COSEWIC
Assessment and Status Report

on the

Bering Cisco
Coregonus laurettae

in Canada

SPECIAL CONCERN
2017

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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COSEWIC 2004. COSEWIC assessment and update status report on the Bering cisco *Coregonus laurettae* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 19 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

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Bering Cisco — Cover photo credit: R. J. Brown, USFWS.

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COSEWIC
Assessment Summary

Assessment Summary – November 2017

Common name
Bering Cisco

Scientific name
Coregonus laurettae

Status
Special Concern

Reason for designation
This is an anadromous fish that annually migrates through Alaskan waters of the Yukon River to access the upper reaches of the river in Canada. The abundance of the species in the Canadian portion of the Yukon River is unknown, but low compared to Alaskan sections of the river. The primary threat to the population in Canada is a combination of directed and bycatch fisheries, but these are currently poorly quantified. If harvest is not managed effectively, the species may become Threatened.

Occurrence
Yukon

Status history
Species considered in April 1990 and placed in the Data Deficient category. Status re-examined and designated Special Concern in November 2004 and November 2017.

COSEWIC
Executive Summary

Bering Cisco
Coregonus laurettae

Wildlife Species Description and Significance

Bering Cisco (*Coregonus laurettae*) is part of the family Salmonidae and subfamily Coregoninae. Bering Cisco shares morphological similarities with the other Cisco species, such as the Arctic Cisco (*Coregonus autumnalis*) and Least Cisco (*Coregonus sardinella*). However, Bering Cisco has a more elongate, less laterally compressed body, and pale pelvic and pectoral fins in comparison to other Cisco species. The Canadian population of Bering Cisco represents the most eastwardly extent of this species' range in North America.

Distribution

Bering Cisco is almost entirely confined to Alaska, with limited numbers observed in Yukon and the eastern coastal regions of Siberia. It occurs in brackish coastal regions of the Beaufort, Bering and Chukchi seas, with spawning migrations restricted to the Kuskokwim, Sustina, and Yukon rivers. In Canada, Bering Cisco is not common and is only known to occur within a 145 km stretch of the Yukon River—from the Alaska / Yukon border to Dawson City, but this is based on limited information.

Habitat

The habitat requirements of Bering Cisco are largely unknown. The only known Canadian population occurs in the mainstem of the Yukon River where it likely migrates for spawning. Bering Cisco probably spawn over gravel and sand beds in swiftly flowing water like other co-occurring anadromous coregonine species. To date no spawning locations have been located in Canada; however, it is presumed that this species is migrating up the Yukon River into Canada to spawn.

Biology

Bering Cisco reach sexual maturity between 4 and 9 years old (5 years on average for females in the Yukon River), with a maximum known age of 13 years. Sexually mature adults have a fork length between 31 and 45 cm, with males at the smaller end of this range. In the fall, Bering Cisco migrate from brackish coastal waters up large river systems. Little is known about spawning behaviour, but larvae hatch in the spring, and then migrate back downstream to feed and develop in brackish coastal waters. They remain in these habitats until sexual maturity, when they return to natal freshwater rivers to spawn. This

species feeds primarily on small fishes, zooplankton, crustaceans, and aquatic insects. Feeding occurs primarily in nearshore coastal waters and deltas, and Bering Cisco are not known to feed during their spawning migrations. Bering Cisco is relatively abundant in the lower Yukon River and, as with other Cisco species, is likely an important part of the Bering Sea food web.

Population Sizes and Trends

The size of the Canadian population of Bering Cisco is unknown, but it likely occurs in Canada in low numbers based on historical incidental catches of <100/year. There are insufficient data to suggest a change in population size in Alaskan waters, and information on Canadian waters is even more limited.

Threats and Limiting Factors

Although existing information is limited for Bering Cisco in Canada, the threats from both Biological Resource Use and Human Intrusions & Disturbance have likely decreased over the past decade. Threats from Energy Production & Mining primarily occur in coastal waters and tributaries with negligible effect on Bering Cisco (as they are restricted to the mainstem of the Yukon River). This species has few if any direct interactions with humans in Canada due to its limited distribution and remote location. Bering Cisco is an anadromous Arctic fish, and as such would be vulnerable to the impacts of climate change and severe weather, but these effects are again less-pronounced in the mainstem and the impact on Bering Cisco is not clear. There is an ongoing source of pollution from effluent of the Dawson City wastewater treatment plant, but this is expected to have negligible effect because it is treated effluent.

Protection, Status and Ranks

COSEWIC designated the Canadian population of Bering Cisco as “Special Concern” in 2004. This population occurs entirely in public waters, and all fish habitat within these waters is under the jurisdiction of the federal *Fisheries Act.* The *Fisheries Act* applies protection to commercial, recreational, and Aboriginal (CRA) fisheries. While Bering Cisco are not specifically targeted in any commercial, recreational or Aboriginal fishery in Canada, Ciscoes and whitefish are collectively harvested by First Nations, in which some of the take may contain Bering Cisco. Also, Bering Cisco and their habitat may be considered to support CRA species (as a prey item) and, hence, be afforded protection under the *Fisheries Act*. There are no recovery efforts specifically targeting Bering Cisco.

Bering Cisco has a global NatureServe conservation rank of G4 (apparently secure), and a rank of N3 (vulnerable) in both the US and Canada. It has rankings of S3 (vulnerable) in both Alaska and Yukon.

TECHNICAL SUMMARY

Coregonus laurettae

Bering Cisco

Cisco de l'Alaska

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

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	4 – 9 years (5 years on average for females in the Yukon River)
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	1,216 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	468 km² continuous 12 km² discrete
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"* (use plausible range to reflect uncertainty if appropriate)	A single stretch of river inferred from 3 documented capture sites In Canada, Bering Cisco is only known to occur in one location: a 145 km stretch of the Yukon River; from the Alaska / Yukon border to Dawson City.
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?	no
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?	unknown
Are there extreme fluctuations in number of "locations"*?	unknown
Are there extreme fluctuations in extent of occurrence?	unknown
Are there extreme fluctuations in index of area of occupancy?	unknown

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
unknown	Unknown, but likely low as inferred by low catches in Canadian waters
Total	

Quantitative Analysis

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

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes on 17 January 2017 Overall Impact: *Medium-Low* Biological Resource Use / Human Intrusions and Disturbance (primarily from fisheries bycatch): *Medium-Low*

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

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Bering Cisco has a global NatureServe conservation rank of G4 (apparently secure), and a rank of N3 (vulnerable) in the US and S3 (vulnerable) in Alaska.
Is immigration known or possible?	yes
Would immigrants be adapted to survive in Canada?	yes
Is there sufficient habitat for immigrants in Canada?	Unknown, but it should be noted that noted that the fish observed in Canada migrate from Alaska
Are conditions deteriorating in Canada?[+]	no
Are conditions for the source population deteriorating?[+]	no
Is the Canadian population considered to be a sink?[+]	no
Is rescue from outside populations likely?	Yes

Data Sensitive Species

Is this a data sensitive species? no

Status History

COSEWIC Status History: Species considered in April 1990 and placed in the Data Deficient category. Status re-examined and designated Special Concern in November 2004 and November 2017.

