depth was recorded to be between 0.6 and 1.5 m, both CPUE and the proportion of trawls with Silver Chub was noticeably higher than at other Secchi depths.

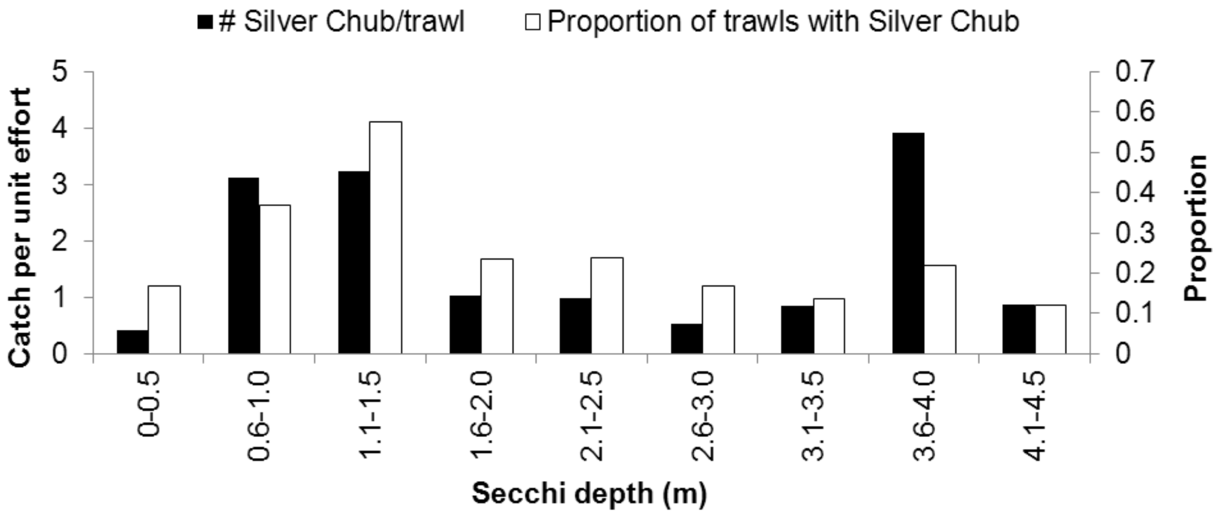


Figure 17. CPUE of Silver Chub at Secchi depth from the Canadian waters of the western basin of Lake Erie between 1987 and 2012 (ODW 2013, Ontario Ministry of Natural Resources 2013a). Proportion of trawls with Silver Chub captured is also plotted.

Substrate

In Ohio, Silver Chub reached greatest abundance over substrates of clean gravel and sand (Trautman 1981). Kinney (1954) reported that it was more commonly found over silt bottoms in Lake Erie. In the United States bordering Lake Erie, Silver Chub is found in stream mouths with fine gravel or sand bottoms (Werner 2004).

FUNCTIONS, FEATURES AND ATTRIBUTES

A description of the functions, features, and attributes associated with Silver Chub habitat can be found in Table 5. The habitat required for each life stage has been assigned a function that corresponds to a biological requirement of Silver Chub. For example, individuals in the spawn to juvenile life stage require habitat for nursery and spawning purposes. In addition to the habitat function, a feature has been assigned to each life stage. A feature is considered to be the structural component of the habitat necessary for the survival or recovery of the species. Habitat attributes have also been provided, describing how the features support the function for each life stage. Optimal habitat attributes from the literature for each life stage have been combined with habitat attributes from current records (records from 2001 to present) to show the maximum range in habitat attributes within which Silver Chub may be found (see Table 5, and references therein). This information is provided to guide any future identification of critical habitat for this species. It should be noted that habitat attributes associated with current records may differ from optimal habitat attributes as Silver Chub may be occupying sub-optimal habitat in areas where optimal habitat is no longer available.

RESIDENCE

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

Table 5. Summary of the essential functions, features and attributes for each life stage of Silver Chub. Habitat attributes from published literature, and habitat attributes recorded during recent Silver Chub surveys captured have been combined to derive the habitat attributes required for the delineation of critical habitat (see text for a detailed description of categories).

