

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*)
Lake Whitefish - Como Lake large-bodied population (*Coregonus clupeaformis*)

in Canada



European Whitefish - Squanga Lake small-bodied population - **THREATENED**
Lake Whitefish - Squanga Lake large-bodied population - **THREATENED**
European Whitefish - Little Teslin Lake small-bodied population - **THREATENED**
Lake Whitefish - Little Teslin Lake large-bodied population - **THREATENED**
European Whitefish - Dezadeash Lake small-bodied population - **THREATENED**
European Whitefish - Dezadeash Lake large-bodied population - **THREATENED**
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**

2018

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:

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. Committee on the Status of Endangered Wildlife in Canada. Ottawa. iv + 42 pp. (<http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1>).

Previous report(s):

BODALY, R.A., CLAYTON, J.W. and LINDSEY, C.C., 1987. COSEWIC status report on the Squanga Whitefish, *Coregonus lavaretus*, in Canada, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-44 pp.

Production note:

COSEWIC would like to acknowledge Nicholas E. Mandrak for writing the status report on the Whitefish, *Coregonus spp.*, in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Dr. John Post, Co-chair of the COSEWIC Freshwater Fishes Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Corégone (*Coregonus* spp.), Corégone européen, population d'individus de petite taille du lac Squanga (*Coregonus lavaretus*), Grand corégone, population d'individus de grande taille du lac Squanga (*Coregonus clupeaformis*), Corégone européen, population d'individus de petite taille du lac Little Teslin (*Coregonus lavaretus*), Grande corégone, population d'individus de grande taille du lac Little Teslin (*Coregonus clupeaformis*), Corégone européen, population d'individus de petite taille du lac Dezadeash (*Coregonus lavaretus*), Corégone européen, population d'individus de grande taille du lac Dezadeash (*Coregonus lavaretus*), Grand corégone, population d'individus de petite taille du lac Opeongo (*Coregonus clupeaformis*), Grand corégone, population d'individus de grande taille du lac Opeongo (*Coregonus clupeaformis*), Grand corégone, population d'individus de petite taille du lac Como (*Coregonus clupeaformis*) et le Grand corégone, population d'individus de grande taille du lac Como (*Coregonus clupeaformis*), au Canada.

Cover illustration/photo:

Lake Whitefish, Opeongo Lake large-bodied (top specimen) and small-bodied (bottom two specimens) forms, by N.E. Mandrak.

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COSEWIC Assessment Summary

Assessment Summary – April 2018

Common name

European Whitefish - Squanga Lake small-bodied population

Scientific name

Coregonus lavaretus

Status

Threatened

Reason for designation

Lake Whitefish and European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This smaller species is known from a single lake in southern Yukon, where it coexists with a species derived from the Lake Whitefish. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.

Occurrence

Yukon Territory

Status history

Squanga Whitefish (*Coregonus sp.*) was considered a single unit and designated Special Concern in April 1987. In April 2018, the unit was split into three separate species of European Whitefish, *Coregonus lavaretus*, and the Squanga Lake small-bodied population of European Whitefish was designated Threatened.

Assessment Summary – April 2018

Common name

Lake Whitefish - Squanga Lake large-bodied population

Scientific name

Coregonus clupeaformis

Status

Threatened

Reason for designation

Lake Whitefish and European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in southern Yukon, where it coexists with a smaller species derived from the European Whitefish. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.

Occurrence

Yukon Territory

Status history

Designated Threatened in April 2018.

Assessment Summary – April 2018

Common name

European Whitefish - Little Teslin Lake small-bodied population

Scientific name

Coregonus lavaretus

Status

Threatened

Reason for designation

Lake Whitefish and European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This smaller species is known from a single lake in southern Yukon, where it coexists with a species derived from the Lake Whitefish. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.

Occurrence

Yukon Territory

Status history

Squanga Whitefish (*Coregonus sp.*) was considered a single unit and designated Special Concern in April 1987. In April 2018, the unit was split into three separate species of European Whitefish, *Coregonus lavaretus*, and the Little Teslin Lake small-bodied population of European Whitefish was designated Threatened.

Assessment Summary – April 2018

Common name

Lake Whitefish - Little Teslin Lake large-bodied population

Scientific name

Coregonus clupeaformis

Status

Threatened

Reason for designation

Lake Whitefish and European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in southern Yukon, where it coexists with a smaller species derived from the European Whitefish. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.

Occurrence

Yukon Territory

Status history

Designated Threatened in April 2018.

Assessment Summary – April 2018**Common name**

European Whitefish - Dezadeash Lake small-bodied population

Scientific name

Coregonus lavaretus

Status

Threatened

Reason for designation

European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This smaller species is known from a single lake in southern Yukon. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.

Occurrence

Yukon Territory

Status history

Squanga Whitefish (*Coregonus sp.*) was considered a single unit and designated Special Concern in April 1987. In April 2018, the unit was split into three separate species of European Whitefish, *Coregonus lavaretus*, and the Dezadeash Lake small-bodied population of European Whitefish was designated Threatened.

Assessment Summary – April 2018**Common name**

European Whitefish - Dezadeash Lake large-bodied population

Scientific name

Coregonus lavaretus

Status

Threatened

Reason for designation

European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in southern Yukon. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.

Occurrence

Yukon Territory

Status history

Designated Threatened in April 2018.

Assessment Summary – April 2018**Common name**

Lake Whitefish - Opeongo Lake small-bodied population

Scientific name

Coregonus clupeaformis

Status

Threatened

Reason for designation

Lake Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in Algonquin Provincial Park, Ontario. Its persistence is threatened by the risk of establishment of invasive species that could alter the distinct ecological niches required to maintain the coevolved species pair. If exotic species invade, this fish could become extinct in a short period of time. In fact, recent surveys suggest that this smaller member of the Opeongo Lake species pair may already be extinct.

Occurrence

Ontario

Status history

Designated Threatened in April 2018.

Assessment Summary – April 2018**Common name**

Lake Whitefish - Opeongo Lake large-bodied population

Scientific name

Coregonus clupeaformis

Status

Threatened

Reason for designation

Lake Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in Algonquin Provincial Park, Ontario. Its persistence is threatened by the risk of establishment of invasive species that could alter the distinct ecological niches required to maintain the coevolved species pair. If exotic species invade, this fish could become extinct in a short period of time. In fact, recent surveys suggest that the other member of this species pair may already be extinct.

Occurrence

Ontario

Status history

Designated Threatened in April 2018.

Assessment Summary – April 2018**Common name**

Lake Whitefish - Como Lake small-bodied population

Scientific name

Coregonus clupeaformis

Status

Extinct

Reason for designation

Lake Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This particular species is known only from Como Lake, Ontario. Both species in the Como Lake pair have become extinct, likely in response to the introduction of an efficient invertebrate planktivore, 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. Whitefish still occur in the lake, but the distinct species pair has become a different, more uniform population of large fish.

Occurrence

Ontario

Status history

Designated Extinct in April 2018.

Assessment Summary – April 2018**Common name**

Lake Whitefish - Como Lake large-bodied population

Scientific name

Coregonus clupeaformis

Status

Extinct

Reason for designation

Lake Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This particular species is known only from Como Lake, Ontario. Both species in the Como Lake pair have become extinct, likely in response to the introduction of an efficient invertebrate planktivore, 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. Whitefish still occur in the lake, but the distinct species pair has become a different, more uniform population of large fish.

Occurrence

Ontario

Status history

Designated Extinct in April 2018.



COSEWIC Executive Summary

Whitefish *Coregonus* spp.

Wildlife Species Description and Significance

Ten designatable units (DUs), representing five species pairs in five lakes, are assessed in this report. Much of the biology specific to these ten DUs is unknown; therefore, unless specifically stated, the general biology of the Lake Whitefish is provided. The Lake Whitefish is elongate, averaging about 30 cm in body length. The head is short with a rounded snout projecting beyond the inferior mouth. Gill-raker counts typically range 19-33. It is silvery in colour with fins ranging from clear or lightly pigmented to black, depending on geographical location. It has undergone significant speciation and local adaptations in many lakes. While this variation makes the classification of whitefish species difficult, it also makes it an exemplary model organism for the study of adaptive evolution and ecological speciation. The rapid evolution of whitefishes has resulted in many populations containing discrete and evolutionary significant forms. Because each whitefish population is geographically isolated from the others, species pairs are unique to their lake. The ten designatable units assessed, in Como, Opeongo, Squanga, Little Teslin and Dezadeash lakes, are found in whitefish species pairs that are likely irreplaceable if lost.

The forms in these lakes have differentiated to varying degrees by different mechanisms but, in all cases, the divergence is likely the result of local adaptation. Hence, there is a strong argument that each form in each species pair in each lake represents a unique component of whitefish diversity; therefore, each DU in each species pair should be considered discrete and significant.

Distribution

The ten whitefish designatable units assessed in this report are found in three regions of Canada. Six whitefish DUs are currently known in three lakes in the Yukon Territory: Dezadeash Lake, Little Teslin Lake, and Squanga Lake. The two Como Lake Whitefish DUs were found in Como Lake, Ontario. The two Opeongo Lake Whitefish DUs were/are found in Opeongo Lake in Algonquin Park, Ontario.

Habitat

Adult Lake Whitefish are bottom feeders and occupy cool waters, typically in the deeper waters of lakes in southern areas of Canada and shallower waters in northern areas.

Biology

Whitefish species pairs typically occur in two different forms: a small-bodied form and a 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, mature faster, and have shorter generation times than the large-bodied form. Lake Whitefish spawning occurs in the fall when eggs are fertilized in the water column and spawning habitat consists of rock and cobble shoals. Spawning is an annual occurrence in the southern parts of its range, but only happens once every second or third year in the northern part of its range. Larval and post-larval stages feed on plankton, and adults consume a variety of benthic invertebrates and small fishes.

Population Sizes and Trends

The population sizes of the ten designatable units are unknown. The Lake Whitefish currently caught in Como Lake does not fit the description of the two forms in the original species pair; therefore, the original species pair is likely extinct.

Threats and Limiting Factors

Invasive species are the main threat to all of the designatable units.

Protection, Status and Ranks

The “Squanga whitefish (*Coregonus* sp.) limnetic form” is listed under Schedule 3 of the federal *Species at Risk Act* (SARA) and, hence, does not receive any legal federal protection. None of the other designatable units have been previously assessed by COSEWIC or are listed under SARA. The Yukon Conservation Data Centre has assessed Squanga Whitefish (*Coregonus* sp. 2) as S3. The Como and Opeongo Lake Whitefish species pairs are not listed under the Ontario *Endangered Species Act*. As potential commercial, recreational, and Aboriginal species, whitefishes are protected under the *Fisheries Act*. The DUs in most of the lakes are afforded some habitat protection as the Opeongo Lake is within a provincial park and the Como and Yukon Territory lakes are present primarily within Crown land. None of the ten designatable units have been assessed by NatureServe or IUCN.

TECHNICAL SUMMARY - European Whitefish Squanga Lake small-bodied population

Coregonus lavaretus

European Whitefish

Squanga Lake small-bodied population

Corégone européen

Population d'individus de petite taille du lac Squanga

Range of occurrence in Canada (province/territory/ocean): Yukon Territory.

Demographic Information

Generation time. Unknown, but likely 4 years based on Little Teslin Lake small-bodied form.	4 y
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 a. clearly reversible and b. understood and c. ceased?	a. n/a b. n/a c. n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	17.2 km ²
Index of area of occupancy (IAO). Less than lake area.	17.2 km ² Note: IAO was set to EOO
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations" ^{1*}	1

¹ See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	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 subpopulation)

N Mature Individuals	Unknown
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Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
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Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Squanga Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ³⁺	n/a
Are conditions for the source population deteriorating? ⁴⁺	n/a
Is the Canadian population considered to be a sink? ⁵⁺	n/a

† See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Is rescue from outside populations likely?	No
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Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Squanga Whitefish (*Coregonus sp.*) was considered a single unit and designated Special Concern in April 1987. In April 2018, the unit was split into three separate species of European Whitefish, *Coregonus lavaretus*, and the Squanga Lake small-bodied population of European Whitefish was designated Threatened.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: D2
Reasons for designation: Lake Whitefish and European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This smaller species is known from a single lake in southern Yukon, where it coexists with a species derived from the Lake Whitefish. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D: Meets Threatened, D2. The species occupies a single location and is prone to the effects of invasion of non-native aquatic species, which are capable of driving the species to extinction over a short period of time.
Criterion E (Quantitative Analysis): None available.

TECHNICAL SUMMARY - Lake Whitefish, Squanga Lake large-bodied population

Coregonus clupeaformis

Lake Whitefish

Squanga Lake large-bodied population

Grand corégone

Population d'individus de grande taille du lac Squanga

Range of occurrence in Canada (province/territory/ocean): Yukon Territory

Demographic Information

Generation time. Unknown, but likely 7 years based on Little Teslin Lake large-bodied form.	7 y
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 a. clearly reversible and b. understood and c. ceased?	a. n/a b. n/a c. n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	17.2 km ²
Index of area of occupancy (IAO). Less than lake area.	17.2 km ² Note: IAO was set to EOO
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations" ^{6*}	1

* See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	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 subpopulation)

N Mature Individuals	Unknown
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Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
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Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Squanga Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ⁸⁺	n/a
Are conditions for the source population deteriorating? ⁹⁺	n/a
Is the Canadian population considered to be a sink? ¹⁰⁺	n/a

⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Is rescue from outside populations likely?	No
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Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Designated Threatened in April 2018.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: D2
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Reasons for designation:

Lake Whitefish and European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in southern Yukon, where it coexists with a smaller species derived from the European Whitefish. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Meets Threatened, D2. The species occupies a single location and is prone to the effects of invasion of non-native aquatic species, which are capable of driving the species to extinction over a short period of time.
Criterion E (Quantitative Analysis): None available.