Recommended Status and Reasons for Designation:

Recommended Status: Special Concern	**Alpha-numeric codes:** Not applicable
Reasons for designation: This is an anadromous fish that annually migrates through Alaskan waters of the Yukon River to access the upper reaches of the river in Canada. The abundance of the species in the Canadian portion of the Yukon River is unknown, but low compared to Alaskan sections of the river. The primary threat to the population in Canada is a combination of directed and bycatch fisheries, but these are currently poorly quantified. If harvest is not managed effectively, the species may become Threatened.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable
Criterion B (Small Distribution Range and Decline or Fluctuation): Although the EOO and IAO are small and there is a single location, there is no evidence of declines nor extreme fluctuations and therefore no sub-criteria are met.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable

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

Criterion D (Very Small or Restricted Population): Not applicable
Criterion E (Quantitative Analysis): Not applicable

PREFACE

The Canadian population of Bering Cisco (*Coregonus laurettae*) is restricted to the mainstem Yukon River, downstream from Dawson City, Yukon. Globally, they are restricted to the coastal waters and rivers of Alaska, with limited observations off the east coast of Siberia. They are abundant in the brackish coastal waters of the Bering Sea where they are thought to be an important part of the coastal food web. Bering Cisco is not abundant in Canada. It is not known where the Canadian population spawns, but it is assumed that they represent individuals on the farthest edge of their anadromous, migratory range, thus warranting special consideration.

There are no new catch data for the Canadian population because the 2004 report, as Fisheries and Oceans Canada (DFO) fish wheels designed to catch and count Pacific salmon at the Canada-US border ceased operation in 2012. These fish wheels provided some Bering Cisco counts as bycatch, but have since been replaced with sonar that cannot differentiate among Cisco species that may migrate up the river, including Least Cisco (*Coregonus sardinella*). However, video observations at Alaskan fish wheels downstream of the international border have noted steady or possibly increasing catches in Bering Cisco since 2001. They continue to be the most commonly observed fish in these fish wheels, suggesting a steady population migrating into Canadian waters.

The main threats to Bering Cisco are Biological Resource Use and Human Intrusions & Disturbance. Most notably, they have become a targeted species for an Alaskan commercial fishery in the lower section of the Yukon River since the 2004 report. This may affect the Canadian population as it migrates up this river to enter Canadian waters. There is no indication that the Canadian population is affected, but the effects of higher harvest quotas are unknown. The fishery is likely to persist for the foreseeable future. There is still potential for Bering Cisco to be caught incidentally in commercial gillnets set for Pacific salmon (primarily Chum (*Oncorhynchus keta*) and Chinook (*O. tshawytscha*) salmon); however, the mesh-size used is larger than what would target fish the size of Bering Cisco. Furthermore, the salmon fishery in the Canadian portion of the Yukon River has been declining over time. It is also likely that Bering Cisco in Canadian waters are incidentally caught along with other salmonids in First Nations subsistence fisheries.

There are no other substantial, direct threats to Bering Cisco in Canadian waters. Previously, hydroelectric development was a concern, but there is currently no reason to assume this to be a threat. Both Energy Production & Mining primarily occur in coastal waters and tributaries with negligible effect on Bering Cisco (as they are restricted to the mainstem). Bering Cisco is an Arctic / sub-Arctic fish, and as such would be vulnerable to the impacts of Climate Change and Severe Weather, but these effects are again less-pronounced in the mainstem and the effect on Bering Cisco is unclear.

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
(2017)

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

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

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

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

Environment and Climate Change Canada
Canadian Wildlife Service
Environnement et Changement climatique Canada
Service canadien de la faune
Canada

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

COSEWIC Status Report

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Kingdom: Animalia

Phylum: Chordata

Class: Actinopterygii

Order: Salmoniformes

Family: Salmonidae

Subfamily: Coregoninae

Genus and Species: *Coregonus laurettae* (Bean 1882)

Common English name: Bering Cisco

French name: Cisco de l'Alaska

Northern Tuchtone: *sunkay*

Han: *ik-canoo*

Other names: Lauretta, herring, lake herring, tulibee, sharp nose

Morphological Description

Bering Cisco (*Coregonus laurettae*) is part of the subfamily Coregoninae and shares morphological similarities with the other Cisco species, such as the Arctic Cisco (*C. autumnalis*) and Least Cisco (*C. sardinella*). Bering Cisco (Figs. 1 and 2) has a more elongate and less laterally compressed body in comparison to other Cisco species (Morrow 1980). They have a terminal mouth, and unlike Arctic Cisco, Bering Cisco have small teeth on the premaxillary bone and anterior end of the lower jaw (Politov *et al.* 2004). The body depth is greatest anterior of the dorsal fin, and the dorsal fin is considered high and falcate, with 11 to 13 rays (Morrow 1980). Pelvic fins have a distinct axillary process common in Cisco species. Adult dorsal colouration varies from brownish to green on back, progressing to silver ventrally along the sides (McPhail and Lindsay 1970), and with darkened caudal and dorsal fins that sometimes appear mottled (Morrow 1980; Mecklenburg *et al.* 2002). Colourless pectoral, pelvic, and anal fins distinguish Bering Cisco from the Least Cisco, and fewer gill rakers (18 – 25) on the lower portion of the first gill arch differentiate it from Arctic Cisco (Morrow 1980). Scales are large and cycloid (McPhail and Lindsay 1970). The average fork length of migrating Bering Cisco in the Yukon River was 37 cm (between 31 and 45 cm at sexual maturity), weighing approximately 600 g (sampled near Fort Yukon

between 1998 and 2001). Male fish in another survey were on average slightly smaller at 34 cm compared to 38 cm for females (Brown *et al.* 2012a). Otherwise there is very little sexual dimorphism exhibited in Bering Cisco (McPhail and Lindsay 1970). Little is known about the morphology of early life history stages.