			Habitat Attributes		
Life Stage	**Function**	**Feature(s)**	**Scientific Literature**	**Current Records**	**For Identification of Critical Habitat**
Spawning (spawning likely occurs late May through to July)	Spawning	Nearshore and open water of large lakes.	• Spawning thought to occur when water temperatures are between 19-23°C (Holm et al. 2010) • Nearshore in Lake Erie (Kinney 1954) • Clean gravel substrates in tributaries to Lake Erie (historically) (Goodyear et al. 1982)		• Spawning thought to occur when water temperatures are between 19-23°C.
Egg to juvenile	Nursery Feeding Cover	Nearshore and open water of large lakes.	• Unknown	• YOY were captured in trawls with adult fish in water ranging in depth from 7.6-9.8 m (P. Kocovsky, USGS, unpubl. data)	• Same features as adult habitat.
Adult (from Age 1 [onset of sexual maturity])	Feeding Cover	Large lakes and connecting rivers.	**Water depth** • In 1995, it was captured at depths of 7.6–12 m in Lake Erie (Schwier et al. 1995a, b) but it has been reported from as deep as 20 m (Kinney 1954)	• In the western basin of Lake Erie, caught at depths from 3.1 to 10.4 m, with nearly 40% of the fish caught at 5.8 m. (P. Kocovsky, USGS, unpubl. data) • In the partnership gill net surveys, Silver Chub have been recorded between 4 and 24 m (average depth = 10.5 m) (Ontario Ministry of Natural Resources 2013a) • In the western basin interagency bottom trawls, Silver Chub was caught at depths from 2.3 to 13.7 m (average depth = 8.2 m) (ODW 2013; Ontario Ministry of Natural Resources 2013a)	• 2.3 to 24 m water depth

			Habitat Attributes		
Life Stage	**Function**	**Feature(s)**	**Scientific Literature**	**Current Records**	**For Identification of Critical Habitat**
			Turbidity • Occur in a wide range of turbidity levels. • Quite tolerant of silty turbid streams (Robison and Buchanan 1992)	• In Lake Erie captured where Secchi depths ranged from 0.25 to 2 m. Close to 40% of the fish were captured where Secchi depth was 0.25 m (P. Kocovsky, USGS, unpubl. data). • In the partnership gill net surveys, Silver Chub was caught when Secchi was recorded between 0.25 and 6.5 m (Ontario Ministry of Natural Resources 2013a) • In the western basin interagency bottom trawls, Silver Chub was caught at Secchi depths from 0.2 to 4.5 m (Ontario Ministry of Natural Resources 2013a)	• Wide range of turbidity levels, from 0.25 to 6.5 m
			Substrate • Favoured lentic substrates are clean gravel and sand (Trautman 1981), silt (Kinney 1954). In stream mouths, found over fine gravel or sand bottoms (Werner 2004).		• Favoured lentic substrates are clean gravel and sand, silt. In stream mouths, found over fine gravel or sand bottoms.

THREATS

A wide variety of threats negatively impact Silver Chub. Our knowledge of threat impacts on Silver Chub populations is limited to general documentation, as there is a paucity of threat-specific cause and effect information in the literature. Many of the greatest threats to the survival and persistence of Silver Chub in Ontario are anthropogenic in origin such as nutrient loading, turbidity and sediment loading, contaminants and toxic substances, and habitat removal and alteration. Furthermore, the presence of numerous invasive species may pose a threat to the survival and persistence of the Silver Chub in Ontario. A lesser threat that may be affecting the survival of Silver Chub is the incidental capture of this species in the commercial fishery; although, this threat may be negligible as the minimum mesh size used in the commercial fishing industry is greater than that required to successfully capture Silver Chub. It is important to note the threats discussed below may not always act independently on Silver Chub populations; rather, one threat may directly affect another, or the interaction between two threats may introduce an interaction effect on Silver Chub populations. It is difficult to quantify these interactions; therefore, each threat is discussed independently.

