COSEWIC
Assessment and Status Report

on the

Warmouth
Lepomis gulosus

in Canada

ENDANGERED
2015

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous report(s):

COSEWIC 2005. COSEWIC assessment and update status report on the warmouth *Lepomis gulosus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 16 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC 2001 (In Press). COSEWIC assessment and status report on the warmouth *Lepomis gulosus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 19 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

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For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: 819-938-4125
Fax: 819-938-3984
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

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Warmouth — Illustration by J. Tomelleri. Reproduced with permission.

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COSEWIC
Assessment Summary

Assessment Summary – May 2015

Common name
Warmouth

Scientific name
Lepomis gulosus

Status
Endangered

Reason for designation
This species of sunfish has a very small distribution in Canada, occurring only within the Lake Erie drainage. It exists at few locations and is subjected to continuing decline in habitat quality due to a complexity of ecosystem modifications to its preferred vegetated habitat, primarily from the establishment of dense beds of non-native aquatic plants and eutrophication resulting from agricultural runoff.

Occurrence
Ontario

Status history
Designated Special Concern in April 1994. Status re-examined and confirmed in November 2001 and in May 2005. Status re-examined and designated Endangered in May 2015.

COSEWIC
Executive Summary

Warmouth
Lepomis gulosus

Wildlife Species Description and Significance

Warmouth (*Lepomis gulosus*) is a member of the family Centrarchidae. It is one of the 11 members of this family, and one of six members of the genus *Lepomis,* in the Canadian Great Lakes basin. Warmouth can be distinguished from other *Lepomis* by the presence of teeth on its tongue, a large mouth, and dark bands radiating from its eye.

Distribution

Warmouth is widely distributed in North America, throughout the Mississippi River, Atlantic and Great Lakes drainages. It has also been introduced into the Pacific drainages of the United States and Mexico. It has been recorded in Canada at three locations, all of which are found within the Lake Erie drainage.

Habitat

Warmouth is a warm water species that prefers highly vegetated embayments of lakes, slow-moving streams and wetlands. It is known to maintain similar habitat preferences throughout all of its life stages.

Biology

Warmouth is a nest spawner, and it is thought that it may spawn several times a summer. It generally creates a nesting site over silt and sand substrates covered with sticks or other debris. The male guards the nest and will actively fan the fertilized eggs. The age and length at the onset of maturity has been recorded at two years and 89 mm. Fecundity is highly variable, but is size-dependent similar to many freshwater fishes. The maximum known age is eight years and survival rates are unknown. Warmouth are known to hybridize with other members of the Centrarchidae family.

Population Sizes and Trends

The size of the Canadian Warmouth population is currently unknown. Relatively high abundances in Point Pelee National Park (2002-2003), and Long Point Bay and surroundings (2003-2013) would indicate that these populations are well established. Relatively lower, but consistent recent detections of Warmouth in Rondeau Bay (2003-2013) provide evidence of a potentially established population at this location as well. Additional research is necessary at all three known locations to determine population size and trends.

Threats and Limiting Factors

A wide variety of threats negatively impact Warmouth across its range. The greatest inferred threats to the survival and persistence of Warmouth in Canada are related to natural system modifications, as a result of aquatic vegetation removal and loss of wetlands, and pollution, as a result of agricultural practices and development. Species-specific evidence of the threats negatively affecting Warmouth populations is currently not available.

Protection, Status, and Ranks

Warmouth is currently listed as Special Concern under both the Canadian *Species at Risk Act* and the Ontario *Endangered Species Act*, 2007. Its habitat may be indirectly protected by the federal *Fisheries Act*, as the Warmouth shares habitat with fishes of Commercial, Recreational, or Aboriginal fishery significance. The species is listed as secure both globally (G5) and in the United States (N5). In Canada, it is ranked as critically imperilled both nationally (N1) and provincially (S1).

TECHNICAL SUMMARY

Lepomis gulosus

Warmouth Crapet sac-à-lait

Range of occurrence in Canada: Ontario

Demographic Information

Generation time	~ 3 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence (EO) Pre-2004 = 1628 km^2 1994-2003 = 1562 km^2	2409 km^2
Estimated extent of occurrence (IAO) Pre-2004 = 44 km^2 1994-2003 = 32 km^2	100 km^2
Is the population severely fragmented?	No
Number of locations • Point Pelee National Park • Rondeau Bay • Long Point Bay/Turkey Point Marshes/Big Creek	3
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] continuing decline in number of populations?	No
Is there an [observed, inferred, or projected] continuing decline in number of locations?	No

Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes, quality
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Point Pelee National Park	Unknown
Rondeau Bay	Unknown
Long Point Bay/Turkey Point Marshes/Big Creek	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown

Threats (actual or imminent, to populations or habitats)

The greatest threats to the survival and persistence of Warmouth in Canada are thought to be related to natural system modifications, as a result of aquatic vegetation removal and loss of wetlands, and pollution, as a result of agricultural practices and development. In addition, dense beds of the invasive Phragmites eliminate Warmouth habitat.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	Michigan (Secure) Ohio (Apparently secure) New York (Not applicable) Pennsylvania (Vulnerable)
Is immigration known or possible?	Unknown
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Unknown
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC: Designated Special Concern in April 1994. Status re-examined and confirmed in November 2001 and in May 2005. Status re-examined and designated Endangered in May 2015.

Status and Reasons for Designation:

Status:	**Alpha-numeric code:**
Endangered	B1ab(iii)+2ab(iii)
Reasons for designation: This species of sunfish has a very small distribution in Canada, occurring only within the Lake Erie drainage. It exists at few locations and is subjected to continuing decline in habitat quality due to a complexity of ecosystem modifications to its preferred vegetated habitat, primarily from the establishment of dense beds of non-native aquatic plants and eutrophication resulting from agricultural runoff.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No information on number of mature individuals is available.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(iii)+2ab(iii) due to the small extent of occurrence (<5,000 km²), small index of area of occupancy (<500 km²), small number of locations (<5), and inferred and projected decline in the quality of habitat.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No information on number of mature individuals is available.
Criterion D (Very Small or Restricted Population): Not applicable. No information on number of mature individuals is available.
Criterion E (Quantitative Analysis): Not available.

PREFACE

Warmouth remains a poorly monitored species, and is not generally the focus of search efforts when it has been detected. Results of sampling efforts in areas known to be occupied by Warmouth over the last 10 years suggest that all remnant populations are currently being maintained. Substantial sampling efforts in areas adjacent to historical Warmouth records have increased the known distribution of this species in both Long Point Bay and Rondeau Bay. Warmouth has not been detected at any new sites since the last status report, despite substantial sampling in areas consistent with its preferred habitat. A comparison of the current (2004-2013) extent of occurrence (EO) to two historical periods (1994-2003 and pre-2004) indicates an increase in EO. Current EO (2004-2013; 2408.62 km^2) has increased by 54.2% when compared to the previous 10 years (1994-2003; 1561.70 km^2) and has increased by 47.9% when compared to all historical records (pre-2004; 1628.36 km^2). The index of area of occupancy (IAO) shows a similar trend with an increase in IAO when current records (2004-2013) are compared to both historical periods (1994-2003 and pre-2004). Current IAO (2004-2013; 100 km^2) has increased by greater than threefold when compared to the previous 10 years (1994-2003; 32 km^2) and has increased greater than twofold when compared to all historical records (pre-2004; 44 km^2). It is difficult to determine the cause of the increases in both EO and IAO as consistent sampling effort and long-term trend data are currently unavailable. Increases in both metrics may be partially attributed to increased sampling efforts in areas known to be occupied by Warmouth. Our knowledge of threat impacts on Warmouth populations is limited to general documentation; however, the greatest threats to the survival and persistence of Warmouth in Canada are thought to be related to natural system modifications, as a result of aquatic vegetation removal and loss of wetlands, and pollution, as a result of agricultural practices and development.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2015)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada

Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Kingdom: Animalia

Phylum: Chordata

Class: Actinopterygii

Order: Perciformes

Family: Centrarchidae

Genus and species: *Lepomis gulosus* (Cuvier, 1829)

English common name: Warmouth (Page *et al*. 2013)

French common name: Crapet sac-à-lait (Page *et al*. 2013)

Due to the unique characteristic of having teeth on its tongue, Warmouth, *Lepomis gulosus*, had previously been placed in the monotypic genus *Chaenobryttus* (Bailey *et al*. 1970). *Chaenobryttus* is considered to be synonymous with *Lepomis* and, although there have been attempts to reinstate *Chaenobryttus* (Crossman *et al.* 1996), Warmouth has been retained in the genus *Lepomis* (Page *et al.* 2013).

Morphological Description

Warmouth is a member of the family Centrarchidae (Page *et al.* 2013). It is characterized by having a large mouth with an upper jaw extending well beyond the anterior margin of the eye (Figure 1; Holm *et al.* 2010). In adults, the upper jaw may extend to the centre of the eye or beyond (Trautman 1981). It has three to five dark bands radiating from the snout and eye (Trautman 1981). The pectoral fin is generally short with a rounded tip (Holm *et al*. 2010). Warmouth is also characterized by a band of tiny teeth on its tongue (Holm *et al*. 2010).

Warmouth body coloration can range from light yellow-olive to dark olive-green (Holm *et al*. 2010). Six to 11 chainlike dark olive double bands are located on the back and sides, while three to five dark grey, brown or lavender bands radiate backward from the snout and eye (Trautman 1981). The soft dorsal, caudal and anal fins are boldly vermiculated, and the paired fins are unspotted, and transparent to olive in colour (Holm *et al*. 2010).

Warmouth is one of 11 members of the Centrarchidae found within the Canadian Great Lakes basin (Holm *et al*. 2010). Warmouth can be easily distinguished from both Largemouth Bass (*Micropterus salmoides*) and Smallmouth Bass (*M. dolomieu*) by the absence of a notched dorsal fin and a deeper body shape (Holm *et al*. 2010). Anal-fin spine counts differentiate Warmouth from Rock Bass (*Ambloplites rupestris*) (three for Warmouth; five to seven for Rock Bass; Holm *et al.* 2010). Warmouth can be distinguished from both White Crappie (*Pomoxis annularis*) and Black Crappie (*P. nigromaculatus*) by the number of dorsal spines, Warmouth having 10 dorsal spines, and crappies having six to eight dorsal spines (Holm *et al*. 2010). Its large mouth, dark bands radiating from the eye and presence of teeth on its tongue distinguish Warmouth from other members of the genus *Lepomis* (Holm *et al*. 2010).

Figure 1. Warmouth, *Lepomis gulosus*. Illustration by J. Tomelleri. Reproduced with permission.

Population Spatial Structure and Variability

There is no information currently available on the population and genetic structure of Canadian Warmouth populations. However, Warmouth population structure has been studied from 14 river drainages extending from South Carolina to Louisiana (Bermingham and Avise 1986). Mitochondrial DNA was used to reconstruct evolutionary relationships, and it was concluded that DNA clones that were closely related genetically were usually geographically contiguous (Bermingham and Avise 1986). Applying these conclusions to Canadian Warmouth populations, one could speculate that because the remaining three Warmouth sites are isolated from each other by distances greater than 50 km and because large stretches of unsuitable habitat are present between locations (effectively not geographically contiguous), genetic isolation over this spatial scale is likely.

Designatable Units

All Canadian Warmouth populations are found in a single COSEWIC National Freshwater Biogeographic Zone (COSEWIC 2011), the Great Lakes-Upper St. Lawrence Biogeographic Zone. Since all Warmouth populations are found within a single biogeographic zone and there is a lack of information on both population structure and genetic viability, Warmouth should be considered to constitute a single designatable unit.

Special Significance

Warmouth is known to exist in only three areas in Canada, Point Pelee National Park, Rondeau Bay and Long Point Bay; therefore, this species and the areas that it occupies should be considered nationally significant.

DISTRIBUTION

Global Range

Warmouth is native to many areas within the Mississippi River, Atlantic and Great Lakes basins. Native populations are known to be widely distributed throughout much of central and eastern United States, from Texas to Florida in the south, and Minnesota to New York in the north (Page and Burr 2011). Warmouth has also been widely introduced to Pacific drainages in the western United States (New Mexico, Arizona, California, Nevada, Idaho, Oregon and Washington; Hubble 1966; Page and Burr 2011; NatureServe 2014). It has also been introduced into Mexico (Page *et al.* 2013). Within its native range in Illinois, it has been widely introduced into impoundments (Larimore 1957). Despite its large distribution in the United States, Warmouth is known only from a few isolated areas in southwestern Ontario.

Canadian Range

In Canada, Warmouth has been recorded from three localities, all situated in the Lake Erie drainage. Warmouth was first recorded from Rondeau Provincial Park in 1966 (RPM F103-66; Crossman and Simpson 1984). An additional two records in 1967, and three records in 1968 were recorded from the park (Crossman and Simpson 1984). Warmouth was not recorded again from Canadian waters until 1983 when one individual was recorded in Lake Pond, Point Pelee National Park (ROM 42752; Crossman and Simpson 1984). Subsequent to this initial discovery at Point Pelee National Park, 46 individuals were collected from a single site between the period of June 3 and October 18, 1983 (Crossman and Simpson 1984). These individuals consisted of 28 adults and 18 young-of-the-year (YOY), providing the first evidence of a breeding population in Canadian waters (Crossman and Simpson 1984).