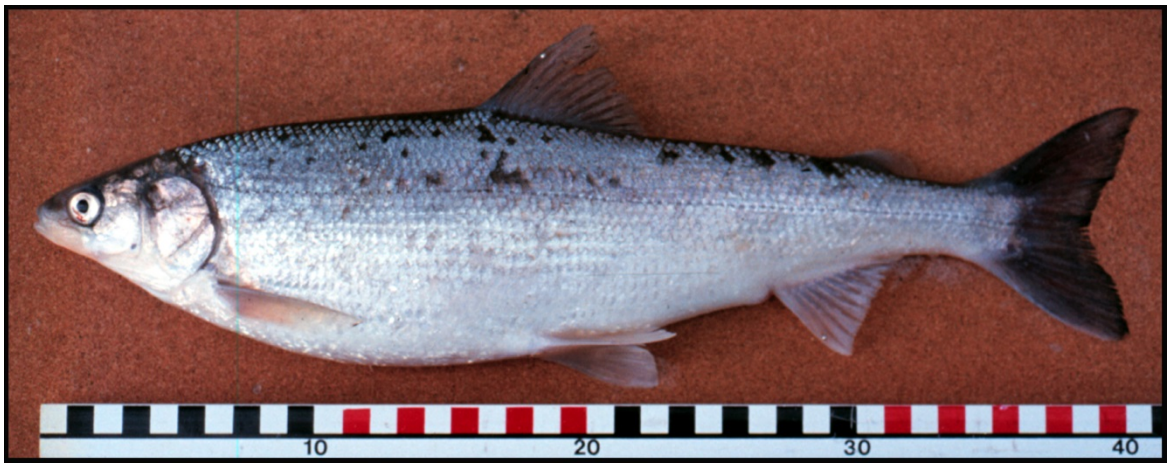

Figure 1. A gravid female Bering Cisco (*Coregonus laurettae*). Photo credit: R. J. Brown, USFWS

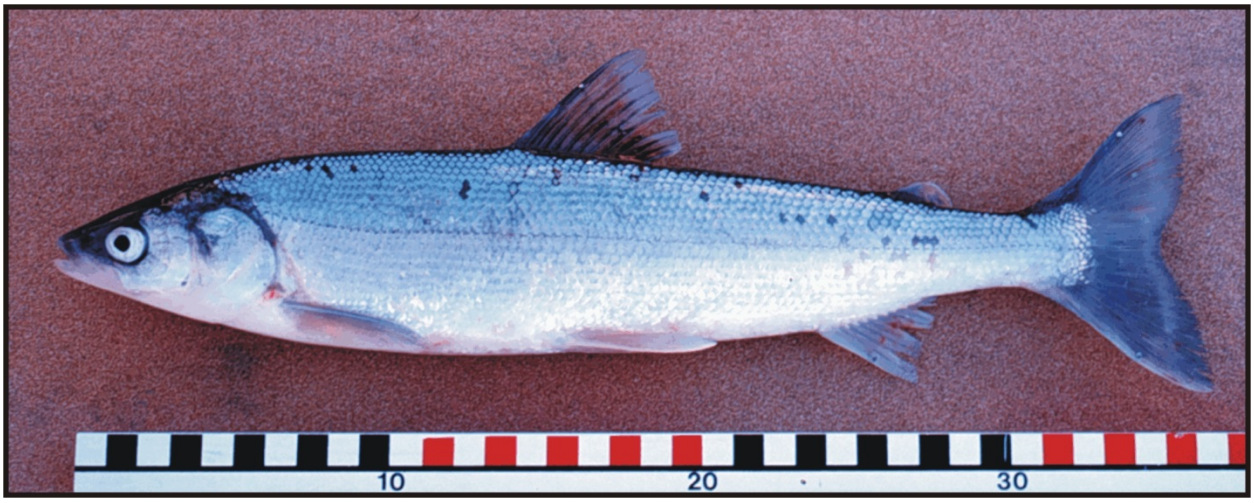

Figure 2. A male Bering Cisco (*Coregonus laurettae*). Photo credit: R. J. Brown, USFWS

Population Spatial Structure and Variability

There has been debate as to whether Bering Cisco is genetically differentiated enough from Arctic Cisco to be considered taxonomically separate. Phylogenetic studies of mtDNA variation have suggested significant genetic divergence (Politov *et al.* 2004), but recent barcoding techniques infer an average sequence divergence less than 0.5%, supporting very close relationship between these species (Schlei *et al.* 2008). There is also evidence of hybridization between the Arctic and Bering Ciscoes (Bickham *et al.* 1997). Russ (2015) found significant genetic divergence among Yukon, Kuskokwim, and Susitna river spawning populations, suggesting that each river supported a discrete stock of Bering Cisco. The Yukon River population constitutes the majority of Bering Cisco in the Alaskan commercial Cisco fishery, and this is probably the same stock that migrates into Canadian waters (see Figure 3 for spawning rivers and commercial fishery location).

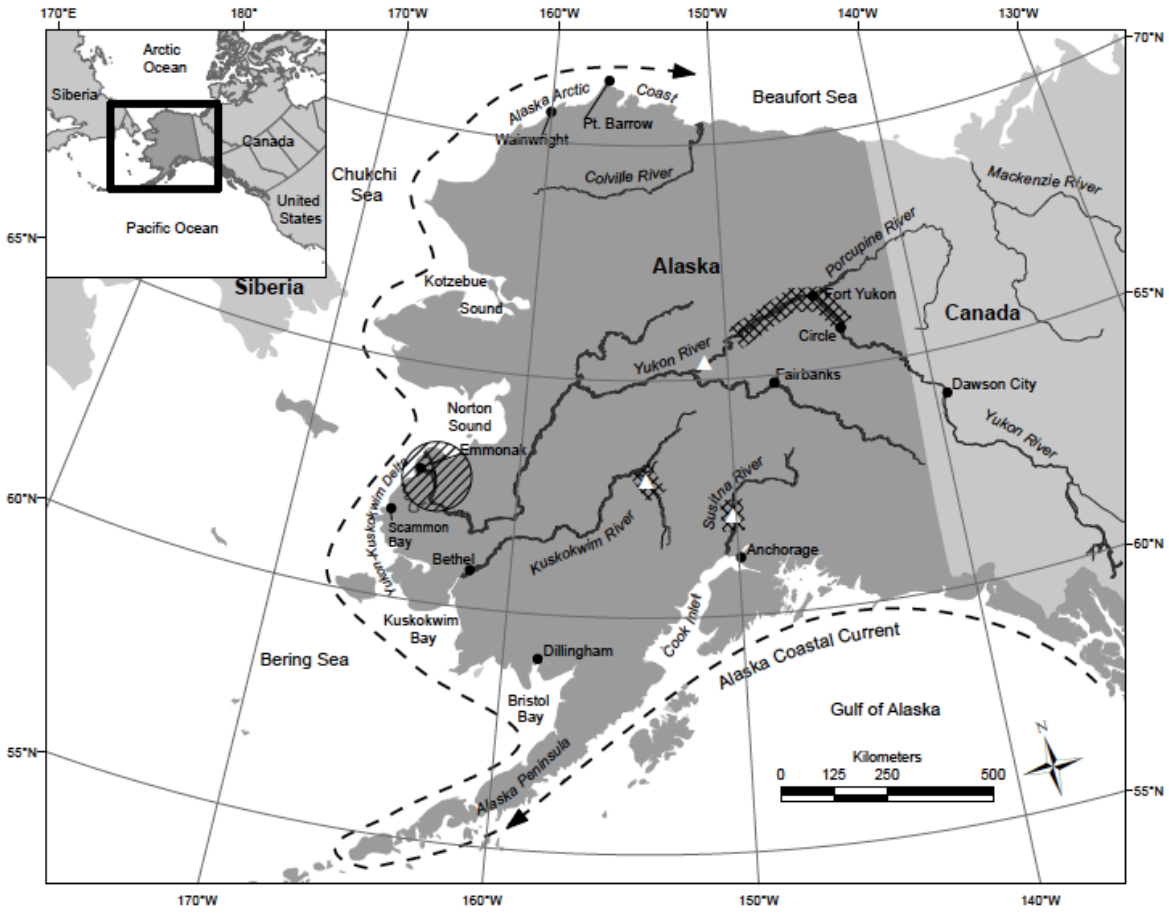

Figure 3. Map of Bering Cisco spawning locations (cross-hatch) and genetics sampling locations (white triangles) in relation to the commercial fishery (hatch circle) and north-flowing Alaska Coastal Current (dashed arrow). From Padilla *et al.* (2015), with permission.