HABITAT REMOVAL AND ALTERATION

It is thought that Silver Chub once used the clean gravel substrates of tributaries to Lake Erie as spawning grounds (COSEWIC 2012b). These tributaries have since been degraded, and it is believed that these areas are no longer suitable to be used as spawning ground for this species and it now spawns in the open water lentic habitat (COSEWIC 2012b).

Of potential increasing concern to Silver Chub may be the proposed development of offshore wind power in Lake Erie. Short term impacts of this type of development would include localized disruptions during the construction process or placement of turbines, and localized disruption from the installation of power lines, both could lead to the potential re-suspension of contaminated sediment (Dempsey et al. 2006). Long-term impacts may include degradation or loss of lake-bottom habitat from wind turbine placement, and continuous emission of noise and vibrations, that may affect fish community distribution (Dempsey et al. 2006). A review was completed by the OMNR with the aim to describe the potential effects of offshore wind power projects in the Great Lakes (Nienhuis and Dunlop 2011). This review concluded that noise, primarily during the construction phase, and to a lesser extent during the long term operation, was predicted to have the highest magnitude of effect on fishes (Nienhuis and Dunlop 2011). Additional threats highlighted in their findings included the release of sediment-bound contaminants into the water column, as well as sedimentation and turbidity during construction, and the unknown effect of electromagnetic fields on various fish species (Nienhuis and Dunlop 2011). The extent that offshore wind power generation will impact Silver Chub populations is currently unknown.

NUTRIENT LOADING

Historical problems related to nutrient loading are well document for Lake Erie. Although nutrients (e.g., phosphates and nitrates) occur naturally in waterbodies, elevated levels from anthropogenic sources, such as sewage treatment plant outputs, agricultural runoff (e.g., manure and fertilizer applications to farmland), industrial sources, failing septic systems and detergents, were linked to elevated nutrient levels in Lake Erie (State of the Great Lakes [SOGL] 2009). These increased nutrient levels can lead to the development of algal blooms and, consequently, to decreased levels of dissolved oxygen once the blooms begin to senesce (Bejankiwar 2009). Substantial efforts, beginning in the 1970s, to reduce phosphorus loadings have been successful; although, local elevated concentrations of phosphorus persists in some embayments, harbors and nearshore areas (SOGL 2009). The Great Lake Water Quality Agreement (GLWQA) phosphorus level guidelines for the western, central and eastern basins of Lake Erie are 15, 10, 10 µg/L, respectively (United States and Canada 1987). Although concentrations in the three basins demonstrate annual fluctuations, the western and the central basin frequently exceed the target levels, while the eastern basin periodically exceeds the target level (SOGL 2009).

Historical eutrophication of Lake Erie also affected Silver Chub indirectly by contributing to the collapse of the *Hexagenia* spp. population, a significant prey item for Silver Chub (see Diet section). Although there were anecdotal sightings and subsequent reports of a *Hexagenia* recovery throughout Lake Erie from 1997 to 2000, lake-wide sampling from 1997-2005 indicated that a lake-wide recovery had not occurred and that increased numbers were linked to environmental variability (Krieger et al. 2007).

TURBIDITY AND SEDIMENT LOADING

The effects of sediment loading on aquatic environments include decreased water clarity, increased siltation, and may have a role in the selective transport of pollutants, including phosphorus (COSEWIC 2012a). Sediment loading can result in increased turbidity, which can affect a species' vision, respiration and behaviour (COSEWIC 2012b). Excess sediment loadings are also related to siltation of substrates that can potentially affect a species by smothering eggs laid on the substrate. Although Silver Chub has been captured from turbid riverine systems, it has been observed to move to cleaner water with gravel substrates when pools became excessively silted (Trautman 1981), and according to Robison and Buchanan (1992) the species reached its greatest abundance over clean, silt-free, substrates of sand and gravel. The impacts of high sediment loads on Silver Chub are currently unknown.