TECHNICAL SUMMARY - European Whitefish, Little Teslin Lake small-bodied population

Coregonus lavaretus

European Whitefish

Little Teslin Lake small-bodied population

Corégone européen

Population d'individus de petite taille du lac Little Teslin

Range of occurrence in Canada (province/territory/ocean): Yukon Territory

Demographic Information

Generation time. Based on: (maximum age-age of maturity)/2. (Bodaly 1979)	4 y
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 a. clearly reversible and b. understood and c. ceased?	a. n/a b. n/a c. n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	4.8 km ²
Index of area of occupancy (IAO). Less than lake area.	4.8 km ² Note: IAO was set to EOO
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations" ^{11*}	1

¹¹ See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"***?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations" ^{12*} ?	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 subpopulation)

N Mature Individuals	Unknown
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Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
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Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Little Teslin Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ¹³⁺	n/a
Are conditions for the source population deteriorating? ¹⁴⁺	n/a
Is the Canadian population considered to be a sink? ¹⁵⁺	n/a

⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Is rescue from outside populations likely?	No
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Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Squanga Whitefish (*Coregonus sp.*) was considered a single unit and designated Special Concern in April 1987. In April 2018, the unit was split into three separate species of European Whitefish, *Coregonus lavaretus*, and the Little Teslin Lake small-bodied population of European Whitefish was designated Threatened.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: D2
Reasons for designation: Lake Whitefish and European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This smaller species is known from a single lake in southern Yukon, where it coexists with a species derived from the Lake Whitefish. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Meets Threatened, D2. The species occupies a single location and is prone to the effects of invasion of non-native aquatic species, which are capable of driving the species to extinction over a short period of time.
Criterion E (Quantitative Analysis): None available.

TECHNICAL SUMMARY - Lake Whitefish, Little Teslin Lake large-bodied population

Coregonus clupeaformis

Lake Whitefish

Little Teslin Lake large-bodied population

Grande corégone

Population d'individus de grande taille du lac Little Teslin

Range of occurrence in Canada (province/territory/ocean): Yukon Territory

Demographic Information

Generation time. Based on: (maximum age-age of maturity)/2. (Bodaly 1979)	7 y
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 a. clearly reversible and b. understood and c. ceased?	a. n/a b. n/a c. n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	4.8 km ²
Index of area of occupancy (IAO). Less than lake area.	4.8 km ² Note: IAO was set to EOO
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations" ^{16*}	1

*See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations" ¹⁷ *?	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 subpopulation)

N Mature Individuals	Unknown
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Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
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Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Little Teslin Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ¹⁸⁺	n/a
Are conditions for the source population deteriorating? ¹⁹⁺	n/a
Is the Canadian population considered to be a sink? ²⁰⁺	n/a

⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Is rescue from outside populations likely?	No
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Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Designated Threatened in April 2018.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: D2
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Reasons for designation:

Lake Whitefish and European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in southern Yukon, where it coexists with a smaller species derived from the European Whitefish. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Meets Threatened, D2. The species occupies a single location and is prone to the effects of invasion of non-native aquatic species, which are capable of driving the species to extinction over a short period of time.
Criterion E (Quantitative Analysis): None available.

TECHNICAL SUMMARY - European Whitefish, Dezadeash Lake small-bodied population

Coregonus lavaretus

European Whitefish

Dezadeash Lake small-bodied population

Corégone européen

Population d'individus de petite taille du lac Dezadeash

Range of occurrence in Canada (province/territory/ocean): Yukon Territory

Demographic Information

Generation time. Based on: (maximum age-age of maturity)/2.	5 y
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 a. clearly reversible and b. understood and c. ceased?	a. n/a b. n/a c. n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	112.0 km ²
Index of area of occupancy (IAO). Less than lake area.	112.0 km ²
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations" ^{21*}	1

²¹ See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"??	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations" ^{22*} ?	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 subpopulation)

N Mature Individuals	Unknown
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Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
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Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Dezadeash Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ²³⁺	n/a
Are conditions for the source population deteriorating? ²⁴⁺	n/a
Is the Canadian population considered to be a sink? ²⁵⁺	n/a

⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Is rescue from outside populations likely?	No
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Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Squanga Whitefish (*Coregonus sp.*) was considered a single unit and designated Special Concern in April 1987. In April 2018, the unit was split into three separate species of European Whitefish, *Coregonus lavaretus*, and the Dezadeash Lake small-bodied population of European Whitefish was designated Threatened.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: D2
<p>Reasons for designation: European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This smaller species is known from a single lake in southern Yukon. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.</p>	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Meets Threatened, D2. The species occupies a single location and is prone to the effects of invasion of non-native aquatic species, which are capable of driving the species to extinction over a short period of time.
Criterion E (Quantitative Analysis): None available.

TECHNICAL SUMMARY - European Whitefish, Dezadeash Lake large-bodied population

Coregonus lavaretus

European Whitefish

Dezadeash Lake large-bodied population

Corégone européen

Population d'individus de grande taille du lac Dezadeash

Range of occurrence in Canada (province/territory/ocean): Yukon Territory

Demographic Information

Generation time. Based on: (maximum age-age of maturity)/2.	7 y
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 a. clearly reversible and b. understood and c. ceased?	a. n/a b. n/a c. n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	112.0 km ²
Index of area of occupancy (IAO). Less than lake area.	112.0 km ² Note: IAO set to EOO
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations" ^{26*}	1

²⁶ See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"??	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations" ²⁷ ??	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 subpopulation)

N Mature Individuals	Unknown
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Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
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Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Dezadeash Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ²⁸⁺	n/a
Are conditions for the source population deteriorating? ²⁹⁺	n/a
Is the Canadian population considered to be a sink? ³⁰⁺	n/a

⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Is rescue from outside populations likely?	No
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Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Designated Threatened in April 2018.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: D2
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Reasons for designation:

European Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in southern Yukon. Its persistence is threatened by the risk of establishment of invasive species that could alter the ecological niches of the species pair. If exotic species invade, this fish could become extinct in a short period of time.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Meets Threatened, D2. The species occupies a single location and is prone to the effects of invasion of non-native aquatic species, which are capable of driving the species to extinction over a short period of time.
Criterion E (Quantitative Analysis): None available.

TECHNICAL SUMMARY - Lake Whitefish, Opeongo Lake small-bodied population

Coregonus clupeaformis

Lake Whitefish

Opeongo Lake small-bodied population

Grand corégone

Population d'individus de petite taille du lac Opeongo

Range of occurrence in Canada (province/territory/ocean): Ontario.

Demographic Information

Generation time. Based on adult size distribution (Kennedy 1943).	3 y
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 a. clearly reversible and b. understood and c. ceased?	a. n/a b. n/a c. n/a
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	150.5 km ²
Index of area of occupancy (IAO). Less than lake area.	150.5 km ² Note: IAO set to EOO
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No

Number of "locations" ^{31*}	1
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No. None left.
Is there an [observed, inferred, or projected] decline in number of "locations" ^{**} ?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	Unknown
Are there extreme fluctuations in number of "locations" ^{32*} ?	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 subpopulation)

N Mature Individuals	Unknown
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Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
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Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Opeongo Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ³³⁺	n/a
Are conditions for the source population deteriorating? ³⁴⁺	n/a

[□] See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is the Canadian population considered to be a sink? ³⁵⁺	n/a
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Designated Threatened in April 2018.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: D2
<p>Reasons for designation: Lake Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in Algonquin Provincial Park, Ontario. Its persistence is threatened by the risk of establishment of invasive species that could alter the distinct ecological niches required to maintain the coevolved species pair. If exotic species invade, this fish could become extinct in a short period of time. In fact, recent surveys suggest that this smaller member of the Opeongo Lake species pair may already be extinct.</p>	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Meets Threatened, D2. The species occupies a single location and is prone to the effects of invasion of non-native aquatic species, which are capable of driving the species to extinction over a short period of time.
Criterion E (Quantitative Analysis): None available.

⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

TECHNICAL SUMMARY - Lake Whitefish, Opeongo Lake large-bodied population

Coregonus clupeaformis

Lake Whitefish

Opeongo Lake large-bodied population

Grand corégone

Population d'individus de grande taille du lac Opeongo

Range of occurrence in Canada (province/territory/ocean): Ontario.

Demographic Information

Generation time. Based on adult size distribution (Kennedy 1943).	8 y
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 a. clearly reversible and b. understood and c. ceased?	a. n/a b. n/a c. n/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	150.5 km ²
Index of area of occupancy (IAO). Less than lake area.	150.5 km ² Note: IAO set to EOO
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations" ^{36*}	1

³⁶ See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations" ³⁷ *?	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 subpopulation)

N Mature Individuals	Unknown
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Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Unknown
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
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Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Opeongo Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ³⁸⁺	n/a
Are conditions for the source population deteriorating? ³⁹⁺	n/a
Is the Canadian population considered to be a sink? ⁴⁰⁺	n/a

⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Is rescue from outside populations likely?	No
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Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Designated Threatened in April 2018.

Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: D2
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Reasons for designation:

Lake Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This species is known from a single lake in Algonquin Provincial Park, Ontario. Its persistence is threatened by the risk of establishment of invasive species that could alter the distinct ecological niches required to maintain the coevolved species pair. If exotic species invade, this fish could become extinct in a short period of time. In fact, recent surveys suggest that the other member of this species pair may already be extinct.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Meets Threatened, D2. The species occupies a single location and is prone to the effects of invasion of non-native aquatic species, which are capable of driving the species to extinction over a short period of time.
Criterion E (Quantitative Analysis): None available.

TECHNICAL SUMMARY - Lake Whitefish, Como Lake small-bodied population

Coregonus clupeaformis

Lake Whitefish

Como Lake small-bodied population

Grand corégone

Population d'individus de petite taille du lac Como

Range of occurrence in Canada (province/territory/ocean): Ontario.

Demographic Information

Generation time. Based on adult size distribution (Bodaly <i>et al.</i> 1992).	5 y
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No. Decline occurred – none left.
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] period, 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. n/a
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	24.5 km ²
Index of area of occupancy (IAO). Less than lake area.	24.5 km ² Note: IAO set to EOO
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of “locations” ^{41*}	1

⁴¹ See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	No. None left.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No. None left.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No. None left.
Is there an [observed, inferred, or projected] decline in number of "locations"***?	No. None left.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No. None.
Are there extreme fluctuations in number of "locations" ^{42*} ?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No. None left.

Number of Mature Individuals (in each subpopulation)

N Mature Individuals	0
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Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	100%
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
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Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Como Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ⁴³⁺	n/a
Are conditions for the source population deteriorating? ⁴⁴⁺	n/a
Is the Canadian population considered to be a sink? ⁴⁵⁺	n/a

⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Is rescue from outside populations likely?	No
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Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Designated Extinct in April 2018.

Status and Reasons for Designation:

Status: Extinct	Alpha-numeric codes: Not applicable
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Reasons for designation:

Lake Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This particular species is known only from Como Lake, Ontario. Both species in the Como Lake pair have become extinct, likely in response to the introduction of an efficient invertebrate planktivore, 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. Whitefish still occur in the lake, but the distinct species pair has become a different, more uniform population of large fish.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Not applicable.
Criterion E (Quantitative Analysis): None available.

TECHNICAL SUMMARY - Lake Whitefish, Como Lake large-bodied population

Coregonus clupeaformis

Lake Whitefish

Como Lake large-bodied population

Grand corégone

Population d'individus de grande taille du lac Como

Range of occurrence in Canada (province/territory/ocean): Ontario.

Demographic Information

Generation time. Based on adult size distribution (Bodaly <i>et al.</i> 1992).	6 y
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No. Decline occurred – none left.
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] period, 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. n/a
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence. Lake area.	24.5 km ²
Index of area of occupancy (IAO). Less than lake area.	24.5 km ² Note: IAO set to EOO
Is the 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 (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of “locations” ^{46*}	1

*See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	No. None left.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No. None left.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No. None left.
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No. None left.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No. None.
Are there extreme fluctuations in number of "locations" ⁴⁷ *?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No. None left.

Number of Mature Individuals (in each subpopulation)

N Mature Individuals	0
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Quantitative Analysis

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

Threats (actual or imminent, to populations or habitats, from highest impact to least)

Invasive species Was a threats calculator completed for this species and if so, by whom? Yes. See Appendix.
--

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	None. Endemic to Como Lake
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	n/a
Is there sufficient habitat for immigrants in Canada?	n/a
Are conditions deteriorating in Canada? ⁴⁸⁺	n/a
Are conditions for the source population deteriorating? ⁴⁹⁺	n/a
Is the Canadian population considered to be a sink? ⁵⁰⁺	n/a

⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect)

Is rescue from outside populations likely?	No
--	----

Data Sensitive Species

Is this a data sensitive species? No

COSEWIC Status History

Designated Extinct in April 2018.

Status and Reasons for Designation:

Status: Extinct	Alpha-numeric codes: Not applicable
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Reasons for designation:

Lake Whitefish are a species complex that has coevolved in certain lakes as species pairs—a larger species and a smaller species. This particular species is known only from Como Lake, Ontario. Both species in the Como Lake pair have become extinct, likely in response to the introduction of an efficient invertebrate planktivore, 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. Whitefish still occur in the lake, but the distinct species pair has become a different, more uniform population of large fish.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Not applicable.
Criterion E (Quantitative Analysis): None available.



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 (2018)

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.