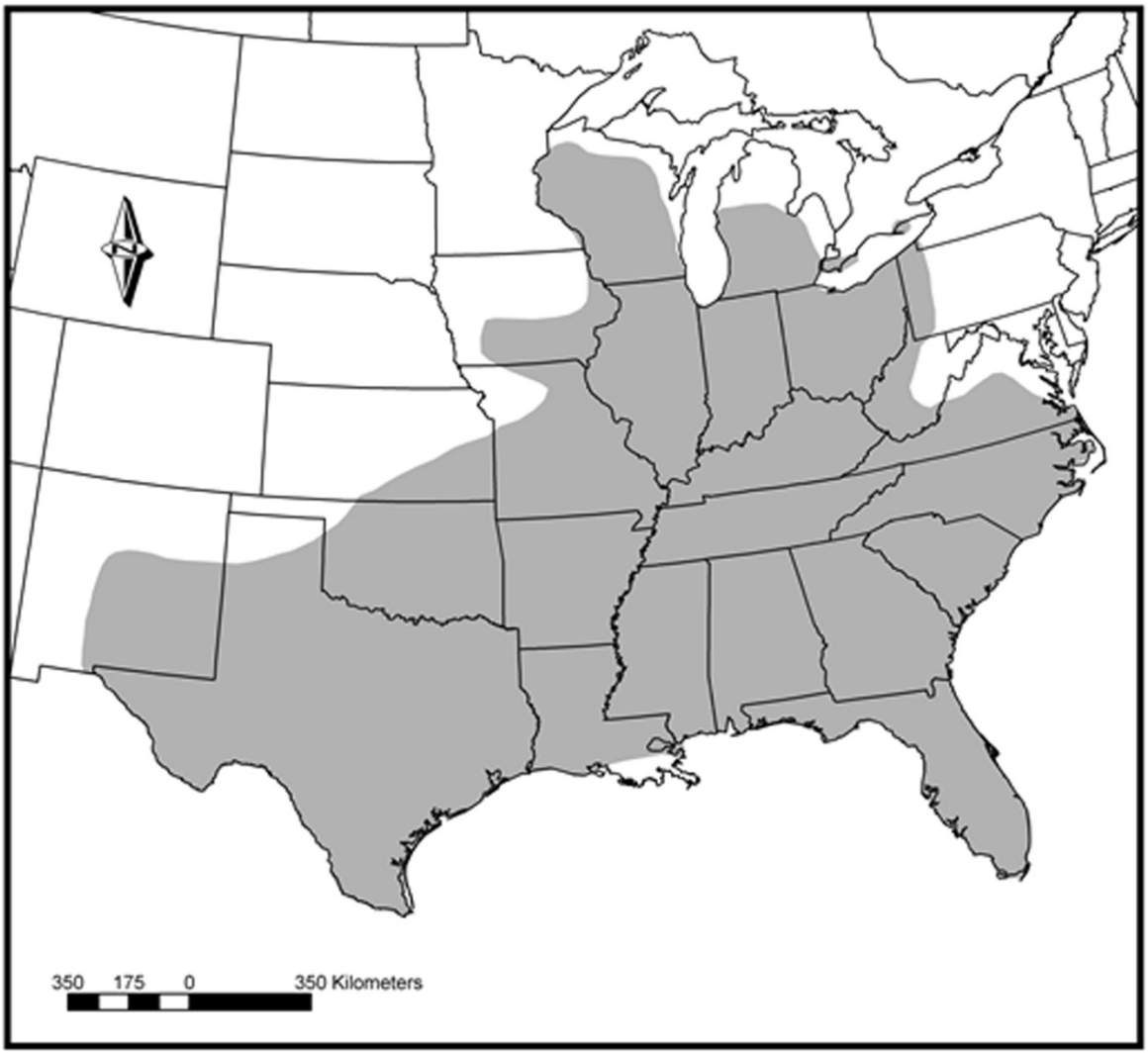

Figure 2. Global distribution of Warmouth. Modified from Page and Burr (1991).

The first record of Warmouth from Long Point Bay and surrounding areas (Big Creek, Big Creek marshes and Turkey Point marshes) was recorded in 2003 when one YOY specimen was collected in the inner bay of Long Point.

Records from two additional sites have been reported in the literature. A YOY specimen from Cedar Creek (a tributary of Lake Erie) collected in 1994 (Leslie *et al*. 1999) was later re-identified as Northern Sunfish (*L. peltastes*) (E. Holm, Royal Ontario Museum, pers. comm. *in* COSEWIC 2005). A second Warmouth was reported from Duck Creek (a tributary of Lake St. Clair; Leslie and Timmins 1998), although this voucher specimen was not recovered or verified and, therefore, is excluded from this report. Limited sampling has occurred in Duck Creek in 2001 and 2004 and Warmouth was not detected during these surveys; however, it is unlikely that Warmouth occupies this system as the habitat does not appear to be suitable (DFO, unpubl. data; Essex Erie Conservation Authority, unpubl. data). In addition, Canadian tributaries of Lake St. Clair have been extensively sampled since 2002 using suitable gear and effort for capturing Warmouth; however, none have been detected (Figure 3a).

Crossman *et al*. (1996) speculated that Warmouth may have more recently colonized Canadian waters relative to other native freshwater fish species and that this recent colonization may be a result of a period of global warming, and/or continuing range expansion following the last glaciation period (COSEWIC 2005). Alternatively, Warmouth may have been recently introduced to these systems as a result of direct human actions. Recent introductions, a few successful, have been reported in US waters (Van Meter and Trautman 1970). However, there are no US populations near the Canadian populations that would have allowed easy transfer, there is no motivation for such a transfer, and it is unlikely that it would be introduced into a highly protected area, such as Point Pelee National Park. It is more likely that Warmouth has been present in Canada since the last Ice Age, but had remained undetected and/or misidentified until the first record of its presence in Rondeau Bay in 1966. This is supported by its generally low detection probability, despite extensive sampling of its known Canada range (see **Search Effort**).

Furthermore, if Warmouth only recently colonized its Canadian range, one would expect it to be present in other suitable habitats along the north shore of Lake Erie that would have acted as colonization stepping stones to the westernmost established population in Point Pelee National Park. Suitable habitat may include the River Canard, Holiday Beach/Big Creek complex and Cedar Creek in Essex County. However, Warmouth were not detected in: River Canard (years sampled: 1980, 1985, 1990-91, 1994, 1996, 2002-04, 2009, 2012-14; various sources); Holiday Beach, intensively sampled by fyke net and boat electrofisher in 2003 and 2004 (L. Bouvier, unpubl. data); Big Creek (tributary to Holiday Beach), sampled by hoop net and seining in 2007 (N. Mandrak, unpubl. data); and Cedar Creek, a tributary to Lake Erie located between Holiday Beach and Point Pelee, sampled in nine different years between 1941 and 2013.

In addition, connectivity between the Point Pelee National Park ponds and Lake Erie proper is regulated by a barrier beach system on the eastern perimeter of the park. The barrier beach is rarely breached, with only five breach events recorded between 1922 and 1983 (Surette 2006). The rarity of these breach events would result in limited colonization opportunities for Warmouth in the time period prior to its first discovery in 1983.

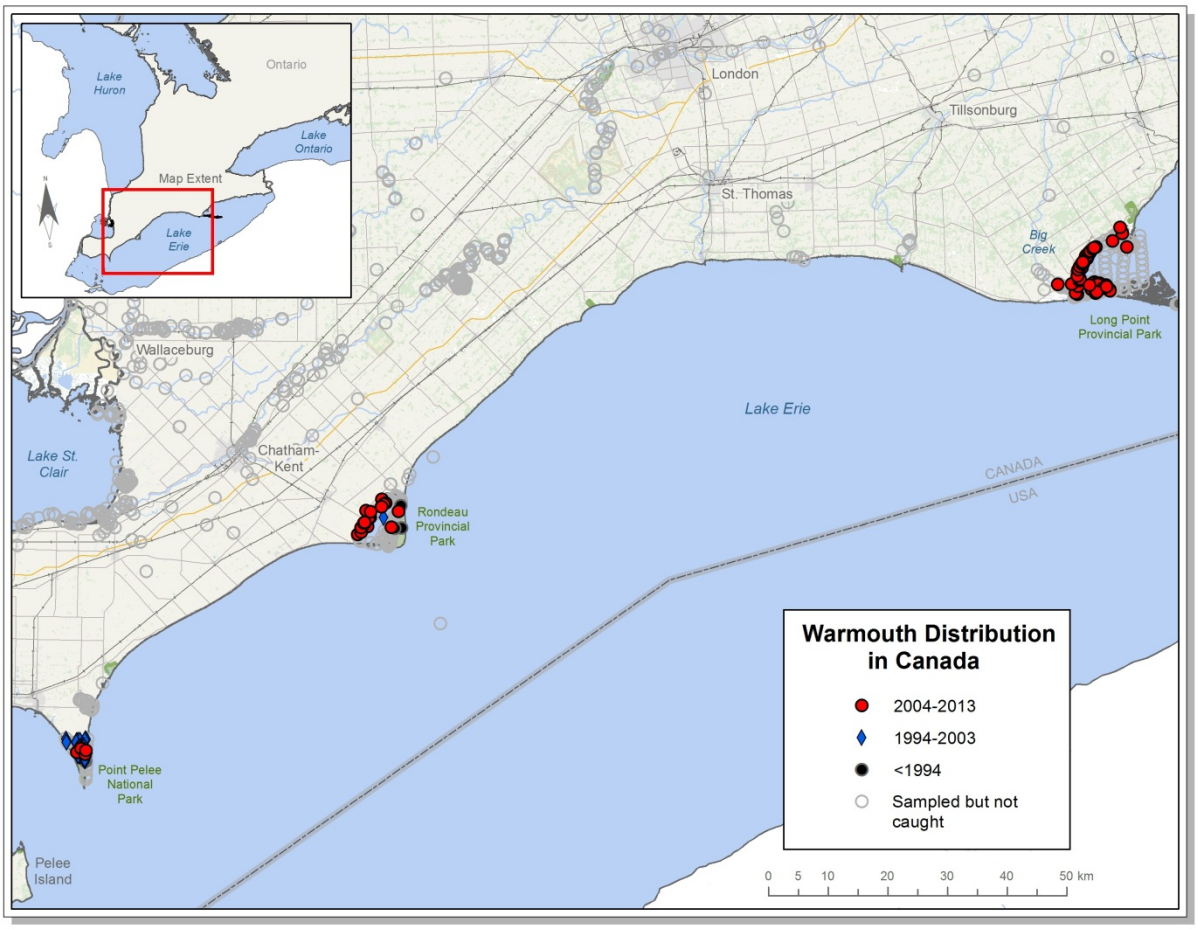

Figure 3(a).Distribution of Warmouth, *Lepomis gulosus*, in Canada. Empty grey circles represent sampling sites where sampling has occurred and Warmouth were not detected.

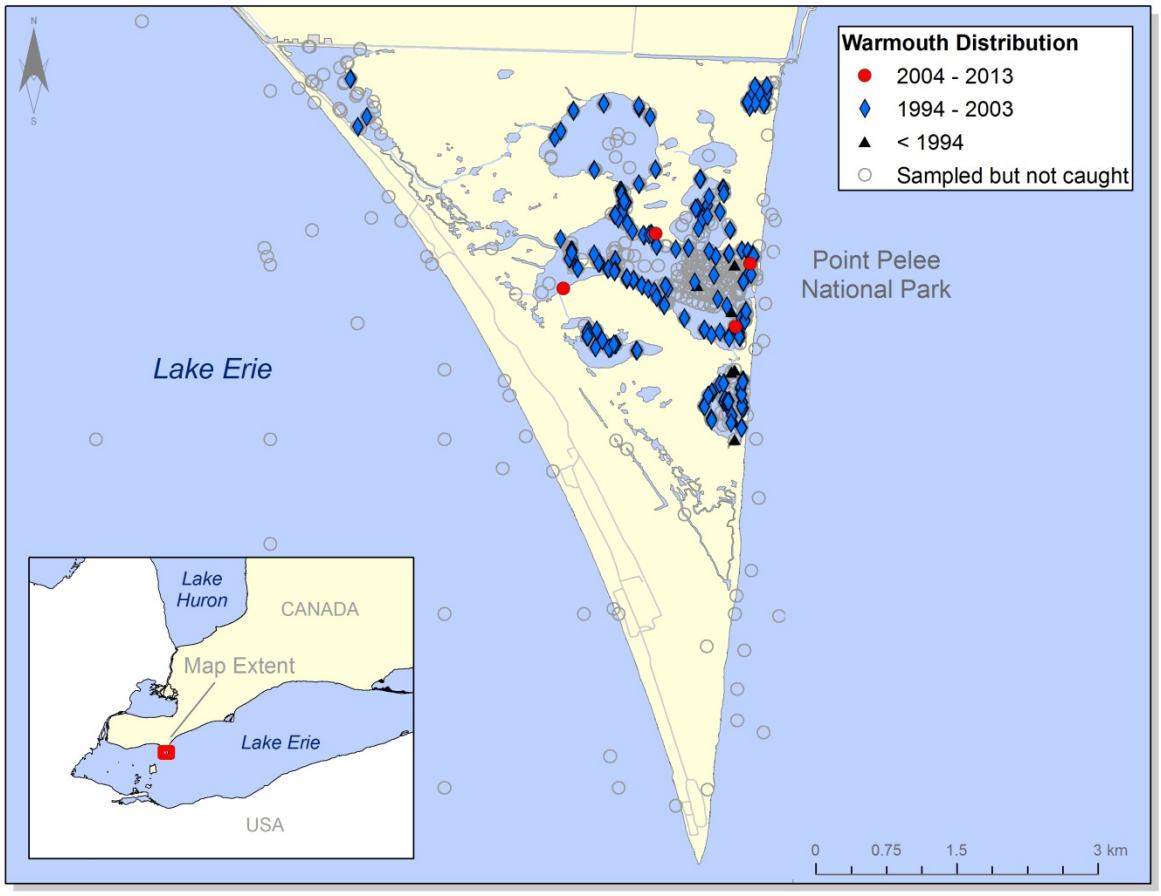

Figure 3(b).Distribution of Warmouth, *Lepomis gulosus,* in Point Pelee National Park. Empty grey circles represent sampling sites where sampling has occurred and Warmouth were not detected.

