

Ontario Species at Risk Evaluation Report for

Lake Whitefish

Grand corégone

(Coregonus clupeaformis)

Opeongo Lake Small-bodied population

Opeongo Lake Large-bodied population

Como Lake Small-bodied population

Como Lake Large-bodied population

Committee on the Status of Species at Risk in Ontario

(COSSARO)

Opeongo Lake Small-bodied population

Opeongo Lake Large-bodied population

Assessed by COSSARO as Threatened

Como Lake Small-bodied population

Como Lake Large-bodied population

Assessed by COSSARO as Extinct

August 2020

Grand corégone (*Coregonus clupeaformis*)

Le grand corégone est un poisson d'eaux froides, long de 30 cm en moyenne, dont l'aire de répartition couvre la quasi-totalité du Canada. Dans certains lacs, le grand corégone a coévolué en paires d'espèces formant deux populations distinctes d'individus de petite taille et d'individus de grande taille. Ces paires se distinguent par leur apparence, occupent des habitats différents et sont les fruits de phénomènes évolutifs récents. Ces paires ne sont pas des espèces différentes, mais des souches distinctes. Ce même phénomène évolutif a été documenté pour d'autres poissons lacustres du Canada, notamment l'épinoche à trois épines (*Gasterosteus aculeatus*) de la Colombie-Britannique et l'éperlan arc-en-ciel (*Osmerus mordax*) du Nouveau-Brunswick.

En Ontario, des paires de grands corégones uniques sont enregistrées dans quatre lacs. Des preuves d'un isolement reproductif entre les paires ont été recueillies pour le lac Opeongo du parc provincial Algonquin et le lac Como, situé dans le bassin de la rivière Micipicoten du lac Supérieur. L'insuffisance de preuves empêche de confirmer un isolement reproductif des paires d'espèces observées dans le lac Supérieur et le lac Simcoe.

Dans le lac Opeongo et le lac Como, le grand corégone comble deux niches d'habitat distinctes. L'une (forme de petite taille) occupe souvent les eaux de surface, tandis que l'autre (forme de grande taille) se trouve fréquemment dans un habitat près du fond du lac.

Les paires d'espèces de grand corégone sont présentes dans un seul emplacement, ce qui les rend vulnérables à l'extinction. Une évaluation des paires de grands corégones du lac Opeongo les classe dans la catégorie des espèces menacées en raison de leur aire de répartition très restreinte et de leur exposition à une rapide extinction.

Dans le lac Como, l'invasion accidentelle du cladocère épineux (*Bythotrephes longimanus*) a entraîné l'extinction des deux formes.

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Executive summary

Lake Whitefish (*Coregonus clupeaformis*) is a cool water fish that averages about 30 cm in length and is distributed across much of Canada. In some lakes, Lake Whitefish have co-evolved as species pairs with two distinct populations of Larger and Smaller bodied individuals. These pairs are distinct in appearance, occupy different habitats and represent recent evolutionary processes. These pairs are not different species, but distinct lineages. This same evolutionary phenomenon has been documented in other lake fishes in Canada including Three-spined stickleback (*Gasterosteus aculeatus*) in BC and Rainbow Smelt (*Ismerus mordax*) in New Brunswick.

In Ontario, unique Lake Whitefish pairs have been documented in four lakes. Evidence of reproductive isolation between the pairs has been documented for Lake Opeongo in Algonquin Provincial Park, and Como Lake, located in the Michipicoten River basin of Lake Superior. There is insufficient evidence to confirm reproductive isolation of the species pairs observed in Lake Superior and Lake Simcoe.

In Lake Opeongo and Como Lake a “Small-bodied” and “Large-bodied” form have evolved to fill two separate niches within the lakes. The Small-bodied form often occupies surface waters, while the Large-bodied-form are often found in near the bottom of lake.

Lake Whitefish species pairs each occur in a single location which makes them vulnerable to extinction. The Lake Opeongo Lake Whitefish pairs are assessed as Threatened because it has a very restricted range and is vulnerable to rapid extinction. In Como Lake, the accidental invasive of the Spiny Waterflea (*Bythotrephes longimanus*) has resulted in the extinction of both forms.