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

COSEWIC Status Report

on the

Whitefish *Coregonus* spp.

in Canada

2018

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class: Actinopterygii

Order: Salmoniformes

Family: Salmonidae

Sub-family: Coregoninae

Genus: *Coregonus*

Scientific name: *Coregonus clupeaformis* (Mitchill 1818)

Common name:

English: Lake Whitefish

French: grand corégone

Other names: whitefish, common whitefish, Sault whitefish, eastern whitefish, Great Lakes whitefish, inland whitefish, gizzard fish, lake herring, Labrador whitefish, sead, humpback, buffalo back, whitebait, corégone, poisson blanc, pi-kok-tok, jikuktok, anahik, kapihilik, pikuktuuq, kakiviatktok, kavisilik, anâdlerk, kakiviarût, keki-yuak-tuk, anadleq, qelaluqaq (Coad 2013).

Scientific name: *Coregonus lavaretus* (Linnaeus 1758)

Common name:

English: European Whitefish

French: lavaret

Other names: powan, pollan

The taxa included in this report belong to two recognized species. Until recently, European Whitefish (*C. lavaretus*) was not considered native to North America (Page *et al.* 2013). Bernatchez *et al.* (1996) found evidence of the species in an mtDNA analysis of Lake Whitefish (*C. clupeaformis*) in the Yukon Territory, but could not rule out this being the result of introgression between Lake Whitefish and European Whitefish in the Beringian refugium during the Wisconsinan glacial period. Mee *et al.* (2015) recognized the European Whitefish as native to North America and, in April 2016, the joint American Fisheries Society/American Society of Ichthyologists and Herpetologists Names Committee added *C. lavaretus* to the official North American names list as native to Canada and the United States (Mandrak pers. comm. 2017). As a result, European Whitefish is present in all, and Lake Whitefish is present in two (Little Teslin and Squanga), of the three lakes in the Yukon Territory included in this report. Only Lake Whitefish is present in the other two lakes (Como, Opeongo) included in this report.

Morphological Description

Ten designatable units (DU) representing species pairs in five lakes in three regions of Canada are assessed in this report (see Designatable Unit section, Table 1). Much of the biology specific to these ten DUs is unknown; therefore, unless specifically stated, the general biology of the Lake Whitefish is provided. This would also include European Whitefish as it has not been differentiated in the existing North American literature and, to date, there has been no description of the biology of European Whitefish in North America.

Table 1. Summary of data used to support identification of whitefish (*Coregonus* spp.) designatable units based on criteria 1-3. See Roger (2009) and Mee *et al.* (2015) for details and references.

DU	Lake	Species	Form	Criterion 1 (sympatric biological species)	Criterion 2(distinct phylogeographic lineages)	Criterion 3 (local adaptation)
1	Squanga	<i>C. lavaretus</i>	Small	allozyme and mtDNA phylogenetic analyses	Beringian (mtDNA)	Significant differences in gill-raker count, depth selection
2	Squanga	<i>C. clupeaformis</i>	Large		Beringian (mtDNA)	
3	Little Teslin	<i>C. lavaretus</i>	Small		Beringian (mtDNA)	Significant differences in size at maturity, gill-raker count, depth selection
4	Little Teslin	<i>C. clupeaformis</i>	Large		Beringian (mtDNA)	
5	Dezadeash	<i>C. lavaretus</i>	Small		Beringian (mtDNA)	Significant differences in gill-raker count, depth selection
6	Dezadeash	<i>C. lavaretus</i>	Large		Beringian (mtDNA)	
13	Opeongo	<i>C. clupeaformis</i>	Small		Mississippi (mtDNA)	Significant differences in size at maturity, depth selection
14	Opeongo	<i>C. clupeaformis</i>	Large		Mississippi (mtDNA)	
17	Como	<i>C. clupeaformis</i>	Small		Mississippi (mtDNA)	Significant differences in size at maturity
18	Como	<i>C. clupeaformis</i>	Large		Atlantic (mtDNA)	

The Lake Whitefish is elongate with the greatest body depth at the front of the dorsal fin (Scott and Crossman 1973). It averages about 30 cm total length (TL) (Figure 1). The head is short with a rounded snout projecting beyond the inferior mouth. Scales are large and cycloid, with 70-97 in the lateral line. Gill-raker counts typically range 19-33. It is silvery in colour with fins ranging from clear or lightly pigmented to black, depending on geographical location. Breeding males have nuptial tubercles on a minimum of three rows of scales above the lateral line and on six rows below it.

In 18 Canadian lakes, including Como Lake, Opeongo Lake, and three Yukon Territory lakes, morphologically, ecologically, and evolutionarily discrete forms of Lake Whitefish have been found to occur sympatrically (Mee *et al.* 2015). These often include a small-bodied form with a smaller mean body size and shorter generation time than the large-bodied form (Table 1) (Mee *et al.* 2015). In Como and Opeongo lakes, small-bodied forms also have significantly lower mean gill-raker counts and growth rates than the large-bodied form (Kennedy 1943; Bodaly *et al.* 1992). Conversely, in the Yukon Territory lakes, small-bodied forms have higher mean gill-raker counts than, and growth rates similar to, the large-bodied form (Bodaly 1979).

In Como Lake, Bodaly *et al.* (1992) found that Lake Whitefish showed a bimodal size distribution, with modes at 170-179 mm and 280-289 mm fork length (FL), indicating the presence of both small-bodied and large-bodied forms. While both forms were found to have a modal gill-raker count of 24, the small-bodied form had a significantly (t-test, $p=0.025$) lower mean gill-raker count (24.4) than the large-bodied form (25.0) (Bodaly *et al.* 1992). Results based on samples taken in 2014 and 2015 indicated a single form present with significantly higher gill-raker count (25.24; ANOVA, $p<0.001$) and greater mean length (252 mm FL) than the historical samples, and no specimens matching the original description of the two forms were caught (Reid *et al.* 2017).

In Opeongo Lake, Kennedy (1943) found a bimodal size distribution with modes at 120 mm (small-bodied) and 240 mm (large-bodied) standard length (SL) with a gap at 150 mm, and “highly” significant (Chi-square; p-value not reported) difference between the small-bodied and large-bodied forms in gill-raker counts (25.4 vs. 27.4). During 1984 and 1986, 65 large-bodied and 42 small-bodied forms were identified based on growth rates (Evans and Ihssen 1993). These 107 specimens exhibited a bimodal size distribution with modes at 195 mm (small-bodied) and 310 mm (large-bodied) SL. Twenty-eight morphometric and ten meristic characters were significantly different between large-bodied and small-bodied forms based on size-corrected discriminant function analysis. Ihssen *et al.* (1981) did not differentiate between forms and reported a mean gill-raker count of 28.13 ± 0.16 and mean standard length of $362.33\text{ mm} \pm 0.85$ based on 170 specimens collected 1953-1977.

In Dezadeash Lake, Bodaly (1979) found a bimodal distribution of gill rakers with a low gill-raker count mode of 23 (range 20-26; n=202) and a high gill-raker count mode of 33 (range 29-36; n=92). The high-raker form was smaller and, hence, considered a small-bodied form (Bodaly 1979). Based on 30 specimens of each form collected in 1992, Bernatchez *et al.* (1996) found that the small-bodied form had a mean of 32.6 gill rakers (range 30-36) and the large-bodied form had a mean of 23.2 (range 21-25).

In Little Teslin Lake, Bodaly (1979) examined 255 whitefishes and found a bimodal distribution of gill rakers with a low gill-raker count mode of 27 (range 23-28) and a high gill-raker count mode of 30 (range 28-35). Based on 30 specimens of each form collected in 1992, Bernatchez *et al.* (1996) found that the small-bodied form had a mean of 30.5 gill rakers (range 28-33) and the large-bodied form had a mean of 25.6 (range 24-27).

In Squanga Lake, Lindsey (1963) examined 449 whitefishes and found a bimodal distribution of gill rakers with a low gill-raker count mode of 23 (maximum 25) and a high gill-raker count mode of 28 (maximum 32). Based on 30 specimens of each form collected in 1992, Bernatchez *et al.* (1996) found that the small-bodied form had a mean of 29.1 (range 26-32) and the large-bodied form had a mean of 23.4 gill rakers (range 22-26).

Note that in the published scientific literature that the small- and large-bodied forms that we refer to in this report are referred to alternately as dwarf and normal or limnetic and benthic or densely rakered and sparsely rakered forms (Bernatchez *et al.* 2010; Bhat *et al.* 2014; Mee *et al.* 2015; Reid *et al.* 2017; Sevellec *et al.* 2018). We chose the small- and large-bodied descriptors as they better define the general evolutionary patterns observed across multiple lakes.

Population Spatial Structure and Variability

The Lake Whitefish is found throughout most of northern North America (Page and Burr 2011). As a result of historical isolation in different glacial refugia, five geographic groupings are present in Canada (Mee *et al.* 2015). These phylogeographic groupings are based on Wisconsinan refugial origins and include Beringia, Nahanni, Mississippi, Atlantic, and Acadia (Mee *et al.* 2015). There appears to be little introgression between the Mississippi, Nahanni, and Beringia races (Bodaly *et al.* 1992). The European Whitefish is native only to Alaska and the Yukon Territory in northwestern North America and had a Beringian refugial origin (Mee *et al.* 2015).

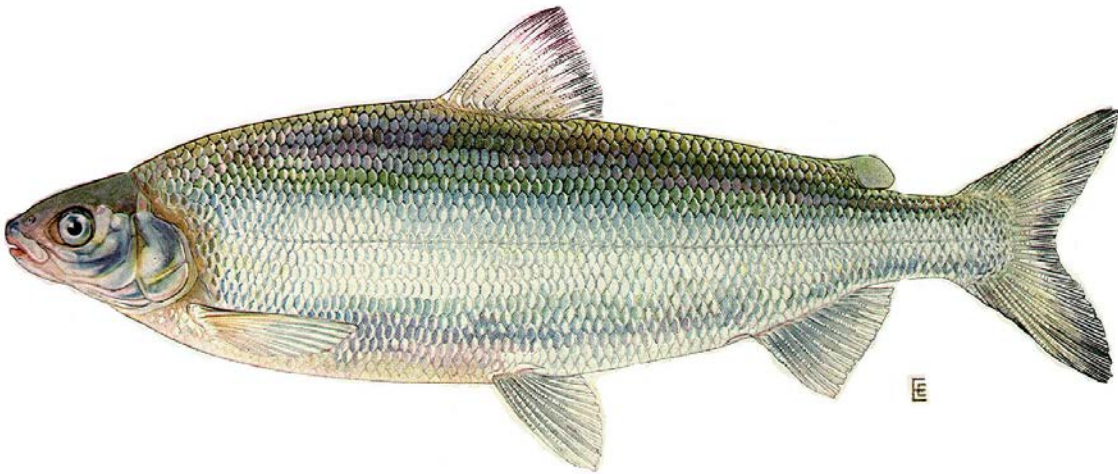
For the DUs being assessed in this report, Lake Whitefish are in the Mississippi group in Opeongo Lake and in the Atlantic and Mississippi groups in Como Lake (Mee *et al.* 2015). Whitefishes in the Yukon Territory are in the Beringia phylogenetic grouping (Table 1) (Mee *et al.* 2015).

Within many Canadian lakes, pairs of populations of whitefishes have been observed (Bernatchez *et al.* 2010; Mee *et al.* 2015). The species pairs, typically small-bodied and large-bodied forms, or limnetic and benthic, are not found in all lakes with Lake Whitefish and are likely the result of independent evolution in each lake (Mee *et al.* 2015). Small-bodied forms of Lake Whitefish typically do not occur when ciscoes (*Coregonus* spp.) are present (Trudel *et al.* 2001). There is direct genetic evidence for reproductive isolation between forms in Como Lake and the Yukon Territory lakes (Mee *et al.* 2015), and in Opeongo Lake (Evans and Ihssen 1993).

Designatable Units

Rogers (2009) and Mee *et al.* (2015) evaluated the potential designatable unit structure for the Lake Whitefish (*Coregonus clupeaformis*) species complex using a set of hierarchical criteria, consistent with the COSEWIC discrete and significant criteria, to identify DUs within the Canadian distribution of the Lake Whitefish species complex. They identified 36 DUs based on the following criteria: (1) the DU comprises a recognized taxonomic entity (i.e. species or subspecies) or is reproductively isolated in sympatry from other DUs; (2) the DU comprises a genetic lineage with a phylogeographic history different from that of other DUs; (3) the DU has a trait (or suite of traits) resulting from independent local adaptation; and (4) the DU inhabits a different National Freshwater Biogeographic Zone (NFBZ) (see Table 1 in this report and Figures 1 and 2 in Mee *et al.* 2015).

A.



B.



Figure 1. The Lake Whitefish, *Coregonus clupeaformis*. A. Illustration by Ellen Edmonson used with permission of the Bureau of Fisheries, NYS DEC, Albany. B. Opeongo Lake large-bodied (top specimen) and small-bodied (bottom two specimens) forms (ROM Catalogue No. 25654). Photo by N.E. Mandrak.