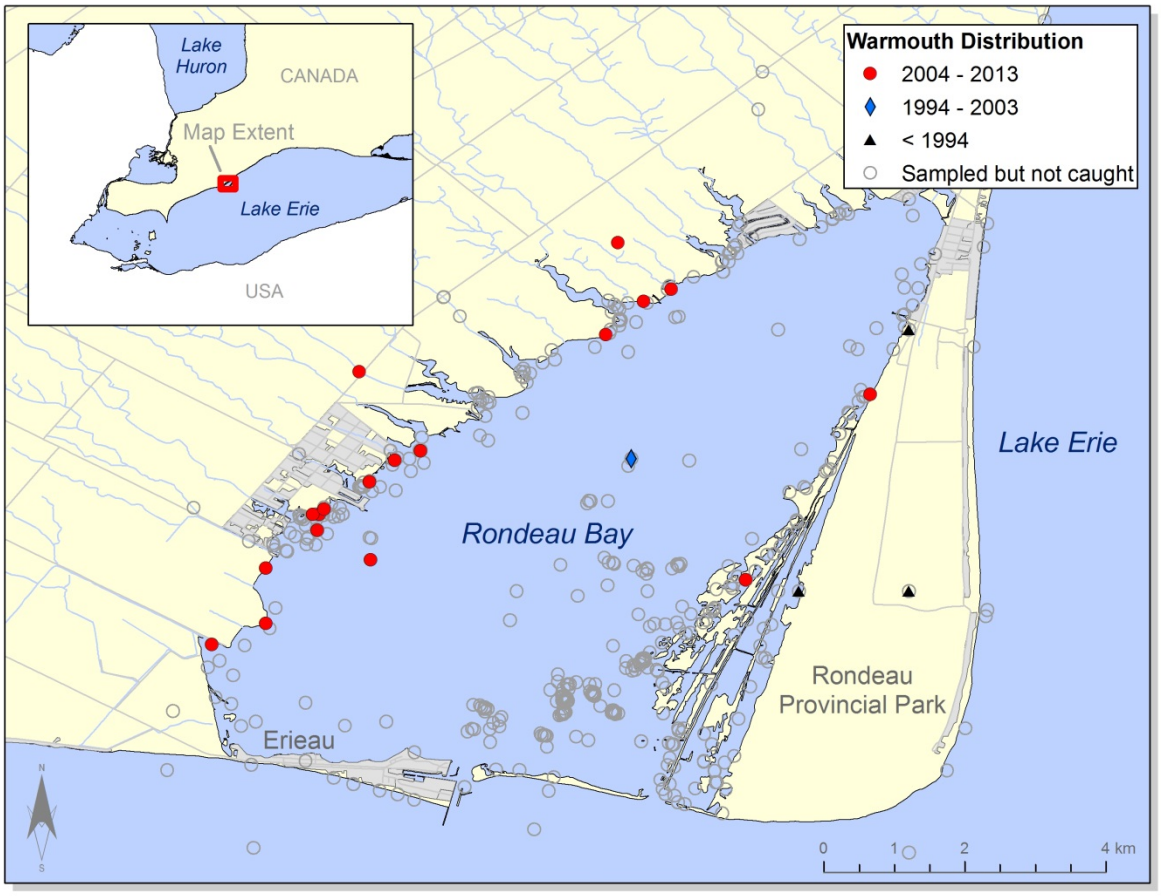

Figure 3(c). Distribution of Warmouth, *Lepomis gulosus,* in Rondeau Bay. Empty grey circles represent sampling sites where sampling has occurred and Warmouth were not detected.

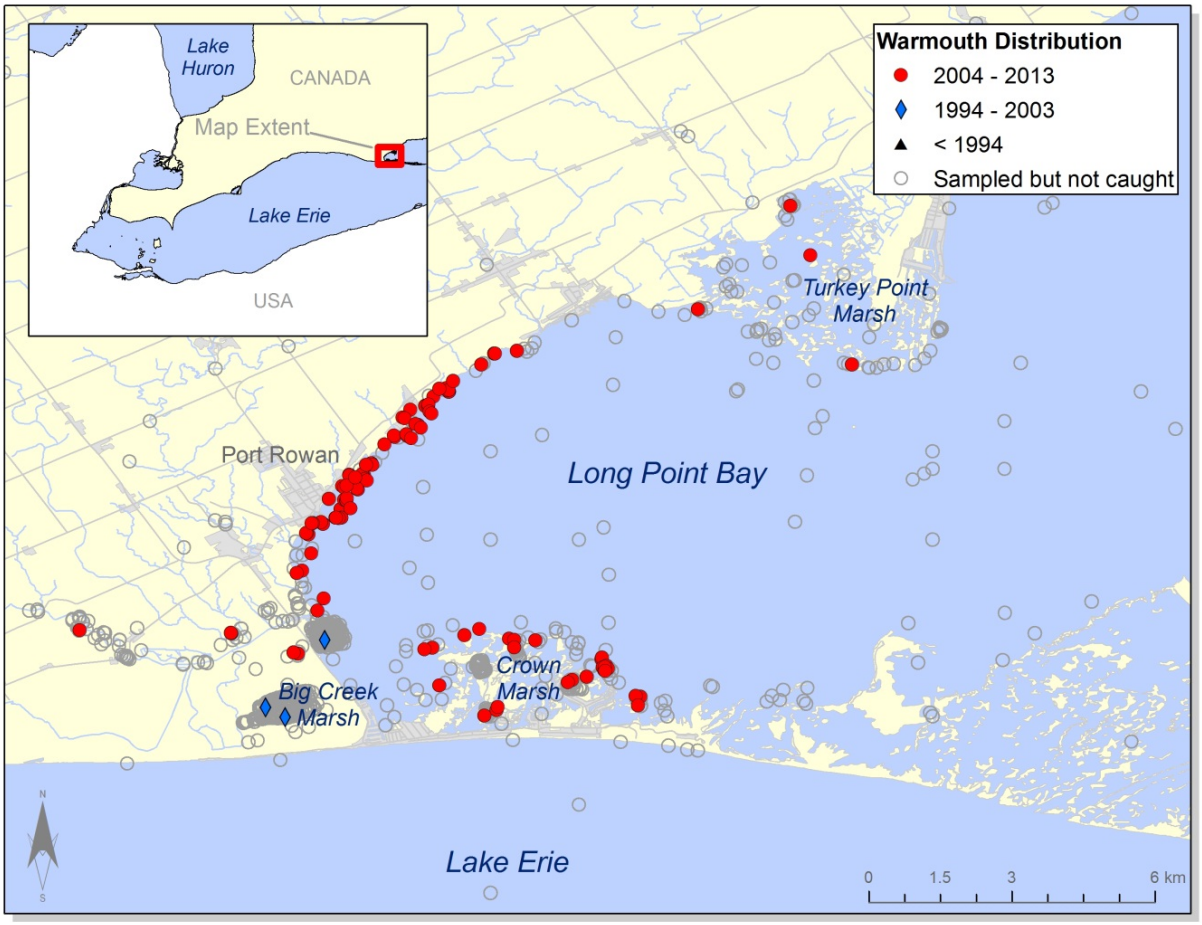

Figure 3(d).Distribution of Warmouth, *Lepomis gulosus,* in Long Point Bay and surrounding area. Empty grey circles represent sampling sites where sampling has occurred and Warmouth were not detected.

Extent of Occurrence and Area of Occupancy

Results of sampling efforts in areas known to be occupied by Warmouth over the last 10 years suggest that all populations are currently being maintained. Substantial sampling efforts in areas adjacent to historical Warmouth records have increased the known distribution of this species in both Long Point Bay, and Rondeau Bay. Decreased sampling efforts over the same time period in Point Pelee National Park may account for the decrease in the number of point occurrences in this system.

Table 1. Summary of historical and current fish sampling effort within the known distribution of Warmouth in (a) Point Pelee National Park, (b) Rondeau Bay and (c) Long Point Bay. Grey cells represent sampling events that have failed to detect Warmouth, *Lepomis gulosus*.

A) Point Pelee National Park

Waterbody	n	Year	Sampling effort	Reference
Point Pelee	0	1913-1982	-15 different years in this time period -mostly completed by seine	CMN, ROM, Point Pelee National Park (PPNP) staff [see Surette (2006) for complete details]
Point Pelee	2	1983	-hoop net set (<24 h x 39 sets)	G. Mouland, unpubl. data (received from J. Keitel, PPNP)
Point Pelee	UK (>1)	1989	-seine net (5 days) -creel survey (unknown effort)	E. Holm and D. Boehm (ROM, unpubl. data) K. Janoki and G. Mouland (Surette 2006)
Point Pelee	0	1992	-creel survey (unknown effort)	T. Linke (Surette 2006)
Point Pelee	11	1993	-trap net (48 h set x 3 sites x 2 events) -seine (10 m x 5 hauls)	Dibble *et a*l. (1995)
Point Pelee	UK (>1)	1997	-seine (2 days) -plastic trap (5 days) -boat electrofisher (4.3 h)	E. Holm, D. Boehm and M. Ciuk (ROM, unpubl. data)
Point Pelee	0	2002	-boat electrofisher (4 sites)	N. Mandrak, unpubl. data
Point Pelee	0	2002	-hoop net (24 h sets x 5 sites) -trap net (24 h sets x 3 sites)	N. Mandrak, unpubl. data
Point Pelee	657	2002-2003	-seine (55 events) -minnow trap (80 events) -Windermere trap (80 events) -trap net (28 events) -hoop net (342 events)	Surette (2006)
Point Pelee	1	2003	-boat electrofisher (100 m x 18 sites) -fyke net (24 h set x 8 sites)	L. Bouvier, unpubl. data
Point Pelee	0	2004	-boat electrofisher (100 m x 18 sites x 2 events) -fyke net (24 h set x 8 sites x 2 events)	L. Bouvier, unpubl. data
Point Pelee	1	2005	-3 paired fyke nets (2 large and 1 small x 2 sites)	Razavi (2006)
Point Pelee	6	2009	-fyke net (24 h set x 16 sets)	B. Glass, unpubl. data

B) Rondeau Bay

Waterbody	n	Year	Sampling effort	Reference
Rondeau Bay	0	1921-1965	14 different years	CMN & ROM (ROM, unpubl. data)
Rondeau Bay	1	1966	Unknown effort	Crossman and Simpson (1984)
Rondeau Bay	2	1967	Unknown effort	Crossman and Simpson (1984)
Rondeau Bay	5	1968	Unknown effort	Crossman and Simpson (1984)
Rondeau Bay	2	1999	Unknown effort	ROM, unpubl. data
Rondeau Bay	0	2002	-boat electrofisher (10 sites)	N. Mandrak, unpubl. data
Rondeau Bay	0	2004	-boat electrofisher (>1000 s/500 m site x 10 sites) -hoop net (24 h set x 28 sites)	N. Mandrak, unpubl. data
Rondeau Bay	2	2005	-hoop net (24 h set x 24 sites)	N. Mandrak, unpubl. data
Rondeau Bay	0	2005	-bag seine (1 haul x 3 sites; 2 hauls x 5 sites; 3 hauls x 14 sites) -boat seine (1 haul x 5 sites)	N. Mandrak, unpubl. data
Rondeau Bay	3	2007	-fyke net (24 h set x 128 sets)	B. Glass, unpubl. data
Rondeau Bay	4	2008	-fyke net (24 h set x 126 sets)	B. Glass, unpubl. data
Rondeau Bay	5	2009	-fyke net (24 h set x 78 sets)	B. Glass, unpubl. data
Rondeau Bay	1	2009	-fyke net (unknown effort)	M. Belore, OMNR, LEMU, unpubl. data

Waterbody	n	Year	Sampling effort	Reference
Rondeau Bay	1	2013	-hoop net (24 h sets x 21 sites)	N. Mandrak, unpubl. data
Rondeau Bay	0	2013	-bag seine (1 haul x 36 sites) -quatrefoil light trap (24 h sets x 21 sites) -pelagic trawl (100 m x 1 pass x 14 sites; 100 m x 3 passes x 1 site)	N. Mandrak, unpubl. data
Rondeau Bay	9	2013	-mini fyke net (24 h sets x 14 sites)	D. Marson, unpubl. data
Rondeau Bay	0	2013	-boat electrofisher (4 x 100 m x 11 sites)	D. Marson, unpubl. data
Mill Creek	1	2013	-fyke net (4 sites)	J. Ciborowski, University of Windsor, unpubl. data

C) Long Point Bay

Waterbody	n	Year	Sampling effort	Reference
Long Point Bay	0	1928-2003	-18 years in this time period, unknown effort	OMNR, ROM & CMN (ROM, unpubl. data)
Big Creek Marsh	0	1983-1985	Unknown effort	CMN & WLU (ROM, unpubl. data)
Big Creek Marsh	0	1979	Unknown effort	Canadian Museum of Nature (CMN) & Wilfred Laurier University (WLU) (ROM, unpubl. data)
Big Creek Marsh	0	2003	-boat electrofisher (50 m x 15 sites x 2 events) -fyke net (24 h set x 4 sites x 2 events)	L. Bouvier, unpubl. data
Long Point Bay	1	2003	-boat electrofisher (50 m x 18 sites x 2 events) -fyke net (24 h set x 4 sites x 2 events)	L. Bouvier, unpubl. data
Long Point Bay	0	2004	-boat electrofisher (50 m x 18 sites x 2 events) -fyke net (24 h set x 4 sites x 2 events)	L. Bouvier, unpubl. data
Long Point Bay	0	2004	-boat electrofisher [<1000 s (1 pass) x 47 sites; >1000 s (2 passes) x 10 sites)]	N. Mandrak, unpubl. data
Big Creek Marsh	4	2004	-boat electrofisher (50 m x 15 sites x 2 events) -fyke net (24 h set x 4 sites x 2 events)	L. Bouvier, unpubl. data
Big Creek Marsh	0	2005	-seine (2 hauls x 1 site)	N. Mandrak, unpubl. data
Long Point Bay	0	2005	-hoop net (24 h sets x 24 sites)	N. Mandrak, unpubl. data
Big Creek Marsh	11	2005	-hoop net (24 h set x 26 sites)	N. Mandrak, unpubl. data
Long Point Bay	0	2007	-hoop net (24 h sets x 58 sites) -seine (1 haul x 2 sites; 2 hauls x 9 sites; 3 hauls x 3 sites; 4 hauls x 1 site)	N. Mandrak, unpubl. data
Long Point Bay	1	2007	-seine (33 sites)	K. Oldenburg, OMNR Lake Erie Management Unit (LEMU), unpubl. data
Long Point Bay	1	2007	-boat electrofisher (524-3860 s x 9 sites)	N. Mandrak, unpubl. data
Big Creek	0	2008	-boat electrofisher (422-843 s x 10 sites) -boat seine (1 haul x 3 sites; 3 hauls x 6 sites; 4 hauls x 1 site) -bag seine (3 hauls x 1 site)	N. Mandrak, unpubl. data
Crown Marsh	0	2008	-minnow traps (24 h x 9 sites) -seine (3 sites)	K. Oldenburg, OMNR LEMU, unpubl. data
Cedar Creek	0	2008	-seine (3 sites)	K. Oldenburg, OMNR LEMU, unpubl. data
Turkey Point	0	2009	-minnow trap (24 h x 12 sites) -fyke net (22 sites)	K. Oldenburg, OMNR LEMU, unpubl. data
Bluff Bar	0	2009	-electrofisher (4 sites) -hoop net (9 sites) -seine (4 sites)	K. Oldenburg, OMNR LEMU, unpubl. data
Long Point Bay	141	2009	-hoop net (24 h set x 368 events)	Gislason *et al*. (2010)
Crown Marsh	4	2009	-electrofisher (5 sites)	K. Oldenburg, OMNR LEMU, unpubl. data
Turkey Point	1	2009	-electrofisher (8 sites)	K. Oldenburg, OMNR LEMU, unpubl. data
Long Point Bay	10	2010	-fyke net (24 h set x 129 sets)	B. Glass, unpubl. data