1. Eligibility for Ontario status assessment

1.1. Eligibility conditions

1.1.1. Taxonomic distinctness

Lake Whitefish (*Coregonus clupeaformis*) is a distinct species. The rapid evolution of whitefishes has resulted in several lakes containing two evolutionary discrete forms, referred to as “species pairs”. Each whitefish species pair is assumed to be geographically isolated from the others, and thus unique to their lake.

1.1.2. Designatable units

COSEWIC recently assessed five whitefish pairs that were divided into ten designatable units (DUs) (COSEWIC, 2018). The pairs in these lakes have differentiated to varying degrees and by different mechanisms but the divergence is likely the result of local adaptation. Hence, there is strong argument that each form in each species pair in each lake represents a unique component of whitefish diversity, and each species pair DU should be considered discrete and significant. These Lake Whitefish species pairs are likely irreplaceable if lost.

The definition and assessment of these species pairs as DUs is consistent with the definition of species in Ontario’s *Endangered Species Act* (2007):
“*species*” means a species, subspecies, variety or genetically or geographically distinct population of animal, plant or other organism, other than a bacterium or virus, that is native to Ontario.

Other species pairs have been assessed by COSEWIC including European Whitefish (*Coregonus lavaretus*) in the Yukon, Threespine Stickleback (*Gasterosteus aculeatus* and *G. spp.*) in British Columbia and Rainbow Smelt (*Osmerus mordax*) in New Brunswick.

There is direct genetic evidence supporting the reproductive isolation of the species pair in Lake Como, and indirect (morphological) evidence of reproductive isolation in Opeongo Lake. However, there is insufficient data to establish reproductive isolation of other whitefish species pairs in Lake Superior and Lake Simcoe. Consequently, these two lakes are not identified as separate designatable units (Mee et al., 2015). They are included in the Great Lakes designatable unit, which includes all Ontario Lake Whitefish other than Opeongo Lake and Como Lake, as well as western Quebec and the upper St. Lawrence River. The Great Lakes DU was not evaluated by COSEWIC in 2018 (COSEWIC, 2018).

The lakes of Algonquin Provincial Park have been thoroughly surveyed, and other forms of Lake Whitefish have been documented that do not occur in Lake Opeongo (Ridgway et al., 2018). Big Trout Lake has the normal form of benthic-feeding Lake Whitefish and a form that is a Cisco mimic that feeds on zooplankton in the open water. The absence of Cisco (*Coregonus artedii*) has allowed Lake Whitefish to develop bottom feeding and

plankton-feeding forms in this lake. Lake La Muir does not have the typical bottom form of Lake Whitefish but rather a plankton-feeding form occupying open water — effectively a cisco mimic. Lake La Muir does not have a deepwater oxygen deficit so the lack of bottom-feeding Lake Whitefish can't be attributed to degraded habitat. This Lake Whitefish population may be the only of its kind in Canada. None of these lakes are connected to Lake Opeongo and these forms have evolved independently.

1.1.3. Native status

Como Lake and Lake Opeongo Lake Whitefish pairs are native to Ontario and the species pairs have evolved in these lakes. Whitefish pairs were first sampled in Como Lake in 1989 (Reid et al., 2017) and in Lake Opeongo in 1938 (Kennedy, 1943).

1.1.4. Occurrence

In Lake Opeongo, the large-bodied form appears to be extant based on sampling from 1999-2013. The age and growth analyses required to identify the small-bodied benthic form have not been conducted since 1986 but it is still likely present (COSEWIC, 2018). Sampling for the benthic form was conducted in the summer of 2018, and analysis is on-going (Ridgway, 2020).

In Como Lake, the species pair first collected in 1989 appears to have been replaced by a single form not morphologically matching either of the original forms based on sampling that was conducted between 2011-2016 (COSEWIC, 2018).