Designatable Units

The Canadian population is assessed as a single designatable unit as it is found in a single National Freshwater Biogeographical Zone and there is no evidence of structure within it.

Special Significance

The occurrence of Bering Cisco in Canada warrants special consideration because they likely represent a spawning population on the farthest edge of their anadromous, freshwater migratory range (COSEWIC 2004). The dominance of Bering Cisco in migration runs in lower Yukon River suggests that they are an abundant and important part of the Bering Sea food web (COSEWIC 2004). Bering Cisco are not intentionally harvested in Canada, but they are incidentally caught along with other salmonids in First Nations subsistence fisheries (COSEWIC 2004).

DISTRIBUTION

Global Range

The geographic range of Bering Cisco is almost entirely confined to Alaska, but the species has been reported in the Yukon River in Canada and from the eastern coastal regions of Siberia (Fig 3). In North America, it occurs in coastal regions of, and in large rivers draining into, the Beaufort, Bering and Chukchi seas. In the northern coastal waters of the Beaufort Sea, it has been reported from Port Barrow east to Oliktok Point near the Corville River (Bickham *et al.* 1997; Mecklenburg *et al.* 2002; COSEWIC 2004). In the southern coastal waters, it has been found in both the Bering Sea and the Gulf of Alaska. The species has been reported in brackish coastal areas of Kotzebue Sound, Norton Sound, Yukon Delta National Wildlife Refuge, and along the Bristol Bay coast associated with the Togiak National Wildlife Refuge, and the Cook Inlet in the Kenai River delta area (COSEWIC 2004). Spawning migrations, however, appear to be restricted to the Kuskokwim River, Sustina River, and the Yukon River (Padilla 2015). It is believed that Bering Cisco survived the most recent glacial advance in the Bering refuge and has not significantly expanded its range postglacially (McPhail and Lindsey 1970). Chereshnev (1984) noted the first observations of Bering Cisco outside of North America, when specimens were collected from the mouth of the Chegitun River in the Chukchi Peninsula of Siberia. However, individuals in Siberia were probably vagrants from Alaska, as no spawning populations have been reported (Padilla *et al.* 2015; NatureServe 2016).

Canadian Range

The Canadian population of Bering Cisco is restricted to the mainstem of the Yukon River (Figure 4). The first confirmed report of Bering Cisco in Canadian waters was in 1977 near Dawson City, 145 km upstream of the Alaska / Yukon border (de Graaf 1981). Since then, sporadic observations (normally < 100 per year) have been recorded at fish wheels that were used to monitor Pacific salmon just upstream of the Alaska / Yukon border (COSEWIC 2004), specifically "White Rock" (64.632623° -140.879730°) and "Sheep Rock" (64.619578° -140.760903°) (S. Gotch, DFO pers. comm.). The upstream limit of Bering Cisco in the Yukon River is not known, but major spawning areas have been identified downstream of the Canada-US border (Brown *et al.* 2012b; see Figure 3). It is conceivable that Bering Cisco also migrate into the Canadian portion of the upper Porcupine River, a large tributary of the Yukon drainage basin, and along the Yukon North Slope in the Bering Sea (as the closely related Arctic Cisco do), but so far Bering Cisco have only been found in the mainstem of the Yukon River (Brown *et al.* 2007). This range overlaps with Least Cisco (*Coregonus sardinella*), Arctic Cisco (*Coregonus autumnalis*), and other whitefishes that may be difficult to distinguish morphologically from Bering Cisco.

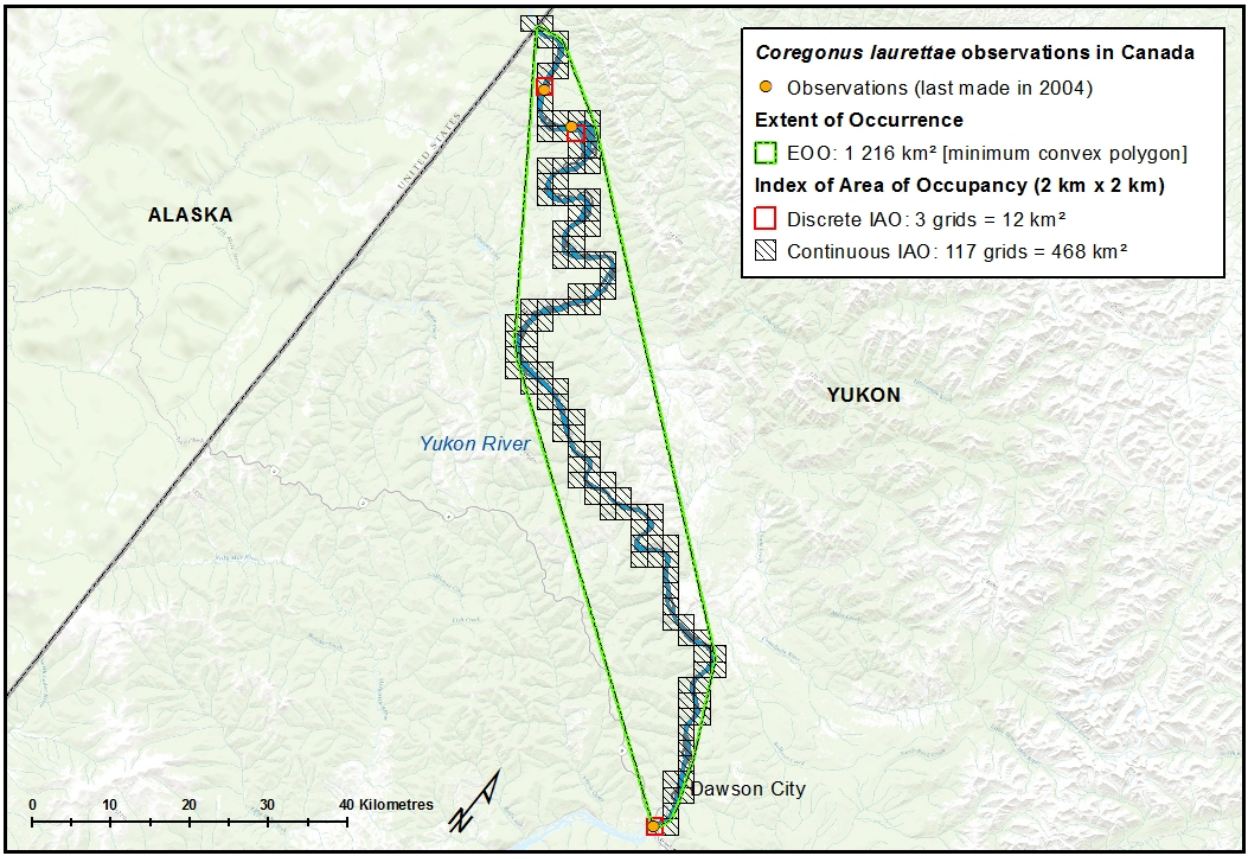

Figure 4. Distribution of Bering Cisco (*Coregonus laurettae*) in Canada.