Waterbody	n	Year	Sampling effort	Reference
Murray Marsh	1	2010	-hoop net (24 h set x 23 sets)	J. Wilson, Long Point Conservation Authority (LPCA), unpubl. data
Big Creek	7	2011	Unknown effort	J. Wilson, LPCA, unpubl. data
Turkey Point Marsh	1	2011	Unknown effort	J. Wilson, LPCA, unpubl. data
Long Point Bay	35	2012	-hoop net (24 h set x 47 sites)	N. Mandrak, unpubl. data
Long Point Bay	11	2012	-bag seine (5 hauls x 60 sites x 2 events)	N. Mandrak, unpubl. data
Long Point Bay	0	2013	-bag seine (5 hauls X 34 sites)	N. Mandrak, unpubl. data
Long Point Bay	0	2013	-bag seine (3 hauls X 1 site) -boat electrofisher (1000 m x 2 sites; 800 m x 1 site; 400 m x 6 sites; 200 m x 2 sites) -trammel net (0.5-0.75 h x 3 sites)	D. Marson, unpubl. data
Long Point Bay	3	2013	-bag seine (5 hauls x 60 sites x 2 events)	N. Mandrak, unpubl. data
Long Point Bay	3	2013	-mini fyke net (24 h sets X 18 sites)	D. Marson, unpubl. data

To examine trends in extent of occurrence (EO) and the current index of area of occupancy (IAO) based on the previous assessment period (1994-2003) and all historical records (pre-2004), the current time period (2004-2013) is compared separately to the previous ten years (1994-2003) and to all historical records (pre-2004). The two historical time periods should not be compared to each other, but rather both should be independently compared to the current time period.

A comparison of the current (2004-2013) EO to both historical periods (1994-2003 and pre-2004; Figure 4) indicates an increase in EO. The current EO (2004-2013; 2408.62 km^2) has increased by 54.2% when compared to the previous 10 years (1994-2003; 1561.70 km^2), and has increased by 47.9% when compared to all historical records (pre-2004; 1628.36 km^2).

The IAO shows a similar trend with an increase in IAO when current records (2004-2013) are compared to both historical periods (1994-2003 and pre-2004). Current IAO (2004-2013; 100 km^2) has increased by greater than threefold when compared to the previous 10 years (1994-2003; 32 km^2), and has increased by greater than twofold when compared to all historical records (pre-2004; 44 km^2).

It is difficult to determine the cause of the increases in both EO and IAO, as consistent sampling effort and long-term trend data are currently unavailable. Increases in both metrics may be partially attributed to increased sampling efforts in areas known to be occupied by Warmouth (Long Point Bay and Rondeau Bay).

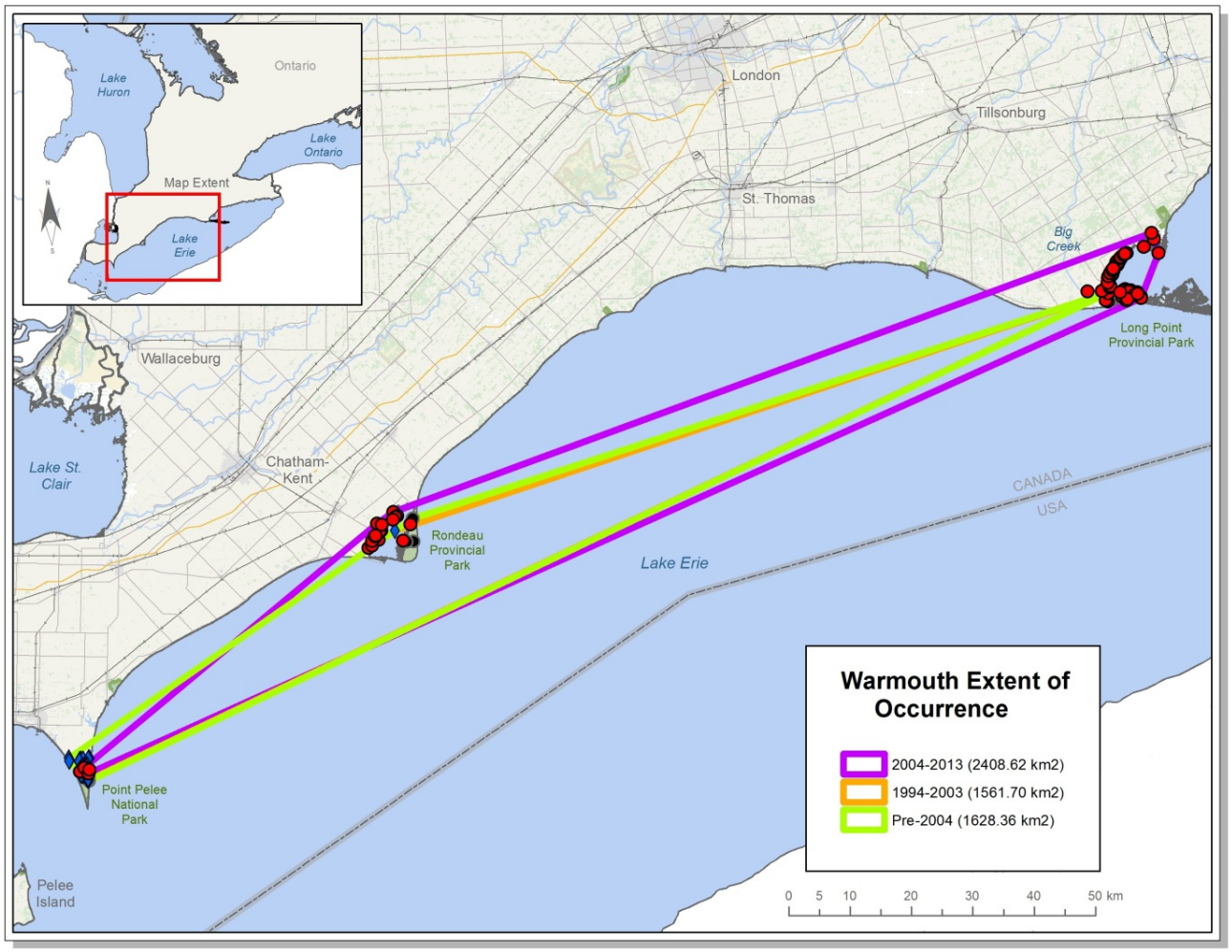

Figure 4. Warmouth, *Lepomis gulosus*, Extent of occurrence as calculated by convex hull polygon over one current (2004-2013) and two historical time periods (1994-2003; pre-2004).

Severely Fragmented

According to the IUCN Standards and Petitions Subcommittee (2014) a taxon can be considered severely fragmented if most of its total area of occupancy (>50%) is in habitat patches that are: 1 – smaller than would be required to support a viable population, and 2 – separated from other habitat patches by large distances. Warmouth would fit the latter criteria, in that populations are separated from one another by greater than 50 km, with little to no areas of preferred habitat in between populations. However, it is unlikely that current populations can be considered as not viable as Warmouth trend data would suggest viable populations at all three sites. Therefore, Warmouth could not be considered severely fragmented.

Search Effort

The vast majority of surveys that have successfully detected Warmouth were not specifically targeting this species. Gear types recorded to have successfully detected Warmouth include boat electrofishing, fyke netting, hoop netting, seining, minnow traps and Windermere traps. Table 1 (a-c) provides an overview of all known sampling events that have occurred in areas known to be inhabited by Warmouth listed by site, waterbody and year. This table also provides an overview of the sampling effort during each sampling event and whether the sampling event was successful in detecting Warmouth.

Point Pelee National Park

Warmouth was first detected in Point Pelee National Park in 1983. Surette (2006) provides an in-depth historical account of fish sampling events that have occurred in Point Pelee from 1940 to 2003 [Table 1.1. in Surette (2006)]. Sixteen sampling events in 15 different years failed to detect Warmouth in this system from 1940 to 1983 using a variety of sampling equipment, including seine nets, gill nets, minnow traps, creel surveys, and trap nets (Table 1a). The first record of Warmouth consisted of two individuals recorded in 1983 (G. Mouland, unpubl. data). Subsequently, the species was recorded from the system in low numbers in 1989, 1993, and 1997. A large-scale fish assemblage study was completed in 2002 and 2003 in which 657 Warmouth were recorded from 87 of 117 sampling events (Surette 2006). The ponds at Point Pelee were re-sampled in 2004, (n=0), 2005 (n=1) and 2009 (n=6), yielding Warmouth detections at low numbers. The substantially greater abundance of Warmouth observed in 2002-2003 when compared to subsequent sampling events is likely a result of decreased sampling effort since the 2002-2003 surveys (see Table 1).

Rondeau Bay

A single Warmouth recorded from Rondeau Bay in 1966 represents the discovery of this species in Canadian waters (Table 1b). Although Warmouth has not been the focus of any studies in this system, substantial sampling with gear known to be effective at detecting Warmouth has occurred in Rondeau Bay in 2007 (128 fyke net sets), 2008 (126 fyke net sets), and 2009 (78 fyke net sets; B. Glass, unpubl. data). These sampling efforts resulted in the detection of three, four, and five Warmouth, respectively (B. Glass, unpubl. data). Additional sampling in 2013 by hoop net and fyke net resulted in the capture of an additional 11 individuals (D. Marson, unpubl. data; N. Mandrak, unpubl. data).

Long Point Bay

The first Warmouth record from Long Point Bay and surroundings (Big Creek, Big Creek Marsh, and Turkey Point Marsh) was recorded in 2003 and is represented by a single individual caught by fyke net (L. Bouvier, unpubl. data). Since this initial detection, the Long Point Bay complex has been intensively sampled (Table 1c). As a result of this intensive sampling, Warmouth has been detected throughout the complex yearly from 2003 to 2013 (with the exception of 2006 and 2008). The largest number of Warmouth recorded was the result of monitoring the commercial hoop net coarse fishery along the north shore of the bay in 2009, in which 141 Warmouth were recorded from 368 hoop net sampling events (Gislason *et al*. 2010). Warmouth appears to occupy all areas within inner Long Point Bay, including Turkey Point Marsh and Big Creek Marsh, but appears to be excluded from outer Long Point Bay. This trend is to be expected considering the lack of suitable habitat in outer Long Point Bay.

HABITAT

Habitat Requirements

Warmouth is a warmwater species that prefers highly vegetated embayments of lakes, slow-moving streams and wetlands (Holm *et al*. 2010; Page and Burr 2011). Individuals generally occupy shallow waters with a large portion of specimens caught in waters less than 2 m deep. Oxygen tolerance levels are unknown for Canadian populations, but Warmouth have been noted to survive in oxygen-depleted systems (down to 3.6 ppm) in Illinois waters when water temperature was 20°C (Larimore 1957 *in* Becker 1983). Substrate descriptions, taken as percent composition estimates, were available from sites where Warmouth was detected in the Long Point Bay complex in 2005 (n=11), 2007 (n=1) and 2012 (n=46) (Figure 6). Substrates were composed of a combination of silt, sand and organic, with only two sites being described as having clay (only 10% at each site). The most abundant dominant substrate type across sites was silt, followed by sand.

Spawning and nursery habitat is thought to be consistent with adult habitat, and characterized by shallow (less than 2 m), heavily vegetated areas with both submergent and emergent vegetation (Becker 1983; Lane *et al*. 1996a, b).