CONTAMINANTS AND TOXIC SUBSTANCES

In a study completed in 2006, 14 of a possible 21 organochlorine compounds were detected from sampling stations in Lake Erie (SOGL 2009). Samples from the western basin of Lake Erie indicated the highest levels of most compounds, while samples from the central and eastern basins were relatively lower. The highest observed mercury levels occurred in the western basin of Lake Erie when compared to all other Great Lakes (SOGL 2009). Although concentrations from the open lake areas were below the U.S. EPA Great Lakes Initiative (GLI) water quality criterion of 1.3 mg/L (U.S. Environmental Protection Agency 2006), higher concentrations in embayments exceeded the GLI water quality criterion for the protection of wildlife. In addition, PAH (polycyclic aromatic hydrocarbon) concentrations and distribution were highest in the western basin of Lake Erie, which is thought to be indicative of urban sources upstream from the St. Clair and Detroit rivers (SOGL 2009).

In terms of PCBs (polychlorinated biphenyls), the Ontario Ministry of the Environment completed a study to explore the historic and current PCB levels in juvenile Spottail Shiner, a species often used as a biomonitor for assessing trends in contaminant levels (SOGL 2009). Results for Lake Erie indicated that although there has been an overall decrease in the concentration of PCBs since the early 1970s at all sites, one site at Leamington (western basin of Lake Erie), showed higher than average PCB concentrations and the most recent sample reported from this location (taken in 2004) had a PCB concentration greater than the GLWQA guideline (United States and Canada 1987). Of increasing concern is the emergence of substances such as flame retardants, plasticizers, pharmaceuticals, and pesticides in the Great Lakes as the long term effect of these substances is unknown.

INVASIVE SPECIES

Invasive species have been categorized as the second most prevalent threat to currently listed freshwater fish species in Canada (Dextrase and Mandrak 2006). Invasive species can affect native species in a variety of ways, including direct competition for food, space and habitat, and through aquatic food web restructuring (COSEWIC 2012b). An invasive species thought to have a significant impact on freshwater fish species at risk of the Great Lakes is Round Goby (*Neogobius melanostomus*). Round Goby was accidentally introduced into the St. Clair River in the mid-1980s, and has since flourished throughout the Great Lakes. However, an increase in Silver Chub population in western Lake Erie occurred concurrently with the Round Goby invasion. Also, Round Goby appear to be facilitating Silver Chub consumption of dreissenid mussels by crushing the shells, which Silver Chub are incapable of doing (P. Kocovsky, pers. comm.). Round Goby may, however, be limiting the abundance of Silver Chub indirectly by limiting the availability of *Hexagenia*, that have been shown to be an important component of the Round Goby diet (French and Jude 2001). The Round Goby population of western Lake Erie was estimated to be 9.9×10^9 individuals in 2002 (Johnson et al. 2005), however trawl data indicate a decline (P. Kocovsky, pers. comm.). Therefore, it is difficult to ascertain whether or not Round Goby is having a negative impact on Silver Chub. The relationship between Silver Chub, Round Goby, and dreissenid mussels remains to be properly studied and understood.

INCIDENTAL HARVEST

Incidental harvest through the commercial fishing industry was listed as a potential threat for Silver Chub (COSEWIC 2001). A study was completed in 2004 by the OMNR to determine the probability of Walleye capture in Yellow Perch (*Perca flavescens*) commercial fishing gear (M. Belore, OMNR, pers. comm.). In this study, two commercial gill net panels (57 mm mesh), as well as index nets, ranging in mesh size from 32 to 102 mm, were used (Figure 18; M. Belore, OMNR, unpubl. data). The vast majority (98%) of Silver Chub captured in this study were recorded from gill nets less than 57 mm (standard commercial mesh size), indicating that the rate of bycatch from the commercial fishing industry is a minimal threat for Silver Chub. It appears as though the mesh size configuration implemented to minimize the capture of forage fish was successful in reducing the capture of Silver Chub.

