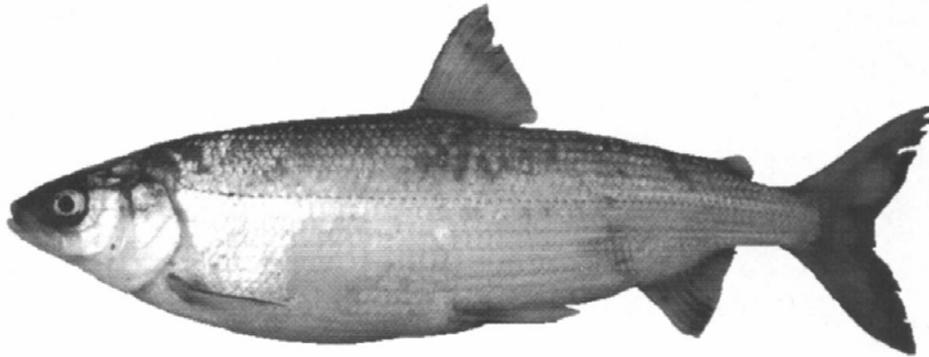


COSEWIC
Assessment and Update Status Report

on the

Shortjaw Cisco
Coregonus zenithicus

in Canada



THREATENED
2003

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE IN
CANADA



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For additional copies contact:

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

Tel.: (819) 997-4991 / (819) 953-3215

Fax: (819) 994-3684

E-mail: COSEWIC/COSEPAC@ec.gc.ca

<http://www.cosewic.gc.ca>

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Shortjaw Cisco — Photograph of a shortjaw cisco, *Coregonus zenithicus*, from Lake Nipigon, Ontario (332 mm, Aug. 1998).
Courtesy of the author, Thomas N. Todd.

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COSEWIC Assessment Summary

Assessment Summary – May 2003

Common name

Shortjaw cisco

Scientific name

Coregonus zenithicus

Status

Threatened

Reason for designation

This species has been extirpated from Lakes Huron and Erie and is in decline in Lake Superior and Great Slave Lake. It is still present in Lake Nipigon and numerous smaller lakes where its status is not well known. Threats include fishing, introduction of exotics and climate change.

Occurrence

Northwest Territories, Alberta, Saskatchewan, Manitoba, Ontario

Status history

Designated Threatened in April 1987. Status re-examined and confirmed Threatened in May 2003. Last assessment based on an update status report.



COSEWIC **Executive Summary**

Shortjaw Cisco *Coregonus zenithicus*

Introduction

The shortjaw cisco (*Coregonus zenithicus*) is a widespread species in the salmonid subfamily, Coregoninae. Originally described from Lake Superior at Duluth, Minnesota by Jordan and Evermann in 1909, it was subsequently discovered in most of the Laurentian Great Lakes and many smaller lakes in central North America. Large specimens generally approach 300 g in mass, and exceptionally large fish can reach 1.0 kg. The biology is best known in the Great Lakes (including Lake Nipigon) where the species was once a major component of vigorous food fisheries, occupying intermediate depths of 20-180 m.

Distribution

While best known from the Great Lakes, shortjaw ciscoes have a widespread distribution throughout central Canada. The species was last verified in Lake Erie prior to 1970, in Lake Michigan in 1975, Lake Huron in 1982, and was never reported from Lake Ontario. It still persists in Lake Superior where it has significantly declined in relative abundance. Other than the Great Lakes, shortjaw ciscoes have been reported from at least 22 lakes in Canada extending from Ontario to the Northwest Territories.

Protection

Shortjaw ciscoes were listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). No specific protection has been provided for the shortjaw cisco in Canada, except for general protection afforded through the Fisheries Act.

Patterns of Phenotypic and Genetic Variability

Shortjaw ciscoes exhibit morphological variability across their geographic range and two basic groups of shortjaw ciscoes exist across Canada. The most common morph is found in large lakes such as Lake Superior, Lake Nipigon, and Great Slave Lake and is characterized by more and longer gillrakers than a morph that seems more typical of small lakes such as Basswood Lake (Ontario), George Lake (Manitoba), and Barrow Lake (Alberta).

Population Sizes and Trends

Shortjaw ciscoes have been an important part of the food fishery in the Great Lakes since at least the mid-1800s. Landing records, on the whole, were not recorded by species, but were lumped into a general category, “chubs”, for all the deepwater cisco species that excluded the shallow-water lake herring. Shortjaw ciscoes seem to have been relatively uncommon in Georgian Bay waters of Lake Huron, but reached levels of 17 - 19% of chub catches from Lake Huron proper in the 1950s. Only individual specimens were taken in the 1970s, and a lone individual was taken in Lake Huron in 1982.

In Lake Michigan, the species (including fish identified as *C. alpenae*) made up about 21% of the chub catch in the 1930s, dropping to 6% in the 1950s, 2% by the early 1960s, and disappeared from the lake in the 1970s.

Other than the few specimens reported from the original paper on Lake Erie shortjaw ciscoes (described as longjaw ciscoes, *C. alpenae*), no subsequent specimens were ever collected.

The species still persists in Lake Superior, but has declined in relative abundance from nearly 90% of the chub catch in the 1920s to about 25% of the catch in the late 1950s, to 6-11% in Michigan waters in the 1970s. Two small collections made in Michigan waters in 1997 revealed abundances of 5% and 11%, in the same range as the 1970s. The abundance of the species in Lake Superior has not been adequately studied, however, and, other than its definite presence in the lake and a drastic decline since the 1920s, little can be said about recent trends.