Extent of Occurrence and Area of Occupancy

The overall extent of occurrence (EOO) of Bering Cisco is 1,216 km^2 using a minimum convex polygon around the two observations of this species in Canada. The index of area of occupancy (IAO) was calculated for 3 grids (using 2 km x 2 km grids), giving a discrete IAO of 12 km^2, and 110 grids for a continuous IAO of 468 km^2, with the section of the Yukon River connecting these two points considered. There have been no new records of Bering Cisco in Canada since the 2004 report was written.

Search Effort

There are no targeted efforts to survey Bering Cisco in Canada, except for the DFO coastal monitoring program outlined below, and most data have historically come from monitoring Pacific salmon runs at the Canada-US border. DFO operated fish wheels and drift gill nets at the border during an annual assessment from the 1970s up to 2004, when transition to the use of Didson sonar began (S. Gotch, DFO pers. comm.). It is not possible to identify Bering Cisco from other small-bodied fishes using this monitoring technique; therefore observations of Bering Cisco in Canadian waters are now scarce. Bering Cisco are not normally caught in the commercial salmon fishery in the Canadian portion of the Yukon River, but this is thought to be due to the large mesh gillnets that are used to target Pacific salmon (S. Gotch, DFO pers. comm.). The earlier timing of the salmon fishery would also largely miss Bering Cisco migration (Oliver Barker, Environment Yukon, pers. comm.).

Rotary screw traps were installed to intercept downstream-migrating juvenile fish near Dawson in 2002, and found 379 putative Bering Cisco juveniles in 2004 (COSEWIC 2004), suggesting that the species is reproducing in Canadian waters. However, juveniles are difficult to identify and these observations have not been confirmed with genetic analyses. Reliable catch information is sparse because of difficulty identifying juvenile Cisco species, often leading investigators to group them all as ‘unidentified coregoninae’ in the absence of molecular biomarker information (e.g., Bradford *et al.* 2008).

For about two decades, DFO had conducted a fish-monitoring program along the coast of the Beaufort Sea coast in Canada’s Western Arctic. Gillnets and trapnets were set along the Yukon North Slope eastwards into the Mackenzie Delta in attempts to catch any fishes that may be present. This program had a mandate to identify fishes, like Bering Cisco, where the presence in the Canadian Western Arctic had not been confirmed. Tens of thousands of fishes were collected and identified, but by the last year of the project (2008), no Bering Cisco had been found. There have also been several community coastal monitoring projects conducted within the Inuvialuit Settlement Area since 2010, but again no Bering Cisco have been found. With the null-catches following extensive sampling programs, DFO has concluded that Bering Cisco does not occur in Canadian coastal waters (J. Reist, DFO pers. comm.).

The Fish and Wildlife Branch of Environment Yukon conducts surveys in freshwater systems within Yukon outside of migratory routes for Pacific salmon. To date, Bering Cisco have not been collected in any lakes, rivers, or streams surveyed by the Yukon government: however, Environment Yukon does not sample the Yukon river mainstem where these fish are likely to be (Oliver Barker, Environment Yukon, pers. comm.). Bering Cisco have also never been reported in the Porcupine River system. Although they have not been specifically targeted in this river, a 2006 study on juvenile salmon outmigration near Old Crow paid special attention to identifying potential Bering Cisco among the many Cisco specimens collected. All Cisco were identified in the field as Least Cisco during the study, and subsequently re-confirmed with photos (Isaac Anderton via William Josie, Vuntut Gwitchin Government, pers. comm.).

Outside of incidental catches in fisheries surveys and incidental harvest by First Nations, it is unlikely for people to encounter Bering Cisco in the Canadian waters due to the nature of fishing activities and gear types used. Also, distinguishing Bering Cisco from other Ciscoes and whitefish is difficult in juvenile stages (S. Gotch, DFO pers. comm.).

HABITAT

Habitat Requirements

Few details are available about the specific habitat requirements of Bering Cisco. It is known that they are anadromous, leaving the brackish coastal or estuarine waters in summer, travelling up rivers, and spawning in the fall, and then returning to the brackish coastal waters after spawning. Bering Cisco spend much of their time prior to maturity in coastal areas, deltas, and estuaries where they develop, feed, and overwinter beneath the ice (McPhail and Lindsey 1970), as has been confirmed with microchemical otolith analyses (Brown *et al.* 2007).

Habitat Trends

There have been no significant habitat changes noted for Bering Cisco in its Canadian range—the mainstem of the Yukon River between the Alaskan boarder and Dawson City. No major developments are proposed that would disturb or alter habitat along this stretch of river. Also, a large, high-speed catamaran Yukon II 2 ceased operating at the end of 2011, resulting in less overall boat traffic and less wake disturbance on shorelines. It should be noted that spawning areas in Canada are unknown, making assessing trends in habitat, other than as a migration route, speculative.

BIOLOGY

Life Cycle and Reproduction

Bering Cisco reach sexual maturity between 4 and 9 years old, with an average of 5 years for females in the Yukon River, at which time they return to natal rivers to spawn in the fall. Bering Cisco are thought to reproduce annually once mature (Brown *et al.* 2012a). Sexually mature adults have a fork length between 31 and 45 cm (COSEWIC 2004). Observations imply broadcast spawning over gravel and sand beds in swiftly flowing water, as with other coregonid species (McPhail and Lindsay 1970; Brown *et al.* 2012a). Females produce between 20,210 and 34,166 eggs, and abandon them quickly to return to brackish coastal waters (Dillinger 1989). Larvae hatch in April and May and spend the beginning of their life migrating downstream over 2000 km in some cases (Brown *et al.* 2007). Bering Cisco juvenile life stages are not found in freshwater habitats beyond river mouths, and they appear to be fully anadromous (Brown *et al.* 2007; COSEWIC 2012). The oldest recorded Bering Cisco reached 13 years (Brown *et al.* 2012b).

Physiology and Adaptability

Little is known about the physiological preferences and adaptability of Bering Cisco, but the closely related Arctic Cisco shows preference of brackish coastal waters (preferred salinity between 27-31‰) and avoidance of the coldest, highly saline marine environments (Alt 1973; Griffiths *et al.* 1992; Fechhelm *et al.* 1993). It is reasonable to believe that Bering Cisco have similar requirements.