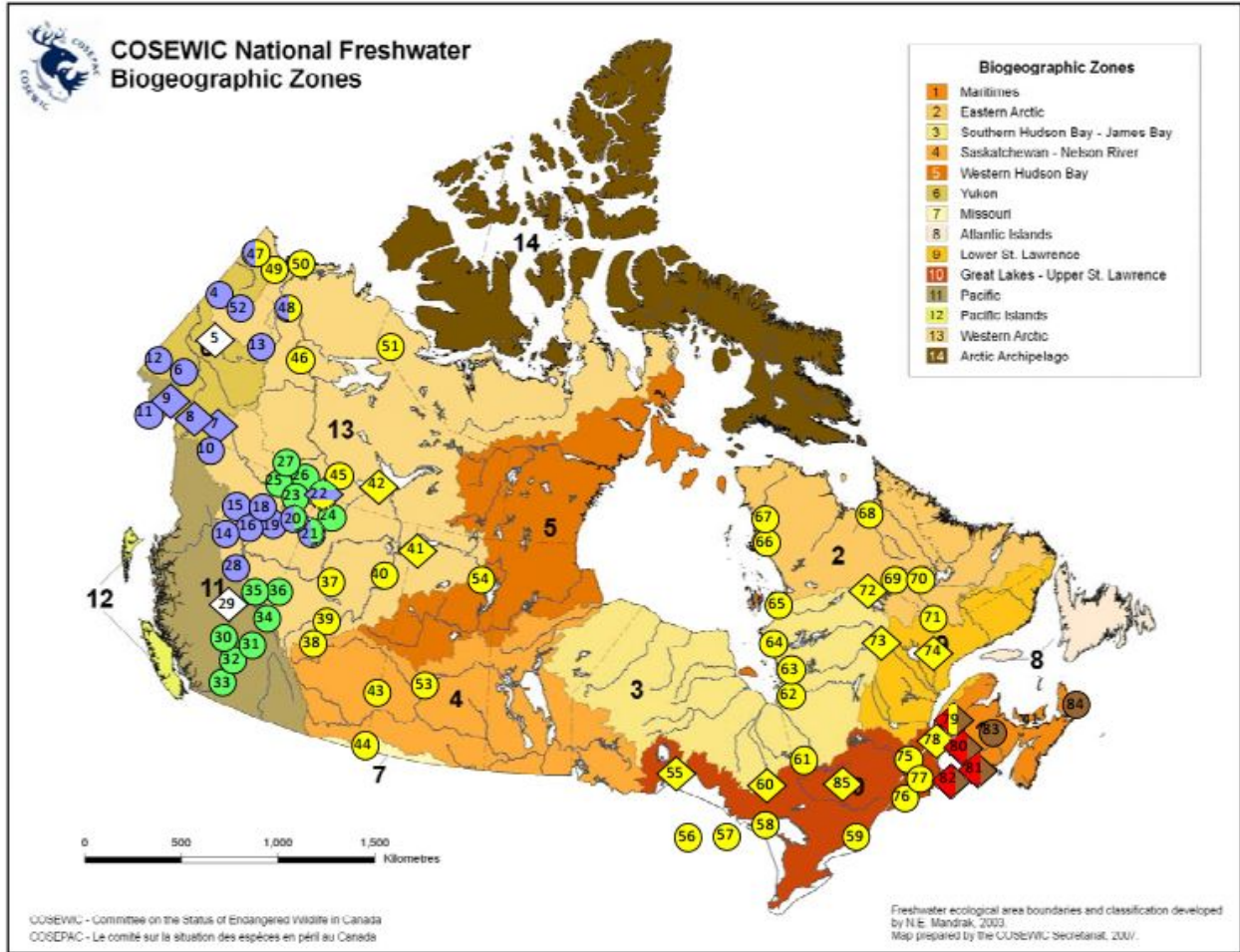


Figure 2. Distribution of Lake Whitefish populations in Canada in relation to National Freshwater Biogeographic zones. The five phylogenetic groupings based on glacial refugia isolation are colour-coded: Blue - Beringia, Green - Nahanni, Yellow - Mississippi, Red - Atlantic, Brown - Acadia. Diamonds represent lakes containing Lake Whitefish species pairs. From Rogers (2009).

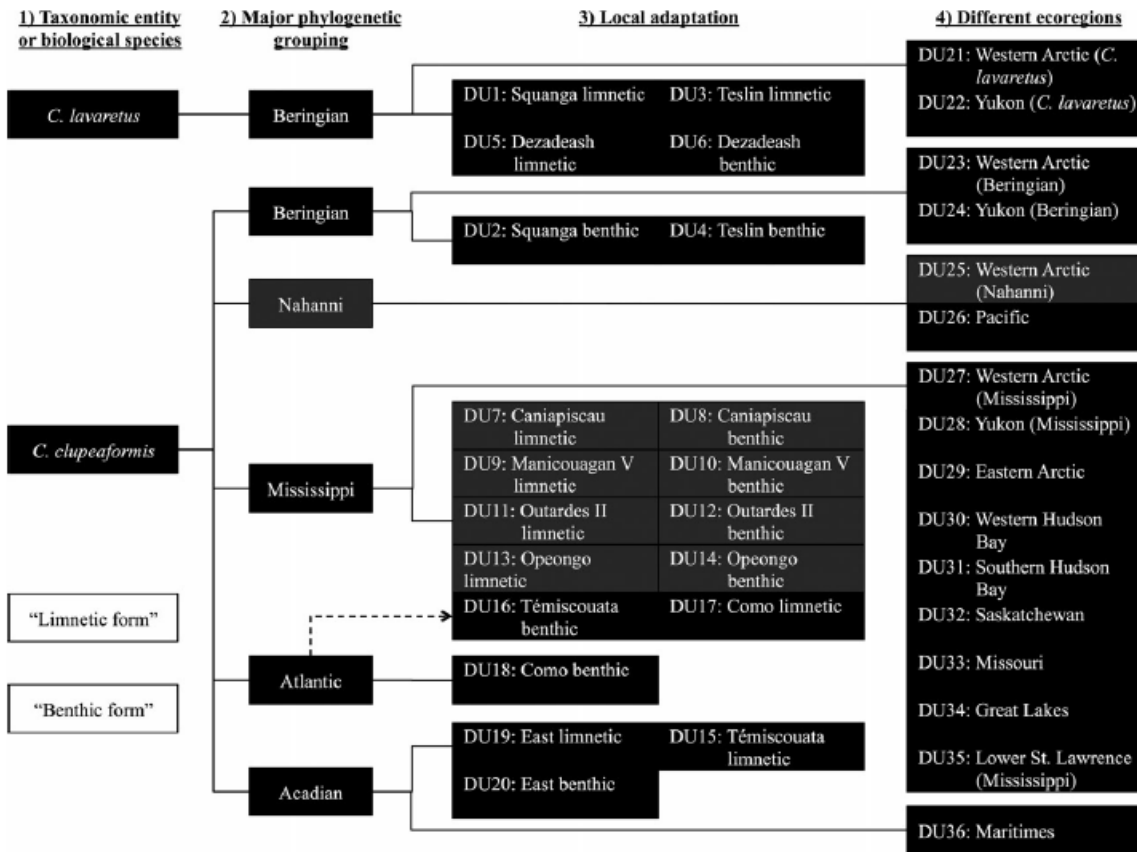


Figure 3. Lake Whitefish species complex DU decision tree. From Mee *et al.* (2015).

Criterion 1 identified species or subspecies, or populations that are sympatric but reproductively isolated and, hence, qualify as a biological species. For criterion 2, the discreteness of phylogeographic lineages was recognized based on evidence for diagnostic alleles or haplotypes, and the significance of these lineages depended on support for their discreteness (e.g. phylogenetic analysis) and evidence that the origin of such lineages was associated with different Wisconsinan refugia. For criterion 3, local adaptation was based on evidence that discreteness among potential DUs in a putatively adaptive trait is genetically controlled and influenced by selection in a particular environment. The local adaptation was deemed significant if the adaptive traits are likely essential for the persistence of populations within their local environments. If multiple populations were adapted to a similar (or even identical) environment, each would be deemed a separate DU if the local adaptation had an independent evolutionary origin (i.e. independently derived). Based on criterion 4, populations that occur in different NFBZ are considered different DUs. There is significant discreteness in populations present in different NFBZ because the geographic isolation reflects distinct biogeographic histories associated with biogeographic provinces with different ecological properties.

Six of the 36 DUs were identified for European Whitefish (*Coregonus lavaretus*), and 30 DUs for Lake Whitefish. Based on allozyme and mtDNA phylogenetic analyses (Bernatchez *et al.* 1991; Bodaly *et al.* 1991b; Bodaly *et al.* 1994; Bernatchez and Dodson 1994; Sajdak and Phillips 1997), some populations in northwestern Canada and Alaska, thought to be Lake Whitefish populations, are phylogenetically more closely related to European Whitefish (*Coregonus lavaretus*). In April 2016, the joint American Fisheries Society/American Society of Ichthyologists and Herpetologists Names Committee added *C. lavaretus* to the official North American names list as native to Canada and the United States (Mandrak pers. comm. 2017). Mee *et al.* (2015) further differentiated populations belonging to European Whitefish into four DUs based on criterion 3, and two additional DUs based on criterion 4 (see Table 1 in this report and Figures 1 and 2 in Mee *et al.* 2015). The remaining 30 DUs were all Lake Whitefish populations and differentiated based on a combination of criteria 2, 3 and 4 (see Table 1 in this report and Figures 1 and 2 in Mee *et al.* 2015).

The ten DUs being assessed here were thought to be of the greatest conservation concern and to have sufficient data for assessment. For these ten DUs, a summary of the data used to assess the DU criteria is presented in Table 1.

Special Significance

Because of their broad distribution, Lake Whitefish and European Whitefish have undergone substantial speciation and local adaptations (Landry *et al.* 2007; Mee *et al.* 2015). While this variation makes the taxonomy of Lake and European Whitefish difficult, it also makes them exemplary model organisms for the study of adaptive evolution and ecological speciation (Landry *et al.* 2007; Mee *et al.* 2015). Each Lake Whitefish and European Whitefish pair is geographically isolated from the others, making species pairs unique and endemic to each lake. Small-bodied forms of Lake Whitefish typically do not occur when ciscoes (*Coregonus* spp.) are present (Trudel *et al.* 2001); therefore, lakes with introduced ciscoes are at a risk of losing ecologically unique lake pairs. Como, Opeongo, and Yukon Territory lakes all contain whitefish species pairs that would likely be irreplaceable if lost.

DISTRIBUTION

Global Range

The Lake Whitefish is found throughout most of northern North America (Page and Burr 2011). The European Whitefish is native only to Alaska and the Yukon Territory in northwestern North America (Mee *et al.* 2015). The Como Lake Whitefish species pair and Opeongo Lake Whitefish species pair are endemic to their respective lakes in Ontario (Figure 4). The Squanga whitefish species pairs are each endemic to one of three lakes in the Yukon Territory (Figure 4).

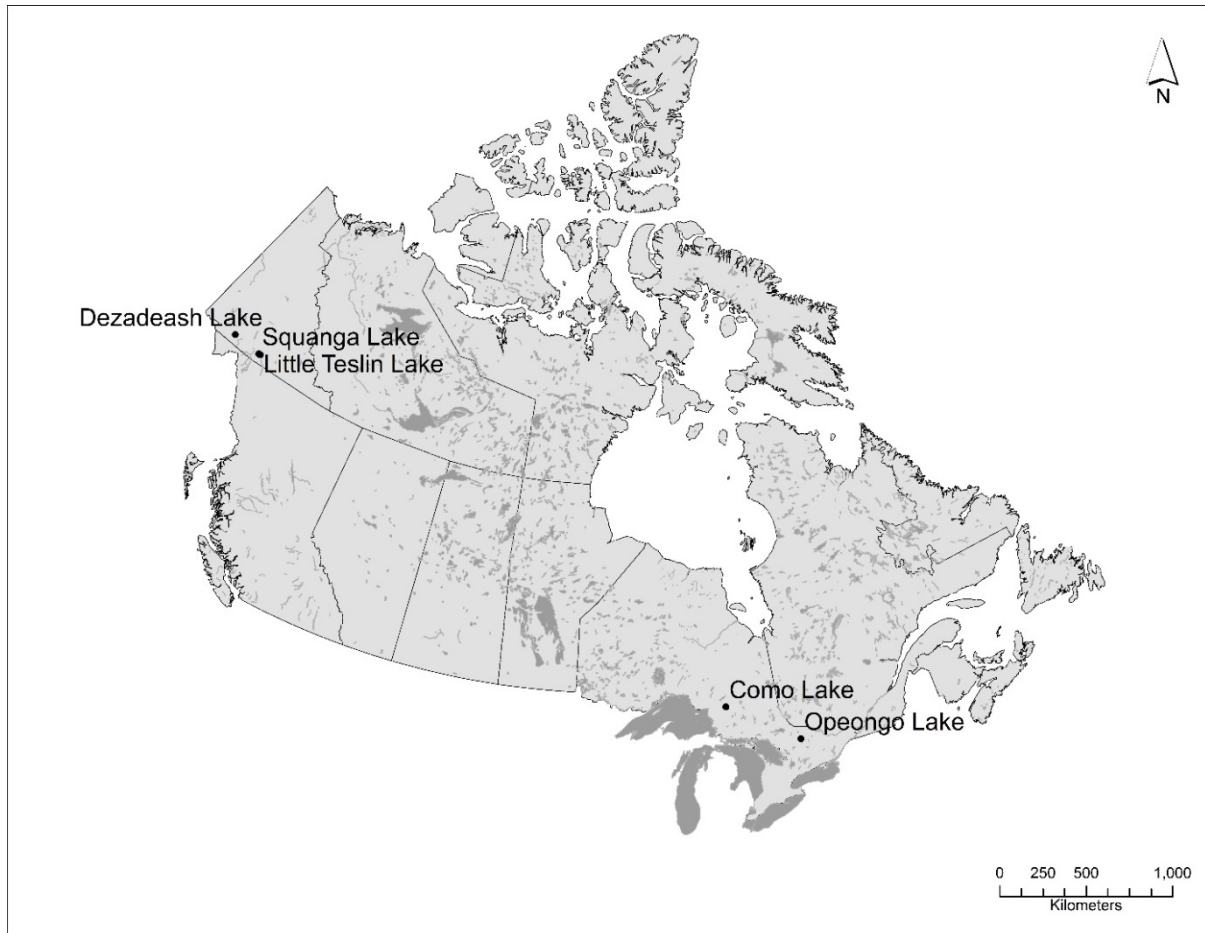


Figure 4. Location of the Como Lake, Opeongo Lake, and Yukon Territory lakes with whitefish species pairs assessed in this report.