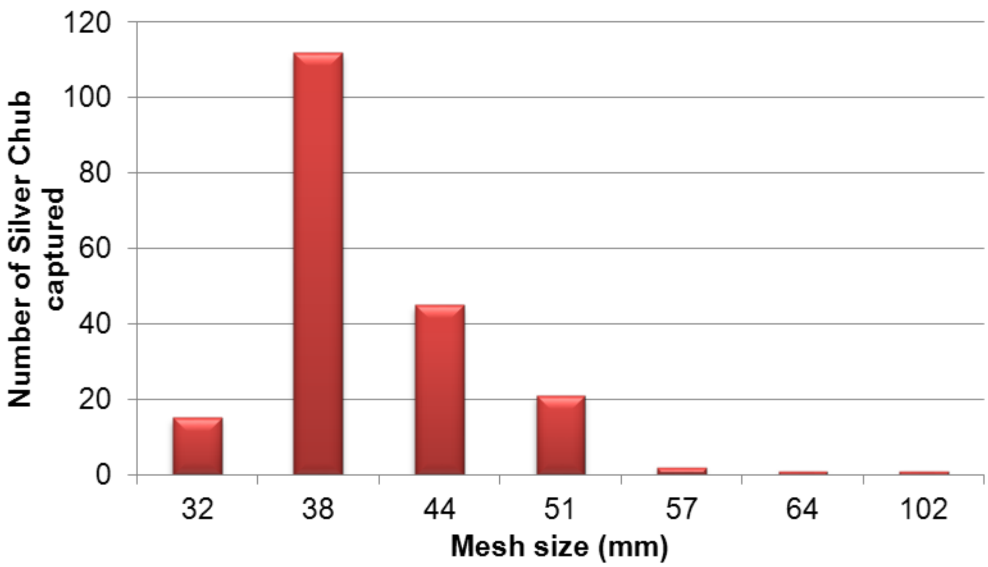


Figure 18. Number of Silver Chub captured in gillnets of various mesh size during a 2004 OMNR study (M. Belore, OMNR, unpubl. data).

CLIMATE CHANGE

Through discussion on the effects of climate change on Canadian fish populations, impacts such as increases in water and air temperatures, decreases in dissolved oxygen, changes (decreases) in water levels, shortening of the 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 have been highlighted, all of which may negatively impact native fishes (Lemmen and Warren 2004; Ficke et al. 2007). Most commonly, global circulation models are used to predict the earth's climate. The Intergovernmental Panel on Climate Change (IPCC) analyzed the results of many global circulation models and determined that there is an increased likelihood of a 1-7°C increase in mean global temperature in the next 100 years (IPCC 2001). This predicted increase in temperature will not only affect Silver Chub but may also substantially affect *Hexagenia*, which were the preferred prey of Silver Chub before dreissenid mussels became available as a food source.

In an attempt to explore a possible link between *Hexagenia* recruitment failure and periods of intermittent stratification in the western basin of Lake Erie from 1997-2002, Bridgeman et al. (2006) created a simple model that included surface temperature, wind speed, and water column data from 2003. The authors concluded that even relatively brief periods of stratification can result in the loss of larval mayfly recruitment, and that this loss is likely the result of a hypoxic environment (Bridgeman et al. 2006). Furthermore, Bridgeman et al. (2006) noted that the increasing frequency of hot summers in the Great Lakes may lead to recurrent loss of mayfly larvae in shallow water areas, such as the western basin of Lake Erie.

The effects of climate change on Silver Chub are speculative. Also, the relationship between Silver Chub, Round Goby, *Hexagenia*, and dreissenid mussels in the context of climate change remains to be properly studied. It is difficult to determine the likelihood and impact of this threat on each Silver Chub population; therefore, this threat is not included in the following population-specific Threat Level assessment.

THREAT LEVEL ASSESSMENT

To assess the Threat Level of Silver Chub populations in Ontario, each threat was ranked in terms of the Threat Likelihood and Threat Impact on a population-by-population basis (Table 6-9). The Threat Likelihood was assigned as Known, Likely, Unlikely, or Unknown, and the Threat Impact was assigned as High, Medium, Low, or Unknown (Table 6). Threat Impact categorization is location specific, in that impact categorization was assigned on a location-by-location basis. If no information was available on the Threat Impact at a specific location, a precautionary approach was used - the highest level of impact from all sites was applied. The Threat Likelihood and Threat Impact for each population (Table 7) were subsequently combined in the Threat Level Matrix (Table 8) resulting in the final Threat Level for each population (Table 9). The level of certainty associated with the Threat Impact assignment has been assessed and classified as: 1=causative studies; 2=correlative studies; and, 3=expert opinion.