Dispersal and Migration

Spawning migration to freshwater begins as early as mid-June, with spawning occurring in early to mid-October (Brown *et al.* 2012a). Catch data from Alaskan fish wheels, 1200 km upstream from the Bering Sea, indicated two distinct migratory peaks: late June and late August / early September. The later peak coincides with more extensive migratory travel and is thought to be the population bound for Canadian waters as Canadian observations occur later in the season (COSEWIC 2004). Bering Cisco were occasionally captured in Canadian fish wheels situated in the Yukon River near the Alaska / Yukon border for monitoring Pacific salmon. The prevalence of migrants this far upstream varied from year to year and was usually <100 fish annually. It is assumed that these Canadian observations represented spawning runs as they always occurred in September to mid-October (COSEWIC 2004). To date, however, no Bering Cisco spawning grounds have been identified within their Canadian range.

Interspecific Interactions

Bering Cisco have a terminal mouth that is adapted for capturing swimming prey, and they feed primarily on small fishes, zooplankton, crustaceans, and aquatic insects (Brown *et al.* 2012a). Runfola (2011) examined stomach contents of 65 Bering Cisco from the Yukon Delta and found Ninespine Stickleback (*Pungitius pungitius*) and Threespine

Stickleback (*Gasterosteus aculeatus*) to be common food items. McPhail and Lindsay (1970) identified amphipods as important in the diet of Bering Cisco, and Alt (1973), reported small sculpin (*Cottus* sp.) among prey items. Feeding occurs primarily in the productive and food-rich nearshore coastal waters and deltas (Lee *et al.* 1980; Morrow 1980). It is thought that Bering Cisco do not feed during their spawning migrations up the Yukon River, but this is not definitive.

Bering Cisco is likely an important food source for piscivorous fishes, birds, and mammals. As young, Bering Cisco would be particularly vulnerable to predation in coastal overwintering areas. Bering Cisco are considered abundant in the lower Yukon River and are likely an important part of the Bering Sea food web (COSEWIC 2004).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

No targeted sampling has been conducted for Bering Cisco in Canadian waters, but specimens have been collected with fish wheels and gillnets targeting other species. In Alaska, video monitoring has also positively identified Bering Cisco (Brown *et al.* 2012a). In the Canadian portion of the Yukon River, most harvesters rely on the use of 6" – 7.5" mesh nets to target Pacific salmon. These nets are too large to regularly catch fish the size of Bering Cisco (S. Gotch, DFO pers. comm.).

In 2002, the rotary screw traps were deployed near Dawson City in the Yukon River to collect juvenile fishes during their downstream movements. Using this method several hundred juvenile ciscoes were trapped, some of which may have been Bering Cisco, but identification of juveniles to species is difficult (COSEWIC 2004).

There was an attempt to identify Bering Cisco amongst Cisco catches from a 2006 study of the Porcupine River system, but none were found. The study was targeting juvenile salmon outmigration near Old Crow using beach seines, and several Ciscoes were captured near Crow Point. All of the specimens were identified as Least Cisco (Isaac Anderton via William Josie, Vuntut Gwitchin Government, pers. comm.).

For over two decades DFO led a coastal fish-monitoring program along the Inuvialuit Settlement Region of the Canadian Beaufort Sea, using trap nets, beach seines, and gillnets designed to catch small-bodied fish, but no Bering Cisco were detected. Following the conclusion of the above-mentioned DFO-led program in 2008, these monitoring methods have been adopted by Inuvialuit-led coastal monitoring programs (J. Reist, DFO pers. comm.).

Aboriginal Traditional Knowledge

Aboriginal Traditional Knowledge (ATK) indicates that the species is known to elders in Dawson City and has a historical presence (COSEWIC 2004). However, no such knowledge exists for this species in the Canadian portion of the Porcupine River (Isaac Anderton via William Josie, Vuntut Gwitchin Government, pers. comm.), or along the Beaufort Sea Coast in the Inuvialuit Settlement Region (Kristen Hynes, Fisheries Joint Management Committee, pers. comm.). In some places the elders have said that Cisco are declining and the texture of the flesh has changed considerably. They also believe that increased parasites in the flesh is due to warming weather (Norma Kassie, Arctic Institute of Community-Based Research, pers. comm. via Jason Harquail COSEWIC ATK sub-committee). In Alaskan communities along the lower Yukon River, this species is abundant enough to be targeted as a subsistence food source. For example, the indigenous Yup'ik fishers harvest 50-100 pounds of Bering Cisco (known as *imarpinraq*) per day in the Yukon River Delta during the fall and spring when these fish migrate to and from brackish marine environments respectively (Runfola 2011).

Abundance

There have been no targeted attempts to assess Bering Cisco abundances in Canada. During migration peaks, up to 200 Bering Cisco are enumerated in Alaskan fish wheels each day (COSEWIC 2004). Prevalence of migrants into Canadian waters appears to be far more limited, with fewer than 100 fish observed in intermittent years since the 1980s (COSEWIC 2004). However, it should be noted that although Bering Cisco were regularly found in fish wheels operated by DFO, non-target species (i.e., species other than Pacific salmon) were not always recorded. Also, distinguishing Bering Cisco from other Ciscoes and whitefish is difficult in juvenile stages (S. Gotch, DFO pers. comm.).

In the US portion of the Yukon River, Bering Cisco are abundant enough to be a component of a commercial Cisco fishery. Quotas for Bering Cisco have more than doubled since the fishery was established in 2005 (see Fluctuations and Trends) because there were more Bering Cisco than previously thought. However, in 2015 a decision was made by the Alaska Department of Fish and Game (ADFG) to cut the quota because it appears that there are fewer than previously thought and further citing "the lack of reliable population abundance information of Yukon River Bering Cisco" (Garcia 2015).

Fluctuations and Trends

There are no recent catch data on which to base estimations of fluctuation or trend in Canadian waters, but a video system set up at a fish wheel in Alaska has noted CPUE is stable or possibly increasing since 2001. Bering Cisco continue to be the most commonly observed fish in these fish wheels (Brown *et al.* 2012a). The 2004 COSEWIC report presented catches of unidentified adult Ciscoes in Canadian fish wheels from 1999-2004, suggesting stability in their pattern of movement and possibly in abundance. This, along with stable catch records in Alaskan fish wheels since 2001, provides limited information to assume a recent change in abundance in Canadian waters.

A commercial coregonid fishery, which included Bering Cisco, was established near the mouth of the Yukon River (Figure 3). Harvest quota was 4500 kg when it opened in 2005 (Brown *et al.* 2012a), but was expanded to 11300 kg by 2014. Acknowledging that population abundance of Bering Cisco is not fully understood, the ADFG has employed the precautionary approach and has capped further quota increases (Garcia 2015). In 2015, eleven species of fish were incidentally harvested at the four sites of the commercial whitefish fishery in the lower Yukon River. The proportion of Bering Cisco in the overall catch ranged from <1% to 83% per site, with females making up 53% of the catch (Garcia 2015).