Extensive, long-term data on the species in Lake Nipigon are lacking, although periodic population assessments have been made since the 1970s. Shortjaw ciscoes comprised 31% of the total catch of ciscoes in 1973 and more recent assessments (1997) from graded-mesh research nets have provided values of 3.4%

Population trends in other lakes that the species inhabits are generally unknown, but different sampling methods in the 1960s selectively caught more shortjaw ciscoes; however, the species has probably been stable over the past few decades. The species undoubtedly forms a portion of food-fishery captures in some of the larger lakes, such as Great Slave Lake, that have either assessment programs or fishery statistical offices, but, in the past, identification of such catches to individual species was apparently not done. Recent efforts to collect specimens from Great Slave Lake have varied in their success at finding any shortjaw ciscoes.

Habitat

In Lakes Superior, Michigan, and Huron, the shortjaw cisco generally inhabits waters 55 to 144 m in depth, although they have been recorded from as deep as 183 m and occasionally in more shallow water. Seasonal differences were noted in Lake Superior

with movement into shallower water during spawning, and the fish inhabited 110-114 m in spring, 55-71 m in summer, and 73-90 m in winter. In Lake Nipigon, shortjaw ciscoes inhabit depths of 10-60 m, although the occasional individual has been captured deeper than 60 m. Habitat preferences in smaller lakes are poorly known.

General Biology

Spawning occurs in either the fall or spring in the Great Lakes. Shortjaw ciscoes in Lakes Michigan, Huron, and Erie spawned solely in the fall. However, Lake Superior fish have been found spawning in either the spring or the fall. Fecundity of shortjaw ciscoes is likely similar to that of other deepwater species such as the bloater, ranging from 3,230 eggs for a fish 241 mm total length (TL) to 18,768 for a fish 305 mm TL (Emery and Brown 1978).

As in most fish species, shortjaw ciscoes grow quickly in their first year of life. While the sexes have been found to have similar growth in length, females grew faster in weight than the males. Maturity occurs in about the fifth year. Coregonines are opportunistic, particulate feeders that generally ingest prey one item at a time. Availability is important, and seasonal prey such as insects show up in the diets of fish in small lakes. Because shortjaw ciscoes may live in the deeper parts of lakes, terrestrial input is limited, and limnetic crustacea (copepods and cladocerans) and benthic organisms (*Mysis* and *Diporeia*) dominate their diets.

Limiting Factors

No single factor is known to be responsible for the decline of the shortjaw cisco in the Great Lakes. In Lake Erie, profound ecological changes have occurred that have shifted the lake to a more mesotrophic condition. While the physical conditions of Lakes Michigan and Huron have not changed much (with the notable exception of Saginaw Bay), the biological community has become considerably altered. The food fisheries had a negative impact earlier in the 1900s, especially on the larger individuals, at first, then on smaller individuals as mesh sizes were reduced to maintain catch levels. However, competition and predation from rainbow smelt and alewives have certainly had more of an impact during the last 30 years—years in which the food fisheries for chubs have been much less extensive than historically. Sea lamprey predation continues to take a toll on Great Lakes species, and affects smaller species such as chubs in addition to larger species such as lake trout, burbot, and lake whitefish. Abiotic factors such as weather and thermal changes in the lakes have also been suspected to play a role in population destabilization.

Factors limiting populations in smaller lakes are essentially unknown. Rainbow smelt have been introduced into many cisco lakes, including Lake Nipigon, Ontario, and have had a noticeable effect on the ecological makeup of those systems.

Special Significance of the Species

The shortjaw cisco, along with the lake herring, appear to be the ancestral colonizing species for most of the post-glacial distribution region of the Mississippi Refugium. Within the Great Lakes, the shortjaw cisco represented one lineage in the most spectacular radiation of sympatric forms in northern lakes. It is a unique form with a distribution that is intimately tied with post-glacial hydrology, and is thus of great scientific interest. Food fisheries in the Great Lakes, especially, included the species as part of a highly desirable and commercialized smoked chub market, but it was not considered more desirable than other cisco species of its same size and condition.

Evaluation

The absence of *Coregonus zenithicus* from Lakes Michigan (since 1975), Huron (since 1982), and Erie (since 1957) supports a conclusion that the species has been extirpated in these lakes. The great and gradual decline of the species in Lake Superior throughout this century, coupled with its extirpation in the lower Great Lakes, should be viewed with alarm. And the introduction of smelt into at least some of the remaining habitat of the shortjaw cisco in Canada could ultimately be detrimental to the species. The species is vulnerable to excessive food harvest, habitat degradation, and introduced exotic species throughout its range. Presently, the U.S. Fish and Wildlife Service is considering the shortjaw cisco for designation as a candidate for potential listing as Threatened or Endangered.



COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* 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.

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.