Canadian Range

The Como Lake Whitefish species pair is found in Como Lake (47°55'0"N, 83°30'0"W) in the Michipicoten River basin of Lake Superior (Figure 4). The Opeongo Lake Whitefish species pair is found in Opeongo Lake (45°38'08"N, 78°21'37"W) in central Ontario (Figure 4). It is the largest lake in Algonquin Provincial Park and on the Ontario side of the Ottawa River basin. Whitefish species pairs are found in three lakes in the Yukon Territory (Figure 4): Dezadeash Lake (60°29'0"N, 136°58'0"W) in the Alsek River basin; and Squanga Lake (60°29'0"N, 133°38'0"W) and Little Teslin Lake (60°29'1"N, 133°27'16"W), in the Squanga Creek basin, which drains into the Teslin River (Figure 4). Whitefish species pairs have also been reported in Seaforth Lake (60°23'55"N, 133°32'29"W), Tatchun Lake (62°18'15"N, 136°6'44"W) and Teenah Lake (60°18'2"N, 133°25'15"W) in the Yukon Territory, but there is no published evidence of local adaptation (Mee *et al.* 2015). A whitefish species pair was also found in Hanson Lake (64°0'40"N, 135°25'50"W) in the Yukon Territory, although it is now considered extirpated due to toxaphene treatment in 1962 to stock Rainbow Trout (*Oncorhynchus mykiss*) (Bodaly *et al.* 1988) and evidence of local adaptation is lacking (Mee *et al.* 2015).

Extent of Occurrence and Area of Occupancy

Each designatable unit is found in a single lake and the distribution of the designatable units within the lakes is unknown. Extent of occurrence is reported in Table 2. Note in all cases the estimate of IAO is greater than the estimate of EOO so IAO is set to EOO (Table 2).

Table 2. Lake area and extent of occurrence for whitefish (*Coregonus* spp.) species pairs in the lakes assessed. Note that the IAO was assumed to be the same as EOO.

Lake	Lake Area (km ²)	Source	EOO (km ²)
Como	15.96	Rogers 2009	24.5
Opeongo	58.6	Rogers 2009	150.5
Dezadeash	77.2	Lindsey <i>et al.</i> 1981	112.0
Little Teslin	3.2	Lindsey <i>et al.</i> 1981	4.8
Squanga	11.1	Lindsey <i>et al.</i> 1981	17.2

Search Effort

There has been no systematic search effort to document the distribution of Lake Whitefish or European Whitefish across Canada, let alone the distribution of whitefish pairs in Canada. The fish inventories that do exist (e.g. Ontario Lake Inventory, 1968-1981; current Ontario Broad-Scale Monitoring Program) do not typically examine the gill rakers and growth rates of whitefishes, required to identify species pairs. The discovery of whitefish species pairs, including the ones in these reports, are the result of more detailed, localized research projects (e.g. Kennedy 1943, Lindsey 1963; Bodaly 1979). For example, Bodaly (1979) found whitefish species pairs in five of 89 lakes sampled between 1968 and 1975 in the Yukon Territory and northern British Columbia.

HABITAT

Little has been published specifically on the habitat use of the ten designatable units. Lake Whitefish and European Whitefish are coolwater species (Scott and Crossman 1973). Over most of the southern range, Lake Whitefish is limited to the hypolimnion during the summer months, although this movement may be unnecessary for both species in northern lakes lacking thermal stratification (Scott and Crossman 1973). Lake Whitefish spawning occurs in the fall, usually November and December in the Great Lakes region, and earlier farther north with variability from year to year within the same lake (Scott and Crossman 1973). Spawning occurs in shallow waters often over hard, sandy, or stony bottoms at depths of less than 7.6 metres, but there are reports of spawning in deeper waters. Young whitefish generally leave the shallow inshore water by early summer and move into deeper water (Scott and Crossman 1973).

In a study including 19 North American lakes, lakes with the most divergent Lake Whitefish species pairs had the greatest hypolimnetic oxygen depletion, lower zooplankton densities, and a narrower range of zooplanktonic prey length (Landry *et al.* 2007).

Como Lake

Como Lake has an area of 15.96 km², mean depth of 9.4 m, and a coolwater fish community, which lacks the Cisco (*C. artedii*) (Bodaly *et al.* 1992). Little else has been published on the habitat of the lake.

Opeongo Lake

Opeongo Lake is the largest lake (58.6 km²) in Algonquin Park, Ontario, has a mean depth of 14.8 m, a maximum depth of 58 m, and a coolwater community including introduced Cisco and Smallmouth Bass (*Micropterus dolomieu*) (Cucin and Faber 1984). It has three main arms (East, South, North) of similar size that are joined by channels. The shoreline is mostly granite with a few sand beaches and protected boggy bays. Some rock and sand bottoms are encountered at 15 m, but the greatest part of the lake has an organic bottom. The water is soft, brown in colour, and low in transparency (Kennedy 1943). Lake Whitefish sought water warmer than 7°C when it was available and the upper limit of the tolerated temperatures varied with season: in July and August, the maximum temperature was 18°C; in September, the maximum temperature dropped to 10°C (Kennedy 1943). Both small-bodied and large-bodied Lake Whitefish were found to occur in the same limnetic habitats and vertical distributions during the growing season. Kennedy (1943) concluded that the difference in size between the two forms was not the result of living in different temperature conditions.

Yukon Territory Lakes

Little is known about the habitat in the lakes in this region. Squanga Lake has a length of 8.5 km and an average width of 1.2 km (Lindsey 1963). Twenty-one percent of the lake's area is less than 3 m deep and a deep central trench 3.2 km long and roughly 183 m wide contains water over 30 m deep. Bodaly *et al.* (1988) provided a summary of the physical, chemical, and biological characteristics of Squanga Lake (Table 3). Significant numbers of whitefishes are found in associated creek environments during most times of the year (McDermid *et al.* 2007). In the three lakes, the form with higher gill-raker counts mainly occupies the limnetic zone, and the low-count form occupies the bottom layers at all depths (Lindsey 1963; Bodaly 1979). Lakes supporting whitefishes were found to be well oxygenated, usually moderately high in total dissolved solids, and moderately high in nutrient concentrations, relative to many other Yukon lakes (McDermid *et al.* 2007). Other than lake area (Table 2), little else is known about the habitats of Dezadeash and Little Teslin lakes.

Table 3. Summary of the physical, chemical, and biological characteristics of Squanga Lake (Bodaly *et al.* 1988).

Parameter	Value
Area (ha)	1017.8
Mean Depth (m)	40
Maximum Depth (m)	>40
Secchi transparency (m)	4.0
pH	8.0
Total dissolved solids (mg·l)	160-243
Conductivity (µS·cm)	260
Hardness (mg CaCO ₃ ·l)	137
Crustacean zooplankton (number·cm ²)	51.7
Crustacean zooplankton (number·l)	43

BIOLOGY

Little has been published specifically on the biology of the ten designatable units, and nothing on the European Whitefish in North America; therefore, unless specifically stated, the general biology of the Lake Whitefish is provided.

Life Cycle and Reproduction

In the spring and early summer, Lake Whitefish occupy shallow areas of lakes. As the temperature of the lake increases, the Lake Whitefish move to deeper, cooler waters. In the fall, mature Lake Whitefish will move back towards shore to spawn. Spawning is an annual occurrence in the southern parts of its range, but only happens once every other or third year in the northern part of its range (Kennedy 1953). Spawning can occur between September and January, with more northern populations generally spawning earlier (Kennedy 1953). One female and one or more males will rise to the surface of the water where the pair will release eggs and milt and then descend back to deeper waters. The number of eggs released is usually in the thousands, but this number depends on the size of the female fish (Scott and Crossman 1973).

The Lake Whitefish is an oviparous species. Spawning can last 7-10 days, and eggs are deposited in small batches over several days to increase egg success. The gestation period for the eggs is, on average, 133 days and can range from 30 days in warmer water (6.1°C) to 140 days in cooler water (0.5°C) (Price 1940). Only about 13% of eggs survive to become larvae (Hart 1930). Eggs hatch in early spring. There is no parental care and larvae group together along the shoreline. This stage lasts through the spring and they leave the shallows as juveniles in the early summer (Hart 1930). It takes 2-5 years for the fish to reach sexual maturity (Weagle and Baxter 1974). Fish of larval and post-larval stages feed on plankton. Once the larvae reach 76–102 mm, they switch to feeding on benthic organisms, which they will consume for the remainder of their lives (Hart 1930).

The Como Lake Whitefish species pair had similar life histories. However, the small-bodied fish tended to mature faster (Age 2) and had lower maximum ages (4-8 years vs. 6-10 years) (Bodaly *et al.* 1992). This early maturation occurred only in the small-bodied form in order to compensate for lower fecundity (Vuorinen *et al.* 1993). The small-bodied form had a much more skewed male:female sex ratio (4.1:1) than the large-bodied form (1.2:1) (Bodaly *et al.* 1992). Preliminary analyses of specimens caught in 2012 and 2014 revealed a single form with faster growth rates, higher maximum sizes and ages than the historical forms, and a male:female 4.4:1 sex ratio (Reid *et al.* 2017). Both forms appeared to spawn at the same time and together in at least some spawning locations (Bodaly *et al.* 1991); however, significant differences in mtDNA haplotype frequency between the two forms suggested that they were reproductively isolated (Vuorinen *et al.* 1993).

The Opeongo Lake Whitefish species pair have similar life histories. Kennedy (1943) concluded that the small-bodied form matured earlier and died younger, maturing by the age of 2 and living no longer than 5 years compared to maturing at 3-7 years and living to 14 years in the large-bodied form (Kennedy 1943). However, Evans and Ihssen (1993) reported much older maximum ages using otoliths rather than scales for aging for fishes caught in 1984 and 1986; the maximum age was 30 years for the small-bodied form and 35 years for the large-bodied form. Spawning habitat is the same for both forms and consists of rock and cobble shoals. Spawning occurs around late October. The gestation period is long, lasting 175 days. The larvae hatch in late April and larval whitefish occupy surface waters where they are vulnerable to surface trawls for 4-6 weeks (Ihssen *et al.* 1981). Both forms lay fewer eggs, 50% less, but more eggs compared to body size, than other whitefish populations (Ihssen *et al.* 1981). They have small eggs and larvae, but high fecundity. Fecundity is estimated to be 7 632 eggs per female and relative fecundity was 27,460 eggs/kg (Ihssen *et al.* 1981).

In the Yukon Territory lakes, the small-bodied form was shorter lived and matured younger than large-bodied form (Bodaly 1979). The growth rates of both forms were similar (Bodaly 1979). In Dezadeash Lake, the forms mature at age 4-5 and the small-bodied form has a maximum age of 7 and the large-bodied form a maximum age of 10 (Bodaly 1979; Bodaly *et al.* 1988). In Little Teslin Lake, the forms mature at age 2-3 and the small-bodied form has a maximum age of 6 and the large-bodied form a maximum age of 10 (Bodaly 1979; Bodaly *et al.* 1988). The age of maturity and maximum age has not been reported for the Squanga Lake whitefish species pair. The spawning behaviour of the Squanga whitefishes is likely similar to other Lake Whitefish populations (Bodaly 1979). Spawning occurs in the fall when eggs are fertilized in the water column and there is no parental care afterwards (Bodaly 1979). Spawning occurs annually and the different forms use the same spawning grounds, sandy or rocky shoals (Bodaly 1979). The small-bodied forms spawn in inlets and outlet streams in November and December. Gonad development in June suggests that the large-bodied forms spawn later (Lindsey 1963). In Squanga Lake, the small-bodied form feeds mainly on plankton, while the large-bodied form feeds on benthic organisms (Lindsey 1963).

Physiology and Adaptability

The Lake Whitefish is a coolwater species. Of the Lake Whitefish that occur in pairs, a “small-bodied” and a “large-bodied” form have evolved to fill two separate niches within the lakes. The small-bodied form is often limnetic as adults, while the large-bodied-form adults are often found in the benthic zone (Mee *et al.* 2015). The species pairs in different lakes have differentiated to varying degrees, and this differentiation has taken multiple trajectories resulting from different modes of divergence but, in all cases, the divergence is likely the result of local adaptation. This adaptation has likely occurred because of an increased predation pressure in the limnetic zone, which drove the small-bodied form to grow slower and mature at a quicker rate (Sparling and Bodaly 2007; Rogers 2009).

Dispersal and Migration

The Lake Whitefish typically spends its entire life cycle in lakes, although some populations are known to migrate into streams for spawning (Dryer 1964). The species may move between shallow and deep waters within a lake, depending on the season (Scott and Crossman 1973). It appears to have a preference for deeper, cooler waters in the summer and shallower habitat in the fall or early winter that is more suitable for spawning (Kennedy 1953; Anras *et al.* 1999). In Como Lake, Lake Whitefish cannot disperse by natural means outside of the lake due to its isolation. There have been no studies of dispersal of Lake Whitefish outside of Opeongo Lake and there is no suspected dispersal by natural means due to its geographic isolation.

Whitefishes in Squanga Lake likely move to other lakes, but these movements have not yet been well studied (Sparling and Bodaly 2007). Little Teslin Lake and Dezadeash Lake are isolated; therefore, dispersal by natural means between and beyond them is not possible (Sparling and Bodaly 2007).