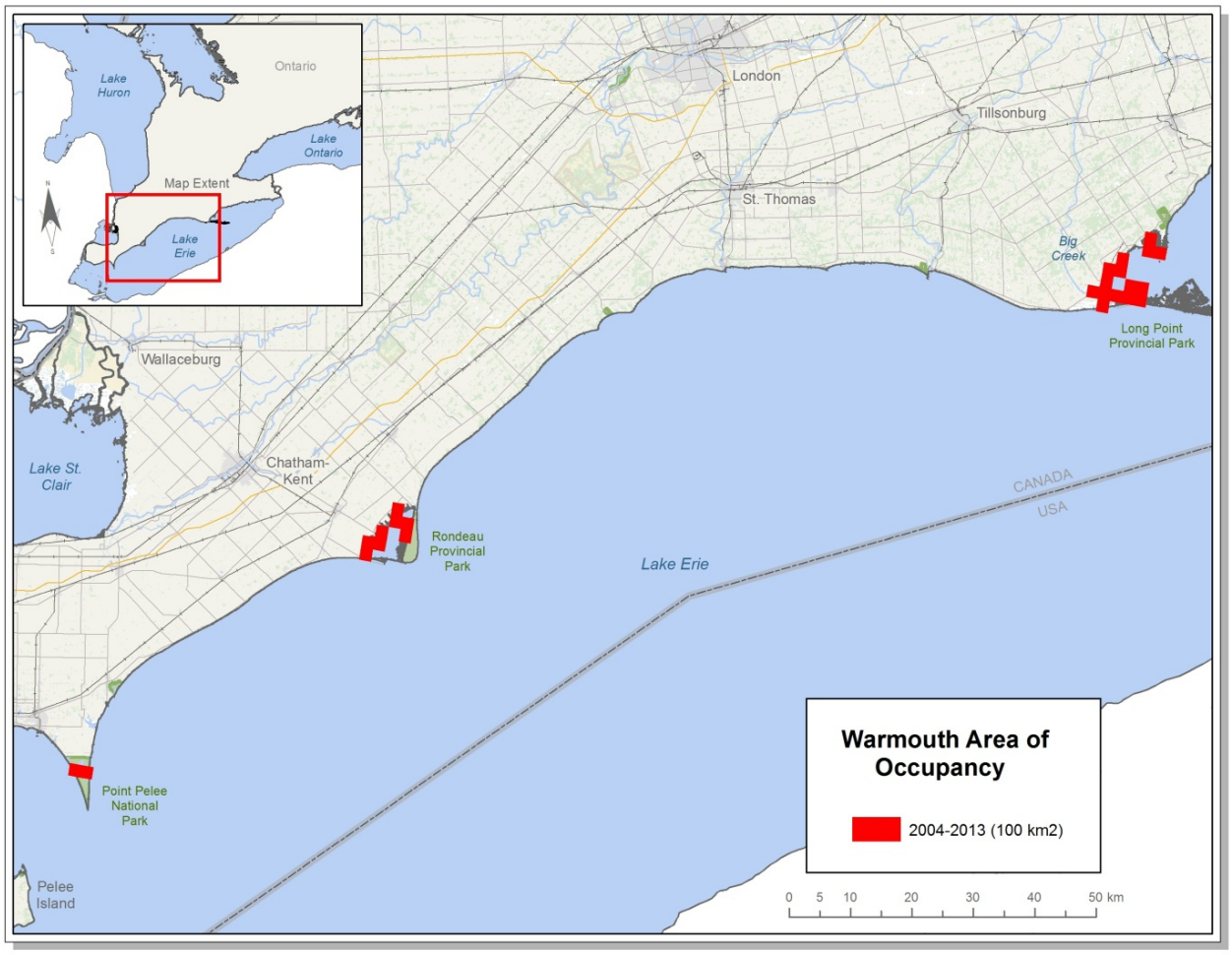

Figure 5(a). Index of area of occupancy for Warmouth, *Lepomis gulosus*, over the last 10 years (2004-2013).

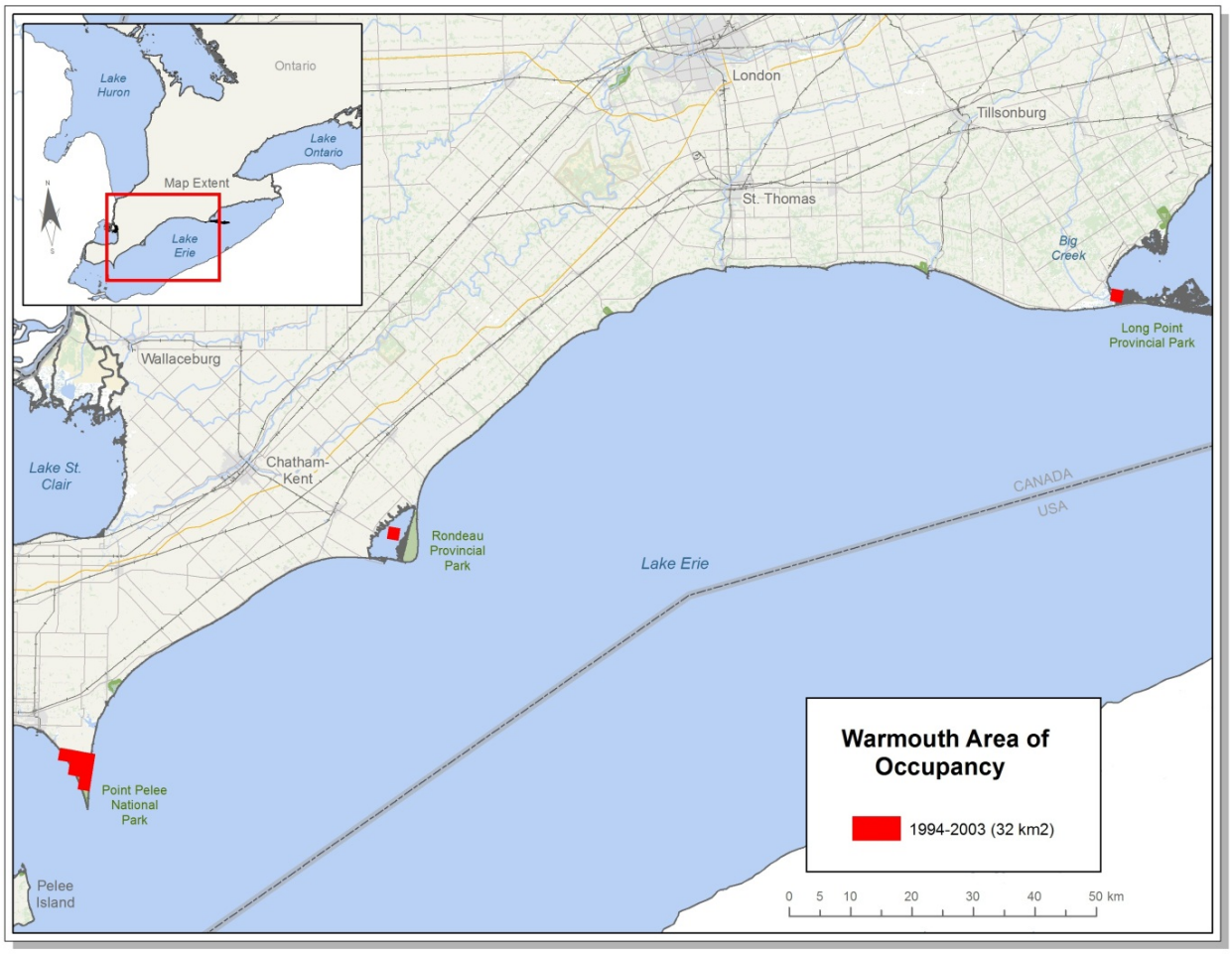

Figure 5(b).Index of area of occupancy for Warmouth, *Lepomis gulosus*, over the period of 10 years prior to last 10 years (1994-2003).

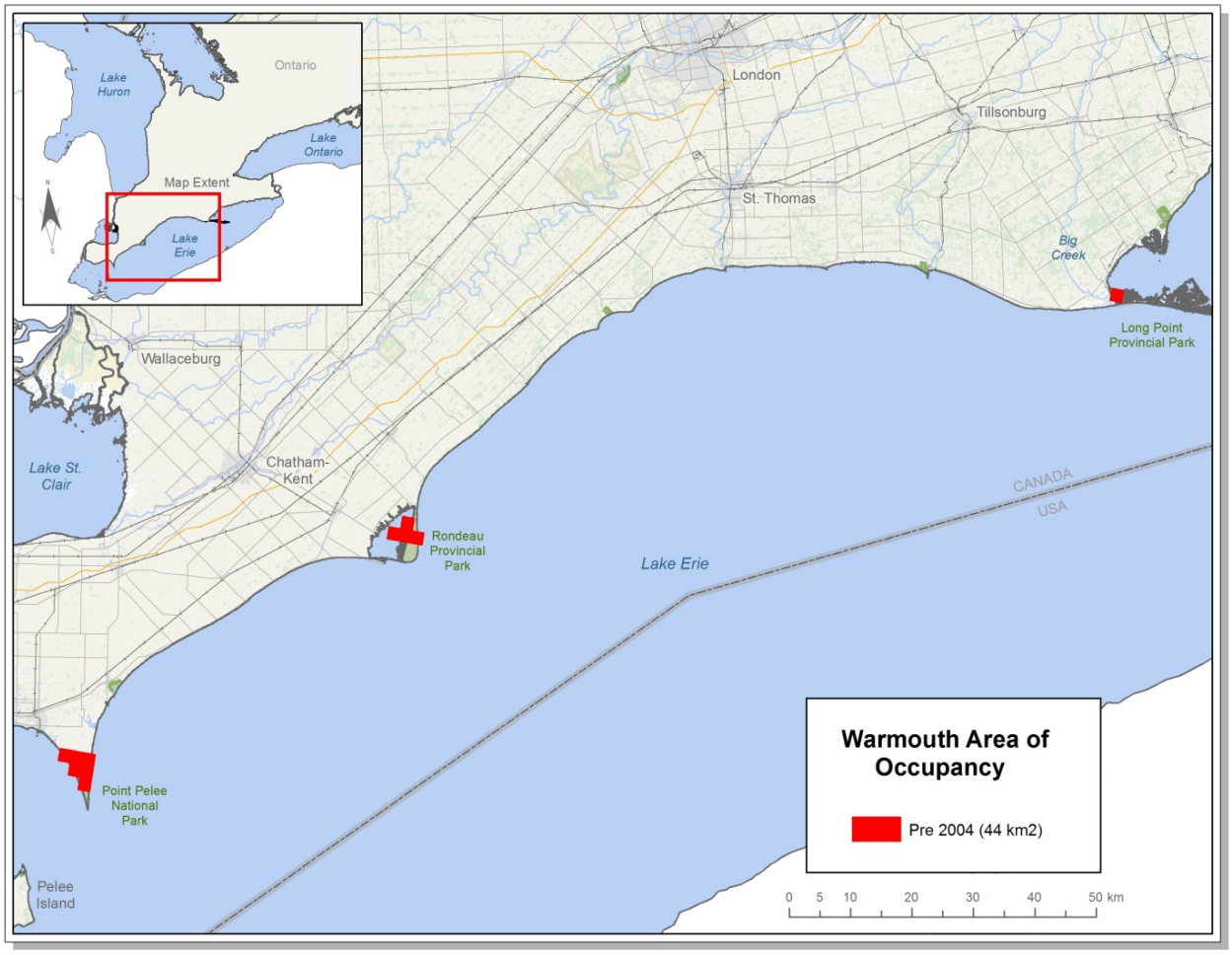

Figure 5(c). Index of area of occupancy for Warmouth, *Lepomis gulosus*, including all historical records (pre-2004).

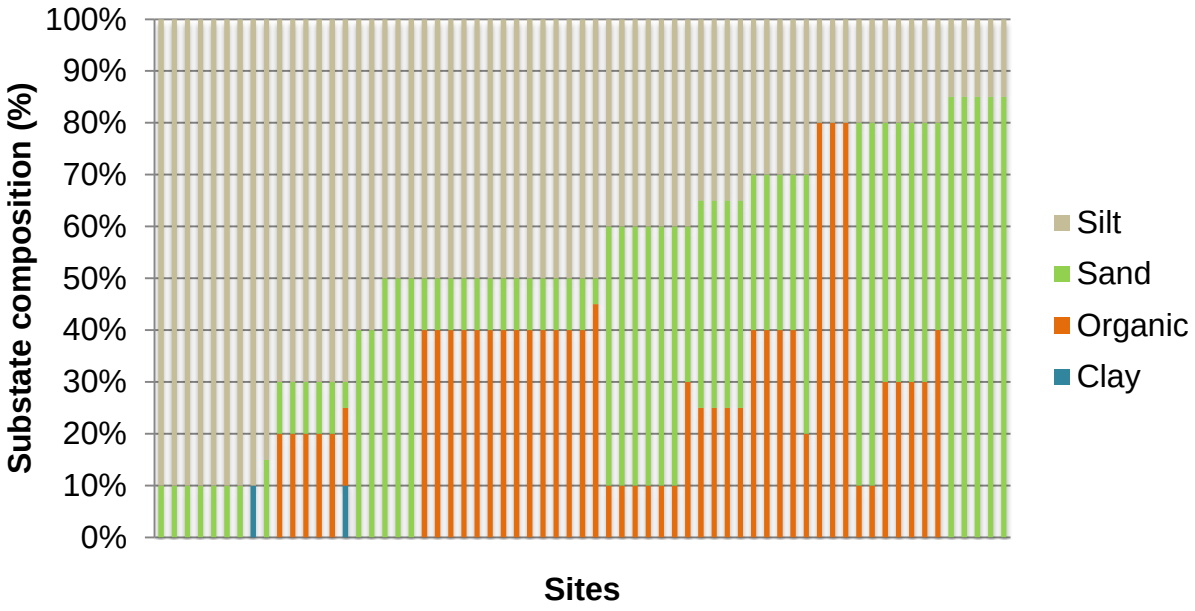

Figure 6. Substrate composition (%) recorded at sites where Warmouth, *Lepomis gulosus*, were recorded from 2005 (n=11), 2007 (n=1) and 2012 (n=46) throughout Long Point Bay.

Habitat Trends

Highlighted as one of the greatest threats to Warmouth populations in Canada (see **THREATS AND LIMITING FACTORS**), extensive historical habitat modifications have occurred in Rondeau Bay and Point Pelee. In Rondeau Bay, approximately 70% of the western shoreline was reclaimed for agricultural or residential use (Gilbert and Locke 2007). Large wetland areas on the northwest shore have been reduced to isolated patches, separated from one another by agricultural fields and residential areas (Gilbert and Locke 2007). The first wetland assessment of Rondeau Bay was conducted in the early 1980s, which estimated the remaining wetlands to cover approximately 740 ha (Gilbert *et al*. 2007). A subsequent estimate of wetland aerial coverage in 2006 indicated that coverage was down to approximately 107 ha (169 ha with buffer areas included) (Gilbert *et al.* 2007). Similarly, it is estimated that close to 60% of the historical wetland at Point Pelee was drained and diked during the late 1800s to mid-1900s for agricultural purposes (Dobbie *et al*. 2006).