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

**Update
COSEWIC Status Report**

on the

Shortjaw Cisco
Coregonus zenithicus

in Canada

Thomas N. Todd¹

2003

¹US Geological Survey
Great Lakes Science Center
1451 Green Road
Ann Arbor, Michigan, USA
48105

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ABSTRACT

Extirpated in most of the Great Lakes, the shortjaw cisco, *Coregonus zenithicus*, is currently found in Lakes Superior and Nipigon in addition to at least 23 Canadian lakes. The species exhibits morphological and genetic variability throughout its range and may consist of more than one distinct taxon. However, a common morph is widely distributed from the Great Lakes to the Northwest Territories, consistent with a hypothesis of preglacial origin for the species. Shortjaw ciscoes have declined because of excessive exploitation by food fisheries, habitat degradation, and predation and competition with introduced and exotic species such as alewife, *Alosa pseudoharengus*, and rainbow smelt, *Osmerus mordax*. The status of the species in most Canadian lakes is unknown, but continuing declines in those lakes that have been monitored suggest that the shortjaw cisco should be considered as threatened throughout its range.

INTRODUCTION

The shortjaw cisco (*Coregonus zenithicus*) is a widespread species in the salmonid subfamily, Coregoninae. Originally described from Lake Superior at Duluth, Minnesota (the “Zenith” city) by Jordan and Evermann (1909), it was subsequently discovered in most of the Laurentian Great Lakes and many smaller lakes in central North America (Scott and Crossman 1973; Clarke 1973; Clarke and Todd 1980). Elliptical in body shape, shortjaw ciscoes, like other ciscoes, are laterally compressed and are covered with large, smooth scales (Figure 1). Generally silver in color with little pigmentation on the paired fins, these fish are olive or tan dorsally shading to white ventrally. The mouth is small and toothless, and the lower jaw is generally even with the upper jaw or shorter and included within the gape of the upper jaw (Eddy and Underhill 1978; Becker 1983). The lower jaw may occasionally extend beyond the premaxillaries in some populations, and, indeed, Jordan and Evermann (1909) typify populations in Lake Superior in this way, although this is inaccurate. The premaxillaries generally make a distinct angle on the snout in contrast to most other cisco species where the premaxillaries are generally in line with the slope of the head or make only a very minor angle at the snout. The gill rakers on the first branchial arch generally number less than 40, and are often in the mid-30s in contrast to most other cisco species that have counts of not only more than 40 but even 45-55. In addition, the gill rakers tend to be moderate or short in length compared to those of most other cisco species (Becker 1983). Unfortunately, no single diagnostic character exists with which to identify the species, but rather an association of characters must be used, of which the single most important is gill raker number. Considerable variation in size exists across the range of the species, and adults of some populations (e.g., George Lake, Manitoba and White Partridge Lake, Ontario) measure less than 150 mm standard length (SL) while adults of other populations reach lengths greater than 300 mm SL up to a maximum of about 400 mm (e.g., Lake Nipigon, Ontario). Large specimens generally approach 300 g in mass, and exceptionally large fish can reach 1.0 kg. The biology is best known in the Great Lakes (including Lake Nipigon) where the species was once a major component of vigorous food fisheries, occupying intermediate depths between 20-180 m.

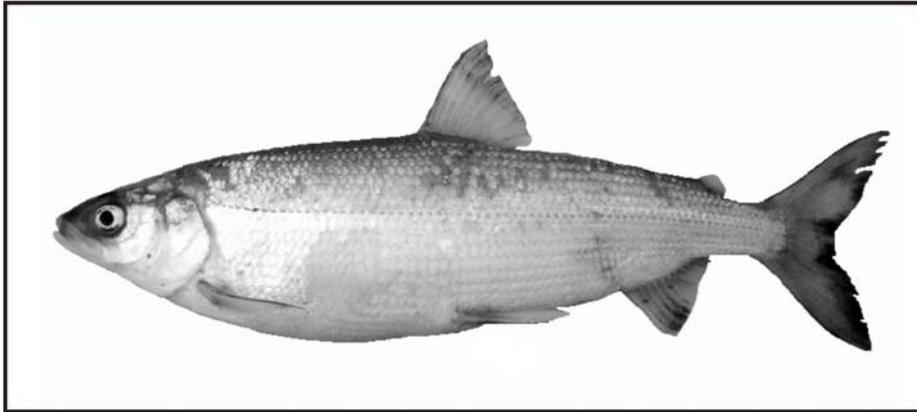


Figure 1. Shortjaw cisco, *Coregonus zenithicus*, from Lake Nipigon, Ontario (332 mm, Aug. 1998).

DISTRIBUTION

While best known from the Great Lakes, shortjaw ciscoes have a widespread distribution throughout central Canada, as well (Figure 2). Shortjaw ciscoes were last verified in Lake Michigan in 1975 and Lake Huron in 1982 (Todd 1985). However, these fish could have been strays from Lake Superior where the species was still reasonably abundant (Ono et al. 1983). Reports of the longjaw cisco, *C. alpenae*, in Lake Erie (Scott and Smith 1962) should be attributed to *C. zenithicus* based on re-examination of the original specimens and the findings of Todd et al. (1981) that concluded *C. zenithicus* and *C. alpenae* were conspecific. Interestingly, the species was not known from Lake Ontario (Koelz 1929).

Other than the Great Lakes, shortjaw ciscoes have been reported from at least 22 lakes in Canada extending from Ontario to the Northwest Territories (Table 1; Clarke 1973; Houston 1988; Etnier and Skelton 2002; Murray and Reist 2003). Most of these identifications were likely based on the key characteristic of low gill raker counts (especially when sympatric pairs of forms were present) and could represent more than one species (Clarke 1973). However, these records appear to be valid, although Clarke's suggestion that the species should be renamed *C. prognathus* based on nomenclatorial priority has been invalidated (Todd 1981a).