1.2. Eligibility results

Lake Whitefish (*Coregonus clupeaformis*) Opeongo Lake Small-bodied population/ Opeongo Lake Large-bodied population, and Lake Whitefish Como Lake Small-bodied population/ Como Lake Large-bodied population are eligible for status assessment in Ontario.

2. Background information

2.1. Current designations

- GRANK (NatureServe 2020)
 - Lake Whitefish - Opeongo Lake Small-bodied population (*Coregonus clupeaformis* pop. 4) (G5TNR)
 - Lake Whitefish - Opeongo Lake Large-bodied population (*Coregonus clupeaformis* pop. 5) (G5TNR)
 - Lake Whitefish - Como Lake Small-bodied population (*Coregonus clupeaformis* pop. 7) (G5TX)
 - Lake Whitefish - Como Lake Large-bodied population (*Coregonus clupeaformis* pop. 8) (G5TX)
- IUCN: Not assessed
- NRANK Canada:
 - Lake Whitefish - Opeongo Lake Small-bodied population (*Coregonus clupeaformis* pop. 4) (N5TNR)
 - Lake Whitefish - Opeongo Lake Large-bodied population (*Coregonus clupeaformis* pop. 5) (N5TNR)
 - Lake Whitefish - Como Lake Small-bodied population (*Coregonus clupeaformis* pop. 7) (N5TX)
 - Lake Whitefish - Como Lake Large-bodied population (*Coregonus clupeaformis* pop. 8) (N5TX)
- COSEWIC:
 - Lake Whitefish - Opeongo Lake Small-bodied population (Threatened)
 - Lake Whitefish - Opeongo Lake Large-bodied population (Threatened)
 - Lake Whitefish - Como Lake Small-bodied population (Extinct)
 - Lake Whitefish - Como Lake Large-bodied population (Extinct)
- SARA: Under consideration
- ESA 2007: Not assessed
- SRANK: (ranked in 2018)
 - Lake Whitefish - Opeongo Lake Small-bodied population (*Coregonus clupeaformis* pop. 4) (S5TNR)
 - Lake Whitefish - Opeongo Lake Large-bodied population (*Coregonus clupeaformis* pop. 5) (S5TNR)
 - Lake Whitefish - Como Lake Small-bodied population (*Coregonus clupeaformis* pop. 7) (S5TX)
 - Lake Whitefish - Como Lake Large-bodied population (*Coregonus clupeaformis* pop. 8) (S5TX)

2.2. Distribution in Ontario

There has been no systematic search to document the occurrence of whitefish species-pairs in Ontario. Most fisheries surveys conducted in the province do not include sufficient data to distinguish typical Lake Whitefish from a species-pair (COSEWIC 2018). They have been documented in four lakes: Lake Opeongo, in Algonquin Park;

Como Lake, in the Michipicoten River basin of Lake Superior; Lake Superior; and Lake Simcoe (Mee et al., 2015). There is insufficient information to assess the Lake Superior and Lake Simcoe pairs. In addition, unique forms of Lake Whitefish have been observed in Big Trout Lake and Lake La Muir in Algonquin Park (Ridgway et al., 2018).

Lake Opeongo and Como Lake each represent a single location for the species pair. The location is based on evidence that a single threat can impact the designatable unit.

2.3. Distribution, broader biologically relevant geographic range and status outside Ontario

Lake Whitefish is broadly distributed throughout Canada and Alaska, south into New England, the Great Lakes basin, and central Minnesota. It is generally common and secure where it occurs. They have also been introduced in several U.S. states.

Lake Whitefish pairs have been assessed by COSEWIC from in five lakes in Canada (COSEWIC, 2018). These pairs include Lake Whitefish, European Whitefish (*Coregonus lavaretus*) and combinations of the two.

Lake Opeongo and Como Lake each represent a single location for the species-pair and therefore do not occur outside of Ontario.

2.4. Ontario conservation responsibility

The Como Lake Whitefish species pair and Lake Opeongo Lake Whitefish species pair are endemic to their respective lakes in Ontario.

2.5. Direct threats

The COSEWIC threats calculator was used for both species pairs.