Interspecific Interactions

Adult Lake Whitefish are bottom feeders, consuming a wide variety of benthic invertebrates and small fishes, and are a principal food source for Burbot (*Lota lota*), Lake Trout (*Salvelinus namaycush*), and Northern Pike (*Esox lucius*) (Scott and Crossman 1973). It is important to understand interspecific interactions, such as competition, for similar food resources and predator-prey relationships, as it may result in a shift in niches or complete loss of the species. Small-bodied forms of Lake Whitefish typically do not occur when ciscoes (*Coregonus* spp.) are present (Trudel *et al.* 2001). For example, the presence of Lake Whitefish in the absence of ciscoes has been observed in the Yukon lakes. The small-bodied form is likely present in Squanga Lake as a result of the absence of Least Cisco (*Coregonus sardinella*) (Lindsey *et al.* 1981). This is likely due to Least Cisco being able to outcompete the small-bodied form for food resources (Bodaly 1979). Therefore, the introduction or dispersal of ciscoes into lakes that support the small-bodied form might lead to a reduction in abundance or loss of small-bodied whitefish from the lake.

Lake Whitefish has also been documented to shift niches in the presence of pelagic Cisco and native, benthic Round Whitefish (*Prosopium cylindraceum*) in the Algonquin Highlands, including Opeongo Lake (Carl and McGuinness 2006). When Cisco is present, Lake Whitefish are fewer and larger in size and shift from feeding on both plankton and benthic prey to primarily benthic prey (Carl and McGuinness 2006). In addition, when Round Whitefish is present, as in Opeongo Lake, Lake Whitefish are fewer and smaller in size and move deeper in the lake due to competition for similar benthic food resources. These interactions are important to consider in areas where Cisco and Round Whitefish are present because they may significantly limit or alter the density and age structure of Lake Whitefish.

The interspecific interaction between Lake Whitefish and invasive Rainbow Smelt (*Osmerus mordax*) has also been examined. Case studies have revealed that the introduction of Rainbow Smelt into Ontario lakes resulted in the decline of Lake Whitefish recruitment due to Rainbow Smelt preying on Lake Whitefish larvae (Evans and Loftus 1987).

Another example of the impact of the invasion of a vertebrate planktivore in native European Whitefish was described for a northern Finnish lake (Bhat *et al.* 2014). In this system, the invasion of a superior trophic competitor resulted in the collapse of a Whitefish pair within about three generations. But efficient invertebrate planktivores can have equivalent impact. Como Lake was invaded by the Spiny Waterflea, *Bythotrephes longimanus*, and its establishment likely caused the extinction of the Lake Whitefish species pair referred to as dwarf and normal forms by Reid *et al.* (2017).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Como Lake

Lake Whitefish was captured with gill nets of mesh sizes 3.8-13.3 cm stretched measure on a spawning shoal overnight on 25-26 October 1989 (Bodaly *et al.* 1991). Additional samples were captured on 28-30 August 1990 with similar gill nets, away from spawning areas (Vuorinen *et al.* 1993). Sampling in 2011, 2012, 2014, and 2016 replicated historical sampling methods (Parna and Reid 2014). Multi-mesh benthic gillnets, ranging 3.8-13.3 cm stretched mesh size, were set overnight on spawning shoals (2-5 m deep in late October).

Opeongo Lake

Sampling has been undertaken by several different means. The most important was the use of gillnets ranging in size from 2.54 to 12.7 cm stretched mesh while few whitefish were taken in 1936 and 1938, the first extensive fishing for whitefish began in 1939 (Kennedy 1943). In 1939, nets were set in both the East and South arms to obtain specimens, especially large fish (over 30 cm). In 1940, most effort was placed on an intensive study of vertical distribution of the whitefish throughout the growing season in the South Arm only. In 1940, a “veiling net” was used to catch smaller fish. This was a Milliner’s net of 1.25 cm mesh hung between two 3.75 cm mesh gillnets. Few whitefish were taken in fyke nets, and some were also obtained from stomachs of Lake Trout and Burbot. There are Royal Ontario Museum records for 11 Lake Whitefish collected in Opeongo Lake in 1958; however, gear was not specified. The Ontario Ministry of Natural Resources and Forestry (OMNRF) conducted gillnet surveys with 5.7-12.7 cm mesh in 1999, 2001, 2010, and 2013 that captured Lake Whitefish (Ridgway pers. comm. 2016). Lake Whitefish was also recorded by the summer index netting program in 1981, 1982, 1986, 1988, and 1995-2000, summer littoral zone index netting in 1990, lake access creel in 1990 and 1991, short-set gill nets in 1990, nearshore community index netting in 1994, companion netting in 1998, Nordic netting in 1999 and 2002 (Reid pers. comm. 2017), and by unspecified gear 1953-1977 (Ihssen *et al.* 1981) and in 1984 and 1986 (Evans and Ihssen 1993).

Yukon Territory

Bodaly *et al.* (1988) reported sampling of Dezadeash Lake in June, July, and August 1974 using experimental gill nets in shallow areas (2.1 m deep), and deep and floating nets in 4.2 m depths. The nets used were 38.1 m long and 2.1 m deep with panels of 24, 41, 76, 38 and 64 mm stretch-mesh monofilament nylon. Bernatchez *et al.* (1996) sampled the lake in August 1992 using experimental gill nets set offshore in 7-15 m depths. The Yukon government conducted a roving angler-harvest survey of Dezadeash Lake in 1991, 1995, 2000, 2001, 2006, and 2013 by interviewing anglers at popular access points; whitefishes, not identified to form, were reported as caught in small numbers, likely as incidental catch, in 1995, 2006, and 2013 (Foos *et al.* 2014).

Bodaly *et al.* (1988) reported sampling of Little Teslin Lake in June and August 1975, setting shallow nets in 2 m depths, and deep sets at, and floating sets over, 17 m depths. The same nets were used as in the Squanga Lake sampling. Bernatchez *et al.* (1996) sampled the lake in August 1992 using experimental gill nets set offshore in 7-15 m depths.

Lindsey (1963) reported sampling of Squanga Lake in 1934, 1945, and 1958. A more intensive survey targeting whitefishes was conducted in June 1960 using floating, shallow, and deep sets. Shallow onshore sets were in a mean depth of 1-5 m, and deep sets on the bottom in 8-40 m depths (Lindsey 1963). Nets were 60 m long and 2.4 m deep with five panels of 38, 63, 89, 51 and 76 mm stretched-mesh monofilament nylon. Floating nets, set on the surface over 12-24 m depths, were 46 m long and 7.6 m deep, with three panels of 38, 51 and 63 mm mesh of monofilament nylon. Bernatchez *et al.* (1996) sampled the lake in August 1992 using experimental gill nets set offshore in 7-15 m depths.

Abundance

Como Lake

No data are available on the abundance of the Lake Whitefish species pair in Como Lake. The analysis of Vuorinen *et al.* (1993) used 50 large-bodied and 51 small-bodied forms caught in late October 1989 and 1990. Some of these were part of the capture of 415 large-bodied and small-bodied forms (exact ratio not provided, but approximately 50:50) in 1989 reported by Bodaly *et al.* (1991).

The 2011, 2012, 2014, and 2016 sampling caught 734 whitefish of a single morphological form that did not match the descriptions of either form caught in 1989 (Reid *et al.* 2017).

Opeongo Lake

No data are available on the relative abundance of the Lake Whitefish species pair in Opeongo Lake over time due to the lack of standardized sampling. In his study, Kennedy (1943) included 10 large-bodied forms collected in 1936, 226 large-bodied and 67 small-bodied forms in 1938, 519 large-bodied and 38 small-bodied forms in 1939, and 250 large-bodied and 62 small-bodied forms in 1940. In 1984 and 1986, using unspecified gear, OMNRF caught 65 large-bodied and 42 small-bodied forms (Evans and Ihssen 1993).

The eleven Lake Whitefish in the Royal Ontario Museum collected in 1958 did not have the age or growth data required to differentiate the forms, and the minimum fork length (FL) was 170 mm, much longer than the maximum size of 140 mm SL reported by Kennedy (1943). The OMNRF collected Lake Whitefish in 1999 (n=115), 2001 (n=158), 2010 (n=114), and 2013 (n=21). Age and length data are available for these specimens but not growth data. Based on Kennedy (1943), the small-bodied form lived to a maximum age of 4 and had a maximum size of 140 mm SL. Although some of the specimens collected in 1999-2013 had ages ≤ 4 , none were shorter than 171 mm FL (slightly longer than SL); therefore, it is highly unlikely that any of the specimens were the small-bodied form.

Lake Whitefish were caught by OMNRF, but age and growth data are not readily available and hence the forms not distinguishable, in the following surveys: summer index netting program in 1981 (n=38), 1982 (n=44), 1986 (n=13), 1988 (n=56), 1995 (n=735), 1996 (n=347), 1997 (n=344), 1998 (n=117), 1999 (n=426), and 2000 (392); summer littoral zone index netting in 1990 (n=1); lake access creel in 1990 (n=2) and 1991 (n=1); short-set gill nets in 1990 (n=319); nearshore community index netting in 1994 (n=20); companion netting in 1998 (n=27); and, Nordic netting in 1999 (n=80) and 2002 (n=67) (Reid pers. comm. 2017). In addition, at least 170 Lake Whitefish were caught, using unspecified gear, between 1953 and 1977 (Ihssen *et al.* 1981).

Yukon Territory Lakes

Whitefishes in the three lakes in this region were relatively abundant as of 1988 (Bodaly *et al.* 1988). Estimates of catch per unit effort are limited (see Table 4 for 1960 estimates). Limited recent sampling indicates that whitefishes, not distinguished by form, are abundant (Jung pers. comm. 2017).

Table 4. Catch-per-unit-effort of Squanga whitefishes in Squanga Lake, Yukon Territory, June 7-19, 1960 (Bodaly *et al.* 1998).

Net Position	Catch-per-Unit Effort	
	Day	Overnight
Shallow	1.22	na
Deep	1.68	na
Floating	3.62	2.32

Fluctuations and Trends

In Opeongo Lake, the large-bodied form appears to be extant based on recent sampling; however, the age and growth analyses required to identify the small-bodied form have not been conducted since 1986 (Evans and Ihssen 1993). In Como Lake, the species pair collected in 1989 appears to have been replaced by a single form not morphologically matching either of the original forms.

As limited data are available for lakes in the Yukon Territory, fluctuations and trends in abundance cannot be determined. Both forms were known to be still extant in all three lakes as of 1992. There are no more recent form-specific data.

Rescue Effect

As all of the lakes are isolated and the species pairs likely originated within each of the lakes; there is no potential for rescue.

THREATS AND LIMITING FACTORS

To identify the nature and magnitude of threats to the ten DUs of whitefish species, a threats calculator was completed based on the IUCN-CMP (World Conservation Union-Conservation Measures Partnership) unified threats classification system (IUCN and CMP 2006; Salafsky *et al.* 2008). Based on the threats calculator, the overall threat impact is Very High for Como Lake, and High-Low for Opeongo and Yukon Territory lakes. Threats are summarized by the subheadings used in the Threats Calculator. The extent of threats specific to each designatable unit is provided under each subheading.

3.0 Energy Production and Mining

On the southwestern end of Squanga Lake, there are substantial mining tenures, which extend into the lake itself.

5.0. Biological Resource Use

Logging is present in Algonquin Provincial Park. The Forest Management Plan identifies proposed harvest areas for 2015-2020 and optional harvest areas surrounding Opeongo Lake (Ontario 1998). However, these activities are highly regulated by Park authorities; therefore, it is unlikely that such activities will pose a threat to the Opeongo Lake Whitefish species pair. There are no commercial fisheries present in Como Lake, Opeongo Lake, and Yukon Territory.

In the Threats Calculator, the impact of this threat is negligible for the Opeongo DUs and did not score for the Como and Squanga DUs.

6.0. Human Intrusions and Disturbance

In Opeongo Lake, recreational fishing pressure is likely minimal as there are currently low angler captures in the summer as indicated by the lake-access creel, and no ice fishing is permitted. Recreational activities, such as motor boating by tourists, are permitted in Opeongo Lake and could pose a potential disturbance to the habitat of the Opeongo Lake Whitefish species pair. Motor boating often leads to increased turbidity, which can have a series of negative effects on fish habitats such as: displacement of adults and larvae; increased predation due to displacement and decreased visibility of individuals; and destruction of spawning grounds and food sources.

In both the Yukon Territory (Sparling and Bodaly 2007) and Como Lake, summer and winter fishing is permitted. There is also a subsistence harvest in Dezadeash Lake that targets whitefish (Jung pers. comm. 2017). While such activities are permitted in these lakes, there is no direct evidence to suggest that they pose a threat to the Como Lake Whitefish species pair or the Yukon Territory lakes species pairs.

Overall, tourism is a potential threat to the Opeongo Lake Whitefish species pair and its habitat in Opeongo Lake, due to the high tourist traffic present in Algonquin Provincial Park. However, the protected status of this park is considered to be successful at maintaining the integrity of the natural heritage of the region, including aquatic habitats (Ontario 1998). Anthropogenic activities, which could pose a threat to Opeongo Lake, are well regulated throughout the park.

There are cottages on all three lakes in the Yukon Territory, campgrounds on Dezadeash and Little Teslin lakes, and a private tourist lodge on Dezadeash Lake (Jung pers. comm. 2017). However, anthropogenic factors are not a known cause of concern to these species pairs due to the remoteness of the Squanga watershed, although humans could still have a negative effect on fish populations, should any future encroachment or pollution take place.

In the Threats Calculator, the impact of this threat is low for the Opeongo and Squanga DUs and did not score for the Como DUs.