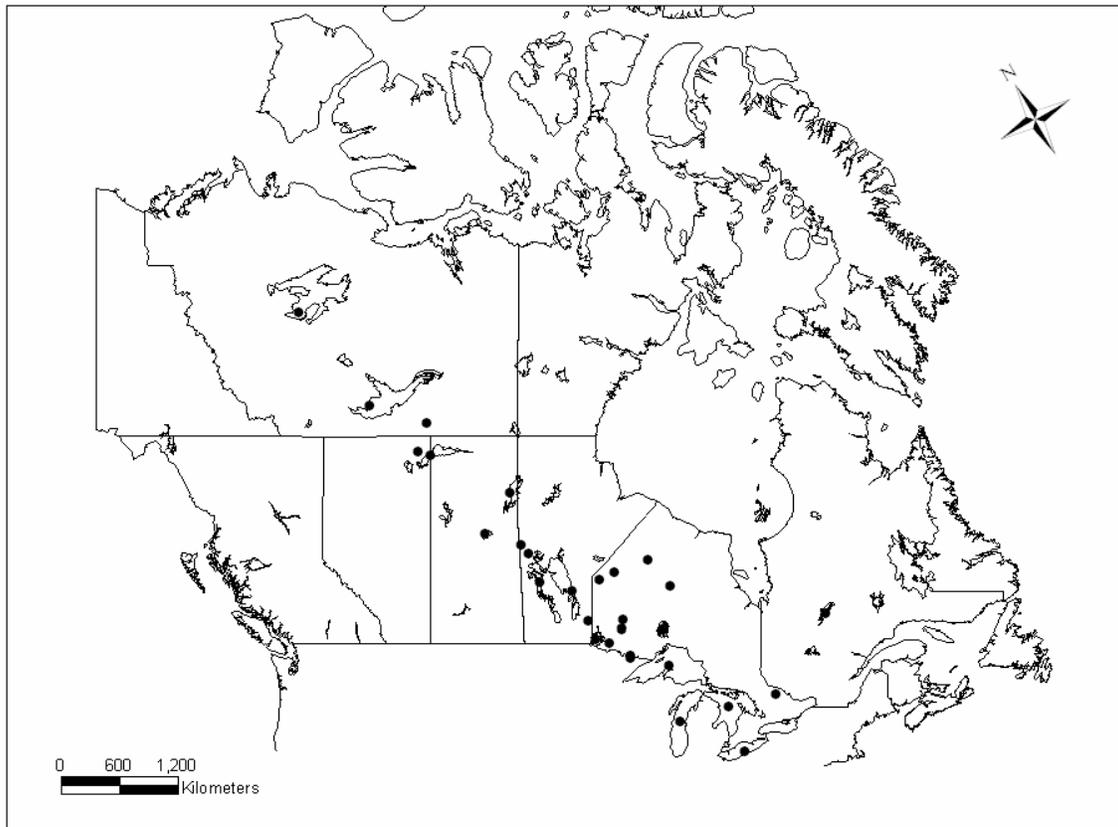


Figure 2. Distribution of known populations of the shortjaw cisco in North American lakes (dots).

PROTECTION

Shortjaw ciscoes were listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1987 (Houston 1988). In general, no specific protection has been provided for the shortjaw cisco in Canada, except for general protection afforded through the Fisheries Act. However, all species of deepwater ciscoes (chubs) in Lake Superior are managed by quota as a group. And, while exploitation in Lake Superior is not currently a threat with the absence of a commercial chub fishery, the quotas could protect the species if the fishery resumes. The lake whitefish fishery of Lake Nipigon takes some shortjaw ciscoes as by-catch, but this by-catch is not regulated by quota. Other populations in Canada are not specifically protected, and are not subject to fishery exploitation, either.

Table 1. Reported localities for occurrence of *Coregonus zenithicus*.

Lake	Province/State	Reference
Lake Athabasca	Saskatchewan	Dymond and Pritchard (1930)
Lake Attawapiskat	Ontario	Ryder et al. (1964)
Barrow Lake	Alberta	Paterson (1969)
Basswood Lake	Ontario	Royal Ontario Museum, analyzed in Steinhilber (2000) and Todd and Steinhilber (2002).
Big Athapapushkow	Manitoba	Clarke (1970) as <i>C. reighardi</i> and as <i>C. zenithicus</i> in Clarke (1973).
Big Trout Lake	Ontario	Ryder et al. (1964)
Clearwater Lake	Manitoba	Clarke (1973)
Deer Lake	Ontario	Ryder et al. (1964) and Clarke (1973)
George Lake	Manitoba	Gibson and Johnson (1969) as <i>C. hoyi</i> and Clarke (1973) as <i>C. zenithicus</i> .
Great Lakes		
Lake Erie	Ontario	Scott and Smith (1962) as <i>C. alpenae</i> and Todd and Smith (1992) as <i>C. zenithicus</i> .
Lake Huron	Michigan, Ontario	Koelz (1929)
Lake Michigan	Illinois, Indiana, Michigan, Wisconsin	Koelz (1929)
Lake Superior	Michigan, Minnesota, Wisconsin, Ontario	Jordan and Evermann (1909)
Lake Nipigon	Ontario	Koelz (1929) as <i>C. reighardi dymondi</i> and Todd and Smith (1981) as <i>C. zenithicus</i> .
Great Bear Lake	Northwest Territories	Collected in 2003 by Randy Eshenroder (Great Lakes Fishery Commission, Ann Arbor, MI, pers. comm.) and Kim Howland (Dept. Fish. Oceans Canada, Freshwater Inst., Winnipeg, Manitoba).
Great Slave Lake	Northwest Territories	Harper and Nichols (1919) as <i>Leucichthys macrognathus</i> ; Dymond (1943) and Rawson (1947) as <i>C. zenithicus</i> ; Clarke (1973) as <i>C. artedi</i> ; and Todd and Steinhilber (2002) as <i>C. zenithicus</i> .
Lake Mistassini	Quebec	Collected in 2003 by Randy Eshenroder (Gr. Lakes Fishery Commission, Ann Arbor, MI, pers. comm.)
Lac la Ronge	Saskatchewan	Rawson and Atton (1953), not verified in Clarke (1973).