The overall threat for the Lake Whitefish species pair in Lake Opeongo was ranked as high. The highest ranking threat was invasive species, although there is a high level of uncertainty regarding the severity.

Threats included competition from native Cisco (*C. artedii*), as lakes with cisco result in larger and fewer whitefish, and pelagic forms disappear. This is likely a past threat. Spiny Waterflea could also be introduced/invade and impact the species pair. Lake Opeongo is the most popular Lake in Algonquin Park for fishing (Ridgway et al., 2018).

Another potential threat is the invasion of Northern Pike (*Esox lucius*) immediately downstream of the outlet dam for Lake Opeongo (Ridgway et al., 2017, Fig 62). This physical barrier is key, as Northern Pike have been documented immediately downstream and are known as a top predator in any aquatic environment that they occupy. Their invasion into the lake would alter the food web of Lake Opeongo and potentially impact the species pair.

The overall threat for the Como Lake Lake Whitefish species pair was ranked as very high. This is based on the ranking of invasive species as very high because Spiny Waterflea that has caused the extinction of this species pair.

2.6. Specialized life history or habitat use characteristics

There are 18 lakes in Canada, including Como Lake and Opeongo Lake with morphologically, ecologically, and evolutionarily discrete forms of Lake Whitefish that co-occur (COSEWIC, 2018).

These often include a small-bodied form with a smaller mean body size and shorter generation time than the large-bodied form. These forms have evolved to exploit different resources within a lake ecosystem and, hence, each form has its own distinct niche. The small-bodied form tends to grow more slowly and mature faster than the large bodied form. In Como Lake and Lake Opeongo, small-bodied forms also have significantly lower mean gill-raker counts and growth rates than the large-bodied form (COSEWIC, 2018).

3. Ontario status assessment (Part A)

Lake Whitefish - Opeongo Lake Small-bodied population
Lake Whitefish - Opeongo Lake Large-bodied population

3.1. Application of endangered/threatened status in Ontario

3.1.1. Criterion A – Decline in total number of mature individuals

Insufficient information.

3.1.2. Criterion B – Small distribution range and decline or fluctuation

Insufficient information.

3.1.3. Criterion C – Small and declining number of mature individuals

Insufficient information.

3.1.4. Criterion D – Very small or restricted total population

Both the Opeongo Lake Large-bodied and Small-bodied population meet the threshold for Threatened under D2. The species occupies a single location and is vulnerable to the effects of invasion of non-native aquatic species, which are capable of driving the species to extinction in a very short period of time.

3.1.5. Criterion E – Quantitative analysis

Does not apply.

3.2. Application of Special Concern in Ontario

Does not apply.

3.3. Status category modifiers

3.3.1. Ontario's conservation responsibility

100 % for all populations included in this assessment.

3.3.2. Rescue effect

Rescue is not possible.

3.4. Other status categories

3.4.1. Data deficient

Not applicable.

3.4.2. Extinct or extirpated

Not applicable.

3.4.3. Not at risk

Not applicable.

3. Ontario status assessment (Part B)

Lake Whitefish - Como Lake Small-bodied population

Lake Whitefish - Como Lake Large-bodied population

3.1. Application of endangered/threatened status in Ontario

3.1.1. Criterion A – Decline in total number of mature individuals

Insufficient information.

3.1.2. Criterion B – Small distribution range and decline or fluctuation

Insufficient information.

3.1.3. Criterion C – Small and declining number of mature individuals

Insufficient information.

3.1.4. Criterion D – Very small or restricted total population

Does not apply.

3.1.5. Criterion E – Quantitative analysis

Does not apply.

3.2. Application of Special Concern in Ontario

Does not apply.

3.3. Status category modifiers

3.3.1. Ontario's conservation responsibility

100% for all populations included in this assessment.

3.3.2. Rescue effect

Rescue is not possible.

3.4. Other status categories

3.4.1. Data deficient

Not applicable.