The introduction and establishment of invasive aquatic macrophytes have also drastically altered the habitat at Rondeau Bay and Long Point Bay. Substantial stands of European Common Reed (*Phragmites australis* subsp. *australis*) in Long Point Bay and in Rondeau Bay have reduced the amount of potential suitable habitat available for Warmouth (Gilbert and Locke 2007; Badzinski *et al*. 2008).

It has been noted that when European Common Reed experiences optimal growing conditions, it can quickly colonize, killing and displacing native marsh vegetation, resulting in increased accretion of marsh substrate, and ultimately impacting composition and abundance of native flora (Badzinksi *et al*. 2008 and references therein). A study conducted in 2006 aimed to quantify the abundance and distribution of European Common Reed throughout five marsh complexes in Long Point Bay, and was specifically designed to compare the current status to its last assessment, which took place in 1999 (Wilcox *et al.* 2003; Badzinski *et al*. 2008). Overall, it was found that European Common Reed was widely distributed within each marsh complex, and that its abundance greatly increased since the 1999 assessment (Badzinski *et al.* 2008). To quantify changes in abundance and distribution, orthophotos were ground-truthed to determine location and size of vegetative communities (Badzinski et al. 2008). Three of the five marsh complexes included in this study are particularly relevant to Warmouth, noting recent detections of Warmouth from these areas. These include Big Creek Marsh, Crown Marsh and Turkey Point Marsh (see Figure 3d). In Big Creek Marsh, current European Common Reed coverage was estimated to be 76 ha, and when compared to 1999 estimates (3 ha), this represents an approximate annual increase of 48% (Badzinski *et al*. 2008). A similar trend was observed in Crown Marsh where historical levels of European Common Reed (8 ha), when compared to 2006 estimates (48 ha), represented an approximate annual increase in coverage of 27.8% (Badzinski *et al*. 2008). Unfortunately, temporal trends for Turkey Point Marsh could not be provided as 1999 estimates were not available. Continuing increases in European Common Reed distribution and abundance could negatively affect Warmouth populations by decreasing both habitat quality and availability.

It is difficult to predict the long-term effects of climate change on habitat availability for Warmouth as climate change may be both beneficial and detrimental to this species. Doka *et al*. (2006) completed an assessment on the projected impacts of climate change on wetland fish assemblages by ranking fish species vulnerability to climate change. A vulnerability matrix was calculated based on species status, and thermal and habitat associations (Doka *et al*. 2006). Results indicated that, of the 99 fish species assessed, Warmouth was ranked as the second most sensitive species. Predicted effects of climate change have included increases in water temperatures and decreases in both water levels and water level fluctuations (Mortsch 1998; Lemmen and Warren 2004). While increases in water temperatures may allow for increased Warmouth dispersal and colonization into novel habitats, decreases in water levels may restrict available habitat in areas currently occupied by Warmouth (e.g., Rondeau Bay), or may facilitate future European Common Reed invasions and expansions (e.g., Long Point Bay) (Badzinski *et al*. 2008).

BIOLOGY

Life Cycle and Reproduction

Although limited information on life history characteristics is available for Warmouth in Canada, detailed information is available from populations in Illinois (Larimore 1957 *in* Becker 1983). The following information is taken from the account of Larimore (1957) as described in Becker (1983), unless otherwise stated.

The nesting season begins in May, reaching its peak in early June, and declining in early July. The length of the nesting period may differ between populations, and is highly variable across years. It has been shown that Warmouth may spawn several times a summer, when water temperature approaches 21.5°C. Warmouth creates a nesting site over silt and sand substrates, sometimes covered with sticks or other debris, in water 0.6 to 0.8 m deep. The male guards the nest and will actively fan the fertilized eggs.

Age and length at the onset of maturity has been recorded at two years and 89 mm (Carlander 1969). Generation time is thought to be approximately three years (COSEWIC 2005). Fecundity is a function of the size of the individual, as is the case for many freshwater fishes. It has been reported that females 89 to 180 mm long held 4,500 to 37,500 eggs, while females 94 to 137 mm long held 17,200 to 63,200 eggs. Fecundity estimates for Warmouth from Blackwater Lake, South Carolina were estimated to range from 798 to 34,257 eggs per female, and it was proposed that fecundity could be expressed with the following relationship: $\log_{10}F = -4.678 + 3.889 \log_{10}TL$, where F = fecundity and TL = total length (mm) ($r^2 = 0.67$)(Panek and Cofield 1978). The fertilized Warmouth egg was reported to be 0.95 to 1.03 mm in diameter. The fertilized eggs hatched in 34.5 h at water temperatures ranging from 25 to 26.4°C.

The maximum known age for Warmouth is eight years (COSEWIC 2005) and survival rates are unknown. A size-frequency histogram resulting from sampling efforts at Point Pelee in 2002 and 2003 indicated that there was likely a minimum of five age-classes in the Point Pelee population at the time of sampling (Figure 7; H. Surette, University of Guelph, unpubl. data in COSEWIC 2005).

Warmouth is known to hybridize with other centrarchids (Childers 1971). The viability of offspring when Warmouth was paired with Bluegill (*L. macrochirus*), Redear Sunfish (*L. microlophus*), and Green Sunfish (*L. cyanellus*) were shown to be 58, 62 and 62%, respectively (Childers 1971). These viability estimates were provided from a laboratory experiment, and rates of hybridization and viability in a non-laboratory setting are currently unknown.

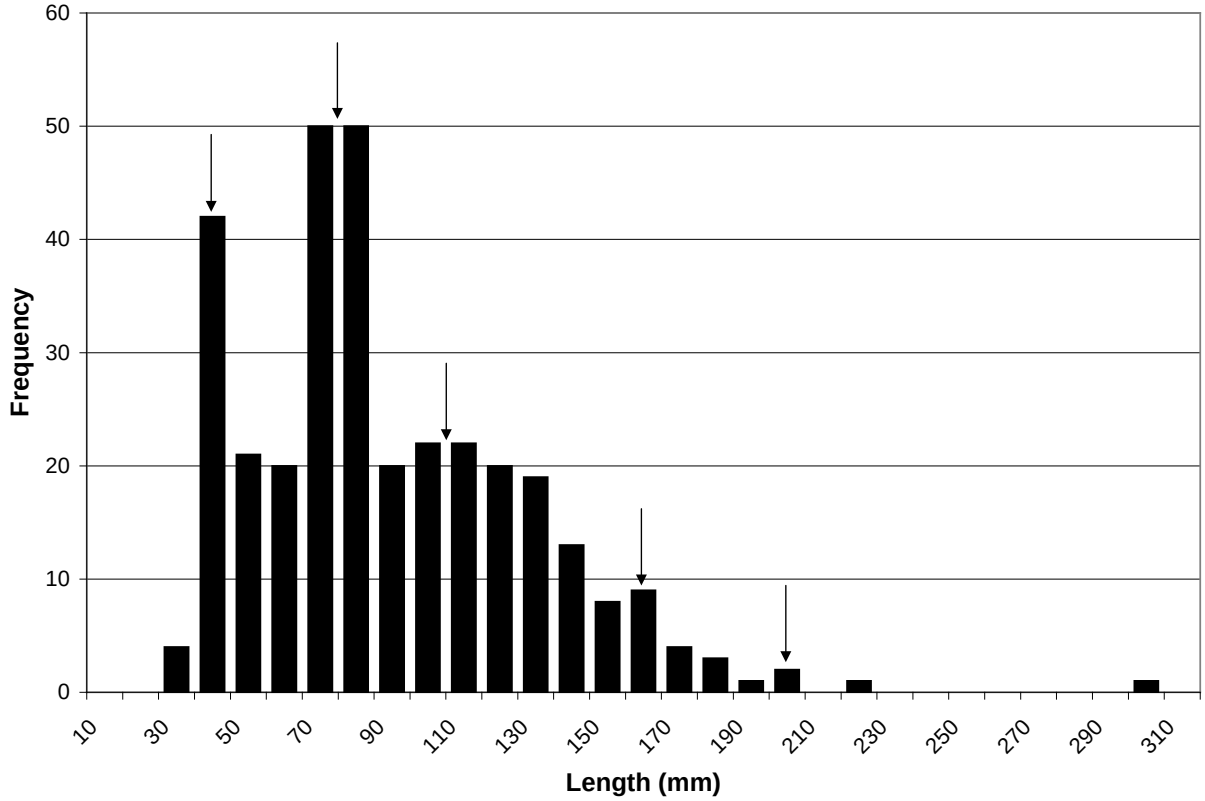

Figure 7. Length-frequency histogram for Warmouth, *Lepomis gulosus*, recorded from Point Pelee National Park in 2002 and 2003 (n=332). Arrows indicate likely year-classes aged 0-4 (H. Surette, University of Guelph, unpubl. data).

Physiology and Adaptability

Little is known regarding the physiology of Warmouth. However, Warmouth is thought to be tolerant of lower oxygen levels and has been noted to survive in oxygen-depleted systems (down to 3.6 ppm) in Illinois waters when water temperature was 20°C (Larimore 1957 *in* Becker 1983). There have been no studies to date that address the adaptability of Warmouth.

Dispersal and Migration

Dispersal ability and movement patterns of Warmouth have been investigated in two eastern Tennessee stream systems (Gatz and Adams 1994). Movement patterns of Warmouth and four additional members of the Centrarchidae family were studied during a three-year mark-recapture study (Gatz and Adams 1994). A total of 123 Warmouth were tagged during the length of the study. Researchers sampled quarterly over the length of the three-year study, and a total of 20 Warmouth were recaptured (Gatz and Adams 1994). The maximum distance a Warmouth travelled between captures was 300 m (Gatz and Adams 1994). Considering all species (Redbreast Sunfish, *Lepomis auratus*, Bluegill, Rock Bass, Largemouth Bass, and Warmouth), a total of 6357 individuals were tagged during the

course of the study, and 1364 were recaptured (Gatz and Adams 1994). Of the recaptured individuals, a total of six fishes (one Redbreast Sunfish, one Largemouth Bass, and three Bluegill) were recorded to have made long distance movements (> 10 km, but no more than 17.6 km). Although this study did not occur in Canadian waters, one could infer that Warmouth demonstrates limited ability for dispersal and migration over large distances.

Interspecific Interactions

Warmouth feeds in both the pelagic and benthic zones and its diet is mainly composed of crustaceans, aquatic insects, crayfishes, molluscs, and other fishes (Carlander 1969; Becker 1983; COSEWIC 2005). Juvenile Warmouth feed primarily on plankton and small insects, while larger Warmouth also include crayfishes, fishes, and insects in their diets (McMahon *et al*. 1984 and references therein). A diet analysis completed by Tumlinson *et al*. (2007) indicated that of the 133 Warmouth stomachs examined, the majority included mayfly (Ephemeroptera) naiads and crayfish.

Circumstantial evidence suggests that Warmouth and Green Sunfish may be competing for resources, in that areas abundant in one species appear to be void of the other species (DFO, unpubl. data). For example, Warmouth appear to be abundant in Point Pelee, where Green Sunfish has not been detected since 1975 (DFO, unpubl. data). Alternatively, Green Sunfish appear to be abundant in Hillman Marsh (a wetland area adjacent to Point Pelee), while Warmouth have not been detected in this system. Additional research is required to elucidate the potential competitive interaction between these two species.

Species-specific information on Warmouth association to both native and non-native aquatic macrophytes is currently not available. However, juvenile sunfish (Bluegill, Green Sunfish, Longear Sunfish and Redear Sunfish) abundance and habitat use among different macrophyte stands has been considered (Collingsworth and Christopher 2010). Sunfish density and plant stem density were compared in non-vegetated areas, stands of Eurasian Milfoil (*Myriophyllum spicatum*), and stands of American Pondweed (*Potomogeton nodosus*) (Collingsworth and Christopher 2010). In this study, juvenile sunfish density was significantly higher in vegetated habitats when compared to non-vegetated; however, there were no significant differences found between the two types of vegetated habitats (Collingsworth and Christopher 2010). It was also noted that although sunfish densities did not differ by macrophyte type, sunfish size structure among vegetated habitats did vary significantly; smaller sunfish selected the denser Eurasian Milfoil stands, while larger sunfish selected for American Pondweed stands (Collingsworth and Christopher 2010). The authors suggested that the denser Eurasian Milfoil stands provided smaller sunfish superior protection from predators.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Sporadic sampling with various gear types makes it difficult to infer trends in Warmouth population sizes. Very little is known of the size of Warmouth populations in Canada. A fish assemblage study conducted in 2002 and 2003 in Point Pelee National Park resulted in the capture of 657 Warmouth (H. Surette, unpubl. data). The size-frequency histogram from this study (Figure 7) indicates an abundance of juveniles, although one must be cautious in the interpretation of these results as it is unknown if repeated captures of juveniles occurred. Many of the larger individuals were PIT-tagged (n=93); however, only three individuals were recaptured, an insufficient number to estimate population size (COSEWIC 2005). The abundance of Warmouth recorded from Point Pelee through this study would suggest an established population.

Since its initial discovery in Long Point Bay in 2003, Warmouth has been detected each year that a sampling event occurred (with the exception of 2008; n=235 detected from 2003 to 2013). The number of individuals detected throughout the various surveys has remained low, with the exception of the commercial hoop net fishery survey completed in 2009 (Table 1c; Gislason 2009). Gislason (2009) reported 141 Warmouth detected from 368 hoop net sets (0.38 catch per lift).

A total of 36 Warmouth have been collected from Rondeau Bay since its discovery in this system in 1966 (Table 1b). Intensive sampling occurred in this system with the appropriate gear in 2004, 2005, 2007, 2008, 2009, for a total of 52 hoop net sets (~24 h sets) and 374 fyke net sets (~24 h sets). When compared to a similar amount of effort in Long Point Bay, Warmouth appears to be present in relatively lower numbers in Rondeau Bay.