Lake	Province/State	Reference
LAC SEUL	ONTARIO	Dymond and Pritchard (1930) as <i>C. nipigon</i> and Clarke (1973) as <i>C. zenithicus</i> .
Lake of the Woods	Ontario	Hinks (1957)
Lake Saganaga	Minnesota, Ontario	Etnier and Skelton (2003)
Lake Winnipeg	Manitoba	Bajkov (1930)
LAKE WINNIPEGOSIS	MANITOBA	Bajkov (1930)
Loonhaunt Lake	Ontario	Royal Ontario Museum and Murray and Reist (2003).
Reindeer Lake	Saskatchewan	Dymond (1943)
Sandy Lake	Ontario	Royal Ontario Museum as <i>C. hoyi</i> and Clarke (1973) as <i>C. zenithicus</i> .
Sandybeach Lake	Ontario	Wain (1993)
Tazin River	Northwest Territory	Harper and Nichols (1919) as <i>C. entomophagus</i> ; Dymond (1943) as <i>C. zenithicus</i> ; and Clarke (1973) as <i>C. artedi</i> .
White Partridge Lake	Ontario	Royal Ontario Museum and Nick Mandrak (Dept. Fish. Oceans Canada, Burlington, ON, pers. comm.)

PATTERNS OF PHENOTYPIC AND GENETIC VARIABILITY

Shortjaw ciscoes exhibit morphological variability across their geographic range (Clarke 1973). Previous studies revealed population subdivision in Lake Superior (Todd and Smith 1980), but the possibility that more than one morph of shortjaw cisco existed in Canada had not been studied. Todd and Steinhilber (2002) found that two basic groups of shortjaw ciscoes exist across Canada. The most common morph is found in large lakes such as Lake Superior, Lake Nipigon, and Great Slave Lake and is characterized by more and longer gill rakers than a morph that seems more typical of small lakes such as Basswood Lake (Ontario), George Lake (Manitoba), and Barrow Lake (Alberta). Recent studies on Lake Athapapushkow (Manitoba) suggested that the few-rakered form ascribable to *C. zenithicus* may actually be a conspecific morph of *C. artedi* (Aoki 2003). However, most populations of shortjaw ciscoes from the Great Lakes across Canada to the Arctic clearly share a similar morphology.

Many genetic analyses on ciscoes have not proved very informative on population differences (Todd 1981b; Reed et al. 1998; Steinhilber et al. 2002). The cisco species as a whole have sufficient genetic variability to suggest that they contain distinctive populations, at least. However, distinct genetic markers for the individual species have been elusive. Recently, though, analyses of microsatellite polymorphisms from Lake Nipigon ciscoes (Turgeon et al. 1999) revealed that shortjaw ciscoes were genetically differentiated from sympatric lake herring (*C. artedi*), bloaters (*C. hoyi*), and blackfin ciscoes (*C. nigripinnis regalis*) even though a species-specific marker was not observed. In this paper, Turgeon's findings supported the presence of two major colonizing groups in North American ciscoes (Smith and Todd 1984; Todd and Smith 1992; Turgeon and Bernatchez 2001a,b). However, a broad scale examination of genetic relationships among several cisco taxa throughout North America strongly revealed that five populations of shortjaw ciscoes (White Partridge Lake, Lake Superior, Lake Nipigon, George Lake, Barrow Lake) were genetically more similar to other sympatric or nearby populations of lake herring than they were to each other. Overall, Turgeon's work strongly suggests that diversification of the cisco assemblage occurred in the postglacial period, as has been shown for several other fish species from postglacial lakes (Schluter 1999).

POPULATION SIZE AND TRENDS

Shortjaw ciscoes have been an important part of the food fishery in the Great Lakes since at least the mid-1800s (Milner 1874; Koelz 1926). Landing records, on the whole, were not recorded by species, but were lumped into a general category, "chubs", for all the deepwater cisco species that excluded the shallow-water lake herring (Baldwin et al. 1979). Shortjaw ciscoes seem to have been relatively uncommon in Georgian Bay waters of Lake Huron, but reached levels of up to 17% of chub catches from Lake Huron proper (Koelz 1929). Collections in U.S. waters of Lake Huron in 1956 revealed that shortjaw ciscoes constituted 19% (including fish identified as *C. alpenae*) of the total chub catch—66% of which was bloaters (U.S.G.S., Great Lakes Science