3.4.2. Extinct or extirpated

Extinct. Both species pairs in the Como Lake pair have become extinct, likely in response to the introduction of the Spiny Waterflea. This aquatic invasive species has altered the food web structure of the lake, eliminating the unique evolutionary processes that maintained the persistence of the species pair. Lake Whitefish still occur in the lake, but the distinct species pair has reverted back to a more uniform population of large fish.

3.4.3. Not at risk

Not applicable.

3. Summary of Ontario status

Lake Whitefish - Opeongo Lake Small-bodied population and Lake Whitefish - Opeongo Lake Large-bodied population (*Coregonus clupeaformis*) is classified as Threatened in Ontario based on meeting criterion D2: Very small or restricted population.

This status of this species is consistent with the definition of Threatened under the Endangered Species Act, 2007.

Lake Whitefish - Como Lake Small-bodied population and Lake Whitefish - Como Lake Large-bodied population (*Coregonus clupeaformis*) is classified as Extinct in Ontario.

This status of this species is consistent with the definition of Extinct under the Endangered Species Act, 2007.

4. Information sources

COSEWIC. (2018). *COSEWIC assessment and status report on the Whitefish Coregonus spp., European Whitefish - Squanga Lake small-bodied population (Coregonus lavaretus), Lake Whitefish - Squanga Lake large-bodied population (Coregonus clupeaformis), European Whitefish - Little Teslin Lake small-bodied population (Coregonus lavaretus), Lake Whitefish - Little Teslin Lake large-bodied population (Coregonus clupeaformis), European Whitefish - Dezadeash Lake small-bodied population (Coregonus lavaretus), European Whitefish - Dezadeash Lake large-bodied population (Coregonus lavaretus), Lake Whitefish - Opeongo Lake small-bodied population (Coregonus clupeaformis), Lake Whitefish - Opeongo Lake large-bodied population (Coregonus clupeaformis), Lake Whitefish - Como Lake small-bodied population (Coregonus clupeaformis) and the Lake Whitefish - Como Lake large-bodied population (Coregonus*

- clupeaformis*) in Canada. Retrieved from Ottawa: <http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1>.
- Kennedy, W. A. (1943). *The whitefish, Coregonus clupeaformis (Mitchill), of Lake Opeongo, Algonquin Park, Ontario*: University of Toronto Press.
- Mee, J. A., Bernatchez, L., Reist, J. D., Rogers, S. M., & Taylor, E. B. (2015). Identifying designatable units for intraspecific conservation prioritization: a hierarchical approach applied to the lake whitefish species complex (*Coregonus* spp.). *Evolutionary Applications*, 8(5), 423-441.
- Reid, S. M., Parna, M., & Reist, J. D. (2017). Collapse of Lake Whitefish *Coregonus clupeaformis* (Mitchill, 1818) species pair in Como Lake, Ontario. *Journal of Applied Ichthyology*, 33(5), 933-939. doi:10.1111/jai.13429
- Ridgway, M. (2020, August 13, 2020). [status of Opeongo whitefish pairs correspondance with D. Kraus].
- Ridgway, M., Middel, T., & Bell, A. (2017). Aquatic ecology, history, and diversity of Algonquin provincial park. *Science and Research Information Report-Ontario Ministry of Natural Resources and Forestry(IR-10)*.
- Ridgway, M., Middel, T., & Wensink, L. (2018). *Aquatic connectivity, fish introductions, and risk assessment for lakes in Algonquin Provincial Park. Ontario*. Retrieved from Peterborough, ON:

Appendix 1: Technical summary for Ontario

Species: Lake Whitefish - Opeongo Lake Small-bodied population (*Coregonus clupeaformis*) (1)

Demographic information

Demographic attribute	Value
Generation time. Based on average age of breeding adult: age at first breeding = X year; average life span = Y years.	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, over a time period including both the past and the future.	Unknown
Are the causes of the decline (a) clearly reversible, and (b) understood, and (c) ceased?	a. Unknown b. Unknown c. Unknown
Are there extreme fluctuations in number of mature individuals?	No