Rescue Effect

The Canadian population of Bering Cisco migrates up the Yukon River through Alaska from the Bering Sea, and the Yukon River is unobstructed, so there is continual opportunity of a rescue effect.

THREATS AND LIMITING FACTORS

Threats

Biological Resource Use

Salmon surveys used to be conducted using fish wheels and some Bering Cisco were incidentally caught, but fish wheels have since been replaced by sonar survey methods (S. Gotch, DFO pers. comm.). There is some test fishing using gillnets to calibrate the sonar, but no catches of Bering Cisco have been reported.

Human Intrusions & Disturbance

The extent of subsistence harvest throughout the range of Bering Cisco is currently unknown but likely small. Bering Cisco is not targeted, but First Nations fishers in the Yukon do not necessarily differentiate them from whitefish in their subsistence fishery. The fish and eggs are used for food, and also often to feed dogs (COSEWIC 2004). Gillnets set for Pacific salmon are larger than those that would target Cisco-sized fish, but there is still the potential for Bering Cisco to be incidentally caught. The salmon fishery has been declining over time and with it this potential threat (S. Gotch, DFO pers. comm.).

In 2005, Bering Cisco became a targeted species for a commercial coregonid fishery in the lower Yukon River in Alaska. The total harvest value of this fishery in 2015 was estimated to be US$42,610.50 (Garcia 2015). The fishery is managed by the Alaska Department of Fish and Game (ADFG), and the US Fish and Wildlife Service (USFWS). Fishing gear is currently limited to one gillnet up to 45.7 m length and a maximum stretch mesh size of 10.2 cm (Brown *et al.* 2012a; Brown and Daum 2015; Padilla *et al.* 2015). While this fishery is not occurring in Canadian waters, it may affect the Canadian

population. Mixed-stock analysis for the lower Yukon River commercial Cisco harvest conducted by Russ (2015) showed that most of Bering Cisco taken by the fishery from 2010-2012 was composed of Yukon River fish, likely the same stock that migrates into Canadian waters. Bering Cisco are targeted as a subsistence food-fish by the indigenous population of the Yukon River Delta (Runfola 2011). At present, however, there is no sign that the Canadian population is being affected (see Population Sizes and Trends).

The World Wildlife Fund (WWF) watershed report identifies forestry-related habitat loss as a high threat to the headwaters of the Yukon River (WWF 2017). This headwater activity would not have a direct effect on Bering Cisco (as they are restricted to the mainstem) and the effect is negligible at present.

Energy Production & Mining

The Canadian Bering Cisco population is restricted to a single river system (Yukon River), making them susceptible to any development on the river or coastal areas that may obstruct passage or disturb habitat. Coastal habitats could be at risk from activities associated with the oil and gas industry; however, there are no major industrial developments proposed within the Canadian range of Bering Cisco, and the exploration for natural resources has been declining (S. Gotch, DFO, Whitehorse, YT pers. comm.). Placer mining in tributaries of the Yukon River could negatively impact water quality and Bering Cisco habitat, but the impacts would likely be negligible. There is some boating traffic down the Yukon River but the large tourist vessel, the “Yukon Queen II”—a high-speed catamaran that operated between Eagle, Alaska and Dawson City, Yukon has ceased operation for the foreseeable future, and therefore there would be less wake impacts resulting in stranding and nearshore habitat degradation (Oliver Barker, Environment Yukon, pers. comm.). The construction of a hydropower dam is planned on the Susitna River, Alaska and could possibly impact certain stocks of Bering Cisco (Padilla 2015); however, the Susitna and Yukon rivers appear to have separate Bering Cisco stocks (Russ 2015) so activities would not impact the Canadian population directly. Due to its limited and remote distribution in Canada, Bering Cisco would likely have few if any direct interactions with humans aside from incidental catch (S. Gotch, DFO, Whitehorse, YT pers. comm.).

Climate Change and Severe Weather

Anadromous fishes are vulnerable to climate-related disturbances such as permafrost slumps, forest fires, extreme weather events, and temperature extremes. Bering Cisco is restricted to the mainstem of the Yukon River where these impacts may be less pronounced. Bering Cisco is a species that lives exclusively in arctic and sub-arctic waters, and as such would be vulnerable to the impacts of a warming climate. The World Wildlife Fund (WWF) watershed report gives a ‘low’ overall threat and ‘good’ overall condition score for the Yukon River watershed, but lists the effects of climate change as one of the most significant threats (WWF 2017). Nonetheless, the impacts of climate change and severe weather on Bering Cisco are not clear.

Pollution

There is an ongoing threat of effluent pollution from the Dawson City wastewater treatment plant, but this treated effluent is expected to pose a negligible effect.

Limiting Factors

None currently known.

Number of Locations

To date, Bering Cisco has been reported in Canada from only one location: the mainstem of the Yukon River from the Alaska / Yukon border 145 km upstream to Dawson City.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

The *Fisheries Act* applies protection to commercial, Aboriginal, and recreational fisheries. While Bering Cisco are not targeted as a commercial, recreational or subsistence fishery in Canada, cisco and whitefish collectively are harvested by First Nations. Also, Bering Cisco and their habitat may be considered to support commercial, recreational and Aboriginal species (as a prey item) and, hence, may be afforded protection under the *Fisheries Act*.

Non-Legal Status and Ranks

In 2004 COSEWIC designated Bering Cisco as “Special Concern”. Bering Cisco has a global NatureServe conservation rank of G4 (apparently secure), and a rank of N3 (vulnerable) in both the US and Canada. It has rankings of S3 (vulnerable) in both Alaska and the Yukon.

Habitat Protection and Ownership

In Canada, Bering Cisco occurs in public waters, and all fish habitat within these waters that supports a commercial, recreational, or Aboriginal fishery is protected by sections of the federal *Fisheries Act.*

Recovery Efforts Since 2004

There have been no recovery efforts specifically targeting Bering Cisco.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Erik Szkokan-Emilson is a Research Associate with the Ecosystems and Global Change Group at the University of Cambridge. Erik received his PhD from Laurentian University where he studied the watershed ecology of aquatic ecosystems impacted by metal mining and forest disturbance. Erik currently splits his time between Cambridge, England and northeastern Ontario where he studies the impacts of watershed disturbance and climate change on carbon cycling and food webs in aquatic ecosystems.

Pete Cott worked with the Department of Fisheries and Oceans for over 15 years, based out of Yellowknife, Northwest Territories. He is currently the environmental advisor for the Department of National Defence – Joint Task Force North, and an adjunct professor with the University of Alberta. Pete received his PhD from Laurentian University where he studied the reproductive ecology of Burbot. He is a member of the COSEWIC Freshwater Fishes Specialist Subcommittee.