It is not possible to estimate population sizes, as there are insufficient data. Consistent sampling, with the appropriate gear to detect Warmouth, would provide a more accurate representation of population sizes and trends through time for the three remaining Warmouth populations in Canada.

Abundance

To date, there have been no studies conducted to determine the abundance or population sizes of Warmouth in Canada.

Fluctuations and Trends

The paucity of historical information and the lack of consistent sampling through time make it impossible to determine population fluctuations or trends associated with Warmouth.

Rescue Effect

Warmouth populations in Canada are currently isolated from one another and from American populations by greater than 50 km. The nearest populations are those in the Michigan tributaries of Lake Erie, not those across Lake Erie in Ohio (Crossman and Simpson 1984). The status ranks of Warmouth populations in neighbouring states are Secure (S5; Michigan), and Apparently Secure (S4; Ohio), Vulnerable (S3; Pennsylvania), while New York is not applicable (SNA) (NatureServe 2014). Large expanses of unsuitable habitat between source Warmouth populations in the United States and current populations in Canada make immigration unlikely. In addition, Warmouth dispersal ability is expected to be limited when compared to other centrarchids (see Gatz and Adams 1994 and **Dispersal and Migration** section).

THREATS AND LIMITING FACTORS

A wide variety of threats negatively impact Warmouth across its range. Our knowledge of threat impacts on Warmouth populations is limited to general documentation, as there is a paucity of threat-specific cause and effect information currently available. The greatest threats to the survival and persistence of Warmouth in Canada are thought to be related to natural system modifications, as a result of aquatic vegetation removal and loss of wetlands, and pollution, as a result of agricultural practices and development.

Threats are discussed and ranked according to the threats calculator (Table 2) following the methods and terminology of Salasky *et al.* (2008), Master *et al*. (2009) and IUCN (2014). The following threat descriptions emphasize the principal threats to Warmouth in Canada. The overall threat impact ranking for Warmouth is medium-low (see Appendix 1).

Table 2. Description of threats that may be impacting Warmouth, *Lepomis gulosus*, in areas where they are known to exist in Canada. The threat classification is based on the IUCN-CMP Unified Classification of Direct Threats classification system (IUCN 2014).

No.	Threat Description	Threat Impact		Scope	Severity	Timing
7.0	Natural system modifications	CD	Medium-Low	Restricted	Extreme-Moderate	High
7.3	Other ecosystem modifications	CD	Medium-Low	Restricted	Extreme-Moderate	High
9.0	Pollution	D	Low	Large	Slight	High
9.1	Household sewage and urban development		Negligible	Large	Negligible	High
9.3	Agriculture and forestry effluents	D	Low	Large	Slight	High
6.0	Human intrusions & disturbance		Negligible	Small	Negligible	Moderate
6.3	Work and other activities		Negligible	Small	Negligible	Moderate
1.0	Residential and commercial development		Negligible	Negligible	Extreme	High
1.1	Housing and urban areas		Negligible	Negligible	Extreme	High
1.3	Tourism & recreation areas		Negligible	Negligible	Serious-Moderate	High
5.0	Biological resource use		Negligible	Pervasive	Negligible	High
5.4	Fishing & harvesting aquatic resources		Negligible	Pervasive	Negligible	High
8.0	Invasive & other problematic species & genes		Unknown	Pervasive	Unknown	High

No.	Threat Description	Threat Impact	Scope	Severity	Timing
8.1	Invasive non-native/alien species	Unknown	Pervasive	Unknown	High
11.0	Climate change & severe weather	Unknown	Pervasive	Unknown	High
11.1	Habitat shifting & alteration	Unknown	Pervasive	Unknown	High
4.0	Transportation & service corridors	Unknown	Small	Unknown	Unknown
4.3	Shipping lanes	Unknown	Small	Unknown	Unknown

Natural System Modifications (7.3 Other ecosystem modifications)

One of the greatest threats to Warmouth is the loss of its preferred habitat consisting of heavily vegetated, shallow areas. Rondeau Bay has undergone extensive modifications. Much of the wetland habitat found along the western shoreline has been lost due to ditching, diking, infilling, and hardening of shoreline for both agricultural and residential purposes (Gilbert *et al*. 2007). Historically, wetlands bordered the entire shore of Rondeau Bay and appeared as a large contiguous system (Gilbert and Locke 2007). The first wetland assessment of Rondeau Bay was conducted in the early 1980s and, by this time, the wetland complex on the northwest shore had been reduced to isolated patches totalling approximately 740 ha, with a further reduction in 2006 to approximately 107 ha (Gilbert *et al*. 2007).

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

The feeding behaviour of Common Carp (*Cyprinus carpio*) is known to have serious negative impacts on aquatic systems by uprooting aquatic vegetation and increasing turbidity levels (Lougheed *et al*. 1998, 2004). This feeding behaviour, known to cause significant alterations to native wetland habitats, may have significant effects on Warmouth, which is dependent on aquatic vegetation for many of its life processes.

A study at Point Pelee National Park (Sanctuary Pond) was completed in 1994 to determine the cause of elevated nutrient concentrations leading to prolific algal growth (Mayer *et a*l. 1999). It was determined that organic matter decomposition was an important mechanism leading to high concentrations of nutrients and that resuspension of bottom sediment, primarily by Common Carp foraging behaviour, was most likely responsible for the hypereutrophic conditions (Mayer *et al*. 1999).

It is also well known that exotic aquatic macrophytes can drastically alter the aquatic vegetation complex by outcompeting native plants. One such invasive plant species is the European Common Reed, which forms dense monotypic stands, outcompeting native species (Gilbert and Locke 2007) and reducing the amount of open-water habitat. European Common Reed is found in abundance at Rondeau Bay and Long Point Bay and is not only reducing the native floral diversity (Gilbert *et al.* 2007; Badzinski *et al*. 2008), but also, in high-density stands, can reduce the amount of available habitat for Warmouth (see **Habitat Trends** for additional information on the spread of European Common Reed in Long Point Bay).

A second, invasive macrophyte that may have both positive and negative effects on Warmouth is Eurasian Milfoil. Collingsworth and Christopher (2010) indicated that small juvenile sunfish preferentially selected stands of Eurasian Milfoil when compared to American Pondweed stands, suggesting that the denser Eurasian Milfoil stands may be providing superior protection from predation (see **Interspecific Interactions** for additional details). However, Eurasian Milfoil is also known to grow into dense vegetation mats, blocking sunlight to submergent macrophytes, increasing phosphorus and nitrogen inputs, increasing pH and temperature, and creating potentially unsuitable habitat for Warmouth (Gilbert *et al*. 2007). This negative effect may be particularly relevant to Warmouth at Point Pelee National Park and Rondeau Bay where Eurasian Milfoil can flourish under ideal growing conditions. The submerged macrophyte community on the western and central to northern sections of Rondeau Bay tend to be dominated by Eurasian Milfoil and Coontail (*Ceratophyllum demersum*), which have been noted to reach high densities and biomass between 500 and 1300 $g \cdot m^{-2}$ dry weight (Gilbert *et al*. 2007). Studies are required to elucidate the overall effect of Eurasian Milfoil on Warmouth populations.

Dreissenid mussels are pervasive throughout the Canadian range of Warmouth. The mussels have improved water clarity in some areas of the Great Lakes (Binding *et al*. 2007), leading to increased growth of both native and invasive aquatic macrophytes (Higgins and Vander Zanden 2010); however, the net effect on Warmouth cannot be readily determined.

Grass Carp (*Ctenopharyngodon idella*), native to Eurasia, has recently been found to be reproducing in Maumee Bay in western Lake Erie (Chapman *et al.* 2013). Grass Carp is an invasive herbivore known to severely negatively impact aquatic macrophytes (Wittmann *et al*. 2014). It is not known if Grass Carp will expand into the Canadian range of Warmouth within the next 10 years but, if it does, it could have a significant negative impact on Warmouth habitat.

Aquatic Vegetation Removal (1.1 Housing and Urban Areas; 1.3 Tourism and Recreation Areas; 4.3 Shipping Lanes)

A habitat modification that requires specific attention is the removal of aquatic vegetation for residential, recreational, and transportation purposes. Warmouth is highly dependent on heavily vegetated, shallow nearshore areas for many of its life processes. Warmouth is known to use these areas throughout its life cycle as spawning and nursery

grounds, as well as foraging habitat. Destruction and removal of aquatic vegetation in the nearshore area of lakes and wetland systems may have detrimental effects on the associated Warmouth population. In addition to the implications of vegetation removal, the physical act of removing aquatic vegetation may also have negative impacts on Warmouth. It has been noted that the mechanical option is preferred to chemical treatment for both habitat and aesthetic reasons, as the mechanical option reduces the oxygen demand from decaying vegetation (Gilbert *et al*. 2007).

Historical large-scale and recent small-scale vegetation removal operations have been recorded for Rondeau Bay. Primarily, these removals have occurred because the presence of submerged aquatic macrophytes can become a nuisance to recreational activities when it reaches high densities (Gilbert *et al*. 2007). In Rondeau Bay, authorized and un-authorized chemical and mechanical vegetation removal are common place.

Limited mechanical vegetation removal does occur at both Long Point Bay (within the area of Warmouth occurrence) and Point Pelee National Park. There has been no known chemical vegetation removal at Point Pelee National Park (V. McKay, Parks Canada Agency, pers. comm. *in* Bouvier and Mandrak 2010) and, although chemical vegetation removal has been known to occur at Long Point Bay, it is now common practice to opt for mechanical removal.

Pollution (9.1 Household sewage and urban wastewater; 9.3 Agriculture and forestry effluents)

Degradation of Warmouth preferred habitat may result from increases in nutrient (nitrates and phosphorus) loading. Increased nutrient loading can be the result of fertilizer releases into the waterbody, loading from sewage treatment plants, and nutrient runoff from manure piles. These increased nutrient levels can subsequently lead to the development of algal blooms and, consequently, to decreased levels of dissolved oxygen once the blooms begin to senesce (Gilbert *et al*. 2007). Nutrient loading has been listed as a primary threat to Long Point Bay, Point Pelee National Park, and Rondeau Bay, which are all areas currently occupied by Warmouth (Essex-Erie Recovery Team 2008).

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

Increases in sediment loading and turbidity may be detrimental to Warmouth survival and recovery. Warmouth was ranked as moderately intolerant to turbidity based on its occurrence and relative abundance pattern across a wetland turbidity gradient (Trebitz *et al*. 2007). Increases in sediment loading and turbidity can be attributed to poor agricultural and land management practices, improper drain maintenance practices, dredging activities, and the removal of riparian vegetation (Staton *et al*. 2012). Indirect negative effects of increased turbidity on Warmouth may include decreases in preferred habitat through decreased water clarity, impeding light penetration, leading to decreasing macrophyte growth, resulting in a loss of habitat.

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

At Point Pelee National Park, altered sediment transport along the Lake Erie shoreline has increased erosion of the barrier beach, leading to increases in breaching events (Dobbie *et al*. 2006; Surette 2006). This has resulted in water quality declines, including increases in turbidity levels in the park (V. McKay, Parks Canada Agency, pers. comm. *in* Bouvier and Mandrak 2010)

An evident turbidity plume has been noted in Long Point Inner Bay originating from the mouth of Big Creek (Bouvier and Mandrak 2010). Although turbidity values are currently not available for this area, the extent of the turbidity plume does encompass the area of occurrence for Warmouth, and may be negatively impacting Warmouth habitat.

Human Intrusions and Disturbance (6.3 Work and other activities)

Incidental harm on Warmouth during implementation of scientific research is thought to be minimal. Precautionary steps are taken to ensure that there is minimal to no harm to the individuals being collected. Provincial and national park scientific collection permits are required for fish sampling in Ontario and would stipulate that all species at risk must be immediately released.

Residential and Commercial Development (1.1 Housing and urban areas)

A distinct challenge presents itself when considering the effect of development on Warmouth at Long Point Bay as the various regions within the bay are facing varying levels of development pressure. Big Creek Marsh would face very little development pressure as this is a National Wildlife Area, which is afforded protection and is managed by Canadian Wildlife Service, Environment Canada. The northwestern shore of the bay faces increasing pressures from residential developments and the construction of marinas.

There remains a very small percentage of natural forest cover (~3.3%) throughout the Rondeau Bay watershed. It is estimated that approximately 70% of the western shoreline has been reclaimed for agricultural or residential use (Gilbert and Locke 2007). Expanding land for farming or residential properties has come at the expense of the nearshore wetlands (Gilbert and Locke 2007).

Biological Resource Use (5.4 Fishing & harvesting aquatic resources)

The use of Warmouth as a baitfish is illegal in Ontario (Ontario Ministry of Natural Resources 2013). However, as with most fisheries, the potential exists for capturing non-target fishes as bycatch during angler and commercial baitfish harvest. The degree of bycatch is dependent on the distribution and intensity of baitfish harvest in relation to the distribution of Warmouth. Bycatch of Warmouth during angler harvest of bait is currently unknown, due to uncertain angler practices (Drake and Mandrak 2014a), but commercial harvest practices have been estimated (Drake and Mandrak 2014b). Drake and Mandrak (2014b) estimated Warmouth bycatch potential from Great Lakes tributaries and determined that the probability of randomly selecting a tributary harvest site containing target baitfishes and Warmouth was $P = 0.000087$ (rarer than 1 out of 11000 sites). Based on a generic harvest model, estimated bycatch-effort relationships indicated that 34,246 harvest events would be necessary for a single event to have a median 95% chance of capturing Warmouth as bycatch during the pursuit of target species (Drake and Mandrak 2014b). Non-target species closely related to Warmouth predicted to be captured frequently, such as Rock Bass and Pumpkinseed (*Lepomis gibbosus*), would require only 17 events for a single event to reach the 95% threshold. The estimated capture probabilities of Warmouth were among the lowest of all species in Ontario waters. A study of the Ontario baitfish pathway (Drake 2011; Drake and Mandrak 2014a) did not document Warmouth during sampling of baitfish retailers (n = 68) or purchased fishes (a cumulative total of 16,886 fishes) in southern Ontario during August-October, 2007 and February 2008 (Drake 2011; Drake and Mandrak 2014a).