Extent and occupancy information in Ontario

Extent and occupancy attributes	Value
Estimated extent of occurrence (EOO).	150.5 km ² (COSEWIC, 2018)
Index of area of occupancy (IAO).	150.5 km ² IAO set to EOO. (COSEWIC, 2018))
Is the total population severely fragmented? i.e., is >50% of its total area of occupancy is in habitat patches that are: (a) smaller than would be required to support a viable population, and	a. No b. No

Extent and occupancy attributes	Value
(b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	
Number of locations.	1
Number of NHIC Element Occurrences	Not available
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?	Unknown
Is there an observed, inferred, or projected continuing decline in number of sub-populations or EOs?	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?	No
Are there extreme fluctuations in number of populations?	Unknown
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?	Unknown

Number of mature individuals in each sub-population or total population (if known)

Sub-population (or total population)	Number of mature individuals
<i>Total population</i>	<i>Unknown</i>

Quantitative analysis (population viability analysis conducted)

Probability of extinction in the wild is unknown, analysis not conducted

Species: Lake Whitefish - Opeongo Lake Large-bodied population (*Coregonus clupeaformis*) (2)

Demographic information

Demographic attribute	Value
Generation time. Based on average age of breeding adult: age at first breeding = X year; average life span = Y years.	8 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, over a time period including both the past and the future.	Unknown
Are the causes of the decline (a) clearly reversible, and (b) understood, and (c) ceased?	a. Unknown b. Unknown c. Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and occupancy information in Ontario

Extent and occupancy attributes	Value
Estimated extent of occurrence (EEO).	150.5 km ² (COSEWIC, 2018)
Index of area of occupancy (IAO).	150.5 km ² IAO set to EEO. (COSEWIC, 2018)
Is the total population severely fragmented? i.e., is >50% of its total area of occupancy in habitat patches that are: (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No

Extent and occupancy attributes	Value
Number of locations.	1
Number of NHIC Element Occurrences	Not available
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 sub-populations or EOs?	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?	No
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?	Unknown

Number of mature individuals in each sub-population or total population (if known)

Sub-population (or total population)	Number of mature individuals
<i>Total population</i>	<i>Unknown</i>

Quantitative analysis (population viability analysis conducted)

Probability of extinction in the wild is unknown, analysis not conducted.

Species: Lake Whitefish - Como Lake Small-bodied population (*Coregonus clupeaformis*) (3)

Demographic information

Demographic attribute	Value
Generation time. Based on average age of breeding adult: age at first breeding = X year; average life span = Y years.	5 years
Is there an observed, inferred, or projected continuing decline in number of mature individuals?	No based on extinction.
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations.	0%
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, over a time period including both the past and the future.	Unknown
Are the causes of the decline (a) clearly reversible, and (b) understood, and (c) ceased?	a. No b. Yes c. No*
Are there extreme fluctuations in number of mature individuals?	No

Extent and occupancy information in Ontario

Extent and occupancy attributes	Value
Estimated extent of occurrence (EOO).	24.5 km ² (COSEWIC, 2018)
Index of area of occupancy (IAO).	24.5 km ² IAO set to EOO. (COSEWIC, 2018)
Is the total population severely fragmented? i.e., is >50% of its total area of occupancy in habitat patches that are: (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No

Extent and occupancy attributes	Value
Number of locations.	1
Number of NHIC Element Occurrences	Not available
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 sub-populations or EOs?	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?	No
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 sub-population or total population (if known)

Sub-population (or total population)	Number of mature individuals
<i>Total population</i>	0

Quantitative analysis (population viability analysis conducted)

Probability of extinction in the wild is 100%.