Center, unpublished data). Only individual specimens were taken in the 1970s, and a lone individual was taken in Lake Huron in 1982 off Ausable Pt., Michigan (Todd 1985). In Lake Michigan, the species (including fish identified as *C. alpenae*) made up about 21% of the chub catch in the 1930s, dropping to 6% in the 1950s, 2% by the early 1960s, and disappeared from the lake in the 1970s (Smith 1964; Todd 1985). Other than the few specimens reported from the original paper on Lake Erie shortjaw ciscoes (described as longjaw ciscoes, *C. alpenae*), no subsequent specimens were ever collected, and so no information is available on the population trends in Lake Erie (Scott and Smith 1962; Scott and Crossman 1973). The species still persists in Lake Superior, but has declined in relative abundance from nearly 90% of the chub catch in the 1920s (Koelz 1929), to about 25% of the catch in the late 1950s (Hoff and Todd 2004), to 6-11% in Michigan waters in the 1970s (Peck 1977). Two small collections made in Michigan waters in 1997 revealed abundances of 5% and 11%, in the same range as the 1970s (Hoff and Todd 2004). The abundance of the species in Lake Superior has not been adequately studied, however, and, other than its definite presence in the lake and a drastic decline since the 1920s, little can be said about recent trends. While the general trend of extirpation in the Great Lakes has been reasonably well documented, the causes for the decline are not well understood. Early fisheries selectively exploited the larger individuals of all the cisco species and had driven the larger species (*C. johanna*e and *C. nigripinnis*) nearly to extinction by the 1920s (Koelz 1929; Hile and Buettner 1955). As these preferred species declined, the fishery shifted to the smaller species and increased their exploitation (Smith 1964, 1968). Proliferation of introduced rainbow smelt (*Osmerus mordax*) and alewife (*Alosa pseudoharengus*) in the 1930s through the 1950s provided additional stress from competition and predation. Also, beginning in the late 1940s, ecological changes brought about by extirpation of nearly all lake trout (*Salvelinus namaycush*) by introduced sea lamprey (*Petromyzon marinus*) resulted in the extinction of the large species, *C. johanna*e and *C. nigripinnis*, and the selective proliferation of the bloater (Smith 1964, 1968) because of a preference for larger prey species by the sea lamprey. As a further consequence of the population destabilizations, hybridization became a factor in the final demise of these species (Smith 1964; Todd and Stedman 1989). The bloater is now the only deepwater cisco species in Lakes Michigan and Huron, and dominates in Lake Superior (Fleischer 1992).

Populations of shortjaw ciscoes in Lake Nipigon are still abundant and coexist with lake herring, bloaters, and blackfin ciscoes (*C. nigripinnis regalis*), as well as lake whitefish (*C. clupeaformis*) and round whitefish (*Prosopium cylindraceum*), rather like the situation in the other Great Lakes (with the exception of blackfin ciscoes). Extensive, long-term data on the species are lacking, although periodic population assessments have been made since the 1970s. Examination of commercial catches (large-mesh nets) and experimental sets in 1973 revealed that shortjaw ciscoes comprised 31% of the total catch of ciscoes (U.S.G.S., Great Lakes Science Center, unpublished data). More recent assessments (1997) from graded-mesh research nets have provided values of 3.4%, although these values are probably biased on the low side because of uncertain identifications (R. Salmon, Ontario Ministry of Natural Resources, Lake Nipigon Assessment Unit, personal communication).

Population trends in other lakes that the species inhabits are generally unknown. Steinhilber and Ruhde (2001) noted that the species formed 4.2-5.7% of cisco collections in Barrow Lake, Alberta in 1996-1997 and 11.6% in 2000 with many immature specimens in all years that suggested good reproduction and juvenile survival. Cisco collections in Barrow Lake in 1966 contained 21% shortjaw ciscoes (Turner 1967; Paterson 1969). Steinhilber and Ruhde (2001) concluded that different sampling methods in the 1960s selectively caught more shortjaw ciscoes and that the species has been stable over the past few decades. The species undoubtedly forms a portion of food-fishery captures in some of the larger lakes, such as Great Slave Lake, that have either assessment programs or fishery statistical offices, but identification of such catches to individual species is apparently not done. Some recent collections from Great Slave Lake have not contained any shortjaw ciscoes while others have (Murray and Reist 2003).

HABITAT

In Lakes Superior, Michigan, and Huron, the shortjaw cisco generally inhabits waters 55 to 144 m in depth, although they have been recorded from as deep as 183 m and occasionally in more shallow water (Scott and Crossman 1973). Seasonal differences were noted in Lake Superior with movement into shallower water during spawning, and the fish inhabited 110-114 m in spring, 55-71 m in summer, and 73-90 m in winter (Dryer 1966). Hoff and Todd (2004) noted during 1999-2001 that Lake Superior shortjaw ciscoes were most abundant at the maximum depths at which they were collected in the 1920s, suggesting a shift to deeper water in the intervening decades. In Lake Nipigon, shortjaw ciscoes inhabit depths between 10-60 m, although the occasional individual has been captured deeper than 60 m (Turgeon et al. 1999).

Habitat preferences in smaller lakes are poorly known. Captures in George Lake, Manitoba from gillnets set in August 1996 between 36-57 m revealed that shortjaw ciscoes inhabited the very deepest stratum of the lake—occurring mostly in gillnets set at 45-47 m, but not in sets shallower than 42 m (Murray and Reist 2003). Likewise, shortjaw ciscoes were found to inhabit the deepest portions of Sandybeach Lake, Ontario, at depths ranging 22-38 m along with sympatric lake herring (Wain 1993). Certainly, once the lakes stratify, the fish will be found in the deeper waters of the hypolimnion. In contrast, shortjaw ciscoes were found quite shallow at depths of 2-16 m in Barrow Lake, Alberta (maximum depth=24 m; Steinhilber et al. 2002).