8.0. Invasive and Other Problematic Species Genes

Invasive species are a cause of concern for Lake Whitefish populations in all five lakes assessed here. The Cisco, not native to Opeongo Lake, was introduced in the 1948 to promote the growth of Lake Trout (Matuszek *et al.* 1990). Cisco and small-bodied Lake Whitefish typically do not co-exist as they have similar niches (Trudel *et al.* 2001), and this introduction likely contributed to the decline of the small-bodied form in Opeongo Lake (Cucin and Faber 1984). Smallmouth Bass was also introduced into Opeongo Lake in the late 1800s; however, it likely had a minimal impact on the Lake Whitefish pair, likely due to different thermal preferences, as evidenced by their continued abundance in the 1930s (Kennedy 1943).

There is a history of using baitfishes in Como Lake. This activity poses a threat to the Como Lake Whitefish species pair by introducing a competitor to the ecosystem. In Como Lake, the introduction of the Spiny Waterflea (*Bythotrephes longimanus*) has altered the ecosystem, which poses a threat to all fish species, including the Como Lake Whitefish species pair (Reid *et al.* 2017). The introduction of Rainbow Smelt in Ontario lakes has been an issue of concern since the late 1980s, as this species has been shown to outcompete Lake Whitefish and prey on its larvae (Evans and Loftus 1987).

Although the use of live bait fish is not permitted in Algonquin Park, where Opeongo Lake is located, and in the Yukon Territory where the other three lakes are located, there is the potential for illegal baitfish use and dumping of bait and other organisms (e.g. invertebrates, pathogens) given the lakes popularity for angling and proximity to well-travelled roads.

Tovey *et al.* (2008) conducted a risk assessment on the potential spread of Smallmouth Bass in British Columbia and concluded that 29% of lakes in the Arctic drainage of British Columbia were suitable for the species and that Smallmouth Bass was a high risk to lakes in the Arctic drainage. In the Threats Calculator, the impact of this threat is very high for the Como DUs and high-low for the Opeongo and Yukon Territory DUs.

9.0. Pollution

Anthropogenic factors are not a known cause of concern to the Squanga species pairs due to the remoteness of the Yukon Territory, although humans could still have a negative effect on fish populations, should any future encroachment or pollution take place. Road salt or toxic spills from the Alaska Highway adjacent to Squanga and Little Teslin lakes, and Haines Road adjacent to Dezadeash Lake, could wash into the lakes.

Pollution and other anthropogenic activities, which could pose a threat to Opeongo Lake, are well regulated throughout Algonquin Park. There are no known pollution threats to Como Lake.

In Europe, eutrophication has caused speciation reversal in some whitefish pairs (Vonlanthen *et al.* 2012). However, eutrophication is not considered a current threat to any of the lakes in this report.

In the Threats Calculator, the impact of this threat is negligible for the Squanga DUs and did not score for the Como and Opeongo DUs.

11.0. Climate Change and Severe Weather

The effects of climate change are of concern for many freshwater fish species in Canada. Due to the uncertain nature of future changes to global climates, which will likely result in changes to landscapes, habitats, species ranges, and ecosystem structure, this threat poses a potential risk to European and Lake Whitefish, but specific threats are unknown.

In the Threats Calculator, the impact of this threat is unknown for all DUs.

Number of Locations

As each of the ten DUs is found in only a single lake in which the most serious threat, invasive species, is or will be pervasive, each DU only has a single location.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

The Squanga Lake whitefish limnetic form is listed under Schedule 3 of the federal *Species at Risk Act* (SARA) and, hence, does not receive any legal federal protection. None of the other designatable units are listed under SARA. The Como and Opeongo Lake Whitefish species pairs are not listed under the Ontario *Endangered Species Act*. As potential commercial, recreational, and Aboriginal species, whitefishes are protected under the federal *Fisheries Act*. All five whitefish pairs are afforded some habitat protection as the Opeongo species pair is present within a provincial park and the Como and Squanga pairs are present primarily within Crown land.

Non-Legal Status and Ranks

None of the ten designatable units have been assessed by NatureServe. The Yukon Conservation Data Centre has assessed Squanga Lake Whitefish (*Coregonus* sp.) as S3, indicating that it is restricted to a handful of small lakes in southern Yukon. Some (e.g. Dezadeash, Hansen) probably have separate origins (Canning pers. comm. 2017).

Habitat Protection and Ownership

Como Lake

Como Lake is situated entirely within the Chapleau Crown Game Preserve, the largest crown game preserve in the world. Within the preserve, no regulated hunting or trapping is allowed (excluding fishing) and the preserve is often used for wildlife research. The area surrounding Como Lake is almost entirely Crown land, designated as General Use land (OMNRF 2014). Along the southeastern shore of the lake is a privately owned resort, Como Lake Resort, which includes eight cabins along the shore, two additional buildings, and a campground (OMNRF 2014).

Opeongo Lake

Opeongo Lake is situated within Algonquin Provincial Park. Its location within the park provides a form of protection through the *Provincial Parks and Conservation Reserves Act*, 2006. The immediate surrounding land of Opeongo Lake is zoned areas known as Recreation/Utilization, Nature Reserves, Wilderness, and Natural Environment (OMNRF 2014).

Yukon Territory Lakes

The lakes with the Squanga whitefish species pairs are situated mostly within territorial Crown land (Yukon Government 2015). There are cottages on all three lakes, campgrounds on Dezadeash and Little Teslin lakes, and a private tourist lodge on Dezadeash Lake (Jung pers. comm. 2017). Carcross/Tagish First Nations and Teslin Tlingit Council have settlement land on Little Teslin and Squanga lakes. Champagne and Aishihik First Nations have settlement lands on Dezadeash Lake.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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INFORMATION SOURCES

Anras, M.B., Cooley, P.M., Bodaly, R.A., Anras, L., and R.J.P. Fudge. 1999. Movement and habitat use by lake whitefish during spawning in a boreal lake: integrating acoustic telemetry and geographic information systems. *Transactions of the American Fisheries Society* 128(5): 939-952.

Barker, O., Foos, A., and Millar, N., 2013. Burbot population assessment: Squanga Lake. Yukon Environment. Retrieved from http://www.env.gov.yk.ca/publications-maps/documents/Squanga_Lake_Burbot_Assessment.pdf

Bernatchez, L., and Dodson, J.J. 1994. Phylogenetic relationships among Palearctic and Nearctic whitefish (*Coregonus* sp) populations as revealed by mitochondrial DNA variation. *Canadian Journal of Fisheries and Aquatic Sciences* 51: 240–251.

Bernatchez, L., Colombani F., and Dodson. J.J. 1991. Phylogenetic relationships among the subfamily Coregoninae as revealed by mitochondrial DNA restriction analysis. *Journal of Fish Biology* 39: 283–290.

Bernatchez, L., J. A. Vuorinen, R. A. Bodaly, and J. J. Dodson. 1996. Genetic evidence for reproductive isolation and multiple origins of sympatric trophic ecotypes of whitefish (*Coregonus*). *Evolution* 50 (2): 624-635.

- Bernatchez, L., Renaut, S., Whiteley, A.R., Derome, N., Jeukens, J., Landry, L., Lu, G., Nolte, A.W., Østbye, K., Rogers, S.M. and St-Cyr, J. 2010. On the origin of species: insights from the ecological genomics of lake whitefish. *Philosophical Transactions of the Royal Society B*. 365:1783-1800.
- Bhat, S., Amundsen P.-A., Knudsen, R., Gjelland, K., Fevolden, S.E., Bernatchez, L., and Praebel, K. 2014. Speciation reversal in European Whitefish (*Coregonus lavaretus* (L.)) caused by competitor invasion. *PLOS ONE* 9:1-10.
- Bodaly, R.A. 1979. Morphological and ecological divergence within the Lake Whitefish (*Coregonus clupeaformis*) species complex in Yukon Territory. *Journal of the Fisheries Research Board of Canada* 36: 1214:1222.
- Bodaly, R.A., Clayton J.W., and Lindsey C.C. 1988. Status of the Squanga Whitefish, *Coregonus* sp., in the Yukon Territory, Canada. *Canadian Field-Naturalist* 102(1): 114-125.
- Bodaly, R.A., Clayton J.W., Lindsey, C.C., and Vuorinen, J. 1992. Evolution of lake whitefish (*Coregonus clupeaformis*) in North America during the Pleistocene: evidence for a Nahanni Glacial Refuge race in the Northern Cordillera region. *Canadian Journal of Fisheries and Aquatic Sciences* 49(4): 760-768.
- Bodaly, R.A., J. Vuorinen, and V. Macins. 1991. Sympatric presence of small-bodied and large-bodied forms of the Lake Whitefish, *Coregonus clupeaformis*, in Como Lake, Ontario. *Can. Field-Naturalist*. 105: 87-90.
- Bodaly, R.A., Vuorinen, J., Reshetnikov, Y.S., and Reist, J.D. 1994. Genetic relationships of five species of coregonid fishes from Siberia. [translated from Russian]. *Journal of Ichthyology/ Voprosy Ikhtiologii* 34:117–130.
- Bodaly, R.A., Vuorinen, J., Wards, R.D., Luczynski, M., and Reist, J.D. 1991b. Genetic comparisons of New and Old-World coregonid fishes. *Journal of Fish Biology* 38:37–51.
- Canada Park and Wilderness Society (CPAWS), 2008. Squanga Lake research report: a preliminary report on the findings of a biological survey at Squanga Lake and area, September 2000. Retrieved from <http://www.cpawsyukon.org/resources/squanga-lake-area-report.pdf>
- Canning, S. pers. comm. 2017. *Email communication*. February 13. Species at Risk Biologist, Yukon Conservation Data Centre.
- Carl, L.M., and McGuinness, F. 2006. Lake whitefish and lake herring population structure and niche in ten south-central Ontario lakes. *Environmental Biology of Fishes* 75: 315-323.
- Coad, B. 2013. *Fishes of Canada: An annotated checklist*. <http://briancoad.com/Complete%20List.htm> accessed April 1, 2015.
- Cucin, D. and Faber, D.J. 1984. Early life studies of Lake Whitefish (*Coregonus clupeaformis*), Cisco (*Coregonus artedii*) and Yellow Perch (*Perca flavescens*) in Lake Opeongo, Ontario. *Ontario Fisheries Technical Report Series* 16.

- Dryer, W.R. 1964. Movements, growth, and rate of recapture of whitefish tagged in the Apostle Islands area of Lake Superior. *Fishery Bulletin* 63(3): 611-618.
- Evans, D.O. and Ihssen, P.E. 1993. Ecological and genetic diversity of two sympatric stocks of Lake Whitefish, *Coregonus clupeaformis*, in Algonquin Park, Ontario. Conference on The Role of Parks in Conservation of Biodiversity. Algonquin Park, Ontario, September 27, 1993.
- Evans, D.O., and Loftus, D.H. 1987. Colonization of inland lakes in the Great Lakes region by rainbow smelt, *Osmerus mordax*: their freshwater niche and effects on indigenous fishes. *Canadian Journal of Fisheries and Aquatic Sciences* 44(Suppl. 2): 249-266.
- Foos, A., Millar, N.P. and Barker, O.E. 2014. Angler harvest survey: Dezadeash Lake 2013 Yukon Fish and Wildlife Branch Report TR-14-08.
- Hart, J.L. 1930. Spawning and early life history of the whitefish (*Coregonus clupeaformis*) in the Bay of Quinte, Ontario. *Contributions to Canadian Biology and Fisheries* 6(7): 50.
- Ihssen, P.E., Evans, D.O., Christie, W.J., Reckahn, J.A. and DesJardine, R.L. 1981. Life history, morphology, and electrophoretic characteristics of five allopatric stocks of Lake Whitefish (*Coregonus clupeaformis*) in the Great Lakes region. *Canadian Journal of Fisheries and Aquatic Sciences* 38: 1790-1870.
- International Union for Conservation of Nature and Conservation Measures Partnership (IUCN and CMP). 2006. IUCN – CMP unified classification of direct threats, ver. 1.0 – June 2006. Gland, Switzerland. 17 pp. [accessed 21 December 2017].
- Jung, T. pers. comm. 2017. *Email communication*. February 21. Senior Wildlife Biologist (Biodiversity), Yukon Department of the Environment.
- Kennedy, W.A. 1943. The whitefish, *Coregonus clupeaformis* (Mitchill), of Opeongo Lake, Algonquin Park, Ontario. Ontario Fisheries Research Laboratory No. 62.
- Kennedy, W.A. 1953. Growth, fecundity and mortality in the relatively unexploited whitefish, *Coregonus clupeaformis*, of Great Slave Lake. *Journal of the Fisheries Board of Canada* 10(7): 413-441.
- Landry, L., Vincent, W.F., and Bernatchez, L. 2007. Parallel evolution of Lake Whitefish small-bodied ecotypes in association with limnological features of their adaptive landscape. *J. Evol. Bio.* 20(3): 971-984.
- Lindsey C.C. 1963. Sympatric occurrence of two species of humpback whitefish in Squanga Lake, Yukon Territory. *Journal of the Fisheries Research Board of Canada*. 20(3): 749-767
- Lindsey, C.C., Patalas, K., Bodaly, R.A., and Archibald, C.P. 1981. Glaciation and the physical, chemical and biological limnology of Yukon lakes. *Canadian Technical Report of Fisheries and Aquatic Sciences* 966: vi + 37p.
- Mandrak, N.E., pers. comm. 2017. *In-person communication*. February 22. Joint American Fisheries Society/American Society of Ichthyologists and Herpetologists Names Committee member.