Table 6. Definition of terms used to describe Threat Likelihood and Threat Impact.

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

Table 7. Threat Likelihood and Threat Impact of each Silver Chub population in Ontario. Certainty has been associated with the Threat Likelihood (TLH) and Threat Impact (TI) based on the best available data. The Threat Likelihood was assigned as Known (K), Likely (L), Unlikely (U), or Unknown (UK), and the Threat Impact was assigned as High (H), Medium (M), Low (L), or Unknown (UK). Certainty (C) has been classified and is based on: 1=causative studies; 2=correlative studies; and 3=expert opinion. References (Ref) are provided.

	Lake St. Clair				Lake Erie Western basin				Lake Erie Central basin			
	TLH	**TI**	**C**	**Ref**	**TLH**	**TI**	**C**	**Ref**	**TLH**	**TI**	**C**	**Ref**
Habitat removal and alteration	L	H	3	12	L	L	3	1,11	L	H	3	1,11
Nutrient loading	L	H	3	2	K	H	3	3,4,5, 6,13	K	H	3	3,4,5, 6,13
Turbidity and sediment loading	K	L	3	2	K	L	3	7,15	K	L	3	15
Contaminants and toxic substances	K	M	3	13	K	H	3	13	K	M	3	13
Invasive species	K	UK	3	2,12	K	UK	3	8,9,10	K	UK	3	8,9,10
Incidental harvest	U	L	3	3,14	K	L	2	3,14	K	L	2	3,14

References:
1. Goodyear et al. (1982)
2. Essex-Erie Recovery Team (2008)
3. COSEWIC (2012)
4. Krieger et al. (2007)
5. Nicholls et al. (2001)
6. U.S. Environmental Protection Agency (2010)
7. P. Kocovsky, USGS, unpubl. data
8. Dextrase and Mandrak (2006)
9. French and Jude (2001)
10. Johnson et al. (2005)
11. Nienhuis and Dunlop (2011)
12. Lake St. Clair Canadian Watershed Coordination Council (2009)
13. SOGL (2009) and references therein
14. M .Belore, OMNR, unpubl. data
15. ODW (2013) and Ontario Ministry of Natural Resources (2013a) trawling survey
16. Silver Chub Recovery Potential Assessment Participants (5 March 2013)

Table 8. The Threat Level Matrix combines the Threat Likelihood and Threat Impact rankings to establish the Threat Level for each Silver Chub population in Ontario. The resulting Threat Level has been categorized as Poor, Fair, Good, or Unknown.

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

Table 9. Threat Level for all Silver Chub populations in Ontario, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets refers to the level of certainty associated with the Threat Impact. Certainty has been classified as: 1= causative studies; 2=correlative studies; and 3=expert opinion.

Threats	Lake St. Clair	Lake Erie Western basin	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)

The Threat Level results were used to assess the overall effect each threat may have on Silver Chub in Ontario. Each threat was categorized in terms of both Spatial and Temporal Extent (Table 10). Spatial Extent was categorized as Widespread (threat is likely to affect the majority of Silver Chub population in Ontario) or Local (threat is not likely to affect the majority of Silver Chub populations in Ontario). Temporal Extent was categorized as Chronic (threat that is likely to have a long-lasting, or re-occurring effect on a population) or Ephemeral (threat that is likely to have a short-lived or non-recurring effect on a population).

Table 10. Overall effect of threats on Silver Chub populations in Ontario. Spatial extent was categorized as Widespread (threat is likely to affect a majority of Silver Chub populations in Ontario), or Local (threat is likely to not affect the majority of Silver Chub populations in Ontario). Temporal Extent was categorized as Chronic (threat that is likely to have a long-lasting, or re-occurring effect on a population) or Ephemeral (threat that is likely to have a short-lived, or non-recurring effect on a population).