Species: Lake Whitefish - Como Lake Large-bodied population (*Coregonus clupeaformis*) (4)

Demographic information

Demographic attribute	Value
Generation time. Based on average age of breeding adult: age at first breeding = X year; average life span = Y years.	6 years
Is there an observed, inferred, or projected continuing decline in number of mature individuals?	No based on extinction.
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations.	0%
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, over a time period including both the past and the future.	Unknown
Are the causes of the decline (a) clearly reversible, and (b) understood, and (c) ceased?	a. No b. Yes c. No*
Are there extreme fluctuations in number of mature individuals?	No

Extent and occupancy information in Ontario

Extent and occupancy attributes	Value
Estimated extent of occurrence (EOO).	24.5 km ² (COSEWIC, 2018)
Index of area of occupancy (IAO).	24.5 km ² IAO set to EOO. (COSEWIC, 2018)
Is the total population severely fragmented? i.e., is >50% of its total area of occupancy in habitat patches that are: (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No

Extent and occupancy attributes	Value
Number of locations.	1
Number of NHIC Element Occurrences	Not available
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 sub-populations or EOs?	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?	No
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 sub-population or total population (if known)

Sub-population (or total population)	Number of mature individuals
<i>Total population</i>	0

Quantitative analysis (population viability analysis conducted)

Probability of extinction in the wild is 100%.

Threats

The COSEWIC threats calculator was used for both species pairs.

The overall threat for the Lake Whitefish species pair in Lake Opeongo was ranked as high. The highest ranking threat was invasive species, although there is a high level of uncertainty regarding the severity.

The overall threat for the Como Lake Lake Whitefish species pair was ranked as very high. This is based on the ranking of invasive species as very high because Spiny Waterflea that has caused the extinction of this species pair.

Rescue effect and broader biologically relevant geographic range

Rescue effect attribute	Value
Does the broader biologically relevant geographic range for this species extend beyond Ontario?	Not applicable. This species is common in Ontario, but immigration of lake pairs is not possible.
Status of outside population(s) most likely to provide immigrants to Ontario	No
Is immigration of individuals and/or propagules between Ontario and outside populations known or possible?	No
Would immigrants be adapted to survive in Ontario?	No
Is there sufficient suitable habitat for immigrants in Ontario?	No
Are conditions deteriorating in Ontario?	No
Is the species of conservation concern in bordering jurisdictions?	No
Is the Ontario population considered to be a sink?	No
Is rescue from outside populations likely?	Not applicable. This species is common in Ontario, but immigration of lake pairs is not possible.

Sensitive species

No

Appendix 2: Broader biologically relevant geographic range

Information regarding rank and decline for:

Opeongo Lake Small-bodied population
 Opeongo Lake Large-bodied population
 Como Lake Small-bodied population
 Como Lake Large-bodied population

Adjacent Jurisdictions	Biologically Relevant to Ontario (n/a, yes, no)	Status & Trends	Condition	Notes & Sources
Quebec	n/a	n/a	n/a	n/a
Manitoba	n/a	n/a	n/a	n/a
Michigan	n/a	n/a	n/a	n/a
Minnesota	n/a	n/a	n/a	n/a
Nunavut	n/a	n/a	n/a	n/a
New York	n/a	n/a	n/a	n/a
Ohio	n/a	n/a	n/a	n/a
Pennsylvania	n/a	n/a	n/a	n/a
Wisconsin	n/a	n/a	n/a	n/a

Broader Biologically Relevant Geographic Range in Other Jurisdictions

Not applicable. These lake pairs only occur in Ontario.

Global Status and Trends

These lake pairs only occur in Ontario. The provincial and global status and trends are the same.

Acronyms

COSEWIC: Committee on the Status of Endangered Wildlife in Canada
COSSARO: Committee on the Status of Species at Risk in Ontario
ESA: Endangered Species Act
EO: Element occurrence (as defined by NHIC)
EOO: extent of occurrence
GRANK: global conservation status assessments
IAO: index of area of occupancy
IUCN: International Union for Conservation of Nature and Natural Resources
MNRF: Ministry of Natural Resources and Forestry
NHIC: Natural Heritage Information Centre
NNR: Unranked
NRANK: National conservation status assessment
SARA: Species at Risk Act
SNR: unranked
SRANK: subnational conservation status assessment
S1: Critically Imperiled
S2: Imperiled
S3: Vulnerable
S4: Apparently Secure
S5: Secure
IUCN: International Union for Conservation of Nature and Natural Resources
CDSEPO: Le Comité de détermination du statut des espèces en péril en Ontario