Erik and Pete co-authored the COSEWIC status appraisal summaries on the Deepwater Sculpin and River Redhorse, and the status report on the Deepwater Sculpin.

COLLECTIONS EXAMINED

No collections were examined in the preparation of this report.

Appendix 1. Threats assessment worksheet for Bering Cisco.

Species or Ecosystem Scientific Name	Bering Cisco (*Coregonus laurettae*) - Canadian Population
Element ID	**Elcode**
Date (Ctrl + ";" for today's date):	17/01/2017
Assessor(s):	John Post (SSC co-chair), Dwayne Lepitzki (moderator), Erik Szkokan-Emilson (writer), Pete Cott (writer and SSC member), Bill Tonn (SSC member), Joel Harding (DFO), Syd Cannings (COSEWIC member for CWS), Angele Cyr (Secretariat).
References:	

Overall Threat Impact Calculation Help:

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

Assigned Overall Threat Impact:	**CD = Medium - Low**
Impact Adjustment Reasons:	
Overall Threat Comments	4-9 yr generation time, therefore 12-27 yrs projection into future. Abundant in Bering Sea, portion of global population spawns in Yukon River downstream of Dawson City, possibly in Canada; threats in Canada but also downstream in Alaska. Stock in Yukon are distinct from other two stocks. Incidental catch from salmon. No Bering Cisco in Canadian portion of Porcupine River. Systems connected but Bering Cisco not yet found in either system. Important to note threats in Canadian range (versus US). Although a high level of uncertainty, no adjustment to the overall threats impact.

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. No known recreation. Boat traffic reduced since Yukon Queen no longer in service.
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						not applicable
2.2	Wood & pulp plantations						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.3	Livestock farming & ranching						not applicable
2.4	Marine & freshwater aquaculture						not applicable. Alaskan estuary not known to affect Bering Cisco.
3	Energy production & mining		Negligible	Negligible (<1%)	Extreme - Moderate (11-100%)	High (Continuing)	
3.1	Oil & gas drilling		Negligible	Negligible (<1%)	Negligible (<1%)	Low (Possibly in the long term, >10 yrs/3 gen)	Drilling and mining decreased. Oil and gas exploration on the decline. Mostly in Eagle Planes versus Yukon. None on the horizon. No future plans known of. Looking at 27 years into the future. NWT has a lot of fracking proposals but with the decline in gas prices, much of this has decreased. Nothing on Alaskan estuary either. mostly incidental issues from frack out or erosion (both threat accounted for under another threat category). drilling under the Yukon would require a proposal prior since the river is huge. Negligible.
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme - Moderate (11-100%)	High (Continuing)	Placer mining is conducted in tributaries of the Yukon River and could impact overall habitat quality. While fish continue on into Canada to spawn, the spawning location remains unknown. Impact is to habitat (alteration) but this is not happening in the mainstem. Bcause the exact spawning location is unknown, it is difficult to gauge the impact from this threat given the size of the Yukon. Likely negligible. Uncertainty is high in this threat category. If mining and quarrying was to occur in the Yukon, the overall impact is high to negligible (depending on whether the ciscoes would move or not).
3.3	Renewable energy						not applicable. Hydro electric is accounted for under dams and water management.
4	Transportation & service corridors						
4.1	Roads & railroads						not applicable. Too remote. Plans for the Dawson bridge have been abandonned for now.
4.2	Utility & service lines						not applicable. Two new big gold mines planned for upstream of Dawson. Impact is unknown. Service lines possible. Pipeline in existence crossing the Yukon may be serviced or expanded. Potential plans and impact unknown.
4.3	Shipping lanes						Low level of shipping along the Yukon River. Ferry docking on the Mackenzie but river is already turbid so low impact.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.4	Flight paths						not applicable. Degraded water quality accounted under Pollution 9.3. Only potential for logging in headwater is in the Liard.
5	Biological resource use	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						not applicable
5.2	Gathering terrestrial plants						not applicable
5.3	Logging & wood harvesting						Limited forestry in headwater areas of Yukon River has potential to effect water quality (accounted for under threat 9).
5.4	Fishing & harvesting aquatic resources	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Infrequent bicatch from salmon fishery. Direct impact from targetted and nontargetted sampling. Catch quota for this species. Fisheries seem sustainable. Future increases in quota has been capped at 11,000kg due to uncertainty in population sizes. Salmon/Chum fisheries harvested over ???kg in 2016 which increases threat impact of bycatch. Chum harvest is at the same time as Bering Cisco spawning. Chinook run is earlier (summer) whereas the Chum run is lateer (fall). Coregonids targetted fishing as well. 100 lbs a day in lower Yukon in the spring when fish are going in and in the fall when theyre coming out. Targetted Alaska fisheries use both gill nets and ??? ... ??? fishery, Bering Cisco is 10-80% of catch.
6	Human intrusions & disturbance	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities						Wake from boats and tourist catamaran both negligible.
6.2	War, civil unrest & military exercises						not applicable
6.3	Work & other activities	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Some research by DFO. Sonar test finishing replaced fish wheels. Set netting and sample netting (Lower Yukon Test Finishing). Pilot and Eagle test fishery sample sites. Identified, examined and returned. Some impact but relatively low.
7	Natural system modifications						
7.1	Fire & fire suppression						not applicable
7.2	Dams & water management/use						One dam planned at a tributary (run of the river hydroelectric) on Alaska side but should not affect stock. Another planned on other two stocks but not on the Yukon. Not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications						not applicable
8	Invasive & other problematic species & genes						
8.1	Invasive non-native/alien species/diseases						not applicable
8.2	Problematic native species/diseases						not applicable
8.3	Introduced genetic material						not applicable
8.4	Problematic species/diseases of unknown origin						not applicable
8.5	Viral/prion-induced diseases						not applicable
8.6	Diseases of unknown cause						not applicable
9	Pollution		Negligible	Negligible (<1%)	Unknown	High (Continuing)	
9.1	Domestic & urban waste water		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Dawson treatment plant and that is discharged into river after treatment. Road salt unlikely an issue.
9.2	Industrial & military effluents		Negligible	Negligible (<1%)	Unknown	High - Moderate	Boat barge traffic that may produce oil spill. Upstream. Ferry at Dawson. Some dillution but still a threat. No reports of cisco die off from spills.
9.3	Agricultural & forestry effluents						not applicable
9.4	Garbage & solid waste						not applicable
9.5	Air-borne pollutants						not applicable
9.6	Excess energy						not applicable
10	Geological events						
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides						Permafrost slumping occuring in the north but nothing identified at the same scale in the Yukon.
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Climate change is generally an issue in the northern regions.
11.1	Habitat shifting & alteration						Water flow and temperature changes affecting discharge is a threat. Major shift in hydrology in Kelowny Lake in 2016 as for example.
11.2	Droughts						not applicable
11.3	Temperature extremes						Increasing temperatures could impact BRCS as it is a cold water fish.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.4	Storms & flooding						Water level changes
11.5	Other impacts						not applicable