- Martin, N. V., and F. E. J. Fry. 1972. Opeongo Lake: effects of exploitation and introductions on the salmonid community. *Journal of the Fisheries Board of Canada* 29: 795-805.
- Matuszek, J.E., Shuter, B.J., and Casselman, J.M. 1990. Changes in lake trout growth and abundance after introduction of cisco in Lake Opeongo, Ontario. *Transactions of the American Fisheries Society* 119: 718-729.
- McDermid, J.L., Reist, J.D., and Bodaly, R.A. 2007. Phylogeography and postglacial dispersal of whitefish (*Coregonus clupeaformis* complex) in northwestern North America. *Advances in Limnology* 60: 91.
- Mee, J.A., Bernatchez, L., Reist, J.D., Rogers, S.M., and 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*. doi: 10.1111/eva.12247
- Ontario Ministry of Natural Resources and Forestry (OMNRF). 2014. Crown land use policy atlas. Ontario Ministry of Natural Resources and Forestry, Peterborough, ON. Accessed from:
<http://www.giscoeapp.lrc.gov.on.ca/web/MNR/NHLUPS/CLUPA/Viewer/Viewer.html>
- Ontario. 1998. Algonquin Provincial Park Management Plan. Queen's Printers for Ontario, Ontario, Canada. Retrieved from
http://www.algonquinpark.on.ca/pdf/management_plan.pdf
- Page, L., H. Espinosa, L.T. Findley, C.R. Gilbert, R.N. Lea, N.E. Mandrak, R.L. Mayden, and J.S. Nelson. 2013. Common and scientific names of fishes from the United States, Canada and Mexico. 7th Edition. American Fisheries Society Special Publication 24. Bethesda, MD, USA.
- Page, L.M., and B.M. Burr. 2011. A field guide to freshwater fishes, North America: North of Mexico. Houghton Mifflin Company. Boston, MA, USA. Xii + 432 pp.
- Price, J.W. 1940. Time-temperature relations in the incubation of the whitefish, *Coregonus clupeaformis*. *Journal of General Physiology* 23(4): 449-468.
- Reid, S. pers. comm. 2017. *Email communication*. February. Research Scientist, Ontario Ministry of Natural Resources and Forestry.
- Reid, S.M., Parna, M.S. and Reist, J.D. 2017. Collapse of Lake Whitefish *Coregonus clupeaformis* (Mitchill, 1818) species pair in Como Lake, Ontario. *Journal of Applied Ichthyology* 33:933-939.
- Ridgway, M. pers. comm. 2016. *Email communication*. October 14. Research Scientist, Ontario Ministry of Natural Resources and Forestry.
- Rogers, S.M. 2009. Designatable units at an appropriate scale for the Lake Whitefish (*Coregonus clupeaformis*) in Canada. Special Report prepared for the Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario. 75 pp.

- Rogers, S.M., and Bernatchez, L. 2007. The genetic architecture of ecological speciation and the association with signatures of selection in natural Lake Whitefish (*Coregonus* sp. Salmonidae) species pairs. *Molecular Biology and Evolution* 24: 1423-1438.
- Sajdak, S.L., and Phillips, R.B. 1997. Phylogenetic relationships among *Coregonus* species inferred from the DNA sequence of the first internal transcribed spacer (ITS1) of ribosomal DNA. *Canadian Journal of Fisheries and Aquatic Sciences* 54: 1494–1503.
- Salafsky, N., Salzer, D., Stattersfield, A.J., Hilton-Taylor, C., Neugarten, R., Butchart S.H.M., Collen, B., Cox, N., Master, L.L., O'Connor, S., and Wilkie, D. 2008. A standard lexicon for biodiversity conservation: unified classifications of threats and actions. *Conservation Biology* 22:897–911.
- Scott, W.B., and Crossman E.J. 1973. *Freshwater fishes of Canada*. Department of Fisheries and Oceans. Fisheries Research Board of Canada. Bulletin 173.
- Sevellec, M., Derome, N., and Bernachez, L. 2018. Holobionts and ecological speciation: the intestinal microbiota of lake whitefish species pairs. *Microbiome* 6:47-62.
- Sparling, P., and Bodaly, R.A. 2007. Update COSEWIC Status Report on Squanga Whitefish (*Coregonus* sp.) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario.
- Tovey, C.P., Bradford, M.J., and Herborg, L-M. 2008. Biological risk assessment for smallmouth bass (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides*) in British Columbia. DFO Canadian Science Advisory Secretariat Research Document 2008/075
- Trudel, M., Tremblay, A., Schetagne, R., and Rasmussen, J.B. 2001. Why are small-bodied fish so small? An energetic analysis of polymorphism in Lake Whitefish (*Coregonus clupeaformis*). *Canadian Journal of Fisheries and Aquatic Sciences* 58:394-405.
- Vonlanthen, P., Bittner, D., Hudson, A.G., Young, K.A., Müller, R., Lundsgaard-Hansen, B., Roy, D., Di Piazza, S., Largiader, C.R., and Seehausen, O. 2012. Eutrophication causes speciation reversal in whitefish adaptive radiations. *Nature* 482: 357–362.
- Vuorinen, J.A., Bodaly, R.A., Reist, J.D., Bernatchez, L., and Dodson, J.J. 1993. Genetic and morphological differentiation between small-bodied and large-bodied size forms of lake whitefish (*Coregonus clupeaformis*) in Como Lake, Ontario. *Canadian Journal of Fisheries and Aquatic Sciences* 50: 210-216.
- Weagle, K.V., and Baxter, W. 1974. The fisheries of Southern Indian Lake. Exploitation and Reproduction. Lake Winnipeg, Churchill and Nelson Rivers Study Board Report. Technical Report. Appendix 5.
- Welcomme, R.L. 1988. International introductions of inland aquatic species. FAO Fish. Tech. Pap. 294. 318 p.

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Nicholas E. Mandrak is an Associate Professor in Biological Sciences at the University of Toronto Scarborough in Toronto, Ontario. His research interests are the biodiversity, biogeography, and conservation of Canadian freshwater fishes. Nick has co-authored over 100 primary publications, over 50 government reports, 40 COSEWIC reports, and three books, including the ROM Field Guide to Ontario Fishes.

The junior authors were students in the Conservation and Biodiversity Section of Advanced Seminar in Environmental Sciences graduate course in the Department of Physical and Environmental Sciences at the University of Toronto Scarborough. As a class assignment, each student was assigned a portion of the report to research and write.

COLLECTIONS EXAMINED

Royal Ontario Museum 24649, 25654, 90674

Appendix 1a. Threats Calculator for Lake Whitefish, *Coregonus clupeaformis*, and European Whitefish *C. lavaretus*, Yukon Territory lakes species pairs.

Date: 06/06/2016

Assessor(s): Nick Mandrak (writer), John Post (co-chair), Dwayne Lepitzki (moderator), Jim Grant and Tim Haxton (SSC members), Scott Reid (COSEWIC member for ON), Nick Orton (OMNR), Angèle Cyr (Secretariat)

Overall Threat Impact Calculation Help:

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

Overall Threat Comments generation time for small-bodied: 3-5 yrs, large-bodied unknown.

Threat	Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1 Residential & commercial development					
1.1 Housing & urban areas					no ongoing development around lake.
1.2 Commercial & industrial areas					
1.3 Tourism & recreation areas					some camping but negligible
2 Agriculture & aquaculture					
2.1 Annual & perennial non-timber crops					
2.2 Wood & pulp plantations					
2.3 Livestock farming & ranching					
2.4 Marine & freshwater aquaculture					
3 Energy production & mining					
3.1 Oil & gas drilling					
3.2 Mining & quarrying					unknown.
3.3 Renewable energy					

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4	Transportation & service corridors						
4.1	Roads & railroads						Alaska Highway 1 near Squanga Lake. Road salt accounted for in 9.4
4.2	Utility & service lines						no information to support the threat of electrical lines.
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						not known.
6	Human intrusions & disturbance			Pervasive (71-100%)		High (Continuing)	
6.1	Recreational activities			Pervasive (71-100%)		High (Continuing)	need to look into. Ice fishing.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities			Pervasive (71-100%)		High (Continuing)	some research ongoing. Unknown impact
7	Natural system modifications						
7.1	Fire & fire suppression						
7.2	Dams & water management/use						no information.
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	
8.1	Invasive non-native/alien species/diseases	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	potential introduction via baitfishes or invertebrate planktivores; impact depends upon species introduced
8.2	Problematic native species/diseases						
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.6	Diseases of unknown cause						
9	Pollution		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
9.1	Domestic & urban waste water		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	road salt. some camp grounds but impact is unknown.
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration						no location specific information. Any information to suggest water levels dropping or water temperatures rising? Shift in spawning times in littoral zones??? Unknown severity since indirect impact.
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						
11.5	Other impacts						

Appendix 1b. Threats Calculator for Lake Whitefish, *Coregonus clupeaformis*, Opeongo Lake small-bodied and large-bodied species pair.

Date: 06/06/2016

Assessor(s): Nick Mandrak (writer), John Post (co-chair), Dwayne Lepitzki (moderator), Jim Grant and Tim Haxton (SSC members), Scott Reid (COSEWIC member for ON), Nick Orton (OMNR), Angèle Cyr (Secretariat)

Overall Threat Impact Calculation Help:

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

Assigned Overall Threat Impact: BD = High - Low

Overall Threat Comments: generation time for small- and large-bodied unknown but presumed to be similar to other Whitefish spp. pairs.

Threat	Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1 Residential & commercial development					
1.1 Housing & urban areas					
1.2 Commercial & industrial areas					
1.3 Tourism & recreation areas					Algonquin Park. Possible for increased boating. Unlimited horse power under another threat category.
2 Agriculture & aquaculture					
2.1 Annual & perennial non-timber crops					
2.2 Wood & pulp plantations					
2.3 Livestock farming & ranching					
2.4 Marine & freshwater aquaculture					
3 Energy production & mining					
3.1 Oil & gas drilling					

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.2	Mining & quarrying						
3.3	Renewable energy						
4	Transportation & service corridors						
4.1	Roads & railroads						bridge was recently widened. Unlikely to widen again in the next 10 years
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						some flights landing in Opeongo lake.
5	Biological resource use		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						bycatch. Ice fishing prohibited. Negligible.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						some logging. Siltation applicable in another threat category.
5.4	Fishing & harvesting aquatic resources		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
6	Human intrusions & disturbance		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Motorboats, occupy shallow waters
6.2	War, civil unrest & military exercises						
6.3	Work & other activities		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	scientific research is ongoing in the lake.
7	Natural system modifications						
7.1	Fire & fire suppression						unknown activity on fire suppression.
7.2	Dams & water management/use						one dam used to manage water levels in Opeongo as well as preventing invasives. Not a threat unless removed.
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species/diseases	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	Cisco (<i>C. artedii</i>) competition. Lakes with cisco presence results in larger and fewer whitefish. Pelagics disappear. This is likely a past threat. More verification will need to be done to clear up severity uncertainty. Spiny Waterflea might be introduced. Pike may not have direct impact.
8.2	Problematic native species/diseases						
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution						
9.1	Domestic & urban waste water						untreated sewage? Unlikely. Dilution effect. Placed strategically to minimize effects.
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						siltation unlikely due to large buffer zones.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	arthquakes/tsunamis						
10.3	valanches/landslides						
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration						no location specific information. Any information to suggest water levels dropping or water temperatures rising? Shift in spawning times in littoral zones. Unknown severity since indirect impact.
11.2	Droughts						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.3	Temperature extremes						
11.4	Storms & flooding						
11.5	Other impacts						

Appendix 1c. Threats Calculator for Lake Whitefish, *Coregonus clupeaformis*, Como Lake small-bodied and large-bodied species pair.

Date:	06/06/2016		
Assessor(s):	Nick Mandrak (author), John Post (co-chair), Dwayne Lepitzki (moderator), Jim Grant and Tim Haxton (SSC members), Scott Reid (COSEWIC member for ON), Nick Orton (OMNR), Angèle Cyr (Secretariat)		
Overall Threat Impact Calculation Help:	Threat Impact		Level 1 Threat Impact Counts
			high range
			low range
	A	Very High	1
	B	High	0
	C	Medium	0
D	Low	0	
	Calculated Overall Threat Impact:	Very High	Very High
	Overall Threat Comments	Generation time small-bodied: 3 yrs, benthic unknown, but longer than 3 yrs?	

Threat	Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1 Residential & commercial development					
1.1 Housing & urban areas					not applicable
1.2 Commercial & industrial areas					not applicable
1.3 Tourism & recreation areas					not applicable
2 Agriculture & aquaculture					
2.1 Annual & perennial non-timber crops					not applicable
2.2 Wood & pulp plantations					not applicable
2.3 Livestock farming & ranching					no evidence to suggest that this a threat
2.4 Marine & freshwater aquaculture					
3 Energy production & mining					
3.1 Oil & gas drilling					
3.2 Mining & quarrying					
3.3 Renewable energy					
4 Transportation & service corridors					

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						no evidence to suggest that this a threat
6	Human intrusions & disturbance						
6.1	Recreational activities						
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications						
7.1	Fire & fire suppression						
7.2	Dams & water management/use						
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes	A	Very High	Pervasive (71-100%)	Extreme (71-100%)	High (Continuing)	
8.1	Invasive non-native/alien species/diseases	A	Very High	Pervasive (71-100%)	Extreme (71-100%)	High (Continuing)	Spiny Waterflea (<i>Bythotrephes longimanus</i>)
8.2	Problematic native species/diseases						
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution						
9.1	Domestic & urban waste water						
9.2	Industrial & military effluents						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather						
11.1	Habitat shifting & alteration						
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						
11.5	Other impacts						