Threat	Spatial Extent	Temporal Extent
Turbidity and sediment loading	Widespread	Chronic
Nutrient loading	Widespread	Chronic
Habitat removal and alteration	Widespread	Chronic
Contaminants and toxic substances	Widespread	Chronic
Invasive species	Widespread	Chronic
Incidental harvest	Local	Ephemeral

MITIGATION AND ALTERNATIVES

Threats to species survival and recovery can be reduced by implementing mitigation measures to reduce or eliminate potential harmful effects that could result from works or undertakings associated with projects, or activities in Silver Chub habitat. Currently, SARA prohibitions do not apply to Silver Chub. In Ontario, the species is listed as Threatened under the *Endangered Species Act* (2007). Legislation exists to prevent the intentional harvest of Silver Chub as bait; however, due to its morphological similarity to other shiners, it may be inadvertently taken. A management plan for Silver Chub in Canada has been completed (Boyko and Staton 2010).

Within Silver Chub habitat, a variety of works, undertakings, and activities have occurred in the past few years. Although Silver Chub primarily occurs in lakes in Ontario, nomenclature for project types is also included from those found along rivers and streams. Projects included: shoreline works (e.g., erosion control, shoreline stabilization), instream or in-water works (e.g., disposal of dredgate), and the placement of structures in water (e.g., pipelines, water intakes). Research has been completed summarizing the types of work, activity, or projects that have been undertaken in habitat known to be occupied by Silver Chub (Table 11). The DFO Program Activity Tracking for Habitat (PATH) database, as well as summary reports of fish habitat projects reviewed by partner agencies (e.g., conservation authorities), have been reviewed to estimate the number of projects that have occurred during the three-year period of 2010-2012. Approximately 70 projects were identified but this likely does not represent a comprehensive list of projects or activities that have occurred in these areas. Some projects may not have been reported to partner agencies or DFO if they occurred under conditions of an Operational Statement. A total of 43 projects occurred along the shoreline and may not directly impact Silver Chub but are included as some may have potential to alter in-lake or coastal processes. In addition, there are existing water intakes that may impact fishes. The table only includes maintenance at one location.

The remaining projects were deemed low risk to fishes and fish habitat and were addressed through letters of advice with standard mitigation. The majority of projects consisted of disposal of dredged materials from river mouths in deeper lake areas. Based on the assumption that historic and anticipated development pressures are likely to be similar, it is expected that similar types of projects will likely occur in or near Silver Chub habitat in the future. The primary project proponents were municipalities.

As indicated in the Threat Analysis, numerous threats affecting Silver Chub populations are related to habitat loss or degradation. Habitat-related threats to Silver Chub have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (FHM) (Table 11). DFO FHM has developed guidance on mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in the Central and Arctic Region (Coker et al. 2010). This guidance should be referred to when considering mitigation and alternative strategies for habitat-related threats. At the present time, we are unaware of mitigation that would apply beyond what is included in the Pathways of Effects.

Table 11. Summary of works, projects and activities that have occurred during the period of January 2010 to January 2013 in areas known to be occupied by Silver Chub. Threats known to be associated with these types of works, projects, and activities have been indicated by a checkmark. The number of works, projects, and activities associated with each Silver Chub population, as determined from the project assessment analysis, has been provided. Applicable Pathways of Effects have been indicated for each threat associated with a work, project or activity (1 - Vegetation clearing; 2 – Grading; 3 –Excavation; 4 – Use of explosives; 5 – Use of industrial equipment; 6 – Cleaning or maintenance of bridges or other structures; 7 – Riparian planting; 8 – Streamside livestock grazing; 9 – Marine seismic surveys; 10 – Placement of material or structures in water; 11 – Dredging; 12 – Water extraction; 13 – Organic debris management; 14 – Wastewater management; 15 – Addition or removal of aquatic vegetation; 16 – Change in timing, duration and frequency of flow; 17 – Fish passage issues; 18 – Structure removal; 19 – Placement of marine finfish aquaculture site).