GENERAL BIOLOGY

Spawning occurs in either the fall or spring in the Great Lakes. Shortjaw ciscoes in Lakes Michigan, Huron, and Erie spawned solely in the fall (Koelz 1929; Scott and Smith 1962). However, Lake Superior fish have been found spawning in either the spring or the fall—a fact noted by Koelz (1929), although he considered it unusual and concluded, along with VanOosten (1936), that Lake Superior shortjaw ciscoes spawned

in the fall. Todd and Smith (1980) reported a more extensive occurrence of spring spawning in this species. Eggs are deposited over the lake bottom (generally clay in the Great Lakes) and left to develop without parental care for a period of three or four months, depending on temperature (Berlin et al. 1977). Fecundity of shortjaw ciscoes is likely similar to that of other deepwater species such as the bloater, ranging from 3,230 eggs for a fish 241 mm total length (TL) to 18,768 for a fish 305 mm TL (Emery and Brown 1978).

As in most fish species, shortjaw ciscoes grow quickly in their first year of life. While the sexes have been found to have similar growth in length, females grew faster in weight than the males—growing an average of about 30 g a year in mature fish with an annual length increase of about 25 mm (VanOosten 1936). Maturity occurred in about the fifth year and resulted in additional growth in weight, primarily due to gonadal development—nearly 60% of potential maximum weight gain occurred after age five compared to growth in length that reached about 80% of its potential maximum value at age five and increased only slowly thereafter (VanOosten 1936). Maximum size for Lake Superior fish has been recorded at 276 g for males 368 mm TL, and females at 292 g (VanOosten 1936). Lake Nipigon shortjaw ciscoes exhibit larger sizes, and have been recorded at weights of 500 g to 1.0 kg and up to 400 mm TL (R. Salmon, Ontario Ministry of Natural Resources, Lake Nipigon Assessment Unit, pers. comm.). Some populations of shortjaw ciscoes mature at much smaller sizes—adult fish in George Lake, Manitoba, for example averaged only 158 mm (127-173 mm) SL (U.S.G.S., Great Lakes Science Center, unpublished data).

Coregonines are opportunistic, particulate feeders that generally ingest prey one item at a time. Availability is important, and seasonal prey such as insects show up in the diets of fish in small lakes. Because shortjaw ciscoes may live in the deeper parts of lakes, terrestrial input is limited, and limnetic crustacea (copepods and cladocerans) and benthic organisms (*Mysis* and *Diporeia*) dominate their diets (Koelz 1929; Bersamin 1948; Anderson and Smith 1971; Wain 1993; Turgeon et al. 1999; Hoff and Todd 2004). Such prey has been found to dominate the diet of shortjaw ciscoes even in shallower habitats—Barrow Lake, Alberta, for example (Steinhilber et al. 2002).

In addition to the species' importance in general food fisheries, shortjaw ciscoes form an important part of the forage base for predators such as lake trout and burbot (*Lota lota*). In the Great Lakes, the species was one of several that functioned in this role, but, in smaller Canadian lakes, it is often the main forage for predators. It is also likely that the species became vulnerable to predation from sea lampreys in the Great Lakes as favored individuals of larger species became depleted.

LIMITING FACTORS

No single factor is known to be responsible for the decline of the shortjaw cisco in the Great Lakes. In Lake Erie, for example, profound ecological changes have occurred that have shifted the lake to a more mesotrophic condition (although the lake has

rebounded from eutrophy because of phosphorus controls and the effects of zebra mussels), to the detriment of the deep-water, more oligotrophic community that historically existed there (Hartman 1972). While the physical conditions of Lakes Michigan and Huron have not changed much, with the notable exception of Saginaw Bay, the biological community has become considerably altered (Smith 1972). Undoubtedly, the vigorous food fisheries had a negative impact earlier in the 1900s, especially on the larger individuals, at first, then on smaller individuals as mesh sizes were reduced to maintain catch levels. However, competition and predation from rainbow smelt and alewives have certainly had more of an impact during the last 30 years—years in which the food fisheries for chubs have been much less extensive than historical levels (Crowder 1980; Rice et al. 1987; Fleischer 1992). Sea lamprey predation continues to take a toll on Great Lakes species, and affects smaller species such as chubs in addition to larger species such as lake trout, burbot, and lake whitefish (U.S.G.S., Great Lakes Science Center, unpublished data). Abiotic factors such as weather and thermal changes in the lakes have also been suspected to play a role in population destabilization (Brown et al. 1987; Eck and Wells 1987; Taylor et al. 1987). Such destabilization can favor one species over another, resulting in competitive displacement or hybridization (Smith 1964; Todd and Stedman 1989; Davis and Todd 1998). The overwhelming preponderance of work on Great Lakes chubs has been with adults or relatively large young-of-the-year fish, primarily because of their vulnerability to capturing gear in both food fisheries and scientific assessment programs. The growing knowledge of how biotic and abiotic changes in the system have influenced populations has revealed that the larval and juvenile stages are the most vulnerable, and factors limiting survival at these stages need better understanding.