Under the Ontario Fishery Regulations, Warmouth is considered a ‘Sunfish’ and can be legally caught under a sport fishing licence, which allows an angler to keep up to 25 and 50 ‘Sunfish’ under a conservation licence and regular licence, respectively. A separate National Parks angling licence is required to sport fish in Point Pelee National Park. Sunfishes are not a preferred sport fish in Ontario and this species rarely grows large enough to be of interest to anglers; therefore, recreational angling likely has a negligible impact on Warmouth.

Incidental catch of Warmouth in commercial fishing does occur. A study was conducted in 2009 at Long Point Bay on the effects of commercial fishing on aquatic species at risk (Gislason *et al*. 2010). In this study, 368 commercial hoop net lifts were monitored for aquatic species at risk, and 141 Warmouth were recorded (0.38 catch per lift; Gislason *et a*l. 2010). Unfortunately, Warmouth abundance estimates in Long Point Bay are not available; creating a challenge in determining what proportion of the population is being affected by commercial fishing practices. As a result of this study, outreach has been undertaken to make fishers aware of the species at risk that they may by-catch and must

release (N. Mandrak, pers. comm.). Increased educational outreach will decrease any potential negative effects of commercial fishing on Warmouth. In addition, the effects of the draw-seine commercial fishing industry on Warmouth at Long Point are currently unknown and require additional research.

Invasive and Other Problematic Species and Genes (8.1 Invasive non-native/alien species)

Round Goby (*Neogobius melanostomus*) and dreissenid mussels are pervasive throughout the Canadian range of the Warmouth. The effects of these species on Warmouth are unknown. The mussels have improved water clarity in some areas of the Great Lakes (Binding *et al*. 2007), leading to increased growth of both native and invasive aquatic macrophytes (Higgins and Vander Zanden 2010); however, the net effect on Warmouth cannot be readily determined.

Climate Change and Severe Weather (11.1 Habitat shifting and alteration)

Through discussion of the effects of climate change on Canadian fish populations, impacts such as increases in water and air temperatures, changes (decreases) in water levels, shortening of the duration of ice cover, increases in the frequency of extreme weather events, emergence of diseases, and shifts in predator-prey dynamics have been highlighted, all of which may negatively impact native fishes (Lemmen and Warren 2004). Aligning with the current hypothesis that Warmouth dispersal and colonization into Canadian waters may be restricted by current water temperatures (Crossman *et al*. 1996), an increase in water temperature, as a result of climate change, may allow for increased dispersal and colonization into novel habitats. Conversely, Warmouth may be particularly sensitive to the effects of climate change due to its thermal and habitat associations (Doka *et al*. 2006), leading to negative overall effects on Warmouth populations. This is supported by an assessment on fish species vulnerability to climate change, in which Warmouth ranked as second most sensitive species when compared to 98 other species assessed (Doka *et al*. 2006).

Number of Locations

The number of locations where Warmouth occur was determined to be three (Rondeau Bay, Point Pelee and Long Point Bay). There is currently no information available to infer population connectivity from genetic assessments. The Warmouth's limited dispersal abilities (see **Dispersal and Migration**), presence of large stretches of unsuitable habitat that inhibit movement, and the non-catastrophic, spatially independent nature of the most serious threat to Warmouth (i.e., natural system modification; see **Threats and Limiting Factors**) is consistent with the identification of these geographic areas as three locations.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Warmouth is currently listed as Special Concern on Schedule 1 of the *Species at Risk Act*. This listing does not afford any protection of the species or its habitat but does require the preparation of a management plan. Although the *Species at Risk Act* does not afford protection to Warmouth directly, the Warmouth populations do co-occur with other species currently listed as Threatened or Endangered under the *Species at Risk Act* (e.g., Spotted Gar, *Lepisosteus oculatus*; Pugnose Shiner, *Notropis anogenus*; Lake Chubsucker, *Erimyzon sucetta*) and, therefore, may be afforded indirect protection.

Warmouth is also listed as Special Concern under the provincial *Endangered Species Act*, 2007, although species of Special Concern do not receive legal protection under this act. Similar to the indirect protections afforded to Warmouth under the *Species at Risk Act*, Warmouth does co-occur with other species currently listed as Threatened or Endangered under the *Endangered Species Act*, providing additional indirect protection.

The collection of freshwater fishes is managed under the *Fish and Wildlife Conservation Act* and requires that a scientific collectors permit be issued by the Ontario Ministry of Natural Resources.

The federal *Fisheries Act* once represented an important piece of legislation in the direct protection of Warmouth habitat. Recent changes to the *Fisheries Act* have altered the protection of Warmouth habitat to allow for protection only in areas where a Commercial, Recreational, or Aboriginal fishery of importance is present. Distributional overlap between Warmouth and various commercial and recreational fisheries species does exist, resulting in application of the new *Fisheries Act* to all locations that Warmouth currently occupy.

Non-Legal Status and Ranks

Warmouth is currently assessed as Special Concern by COSEWIC. It is listed as globally secure (G5) and nationally secure (N5) in the United States (Table 3). It is considered secure or apparently secure in the majority of states, with the exception of Virginia (S2; imperiled), Pennsylvania (S3; vulnerable) and Illinois (S3S4; vulnerable/apparently secure). In Canada, it is ranked as critically imperilled both federally (N1) and provincially (S1).

Table 3. Global (G), National (N) and Sub-national (S; State or Province) ranks and status of Warmouth, *Lepomis gulosus* (NatureServe 2014).

Global	National		Subnational	
	United States	**Canada**	**United States**	**Canada**
G5 (Sept 1996)	**N5** (Dec 1996)	**N1** (Oct 2012)	**S2**: Virginia **S3**: Pennsylvania **S3(?)**: Maryland **S3S4**: Illinois **S4**: Arkansas, Indiana, Ohio, Wisconsin **S5**: Alabama, Louisiana, Michigan, Mississippi, North Carolina, Oklahoma, Tennessee, Texas, Virginia **S4S5**: Georgia, Kansas, Kentucky **SNA**: Arizona, Delaware, District of Columbia, Idaho, Nevada, New Jersey, New Mexico, New York, Oregon, Washington **SNR**: Florida, Iowa, Minnesota, Missouri, South Carolina	**S1**: Ontario

*G/S ranks: 1=critically imperiled; 2=imperiled; 3=vulnerable; 4=apparently secure; 5= secure; SNA =Not applicable; SNR = Unranked.

Habitat Protection and Ownership

!!In Canada, amendments to the federal *Fisheries Act* came into force in November 2013. These amendments allow for habitat protection only for Commercial, Recreational or Aboriginal fisheries. As Warmouth co-occurs with these fisheries, it would receive indirect protection under the *Fisheries Act.* Habitat for the species may also be protected by other federal legislation including the *Canadian Environmental Assessment Act*.

Although Warmouth is currently listed as Special Concern under both the *Species at Risk Act* and the *Endangered Species Act*, 2007, this designation does not afford Warmouth any additional habitat protection. However, Warmouth habitat would receive indirect protection under the Federal Policy on Wetland Conservation (Environment Canada 1991). Other Ontario legislation that may protect Warmouth habitat includes the *Environmental Protection Act*, *Ontario Environmental Assessment Act*, *Planning Act*, and *Water Resources Act*. In Ontario, aquatic habitats that fall within regulated lands of a Conservation Authority are protected against wetland infilling, shoreline alterations and work occurring within the floodplain by the *Conservation Authorities Act*. Despite these legislative protections, many of the threats facing Warmouth are not currently regulated.

Warmouth is known to occupy both Point Pelee National Park and Rondeau Bay Provincial Park; therefore, Warmouth habitat may receive additional protections under the *National Parks Act* and *Provincial Parks Act.*

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BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Lynn D. Bouvier is a Species at Risk Science Advisor with Fisheries and Oceans Canada in Burlington, Ontario. She holds a BSc (Hons.) in Marine and Freshwater Biology from the University of Guelph (2003). She also completed an MSc in Zoology at the University of Guelph (2006), where she researched the effects of wetland aquatic connectivity on freshwater fish assemblages. Lynn has been studying freshwater fish and mussel fauna of the Great Lakes for over 10 years. Her current interests include biodiversity, fish and mussel species at risk in Canada, and the assessment of the threats negatively affecting these species.

Dr. Nicholas E. Mandrak is a Research Scientist with Fisheries and Oceans Canada in Burlington, Ontario. His research interests are the biodiversity, biogeography and conservation of Canadian freshwater fishes. Nick has co-authored 35 COSEWIC reports and the ROM Field Guide to Freshwater Fishes of Ontario.

COLLECTIONS EXAMINED

None.

Appendix 1. IUCN Threats Calculator on the Warmouth (*Lepomis gulosus*)

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Warmouth (*Lepomis gulosus*)
Element ID	
Date	03/06/2014
Assessor(s):	Ruben Boles, Jen Shaw, Scott Reid, Nick Mandrak, John Post, Mary Sabine, Angele Cyr, Dave Fraser, Doug Watkinson
References:	

Overall Threat Impact Calculation		**Level 1 Threat Impact Counts**	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	1	0
D	Low	1	2
Calculated Overall Threat Impact:		Medium	Low

Assigned Overall Threat Impact:	**CD = Medium - Low**
Impact Adjustment Reasons:	
Overall Threat Comments	***Generation Time ~ 3 years. 3 X gen time = 9 years***

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	development has already occurred. No projections for growth. Cottages but no plans for development of new cottages. This threat has occurred in the past. Negligible in the future.
1.2	Commercial & industrial areas						ongoing effects from existing marina. Not likely to have new marina development. Some loss of habitat (lost vegetation) from dredging. Sedimentation from dredging is accounted for in 4.3. also weed removal from weed wacking. Quick recolonization assumed.
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Serious - Moderate (11-70%)	High (Continuing)	not applicable
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						some pollution that is ongoing accounted for in 9.0. no land conversion from agriculture
2.2	Wood & pulp plantations						not applicable
2.3	Livestock farming & ranching						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.4	Marine & freshwater aquaculture						not applicable
3	Energy production & mining						
3.1	Oil & gas drilling						not applicable
3.2	Mining & quarrying						not applicable
3.3	Renewable energy						not applicable
4	Transportation & service corridors		Unknown	Small (1-10%)	Unknown	Unknown	
4.1	Roads & railroads						not applicable
4.2	Utility & service lines						not applicable
4.3	Shipping lanes		Unknown	Small (1-10%)	Unknown	Unknown	Rondeau Bay has some boating but no ships. Ongoing threat from this activity. Maintaining and usage unknown. Need to verify if the same lanes are used or if these are changed since this will affect the severity. Diquad applications lack precision.
4.4	Flight paths						not applicable
5	Biological resource use		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						not applicable
5.2	Gathering terrestrial plants						not applicable
5.3	Logging & wood harvesting						not applicable
5.4	Fishing & harvesting aquatic resources		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	ongoing threat from recreational fishing causing decline in recruitment. Bycatch. However not intensive.
6	Human intrusions & disturbance		Negligible	Small (1-10%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	
6.1	Recreational activities						recreational boating not directly impacting population size
6.2	War, civil unrest & military exercises						not applicable
6.3	Work & other activities		Negligible	Small (1-10%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	incidental harm during scientific research minimal.
7	Natural system modifications	CD	Medium - Low	Restricted - Small (1-30%)	Extreme - Moderate (11-100%)	High (Continuing)	
7.1	Fire & fire suppression						not applicable
7.2	Dams & water management/use						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications	CD	Medium - Low	Restricted - Small (1-30%)	Extreme - Moderate (11-100%)	High (Continuing)	past agricultural activities (removal of shoreline vegetation) is historical. Ongoing modification related to marinas, cottages and shipping lanes accounted for under threat 1, 2 and 4. possible net benefit from increased submerged vegetation as a result of removal of floating vegetation from increased light penetration. possibly negligible impact. Invasives altering habitat such as conversion of aquatic habitat into terrestrial. Phragmites and Milfoil altering habitat to terrestrial as well as altering the the pH and dissolved oxygen at Long Point Bay and Rondeau Bay. decreased water levels. Common Carp feeding behaviour known to have serious negative impacts by uprooting aquatic vegetation and increasing turbidity levels. This threat could be underscored if Milfoil and Carp have a higher impact then predicted since only Phragmites considered in calculation. Grass Carp now established in lake Erie. Unlikely establishment in Warmouth habitat in the next 10yrs but possible. Zebra Mussels increasing clarity of water altering habitat.
8	Invasive & other problematic species & genes		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Ongoing threats from Phragmites, Milfoil and Carp all result in habitat alteration and therefore accounted for in 7.3. Effects of Round Goby are prevasive in Long Point Bay. This needs confirmation. Zebra mussels increased clarity of water impacts habitat alteration (7.3)
8.2	Problematic native species						not applicable
8.3	Introduced genetic material						not applicable
9	Pollution	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
9.1	Household sewage & urban waste water		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	loading from household sewage treatment plant is ongoing but nutrients are likely from agricultural runoff (9.3). Septic systems in Long Point Bay and Rondeau affecting water quality. Nutrient loading is causing algal blooms in Lake Erie.
9.2	Industrial & military effluents						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.3	Agricultural & forestry effluents	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	agricultural runoff and drainage affecting the quality of water and nutrient loading. Sediment loading from drains is also prevelent but uncertainty wrt impact. This threat is historical.
9.4	Garbage & solid waste						not applicable
9.5	Air-borne pollutants						not applicable
9.6	Excess energy						not applicable
10	Geological events						
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides						not applicable
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	accounted for in 7.3 for aquatic habitat conversion.
11.2	Droughts						prediction of lowered water levels from increased evaporation as a result of increased temperatures. Unknown anticipated decline from drought. Changes in precipitation and temperature changes or droughts are all interrelated and accounted for in 11.1.
11.3	Temperature extremes						not applicable
11.4	Storms & flooding						changes in population isolation patterns from predators breached as a result of storm events such as Round Goby. Indirect effect of invasive species accounted for under 8.1.

Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).