Work/Project/Activity	**Threats** (associated with work/project/activity)						**Watercourse / Waterbody** (number of works/projects/activities between Jan 2010- Jan 2013)		
	Habitat removal and alteration	**Nutrient loading**	**Turbidity and sediment loading**	**Contaminants and toxic substances**	**Invasive species**	**Incidental harvest**	**Lake St. Clair**	**Lake Erie – western basin**	**Lake Erie – central basin**
Applicable pathways of effects for threat mitigation and project alternatives	1,2,3,4, 5,7,9,10, 11,12,13, 15,18	1,4,7, 9,11, 13,14 15,19	1,3,4 5,9,10, 11,13, 16,18	1,4,5,7, 10,11, 13,14, 15,18					
Shoreline work (stabilization, breakwater repair, groynes and jetties)	✓		✓	✓			7	16	19
In–lake works (disposal of dredgate, seismic exploration)	✓	✓	✓	✓			19	1	3
Water management (stormwater management, water withdrawal)									
Structures in water (water intakes, gas pipeline installation, plug wells, lighthouse repair)	✓		✓					1	4
Commercial fishing						✓			
Invasive species introductions (accidental and intentional)					✓				

Additional mitigation and alternative measures, specific to Silver Chub, related to invasive species and incidental harvest are listed below.

INVASIVE SPECIES

As discussed in the **THREATS** section, aquatic invasive species (e.g., Round Goby) introduction and establishment could have negative effects on Silver Chub populations.

Mitigation

- Physically remove non-native species from areas known to be inhabited by Silver Chub.
- Monitor for invasive species that may negatively affect Silver Chub populations directly, or negatively affect Silver Chub preferred habitat.
- Develop a plan to address potential risks, impacts, and proposed actions if monitoring detects the arrival or establishment of an invasive species.
- Introduce a public awareness campaign and encourage the use of existing invasive species reporting systems.

Alternatives

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

INCIDENTAL HARVEST

As discussed in the **THREATS** section, incidental harvest of Silver Chub through the commercial fisheries industry was recognized as a potentially low risk threat.

Mitigation

- Provide information and education to commercial harvesters on Silver Chub to raise awareness.
- Immediate release of Silver Chub if incidentally caught, as defined under the Ontario Recreational Fishing Regulations (Ontario Ministry of Natural Resources 2013b).
- Education through mandatory training on species at risk for commercial harvesters.

Alternatives

- Seasonal or zonal restrictions applied to commercial harvest during Silver Chub spawning season.

If Silver Chub is listed under the SARA, it is possible that alternatives in addition to mitigation may be required. However, alternatives, such as redesigning projects, have also been used as mitigation in many of the works that have taken place in the last few years. Offsetting may be required in some instances if future projects are permitted to result in the destruction of critical habitat.

SOURCES OF UNCERTAINTY

A number of key sources of uncertainty exist for this species related to population distribution and structure, habitat preferences, and factors limiting their existence. Resolving these sources of uncertainty would greatly enhance our understanding of Silver Chub in Ontario.

There is a need for a continuation of quantitative sampling of Silver Chub in areas where it is known to occur with the appropriate gear type to determine population size, current trajectory, and trends over time. Standardized trawling surveys should be extended to the central basin of Lake Erie where Silver Chub continues to be collected in gill net surveys. Trawling surveys should also be extended to Lake St. Clair to determine the status of the Silver Chub population in this system. These baseline data are required to monitor Silver Chub distribution and population trends as well as the success of any recovery measures implemented. Tissue samples should be collected from Silver Chub captured from the central and western basin of Lake Erie, as well as Lake St. Clair to determine the genetic structure of these populations.

The current distribution and extent of suitable Silver Chub habitat is unknown and should be investigated and mapped. These areas should be the focus of future targeted sampling efforts for this species. There is also a need to refine habitat requirements for each life stage. There is very little information available for both spawning and egg to juvenile habitat requirements, necessitating the inference of these requirements from other life stages. Larval surveys are needed to identify both spawning and nursery grounds. It is currently assumed that Silver Chub are open water spawners as the rivers that were historically used for spawning are degraded and no longer suitable for spawning. This assumption should be tested.

Numerous threats have been identified for Silver Chub populations in Ontario, although the direct impacts of these threats on Silver Chub are highly speculative. There is a need for more causative studies to evaluate the impact of each threat on Silver Chub populations with greater certainty as well as an estimation of the cumulative effects of interactive threats. There is a need to determine threshold levels for water quality parameters (e.g., nutrients, turbidity) and to determine physiological parameter limits including temperature, pH, dissolved oxygen, and pollution tolerance.

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