Factors limiting populations in smaller lakes are essentially unknown. Rainbow smelt have been introduced into many cisco lakes, including Lake Nipigon, Ontario, and have had a noticeable effect on the ecological makeup of those systems (Wain 1993; Franzin et al. 1994). The effects that rainbow smelt have on reducing and altering zooplankton populations have apparently not resulted in the extirpation of populations of shortjaw ciscoes, but alarm should be taken in situations of sympatric occurrence of rainbow smelt and shortjaw ciscoes in small lacustrine systems because of the potential for ecological destabilization.

SPECIAL SIGNIFICANCE OF THE SPECIES

The shortjaw cisco, along with the lake herring, appears to be the ancestral colonizing species for most of the post-glacial distribution region of the Mississippi Refugium (Todd and Smith 1992). Within the Great Lakes, the shortjaw cisco represented one lineage in the most spectacular radiation of sympatric forms in northern lakes (Smith and Todd 1984). It is a unique form with a distribution that is intimately tied with post-glacial hydrology, and is thus of great scientific interest. Presumably, its morphological differences from the lake herring group of ciscoes “adapt” it in some unique, but as yet unrevealed, manner to survival in northern aquatic ecosystems because of its persistence throughout the past millenia. Food fisheries in the Great

Lakes, especially, included the species as part of a highly desirable and commercialized smoked chub market, but it was not considered more desirable than other cisco species of its same size and condition.

EVALUATION

The absence of *Coregonus zenithicus* from Lakes Michigan (since 1975), Huron (since 1982), and Erie (since 1957) supports a conclusion that the species has been extirpated in these lakes (Todd 1985). The great and gradual decline of the species in Lake Superior throughout this century, coupled with its extirpation in the lower Great Lakes, should be viewed with alarm. And, the introduction of smelt into at least some of the remaining habitat of the shortjaw cisco in Canada could ultimately be detrimental to the species. The species is vulnerable to excessive food harvest, habitat degradation, and introduced exotic species throughout its range. Assessments of population abundance are especially needed from most of the Canadian lakes in which the species is extant in addition to Lake Superior. Previously considered by the U.S. Fish and Wildlife Service as a Category 2 species for potential listing under the U.S. Endangered Species Act, the species currently occupies an indeterminate status following elimination of these categories (Department of Interior 1996). Presently, the U.S. Fish and Wildlife Service is considering the shortjaw cisco for designation as a candidate for potential listing as Threatened or Endangered, and, in support of this potential designation, is considered as a "Species at Risk" by the U.S. Geological Survey for priority in research. The shortjaw cisco was designated as "Threatened" by the Committee on Status of Endangered Wildlife in Canada (Houston 1988), considered as "May Be at Risk" by the Province of Alberta (Steinhilber and Ruhde 2001), listed as "Threatened" by the Michigan Department of Natural Resources (MIDNR 1974, Latta 1998), and listed as "Endangered" by the Wisconsin Department of Natural Resources (WDNR 1975). "Threatened" status is recommended for this species throughout its range.

TECHNICAL SUMMARY

Coregonus zenithicus

Shortjaw Cisco

Range of Occurrence in Canada

Cisco à mâchoires égales

NT, AB, SK, MB, ON

Extent and Area Information

Extent of occurrence

>1 x 10⁶ km²

Area of occupancy:

>175,000 km²

Trend

Declining

Number of extant locations:

20-21

Number of historic locations from which the species
has been extirpated

2 possibly 3

Habitat trend

Decline in extent and quality
of habitat in some areas

Population Information

Number of mature (capable of reproduction) individuals
in the Canadian population:

Unknown

Generation time:

5 years

Population trend:

Declining

Rate of decline: Current rate is not known, but historic decline is

>30%

Is population fragmented?

Yes

Number of individuals in each sub-population

Unknown

Does the species undergo fluctuations?

Not known to occur

Threats

Food fisheries; habitat loss and degradation resulting from urban, agriculture and industrial activities; introductions of exotic species; sea lamprey predation; and population destabilization resulting from climatic change, and introgressive hybridization. Populations are fragmented and fringe populations are in decline so therefore no rescue effect, especially as only remaining U.S. populations are those in Lake Superior which are probably endangered (A4a-e).

Rescue Potential

Does the species exist elsewhere?

Negligible

Is immigration known or possible?

No

No

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THE AUTHOR

Thomas Todd has a B.A. in Biology from California State University at Fullerton (1970) and a M.S. in Zoology from The University of Michigan (1972). His earliest academic interests were in fossil fishes (three publications), but concentrated on the Great Lakes subsequent to his employment at the Great Lakes Fishery Laboratory in Ann Arbor, Michigan by the U.S. Fish and Wildlife Service in 1972. Specifically, his work on the diverse fauna of whitefishes in the Great Lakes (genus *Coregonus*) has brought him international recognition, and he has represented these research interests on the international steering committees of several symposia concerned with the biology and management of these fishes. He is a past president of the Michigan Chapter of the American Fisheries Society and a member of the Editorial Advisory Board of the *Polish Archives of Hydrobiology*. He has also served on the editorial committees for the published proceedings of three international whitefish symposia and was the primary editor of two other such volumes. Other research interests include the population genetics and ecology of yellow perch and walleye as well as the salmonid fishes of the Great Lakes. Mr. Todd has been Chief of the Branch of Ecosystem Dynamics at the Great Lakes Science Center (U.S. Geological Survey successor of the USFWS Great Lakes Fishery Laboratory) heading up a diverse team of researchers who are examining the biodiversity, genetics, health, feeding, behavior, and taxonomy of fishes and invertebrates in the Great Lakes. Currently, he is the Assistant Director of the Great Lakes Science Center.